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Structure of Self-Reported Current Affect: Integration and Beyond

Michelle S. M. Yik and James A. Russell
University of British Columbia

Lisa Feldman Barrett
Boston College

Current affect has been described with various dimensions and structures, including J. A. Russell's (1980) circumplex, D. Watson and A. Tellegen's (1985) positive and negative affect, R. E. Thayer's (1989) tense and energetic arousal, and R. J. Larsen and E. Diener's (1992) 8 combinations of pleasantness and activation. These 4 structures each presuppose bipolar dimensions and have been thought of as interchangeable or 45° rotations of one another, but past data were inconsistent. Huge but not perfect overlap among these four structures was found here in 2 studies of self-reported current affect (Ns = 198 and 217) that controlled for random and systematic errors of measurement. The 4 structures were integrated into a common space defined by 2 bipolar dimensions.

Current affect has been described with various dimensions and structures, including Russell's (1980) circumplex, Watson and Tellegen's (1985) positive and negative affect, Thayer's (1989) tense and energetic arousal, and Larsen and Diener's (1992) eight combinations of pleasantness and activation. In this article, we argue that it is possible to integrate these various concepts in a simple scheme, thereby taking a large step towards unifying dimensional approaches to affect as a person experiences and reports it.

There have been three major approaches to the broad, general dimensions of reported affect. One approach has focused on activation (also known as arousal, energy, tension, and activity). Sleep, drowsiness, alertness, activation, hyperactivation, and, finally, frenzied excitement describe increasing degrees of activation. Activation was prominent in psychological writing throughout most of this century (Berlyne, 1960; Cannon, 1927; Duffy, 1957; Hebb, 1955; Lindsley, 1951; Mandler, 1984; Schachter & Singer, 1962; Zillmann, 1983). Thayer (1989, 1996) has spearheaded a research program on the causes and consequences of everyday affect, conceptualized in terms of types and degrees of activation, demonstrating that self-reported activation is related to everything from diet to personality to neurochemistry.

Michelle S. M. Yik and James A. Russell, Department of Psychology, University of British Columbia, Vancouver, British Columbia, Canada; Lisa Feldman Barrett, Department of Psychology, Boston College.

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Correspondence concerning this article should be addressed to Michelle S. M. Yik, who is now at the School of Business, Pokfulam Road, University of Hong Kong, Hong Kong, or to James A. Russell, Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver, British Columbia, Canada V6T 1Z4. Electronic mail may be sent to myik@business.hku.hk or to jrussell@psych.ubc.ca.

In a second and older approach, the emphasis has been on valence. When Wundt, Stumpf, and Titchener introspected, they concluded that pleasure–displeasure was an elementary dimension of conscious feeling (see Reisenzein, 1992; Reisenzein & Schonpflug, 1992). Pleasure is currently making a comeback as a key concept in diverse areas (Abramson & Pinkerton, 1995; Cabanac, 1995; Piasecki & Kenford, 1997). Valence sometimes is the only general factor found in self-reports of affect (Feldman, 1995; McConville & Cooper, 1992; Wessman & Ricks, 1966; Williams, 1989, 1990). Indeed, in some articles, the words *mood, affect,* and *valence* are used interchangeably.

A third approach has been to include both valence and activation as separate and equally emphasized dimensions within one descriptive structure (Bradley, 1994; Lang, 1978, 1994; Lang, Bradley, & Cuthbert, 1992; Osgood, 1966; Osgood, May, & Miron, 1975; Russell, 1978, Wundt, 1924). In this article, we pursue this third approach. Of course, other broad dimensions have been proposed, and we do not want to be misunderstood as claiming that valence and activation are the only dimensions of affect. What we do believe is that these two are essential and that it is essential to study them simultaneously. Doing so provides a conceptual clarity otherwise missing. Psychometric research that has emphasized activation over valence or vice versa has resulted in a puzzling state of affairs. Here are two examples.

First, Watson and Tellegen's (1985) psychometric research on positive and negative affect led not to a single dimension, but to a two-dimensional structure (as shown in Figure 1). They interpreted both dimensions in terms of valence—high versus low positive affect and high versus low negative affect—although activation was implicit in their framework. Second, Thayer's (1986) psychometric work on activation led not to a single activation–deactivation dimension, but to a two-dimensional structure (also shown in Figure 1). Thus, the study of valence alone may seem to yield two valence dimensions, just as the study of activation alone may seem to yield two activation dimensions. A structure that unites valence and activation resolves such puzzles. According to the hypothesis to be examined in this article, when all dimensions are measured simultaneously, the result will not be four dimensions, but two.

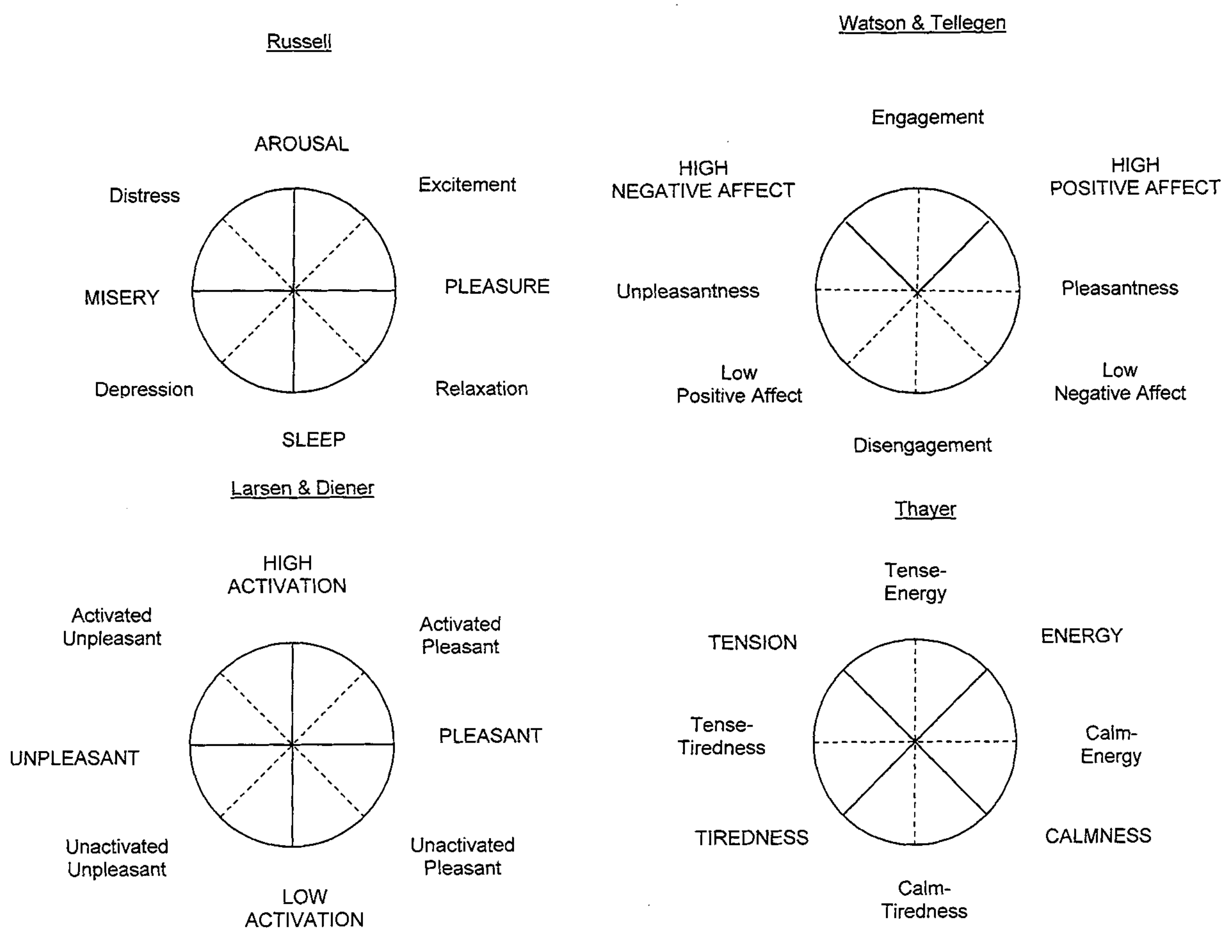

Figure 1. Four schematic descriptions of affect. Structures shown are based on those presented by (a) Russell (1980, p. 1164), (b) Watson and Tellegen (1985, p. 221), (c) Larsen and Diener (1992, p. 39), and (d) Thayer (1996, p. 150). Nevertheless, what we show here is rotated and reoriented from the original to highlight the similarity we hypothesize among these four structures. The focal dimensions are shown in capital letters. Watson and Tellegen's dimensions are capitalized in the upper half to show that they emphasize the high activation part of each construct. Adapted from "Core Affect, Prototypical Emotional Episodes, and Other Things Called Emotion: Dissecting the Elephant," by J. A. Russell and L. Feldman Barrett, 1999, *Journal of Personality and Social Psychology, 76,* p. 810. Copyright 1999 by the American Psychological Association.

On our hypothesis, Watson and Tellegen's (1985) structure of positive and negative affect and Thayer's (1989) structure of tense and energetic activation describe one and the same space, just differently labeled and conceptualized. Moreover, their two structures describe the same space captured by Russell (1980) and by Larsen and Diener (1992), who gave equal emphasis to both valence and activation (their structures are also shown in Figure 1). If so, this convergence, despite different starting places, would be very encouraging to the utility of an integrated two-dimensional structure for self-reported affect.

The 45°-Rotation Hypothesis

The four structures of Figure 1 have each been proposed as broad general descriptions of temporary affective states. Each has guided research, often in quite different domains. Each has been the basis of specific measures of affect. Integration of these structures is something to be desired, potentially uniting an impressive and diverse array of research.

Many writers have assumed that integrating these four structures is extremely simple. Indeed some writers—including all the authors of these structures—have assumed that these structures are rotational variants of one another (Barlow, 1988; Hutchison et al., 1996; Lang et al., 1992; Mano, 1991). The assumption is captured in Figure 2 by placing all four structures within the same two-dimensional space with 45° between dimensions. Figure 2 is based Larsen and Diener's (1992) conceptual analysis and is simply the Cartesian space formed from the pleasantness–unpleasantness and activation–deactivation axes. This simple schematic diagram captures the main features of the structures of Figure 1 as well as those offered by Feldman (1995), Green, Goldman, and Salovey (1993),

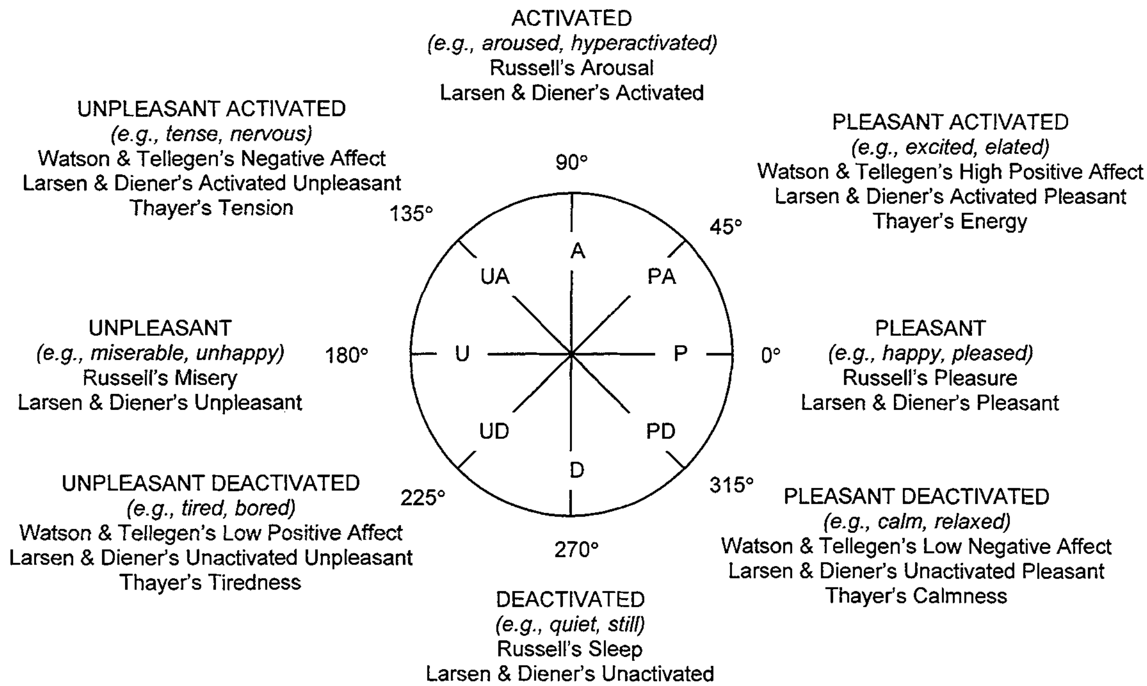

Figure 2. The 45°-rotation hypothesis: 20 unipolar affect constructs within a two-dimensional space.

Lang (1994), and Reisenzein (1994). Further, Figure 2 incorporates a circular ordering among the elements (Plutchik, 1962; Russell, 1980; Schlosberg, 1952, 1954).

As shown in Figure 2, the 45°-rotation hypothesis makes extremely strong predictions. Some dimensions, despite quite different labels—for example, Watson and Tellegen's (1985) High Positive Affect, Larsen and Diener's (1992) Activated Pleasant Affect, and Thayer's (1989) Energy—are identical. Each unipolar dimension has another dimension that is its bipolar opposite. All individual dimensions are separated by multiples of 45°. Any two nonredundant dimensions account for all the substantive variance in all the other dimensions.

The 45°-rotation hypothesis is often assumed to be correct, but there is little empirical evidence on how similar the four structures actually are, and what data exist have not been consistent (Burke, Brief, George, Roberson, & Webster, 1989; Feldman Barrett & Russell, 1998; Hutchison et al., 1996; Mayer & Gaschke, 1988; Nemanick & Munz, 1994; Russell, 1979; Russell & Mehrabian, 1977; Russell, Weiss, & Mendelsohn, 1989). For instance, Hutchison et al. examined the equivalence of Watson and Tellegen's (1985) system with the pleasure–arousal system and obtained correlations between .09 and .45 in magnitude for variables assumed to be 45° apart (under ideal measurement conditions, two variables separated by 45° correlate .71). They therefore concluded that "it may be misleading to assume that data obtained by measuring dimensions from one of the models can be used to make inferences about dimensions of the other model" (p. 785). Similarly, Burke et al. administered Watson and Tellegen's scales of high Positive Affect and high Negative Affect and what, according to Figure 2, would be their hypothesized bipolar opposites. Precisely contrary to that hypothesis, a model with four orthogonal unipolar factors fit the data better than did a model with two bipolar factors.

Overview

The present study examined the hypothesis that the schematic structure presented in Figure 2 is capable of integrating the four specific structures of self-reported current affect shown in Figure 1. Russell's (1980) structure was represented in an updated version developed by Feldman Barrett and Russell (1998). Their scales were used to define the horizontal and vertical axes and can also be thought of as representing the equivalent dimensions proposed by Larsen and Diener (1992). The focal question then was the relation of the Pleasant–Unpleasant and Activated–Deactivated axes to all dimensions 45° away from the axes in Figure 2—in other words, the diagonal dimensions.

In a first study, we replicated results reported by Feldman Barrett and Russell (1998) showing that Watson and Tellegen's (1985) dimensions labeled Positive Affect and Negative Affect have the specified bipolar opposites and fit well into our proposed integrated structure. By *fit,* we specifically mean (a) that unipolar dimensions shown in Figure 2 as 180° apart are approximately bipolar, (b) that nearly all of the reliable variance in these four constructs is accounted for by the Pleasant–Unpleasant and Activated–Deactivated axes, and (c) that the integration makes conceptual sense: The four constructs fit meaningfully into the proposed structure.

In a second study, we show that Thayer's (1989, 1996) schematic structure of activation fits into our proposed integrated structure in the same sense. Because of the extensive program of research centered on Thayer's dimensions, incorporating them within our structure is an exciting possibility. In the same study, we also show that four constructs at 45° from the axes in Larsen and Diener's (1992) structure fit into our structure in the same sense.

Above we noted that past research has not found the high correlations that our proposed integration requires. We explore the possibility that in past studies, errors of measurement may have concealed the underlying structure. In the first place, past studies of self-reported affect may have suffered from an overly long or vague time frame. Some instructions ask participants to describe their affective state over a period ("so far today," "this morning," or longer) during which various and even opposite feelings might have occurred. Even instructions to describe feelings of the current moment might be problematic if the respondent then completes a long questionnaire, over the course of which different feelings occur. The present studies try to minimize this problem of time frame by asking participants to consider a specific moment, to pause and think about how they felt during that moment, and then to answer all subsequent questionnaires with respect to that moment.

More important are the random and systematic errors inherent in measurement. Hutchison et al. (1996) relied on correlations among observed variables, and although Burke et al. (1989) used a structural equation model to control random error, each variable was assessed with a single response format, and hence their measures may have been influenced by systematic error. Green et al. (1993) showed that random and systematic errors inherent in measurement can obscure the underlying structure: Data gathered with different response formats and then analyzed with a structural equation model revealed simple and powerful relations not evident in observed measures. In the present study, each dimension was therefore assessed with three different formats. To assess Larsen and Diener's (1992), Watson and Tellegen's (1985), and Thayer's (1986) constructs, adjective scales were taken directly from these authors, but additional scales were constructed to fit the multiformat method of Green et al. (1993). The structural equation modeling software SEPATH (Steiger, 1995) was used to analyze the data. Finally, to explore the apparent circular ordering seen in Figure 2, the data were also analyzed with Browne's (1992) structural equation modeling technique for testing circumplexity (see Fabrigar, Visser, & Browne, 1997, for a readily accessible description of this procedure).

Method

Participants

Participants were 198 undergraduates from Boston College (Boston sample) and 217 from the University of British Columbia (Vancouver sample). They were enrolled in various psychology courses and received course credit in exchange for their participation.

Procedure

Participants in the Boston sample completed a battery of questionnaires in groups of 10 to 15 in a laboratory. Those in the Vancouver sample completed a partially different battery during class. On the front page of both batteries were the same general instructions, including the request that "Before you begin, please pause to consider how you are feeling RIGHT NOW, THIS INSTANT." All subsequent questionnaires were to be answered with respect to that moment. Participants were instructed specifically not to describe their feelings as they changed over the time they were completing the battery. Rather, they were to describe how they had felt in that instant just at the beginning of the instructions. On average, completion took approximately 30 min.

Affect Scales

Both samples received an affect questionnaire in three parts, corresponding to three different response formats: (a) an adjective list with each item accompanied by a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*; adjective format; ADJ); (b) a list of statements with which participants were asked to indicate their degree of agreement, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*; "agree–disagree" format; AGREE); and (c) a list of statements, for each of which participants were to indicate how well it described their feelings, ranging from 1 (*not at all*) to 4 (*very well*; "describes me" format; DESCRIBE). All items are available from the authors.

Current Mood Questionnaire (CMQ). Participants in both samples completed scales of Pleasant, Unpleasant, Activated, and Deactivated states developed by Feldman Barrett and Russell (1998), who found these scales to have good convergent and discriminant validities. Participants also completed the semantic differential scales of Pleasure and Arousal (Mehrabian & Russell, 1974).

Watson, Clark, and Tellegen's scales. Participants in the Boston sample completed scales of Watson, Clark, and Tellegen's (1988) Positive Affect and Negative Affect and their hypothesized bipolar opposites. Our three-format version of Watson et al.'s scales was adopted from Feldman Barrett and Russell (1998). The adjective items for Positive Affect and Negative Affect were taken from Watson et al.'s Positive and Negative Affect Schedule (PANAS). Scales had been constructed to measure their hypothesized bipolar opposites, Low Positive Affect and Low Negative Affect (as defined in Figure 2) using the Fatigue and Serene subscales of the Positive and Negative Affect Schedule—Expanded Form (Watson & Clark, 1994). AGREE and DESCRIBE scales were constructed with the same or similar adjectives.

Larsen and Diener's and Thayer's scales. Participants in the Vancouver sample completed scales measuring (a) Larsen and Diener's (1992) Activated Unpleasant, Unactivated Unpleasant, Activated Pleasant, and Unactivated Pleasant Affect variables and (b) Thayer's (1996) Energy, Tiredness, Tension, and Calmness variables. Adjectives were taken directly from the authors. AGREE and DESCRIBE scales were constructed with the same or similar adjectives.

Item overlap. Given our hypothesis about the strong interrelationships among the variables assessed, we were not surprised by item overlap among the different scales. In order to examine our hypotheses, we made sure that the four scales of the CMQ (used here to assess the vertical and horizontal axes of Figure 2) had no item overlap whatsoever with any other scale. Among the remaining scales (all of which were meant to assess constructs at 45° from the axes), item overlap varied with response format. For instance, the adjective format for Watson and Tellegen's (1985) Low Positive Affect and Low Negative Affect coincided entirely with Larsen and Diener's (1992) Unactivated Unpleasant and Unactivated Pleasant scales, respectively. In contrast, because we constructed the items for other formats, the AGREE scales showed only partial overlap. Across the three formats, 25 of the 84 items of Watson and Tellegen's scales also appeared on Larsen and Diener's scales, and 10 appeared on Thayer's (1996) scales; 8 of the 47 items on Larsen and Diener's scales appeared on Thayer's scales.

Data Analysis

Correlation matrices for manifest variables were submitted to confirmatory factor analyses and structural equation modeling using SEPATH in

Statistica (Steiger, 1995).[1] Completely standardized solutions were obtained. (Thus, both latent and manifest variables were scaled to a variance of 1.00.) To control systematic error variance, we estimated the correlations between the error terms for manifest scales with the same response format.

For SEPATH, many different indexes are available to assess the degree to which a structural equation model fits the observed data. Because different fit indexes are suitable for evaluating different aspects of the hypothesized models, such as parsimony, variance explained, and so on, no single measure of model fit should be relied on exclusively (Bollen & Long, 1993). We used five indexes to assess model fit when data samples were analyzed separately.

First, the chi-square statistic was used. This statistic tests the null hypothesis that the hypothesized model reproduces the correlation matrix perfectly for the manifest variables. While keeping the sample size constant, the larger the chi-square, the more the correlation matrix specified by the hypothesized model deviates from the correlation matrix for the manifest variables. The chi-square statistic is dependent on sample size, however, such that it can be significant even for models that fit the data relatively well (Bentler, 1990). Second, we used χ^2/df, which indexes the size of chi-square relative to degrees of freedom. The lower the ratio, the better the model fit. Third, Steiger and Lind's (1980) root mean square error of approximation (RMSEA), which can roughly be regarded as a root mean square standardized residual, was used. RMSEA is adjusted for model complexity and is therefore useful in comparing two nested models. Greater values indicate poorer fit. Fourth, the adjusted goodness-of-fit index (AGFI), which provides a direct measure of goodness of fit, was used. The values fall between 0 (a complete lack of fit) and 1 (a complete fit). This index is similar to an adjusted R^2 statistic used in the general linear model (Tanaka, 1993). Fifth, the comparative fit index (CFI; see Bentler, 1990), which is a normed-fit index that evaluates the adequacy of the hypothesized model in relation to a baseline model, was used. 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.

Occasionally we report multisample analyses. Both AGFI and CFI are single-sample based statistics designed for standard structural equation models and are not appropriate for a multisample analysis. For our multisample analyses and Browne's (1992) CIRCUM, we therefore relied on chi-square, χ^2/df, and RMSEA.

Results

The results are presented in four sections. First, the bipolarity implicit in each of the four structures was tested. Second, each of the original structures was examined separately to determine whether the measurement model for each structure was adequate. Third, the relationships among the various structures were explored to determine whether the Pleasant versus Unpleasant and Activated versus Deactivated axes could account for all of the remaining dimensions assessed. Fourth, the 45°-rotation hypothesis was compared to a circumplex structure in which dimensions are allowed to fall at different angles throughout the two-dimensional space.

Test for Bipolarity

A critical assumption in each of the structural models is that certain of its dimensions are bipolar—namely, those shown 180° apart in Figure 2. We begin with an assessment of this assumption.

Russell and Carroll (1999) noted a contradiction in previous analyses of bipolarity, which had required unipolar response formats and a correlation of −1.00. These two requirements cannot be met simultaneously. Even when random and nonrandom error has been completely eliminated, to achieve a correlation of −1.00 requires a strictly bipolar response format, and yet bipolar response formats are (rightly) deemed illegitimate and not used. Unipolar formats were used, but the more strictly unipolar the format, the farther from −1.00 is the expected correlation between bipolar opposites. Further, ostensibly unipolar formats, such as those used in our questionnaires, vary in just how strict they are. Russell and Carroll argued that the type of format we used is ambiguous, explicitly unipolar but implicitly bipolar, because some but not all participants interpret it as bipolar.

The implication of Russell and Carroll's (1999) analysis is that testing bipolarity is not as straightforward as once thought. One cannot simply calculate a correlation and see how close it is to −1.00. Testing bipolarity requires a number of additional assumptions, such as that the latent bipolar dimension is normally distributed. With these assumptions, and for the types of format used here, we suggest the following indications of bipolarity:

1. The correlation falls within the range of −.47 to −1.00. The closer to −1.00, of course, the more confident one is of bipolarity. By correlation, we refer to the correlation estimated by a structural equation modeling procedure that takes into account both random and nonrandom error.

2. When the correlation is far from −1.00, then at least one of the variates and possibly both show a positive skew (when they are scored, as is done traditionally and as was done here, with the lowest score corresponding to neutral and the highest score to a high degree of the named variable, such as sadness). The more positive the skew seen in the two variables, the lower in magnitude is the correlation between them.

3. The bivariate frequency distribution tends to be triangular, with more scores falling in the triangle that includes 1, 1 than in the triangle that includes 5, 5, when the rating scale is 1 to 5. We call this triangle the lower triangle.

These three criteria are to some extent overlapping, and must be considered tentative. Still, for the kinds of response formats in common use, such rules of thumb may be the best we can do for now.

Table 1 shows relevant statistics for eight hypothesized bipolar opposites. For example, consider Pleasant and its hypothesized bipolar opposite, Unpleasant, in the Boston sample. Pleasant showed negative skew, but Unpleasant showed positive skew much greater in magnitude than the negative skew of Pleasant. For all three formats, more cases fell in the lower than in the upper triangle of the bivariate frequency distribution. Finally, the correlation between Pleasant and Unpleasant was estimated with a confirmatory factor analysis with correlated error terms. The result, −.92, fell within the predicted range and, indeed, was substantial in magnitude. Thus, Pleasant and Unpleasant are clearly bipolar opposites.

[1] Cudeck (1989) pointed out that structural equation modeling procedures then available analyzed correlation matrices as if they were covariance matrices, resulting in the possibility of incorrect results. Browne (1982) developed constrained estimation procedures that allow the correct analysis of correlation matrices in a structural equation. SEPATH (Steiger, 1995) incorporates Browne's procedures and thus provides correct results for the analysis of a correlation matrix.

Table 1
Statistics for a Test of Bipolarity

Format	Variable	Skew	Hypothesized opposite	Skew	Proportion of cases: Lower triangle	Proportion of cases: Upper triangle	Φ
Boston sample (*N* = 198)							
Horizontal axis: Pleasant vs. Unpleasant							−.92
ADJ	Pleasant	0.22	Unpleasant	1.16	88	3	
AGREE	Pleasant	−0.27	Unpleasant	0.37	65	17	
DESCRIBE	Pleasant	−0.27	Unpleasant	0.40	50	31	
Vertical axis: Activated vs. Deactivated							−.77
ADJ	Activated	0.69	Deactivated	0.18	78	10	
AGREE	Activated	0.38	Deactivated	−0.50	42	39	
DESCRIBE	Activated	0.52	Deactivated	−0.05	68	24	
Watson & Tellegen's (1985) High vs. Low Positive Affect							−.73
ADJ	High Positive Affect	0.23	Low Positive Affect	0.45	79	20	
AGREE	High Positive Affect	0.02	Low Positive Affect	−0.27	40	58	
DESCRIBE	High Positive Affect	0.33	Low Positive Affect	−0.10	67	33	
Watson & Tellegen's (1985) High vs. Low Negative Affect							−.79
ADJ	High Negative Affect	1.03	Low Negative Affect	−0.06	91	8	
AGREE	High Negative Affect	0.13	Low Negative Affect	−0.23	79	19	
DESCRIBE	High Negative Affect	0.48	Low Negative Affect	−0.11	79	17	
Vancouver sample (*N* = 217)							
Horizontal axis: Pleasant vs. Unpleasant							−.89
ADJ	Pleasant	−0.00	Unpleasant	1.00	88	6	
AGREE	Pleasant	−0.40	Unpleasant	0.66	65	14	
DESCRIBE	Pleasant	−0.32	Unpleasant	0.41	38	38	
Vertical axis: Activated vs. Deactivated							−.71
ADJ	Activated	0.71	Deactivated	0.08	80	10	
AGREE	Activated	0.30	Deactivated	−0.61	48	36	
DESCRIBE	Activated	0.35	Deactivated	−0.27	71	25	
Larsen & Diener's (1992) Activated Pleasant vs. Unactivated Unpleasant							−.52
ADJ	Activated Pleasant	0.73	Unactivated Unpleasant	0.57	92	8	
AGREE	Activated Pleasant	0.31	Unactivated Unpleasant	0.10	74	25	
DESCRIBE	Activated Pleasant	0.46	Unactivated Unpleasant	−0.01	74	16	
Larsen & Diener's (1992) Activated Unpleasant vs. Unactivated Pleasant							−.76
ADJ	Activated Unpleasant	1.01	Unactivated Pleasant	−0.20	90	8	
AGREE	Activated Unpleasant	0.33	Unactivated Pleasant	−0.49	55	30	
DESCRIBE	Activated Unpleasant	0.67	Unactivated Pleasant	−0.18	72	18	
Thayer's (1989) Energy vs. Tiredness							−.69
ADJ	Energy	0.68	Tiredness	0.23	82	12	
AGREE	Energy	0.38	Tiredness	0.09	67	20	
DESCRIBE	Energy	0.60	Tiredness	0.05	75	19	
Thayer's (1989) Tension vs. Calmness							−.66
ADJ	Tension	0.85	Calmness	−0.04	92	6	
AGREE	Tension	0.54	Calmness	−0.15	78	12	
DESCRIBE	Tension	0.58	Calmness	−0.55	61	30	

Note. ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. The lower triangle indicates the percentage of participants who fall below the diagonal in a bivariate distribution of the hypothesized opposites; the upper triangle indicates the percentage of participants who fall above the diagonal. Because of cases falling on the diagonal, the two proportions do not sum to 100. Φ indicates the latent correlation between the hypothesized opposites in a confirmatory factor analysis, each variable indicated by its three response formats. All Φ coefficients are significant at the .001 level.

Overall, the results fit our criteria for bipolarity for all pairs considered. The weakest estimated correlation (−.52) occurred with Larsen and Diener's (1992) Pleasant Activated versus Unpleasant Deactivated. Accounting for the attenuated correlation is the positive skew in five of six cells and the disproportionate number of cases in the lower triangle.

These results do not allow us to declare all eight pairs perfect bipolar opposites. Still, the results do fit the pattern expected of bipolar opposites. In the remaining analyses, we assume that we are justified in combining these pairs into single bipolar variables. Our rationale is similar to that used when imperfectly correlated items or subscales are combined into a single variable.

Measurement Models

In this section, we examine the ability of the various scales used to assess the original structures from which the scales were derived. For all measurement models, the following parameters were 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 variances with the same response format, and (d) correlation between latent constructs.

Pleasant versus Unpleasant and Activated versus Deactivated axes. The horizontal and vertical axes of Figure 2 were assessed by the CMQ. The psychometric properties of the CMQ replicated those found by Feldman Barrett and Russell (1998). The CMQ assesses four unipolar constructs (Pleasant, Unpleasant, Activated, and Deactivated) with 12 unipolar scales (4 constructs × 3 response formats). The first analysis used confirmatory factor analysis with four latent constructs to show that these 12 scales capture the two axes defining the proposed structure of Figure 2. The semantic differential scales were not used in these analyses. As shown in Table 2, the hypothesized model fit the data moderately well. Details of the measurement model are given in Table 3.

Next, we compared the measurement model to the one in which the correlations among all four latent constructs were fixed to .00. This comparison model thus posits four orthogonal unipolar factors and is what Burke et al. (1989) had found superior to a two-dimensional bipolar model. As shown in Table 2, the original measurement model fit the data significantly better than did the comparison model: For the Boston sample, $\Delta\chi^2(6, N = 198) = 302.30$, $p < .001$, and RMSEA changed from .10 to .20. For the Vancouver sample, $\Delta\chi^2(6, N = 217) = 401.42$, $p < .001$, and RMSEA changed from .07 to .20.

As shown in Table 3, the parameter estimates for the four constructs underlying the CMQ varied slightly from one sample to the other. Because these constructs are the cornerstones of the two-dimensional space of our proposed integrated structural model, we wanted to obtain more stable estimates so that results from our two samples could be more meaningfully compared and so that we could use these estimates in more direct tests of our model. We therefore conducted a multisample confirmatory factor analysis using data from our two samples and data from Study 3 of Feldman Barrett and Russell (1998). In each analysis, the parameter estimates for factor loadings and for interfactor correlations (but not error terms) were constrained to be equivalent across all data sets. We examined three models.

Table 2
Indexes of Fit for Measurement Models

Model	Indexes of fit					
	χ^2	*df*	χ^2/df	RMSEA	AGFI	CFI
Boston sample (N = 198)						
CMQ						
Model with correlated constructs	93.17	30	3.11	.10	.82	.95
Model with correlations between constructs fixed to zero	395.47	36	10.99	.20	.54	.69
Watson & Tellegen's (1985) unipolar constructs						
Model with correlated constructs	63.31	30	2.11	.07	.88	.98
Model with correlations between constructs fixed to zero	340.56	36	9.46	.20	.54	.80
Vancouver sample (N = 217)						
CMQ						
Model with correlated constructs	70.72	30	2.36	.07	.87	.98
Model with correlations between constructs fixed to zero	472.14	36	13.12	.20	.55	.78
Larsen & Diener's (1992) unipolar constructs						
Model with correlated constructs	52.60	30	1.75	.06	.90	.99
Model with correlations between constructs fixed to zero	303.22	36	8.42	.17	.63	.87
Thayer's (1989) unipolar constructs						
Model with correlated constructs	63.13	30	2.10	.07	.88	.99
Model with correlations between constructs fixed to zero	320.79	36	8.91	.16	.66	.87
Combination of Larsen & Diener's (1992) and Thayer's (1989) unipolar constructs						
Model with correlated constructs	253.94	140	1.81	.06	.82	.98
Model fixing between-structure correlations to zero	2,088.77	204	10.24	.15	.53	.69
Model setting the correlations between hypothesized equivalents to 1.00	458.63	144	3.18	.10	.70	.95

Note. RMSEA = root mean square error of approximation; AGFI = adjusted goodness-of-fit index; CFI = comparative fit index.

Table 3
Current Mood Questionnaire: Standardized Factor Loadings and Interfactor Correlations in the Boston (B) and Vancouver (V) Samples

	Pleasant		Unpleasant		Activated		Deactivated		*M*		*SD*		α	
Construct and format	B	V	B	V	B	V	B	V	B	V	B	V	B	V
							Factor loadings							
Pleasant														
ADJ	.74*	.84*							2.70	2.85	0.92	0.88	.74	.83
AGREE	.85*	.91*							3.18	3.30	0.86	0.82	.77	.89
DESCRIBE	.76*	.85*							2.66	2.88	0.95	0.76	.77	.78
Unpleasant														
ADJ			.85*	.91*					1.99	1.95	1.01	0.94	.86	.86
AGREE			.90*	.92*					2.42	2.26	1.02	1.01	.83	.88
DESCRIBE			.83*	.91*					2.17	2.10	1.00	0.92	.85	.89
Activated														
ADJ					.47*	.68*			2.16	2.23	0.81	0.75	.59	.66
AGREE					.91*	.92*			2.67	2.52	0.92	0.75	.54	.59
DESCRIBE					.41*	.79*			2.05	2.18	0.76	0.62	.69	.56
Deactivated														
ADJ							.63*	.78*	2.92	2.87	0.89	0.89	.55	.66
AGREE							.47*	.72*	3.35	3.36	0.90	0.85	.53	.72
DESCRIBE							.73*	.83*	2.45	2.48	0.74	0.61	.71	.65
							Interfactor correlations							
Pleasant	—	—												
Unpleasant	−.92*	−.90*	—	—										
Activated	.44*	.22	−.33*	−.03	—	—								
Deactivated	−.10	−.10	.08	.11	−.70*	−.71*	—	—						

Note. N = 198 for the Boston sample, and N = 217 for the Vancouver sample. ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. Possible mean scores range from 1 to 5 for ADJ and AGREE formats and from 1 to 4 for DESCRIBE format.
$^* p < .001$.

The first analysis (Model 1) used data from the three samples (Ns = 198, 217, and 316) to replicate the results shown in Table 3: There were four latent unipolar constructs (Pleasant, Unpleasant, Activated, and Deactivated), each indicated by three different response formats, with the correlations between the constructs estimated. The hypothesized model fit the data well: $\chi^2(126, Ns = 198, 217, 316) = 345.42, p < .001, \chi^2/df = 2.74$, RMSEA = .08. Parameter estimates for this model are shown in Figure 3. A comparison model (a four-factor model in which correlations among latent constructs were fixed to 0) fit the data poorly: $\chi^2(132, Ns = 198, 217, 316) = 1{,}678.68, p < .001, \chi^2/df = 12.72$, RMSEA = .19. The measurement model (Model 1) fit the data significantly better than did the comparison model: $\Delta\chi^2(6, Ns = 198, 217, 316) = 1{,}333.26, p < .001$, and RMSEA changed from .08 to .19.

The results just reported, as well as those of Table 1, justified combining Pleasant and Unpleasant, and Activated and Deactivated, into bipolar constructs. We therefore specified a factor model (Model 2) with two constructs, Pleasant versus Unpleasant and Activated versus Deactivated. We computed the bipolar version of each response format by taking the difference between the mean bipolar opposite scales. For instance, the bipolar version of the ADJ of the Pleasant versus Unpleasant score was computed as the difference between the means of Pleasant and Unpleasant adjective scales. We estimated the loadings of the six bipolar scales (2 constructs × 3 response formats) on their intended latent factor. The semantic differential scale of Pleasure was allowed to load only on Pleasant versus Unpleasant and the scale of Arousal only on Activated versus Deactivated. The correlation between the two latent constructs was estimated. The data fit the model moderately well: $\chi^2(71, Ns = 198, 217, 316) = 280.61, p < .001, \chi^2/df = 3.95$, RMSEA = .11. The correlation between Pleasant versus Unpleasant and Activated versus Deactivated was estimated to be .14 (p = .001), indicating that they were largely but not completely independent.

For use in later analyses, we specified another factor model (Model 3) whose model specifications were identical to those of Model 2, except that the correlation between Pleasant versus Unpleasant and Activated versus Deactivated was fixed to .00. The data fit the model moderately well: $\chi^2(72, Ns = 198, 217, 316) = 292.06, p < .001, \chi^2/df = 4.06$, RMSEA = .11. Compared with Model 2, Model 3 yielded $\Delta\chi^2(1, Ns = 198, 217, 316) = 11.45, p < .001$. However, the RMSEA was identical for Models 2 and 3, indicating that neither model was necessarily better than the other. Model 2 is thus the clearest representation of the axes as assessed with the present set of scales (CMQ). Model 3 provides a more theoretical representation of the orthogonal components of the variables. We therefore used Model 3 (orthogonal axes) only for the purpose of constructing the graph shown in Figure 5, and we used Model 2 (correlated axes) in constructing structural equation models.

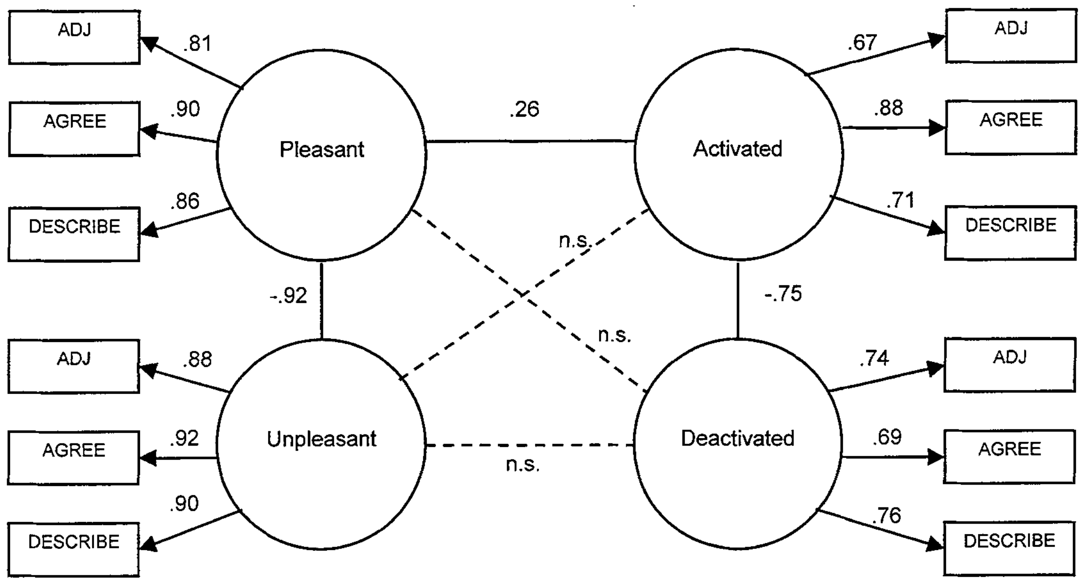

Figure 3. A structural equation model for the four Current Mood Questionnaire unipolar constructs. Only those coefficients significant at the .001 level are shown. Dotted lines indicate the paths that were estimated but for which the coefficients were not significant at the .001 level. Error terms and correlation between error terms with the same response format were also estimated but are not shown. ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format.

Watson and Tellegen's constructs. With data from the Boston sample, we replicated Feldman Barrett and Russell's (1998; Study 3) analysis of the structure of Watson and Tellegen's (1985) Positive Affect and Negative Affect as well as Low Positive Affect and Low Negative Affect. We tested a model that specified four unipolar constructs (High and Low Positive Affect, High and Low Negative Affect), each indicated by three response formats. As shown in Table 2, the measurement model fit the data well. Parameter estimates and descriptive statistics are given in Table 4. Positive Affect and Negative Affect were significantly correlated (−.36) and therefore not independent. Other estimations of this correlation ranged from −.58 (Green et al., 1993) to −.43 (Tellegen, Watson, & Clark, 1994, in press).

As we did before, we also examined a four-factor comparison model (four orthogonal unipolar constructs with their correlations fixed to .00). The measurement model fit the data significantly better than did the comparison model: $\Delta\chi^2(6, N = 198) = 277.25$, $p < .001$, and RMSEA changed from .07 to .20.

Larsen and Diener's constructs. With data from the Vancouver sample, we tested a model that specified four unipolar constructs (Activated Pleasant, Unactivated Unpleasant, Activated Unpleasant, and Unactivated Pleasant), each indicated by three response formats. As shown in Table 2, the hypothesized model fit the data well. Parameter estimates and descriptive statistics are given in Table 5. This measurement model fit the data significantly better than did a four-factor comparison model (the correlations among latent constructs fixed to .00): $\Delta\chi^2(6, N = 217) = 250.62$, $p < .001$, and RMSEA changed from .06 to .17.

Thayer's constructs. With data from the Vancouver sample, we tested a model that specified four unipolar constructs (Energy, Tiredness, Tension, and Calmness), each indicated by three response formats. As shown in Table 2, the measurement model fit the data well. Parameter estimates and descriptive statistics are given in Table 6. This measurement model fit the data significantly better than a four-factor comparison model (the correlations among latent constructs fixed to 0): $\Delta\chi^2(6, N = 217) = 257.66$, $p < .001$, and RMSEA changed from .07 to .16.

Interim summary. The analyses so far supported the formulations of the authors of the four structures portrayed in Figure 1. Individual constructs were adequately measured, and the constructs within each original structure correlated approximately in the manner predicted by the original authors and as summarized in Figure 1. In every case, a model with four unipolar orthogonal factors fit the data significantly less well than a model with factors that were correlated. Each of the original structures was supported, and the next question to be addressed is the relations among those structures.

Integrating Larsen and Diener's With Thayer's Structures

Our thesis is that the various structures shown in Figure 1 are variants of one and the same structure. This hypothesis predicts specific relations between any two. Because both Larsen and Diener's (1992) and Thayer's (1989) structures were assessed in the same sample (Vancouver) and because of the hypothesized equivalence of the corresponding dimensions assessed here (that is, no 45° rotation is involved), the most straightforward comparison concerns these two structures. Thus, we first examined several corollaries of our main thesis—namely, that Larsen and Diener's Activated Pleasant is equivalent to Thayer's Energy, Unactivated Unpleasant is equivalent to Tiredness, Activated Unpleasant is

Table 4
Watson and Tellegen's (1985) Unipolar Constructs: Standardized Factor Loadings and Interfactor Correlations

Construct and format	High Positive Affect	Low Positive Affect	High Negative Affect	Low Negative Affect	*M*	*SD*	α
			Factor loadings				
High Positive Affect							
ADJ	.75*				2.56	0.72	.82
AGREE	.78*				2.94	0.69	.78
DESCRIBE	.87*				2.18	0.66	.83
Low Positive Affect							
ADJ		.76*			2.60	0.94	.85
AGREE		.85*			3.15	0.82	.78
DESCRIBE		.84*			2.50	0.75	.79
High Negative Affect							
ADJ			.84*		1.84	0.74	.87
AGREE			.85*		2.52	0.88	.85
DESCRIBE			.84*		1.87	0.72	.87
Low Negative Affect							
ADJ				.66*	2.96	0.88	.75
AGREE				.62*	2.80	0.65	.54
DESCRIBE				.93*	2.59	0.82	.88
			Interfactor correlations				
High Positive Affect	—						
Low Positive Affect	−.73*	—					
High Negative Affect	−.36*	.28*	—				
Low Negative Affect	.49*	−.26	−.79*	—			

Note. $N = 198$ (Boston sample). ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. Possible mean scores range from 1 to 5 for ADJ and AGREE formats and from 1 to 4 for DESCRIBE format.
* $p < .001$.

equivalent to Tension, and Unactivated Pleasant is equivalent to Calmness.

In this analysis, we examined a structural equation model that specified eight unipolar constructs—Larsen and Diener's (1992) four and Thayer's (1989) four constructs—each indicated by its three response formats. We estimated the factor loadings between each construct and its three manifest indicators, the correlations between the eight constructs, and systematic and random errors. As shown in Table 2, the measurement model fit the data well. Estimated correlations between the two structures are shown in Table 7.

To be sure that the correlations across the sets of constructs were significantly different from zero, we compared our hypothesized model with a first comparison model in which the interfactor correlations among Thayer's (1989) constructs and those among Larsen and Diener's (1992) constructs were estimated, but the correlations between constructs of the two structures were fixed to zero. Correlation between error terms with the same response format was estimated within each structure only. This comparison model, which is a null hypothesis of no relation between the two structures, fit the data significantly worse than did the measurement model: $\Delta\chi^2(64, N = 217) = 1{,}834.83$, $p < .001$, and RMSEA changed from .06 to .15.

Next, we specified another comparison model to examine the exact equivalence of constructs from the two structures. Correlations between each pair of hypothesized equivalents (e.g., Larsen and Diener's, 1992, Activated Pleasant and Thayer's 1989, Energy) were fixed to 1.00. All the remaining cross-structure and within-structure correlations were estimated. As shown in Table 2, this second comparison model fit the data moderately well. Nevertheless, our measurement model (with correlations between eight constructs estimated) fit the data significantly better than did this second comparison model: $\Delta\chi^2(4, N = 217) = 204.69$, $p < .001$, and RMSEA changed from .06 to .10.

In short, of the three models tested, the "hypothesized" model (with all correlations estimated) best fit the data. As shown in Table 7, the correlations testing our hypothesized equivalences (highlighted in bold) were all above .90. From the two comparison models, it can be inferred that these correlations are much greater than zero but still less than 1.00. Because of item overlap, some degree of correlation is assured. We proceeded with and reported this analysis anyway, for four reasons. First, it is important to know the empirical relation between the two structures so that past studies using one or other of the scales can be properly integrated. Second, the conceptualization of the constructs involved is importantly different in the writings of Larsen and Diener (1992) and Thayer (1989). For theoretical comparison, it is important to state the empirical relations. Third, the item overlap was far from complete. And fourth, when these analyses were repeated without item overlap (by arbitrarily allocating items to one or other structure), similar results were obtained. Correlations between hypothesized equivalents were all above .90.

Table 5
Larsen and Diener's (1992) Unipolar Constructs: Standardized Factor Loadings and Interfactor Correlations

Construct and format	Activated Pleasant	Unactivated Unpleasant	Activated Unpleasant	Unactivated Pleasant	*M*	*SD*	α
			Factor loadings				
Activated Pleasant							
ADJ	.84*				2.07	0.84	.86
AGREE	.83*				2.77	0.66	.70
DESCRIBE	.89*				2.01	0.72	.81
Unactivated Unpleasant							
ADJ		.82*			2.29	0.91	.89
AGREE		.93*			2.65	0.91	.77
DESCRIBE		.92*			2.30	0.90	.78
Activated Unpleasant							
ADJ			.78*		1.96	0.84	.87
AGREE			.87*		2.63	0.94	.73
DESCRIBE			.93*		1.95	0.84	.86
Unactivated Pleasant							
ADJ				.85*	2.90	0.90	.88
AGREE				.91*	3.13	0.80	.78
DESCRIBE				.89*	2.60	0.77	.83
			Interfactor correlations				
Activated Pleasant	—						
Unactivated Unpleasant	−.52*	—					
Activated Unpleasant	−.28*	.34*	—				
Unactivated Pleasant	.38*	−.18	−.76*	—			

Note. $N = 217$ (Vancouver sample). ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. Possible mean scores range from 1 to 5 for ADJ and AGREE formats and from 1 to 4 for DESCRIBE format.
* $p < .001$.

Variance Explained by the Pleasant Versus Unpleasant and Activated Versus Deactivated Axes in Other Variables

We next used the Pleasant versus Unpleasant and the Activated versus Deactivated axes as exogenous variables to predict other variables. By treating all other variables as endogenous, we could thus test our hypothesis that the two axes predict nearly all of the variance in every construct of the other structures (when random and systematic errors are removed).

In the following structural equation models, the factor loadings between exogenous constructs (Pleasant vs. Unpleasant and Activated vs. Deactivated) and their corresponding four manifest variables (2 constructs × 3 response formats; semantic differential scale) and the correlation between the exogenous constructs were adopted from Model 2 (correlated axes) of the multisample analysis. In each analysis, we estimated (a) the loadings between the endogenous construct and its three indicants, (b) the regression weights of the endogenous construct on the exogenous constructs, and (c) the percentage of variance accounted for by Pleasant versus Unpleasant and Activated versus Deactivated for each endogenous construct.

Watson and Tellegen's constructs. We conducted a separate analysis for each of Watson and Tellegen's four unipolar constructs (High and Low Positive Affect, High and Low Negative Affect). We specified a structural equation model with three latent constructs. Two—Pleasant versus Unpleasant and Activated versus Deactivated—were considered as exogenous. One—one of Watson and Tellegen's (1985) constructs—was considered as endogenous. We also conducted parallel analyses with bipolar endogenous constructs.

Results for the unipolar latent construct of High Positive Affect are shown in Figure 4. As anticipated, High Positive Affect was related positively to both Pleasant versus Unpleasant and Activated versus Deactivated axes. The variance of the disturbance term was .10. This latter result is equivalent to saying that 90% of the variance in the latent construct High Positive Affect was predicted from the Pleasant versus Unpleasant and Activated versus Deactivated axes; 10% remained unaccounted for. This same result is equivalent to saying that the square of the multiple correlation for predicting High Positive Affect was .90 or that $R = .95$.

Results for Watson and Tellegen's (1985) remaining unipolar constructs are not graphed but simply summarized in Table 8. All unipolar constructs could be substantially explained by the two axes. The variance explained was 79% to 90%, with a mean of 87%. Further, the pattern of relationships was approximately as expected in Figure 2. Results for the two bipolar dimensions were even clearer; the mean variance explained was 95%. (We also conducted another series of analyses that were identical to the preceding six, except that exogenous model parameters were estimated rather than fixed to predetermined values. Results were almost identical to those obtained in the just reported analyses.)

This huge amount of overlap might seem to contradict previous studies that have found the two affect structures to be empirically much less related to each other (e.g., Burke et al., 1989; Hutchison et al., 1996; Russell et al., 1989). These previous studies had largely

Table 6
Thayer's (1989) Unipolar Constructs: Standardized Factor Loadings and Interfactor Correlations

Construct and format	Energy	Tiredness	Tension	Calmness	*M*	*SD*	α
			Factor loadings				
Energy							
ADJ	.84*				2.16	0.86	.89
AGREE	.91*				2.62	0.83	.83
DESCRIBE	.92*				1.97	0.75	.89
Tiredness							
ADJ		.88*			2.87	0.93	.86
AGREE		.93*			2.91	0.90	.77
DESCRIBE		.93*			2.40	0.84	.85
Tension							
ADJ			.83*		2.05	0.85	.86
AGREE			.96*		2.37	0.89	.83
DESCRIBE			.92*		2.01	0.83	.87
Calmness							
ADJ				.73*	2.71	0.81	.60
AGREE				.84*	2.83	0.65	.62
DESCRIBE				.85*	2.66	0.69	.75
			Interfactor correlations				
Energy	—						
Tiredness	−.70*	—					
Tension	−.06	.26*	—				
Calmness	.00	.07	−.66*	—			

Note. N = 217 (Vancouver sample). ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. Possible mean scores range from 1 to 5 for ADJ and AGREE formats and from 1 to 4 for DESCRIBE format.
* $p < .001$.

relied on correlations among manifest variables, rather than among the latent constructs underlying the manifest variables or on single response formats. Thus, the true correlation between the constructs might have been obscured by errors introduced in the process of measurement. To clarify past and present findings, we conducted analyses parallel to those just reported, but with the endogenous variable defined by the manifest variable rather than the latent construct. In each analysis, there was one manifest variable for the endogenous variable and the path between them was fixed to 1.00. There were thus 12 separate analyses (4 constructs × 3 formats). Results for all 12 manifest variables are summarized in Table 8. The patterns are consistent with those of the latent constructs, but the magnitude of the relations was attenuated. The variance explained ranged from 46% to 76%, with a mean of 63%. Studies that rely on manifest variables thus run the risk of underestimating or distorting the actual relationship among variables.

Larsen and Diener's constructs. We repeated the analysis sequence of the preceding section, this time with Larsen and Diener's (1992) constructs as the endogenous variables. We created six structural equation models based on predetermined values (factor loadings and latent correlation) from Model 2 (correlated axes) of the multisample analysis for the exogenous variables.

Table 7
Estimated Correlation Among Larsen and Diener's (1992) and Thayer's (1989) Unipolar Latent Constructs

	Larsen & Diener's constructs			
Thayer's constructs	Activated Pleasant	Unactivated Unpleasant	Activated Unpleasant	Unactivated Pleasant
Energy	**.91***	−.69*	−.21	.21
Tiredness	−.54*	**.94***	.29*	−.16
Tension	−.20	.30*	**.95***	−.76*
Calmness	.23	.08	−.67*	**.93***

Note. N = 217 (Vancouver sample). Values in bold are correlations between scales hypothesized to be equivalents in the structural model of Figure 2.
* $p < .001$.

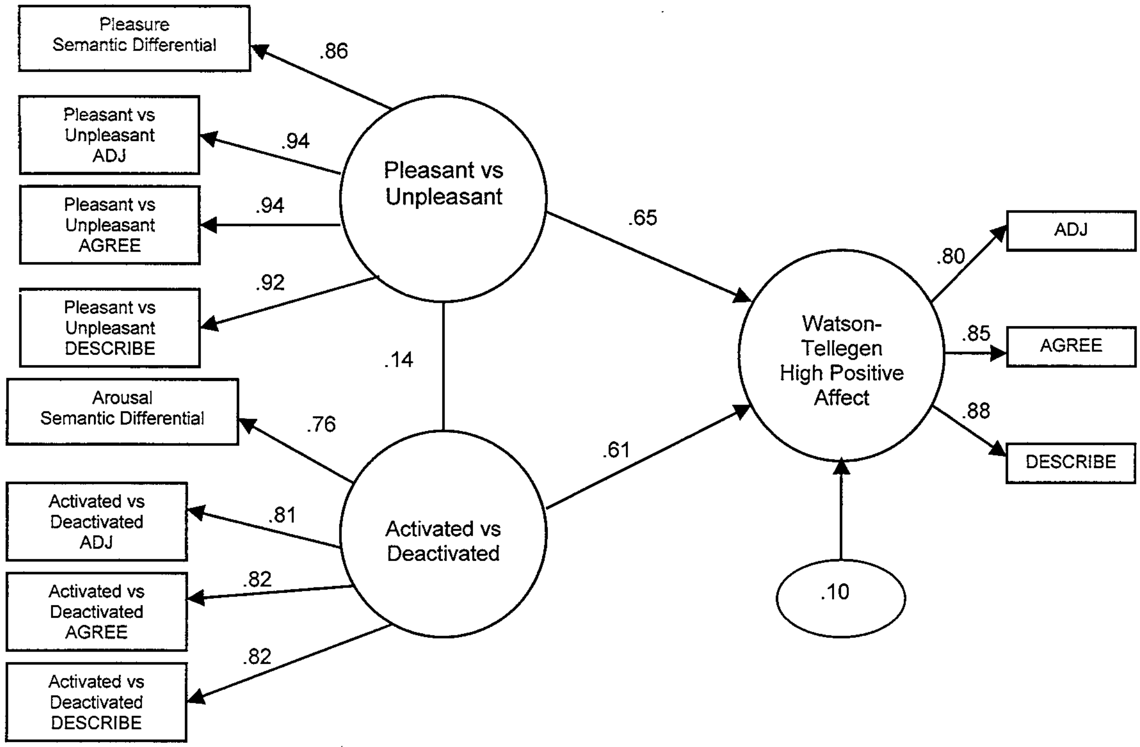

Figure 4. Path diagram showing a structural equation model for the unipolar construct underlying Watson and Tellegen's (1985) High Positive Affect. Error terms and correlation between error terms with the same response format were also estimated but are not shown. ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format.

Results are summarized in Table 9. For the four unipolar constructs, the variance explained ranged from 53% to 77%, with a mean of 66%. Further, the pattern of relationships was approximately as expected in Figure 2. For the bipolar endogenous dimensions, the mean variance explained was 82%. (When exogenous model parameters were estimated rather than fixed to predetermined values, results were almost identical to those just reported.)

To examine the manifest variables, 12 parallel analyses were conducted. Once again, manifest variables were substantially less predictable than their latent counterparts. Variance explained ranged from 35% to 64%, with a mean of 50%.

Thayer's constructs. Finally, we repeated the same analysis sequence, this time for Thayer's (1986) constructs. Results are summarized in Table 10. For the unipolar constructs, the variance explained ranged from 57% to 75%, with a mean of 64%. Further, the pattern of relationships was approximately as expected in Figure 2. For the bipolar endogenous dimensions, the mean variance explained was 77%. (When exogenous model parameters were estimated rather than fixed to predetermined values, results were almost identical to those just reported.)

To examine the manifest variables, 12 parallel analyses were conducted. Once again, manifest variables were substantially less predictable than their latent counterparts. Variance explained ranged from 33% to 63%, with a mean of 49%.

Interim summary. Watson and Tellegen's (1985), Larsen and Diener's (1992), Thayer's (1989), and Feldman Barrett and Russell's (1998) structures are all highly interrelated, supporting our thesis that they are alternative descriptions of the same two-dimensional space. This convergence was less clear when manifest variables were analyzed but extremely clear when latent constructs were analyzed, clear enough when unipolar latent constructs were analyzed and extremely clear when bipolar latent constructs were analyzed. Variables that, according to Figure 2, are hypothesized equivalents, were extremely highly correlated. Much, although not all, of the variance in any one unipolar construct and almost all of the variance in the bipolar construct could be accounted for by the vertical and horizontal axes of Figure 2. Thus, the various structures can be integrated into a two-dimensional space, and we now turn to specifying the exact nature of that integrated structure.

The Full Two-Dimensional Space

The analyses reported so far justify representing all constructs simultaneously within a two-dimensional space. To portray this full representation, we used data from both samples to place the 12 constructs allegedly 45° from the axes within a structure defined by two exogenous latent constructs representing the horizontal and vertical axes, Pleasant versus Unpleasant and Activated versus Deactivated. Factor loadings for exogenous constructs were adopted from Model 3 (orthogonal axes) of the multisample analysis. In 12 separate analyses, 1 of 12 remaining unipolar constructs was treated as the endogenous latent construct, which was indicated by its three response

Table 8
Watson and Tellegen's (1985) Structure Explained by the Pleasant Versus Unpleasant and Activated Versus Deactivated Axes

Construct and format	Regression weights		% variance explained	Fitness indexes			
	Pleasant vs. Unpleasant	Activated vs. Deactivated		χ^2	RMSEA	AGFI	CFI
High Positive Affect							
ADJ	.42	.61	62	125.20	.10	.88	.92
AGREE	.70	.35	68	129.79	.10	.87	.92
DESCRIBE	.52	.59	70	146.88	.11	.86	.90
Unipolar construct	.65	.61	90	218.62	.12	.82	.89
Low Positive Affect							
ADJ	−.32	−.65	58	132.50	.10	.87	.91
AGREE	−.38	−.63	61	123.72	.10	.88	.92
DESCRIBE	−.34	−.61	55	144.17	.11	.85	.90
Unipolar construct	−.41	−.73	79	192.96	.11	.83	.90
High vs. Low Positive bipolar construct	.54	.72	92	275.49	.14	.77	.87
High Negative Affect							
ADJ	−.79	.37	69	127.25	.10	.87	.92
AGREE	−.85	.29	73	131.08	.10	.87	.92
DESCRIBE	−.81	.33	69	153.08	.11	.85	.90
Unipolar construct	−.92	.37	90	207.30	.11	.82	.90
Low Negative Affect							
ADJ	.61	−.49	53	133.02	.10	.87	.91
AGREE	.67	−.23	46	121.22	.10	.88	.92
DESCRIBE	.86	−.32	76	158.58	.11	.85	.90
Unipolar construct	.92	−.39	89	207.38	.11	.83	.89
High vs. Low Negative bipolar construct	−.96	.41	97	241.51	.12	.80	.89

Note. N = 198 (Boston sample). RMSEA = root mean square error of approximation; AGFI = adjusted goodness-of-fit index; CFI = comparative fit index; ADJ = adjective format; AGREE = "agree–disagree" format; DESCRIBE = "describes me" format. All regression weight are significant at the .001 level. For single-format variables, df = 42; for both unipolar and bipolar constructs, df = 58.

formats. Regression coefficients were estimated between each exogenous construct and the endogenous construct. The two coefficients were used as coordinates to project each unipolar construct onto the same two-dimensional space.

The resulting plot is shown in Figure 5. In each quadrant fell exactly the three constructs expected to fall there, but the three were not completely overlapping nor did the clusters always fall exactly 45° from the axes. Hence, most empirical angles deviated somewhat from the exact values expected on the 45°-rotation hypothesis. For instance, the angle between Watson and Tellegen's (1985) High Positive Affect and High Negative Affect was 116° rather than 90°.

Testing Circumplexity

Figure 2, and its empirical counterpart in Figure 5, shows a structure that appears to be a circumplex. In a circumplex, all variables array in a circular fashion within a two-dimensional space, but not necessarily 45° apart. To examine how well our data conformed to a circumplex, we used the above-mentioned structural equation modeling program (CIRCUM) developed by Browne (1992; Fabrigar et al., 1997). This program provides estimates of the location of each variable on a circle.

We first created a single score for each unipolar construct in each sample by summing the z scores of their three separate scales

Table 9
Larsen and Diener's (1992) Structure Explained by the Pleasant Versus Unpleasant and Activated Versus Deactivated Axes

Construct	Regression weights		% variance explained	Fitness indexes			
	Pleasant vs. Unpleasant	Activated vs. Deactivated		χ^2	RMSEA	AGFI	CFI
Activated Pleasant	.50	.47	53	139.60	.08	.88	.96
Unactivated Unpleasant	−.47	−.60	66	154.98	.09	.87	.96
Activated Pleasant vs. Unactivated Unpleasant	.56	.65	83	175.20	.10	.85	.96
Activated Unpleasant	−.87	.29	77	159.42	.09	.87	.96
Unactivated Pleasant	.76	−.41	66	131.14	.08	.89	.97
Activated Pleasant vs. Unactivated Pleasant	−.87	.38	81	159.81	.09	.87	.96

Note. N = 217 (Vancouver sample). RMSEA = root mean square error of approximation; AFGI = adjusted goodness-of-fit index; CFI = comparative fit index. All regression weights are significant at the .001 level. For both unipolar and bipolar constructs, df = 58.

Table 10
Thayer's (1989) Structure Explained by the Pleasant Versus Unpleasant and Activated Versus Deactivated Axes

	Regression weights			Fitness indexes			
Construct	Pleasant vs. Unpleasant	Activated vs. Deactivated	% variance explained	χ^2	RMSEA	AGFI	CFI
Energy	.41	.71	75	122.49	.07	.89	.97
Tiredness	−.35	−.62	57	172.50	.09	.86	.95
Energy vs. Tiredness	.42	.73	80	188.32	.10	.85	.95
Tension	−.74	.37	62	142.72	.08	.88	.96
Calmness	.59	−.62	63	142.78	.08	.88	.96
Tension vs. Calmness	−.76	.51	73	169.81	.09	.86	.96

Note. N = 217 (Vancouver sample). RMSEA = root mean square error of approximation; AFGI = adjusted goodness-of-fit index; CFI = comparative fit index. All regression weight are significant at the .001 level. For both unipolar and bipolar constructs, df = 58.

with different response formats. (The semantic differential scales were not used in this analysis.) A correlation matrix was then computed from the sums. In the CIRCUM analyses, we designated Pleasant as the reference variable (its location was fixed at 0°). The locations of other unipolar variables were then estimated relative to Pleasant. The communality estimates of all variables were left free to vary. (When communality was constrained to be equivalent, nearly identical results were obtained.) No constraints were put on the minimum common score correlation.

With data from the Boston sample, an 8 × 8 correlation matrix—Pleasant, Unpleasant, Activated, Deactivated, Watson and Tellegen's (1985) Positive Affect, Negative Affect, Low Positive Affect, and Low Negative Affect—was submitted to maximum-likelihood analysis using CIRCUM. 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 26 free parameters. The data fit the model moderately well: $\chi^2(10, N = 198) = 43.64$, $p < .001$, $\chi^2/df = 4.36$, RMSEA = .13.

With data from the Vancouver sample, a 12 × 12 correlation matrix—Pleasant, Unpleasant, Activated, Deactivated, Larsen and Diener's (1992) Activated Pleasant, Unactivated Unpleasant, Activated Unpleasant, and Unactivated Pleasant, and Thayer's (1989) Energy, Tiredness, Tension, and Calmness—was submitted to an identical analysis, which converged on a solution in 12 iterations. Four 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 39 free parameters. The data fit the model moderately well: $\chi^2(39, N = 217) = 168.39$, $p < .001$, $\chi^2/df = 4.32$, RMSEA = .12.

The results of both analyses (when communality was constrained to be equivalent) are shown superimposed on one another

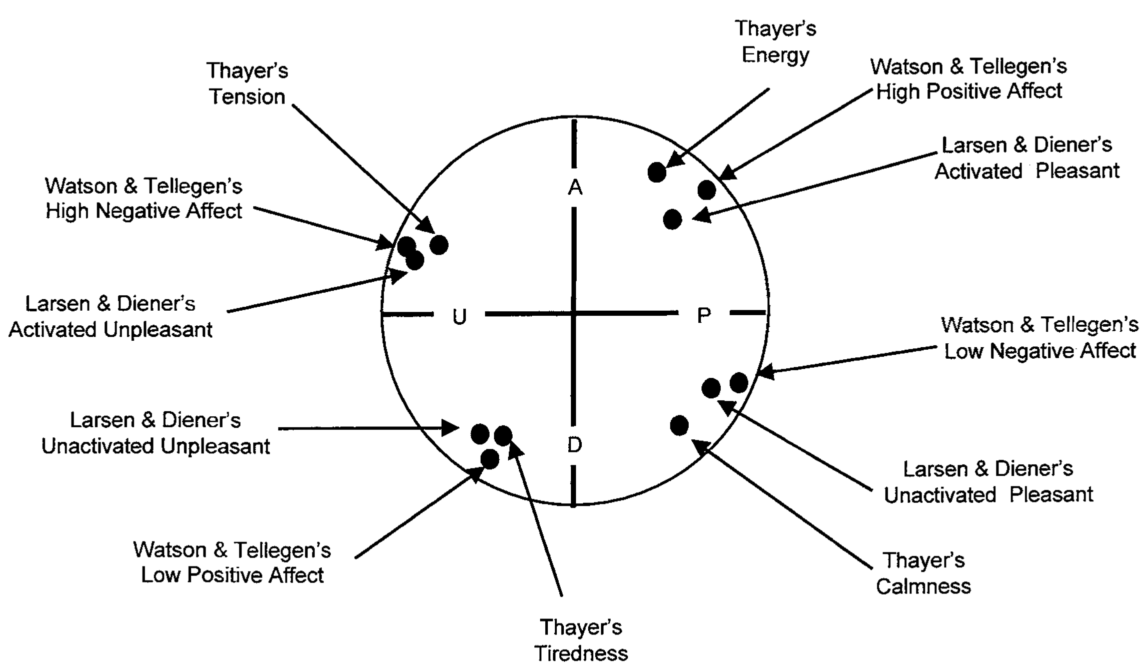

Figure 5. Twelve unipolar constructs in the integrated two-dimensional space. The horizontal and vertical axes were also assessed, but the scales are not shown. A = Activated; D = Deactivated; U = Unpleasant; P = Pleasant.

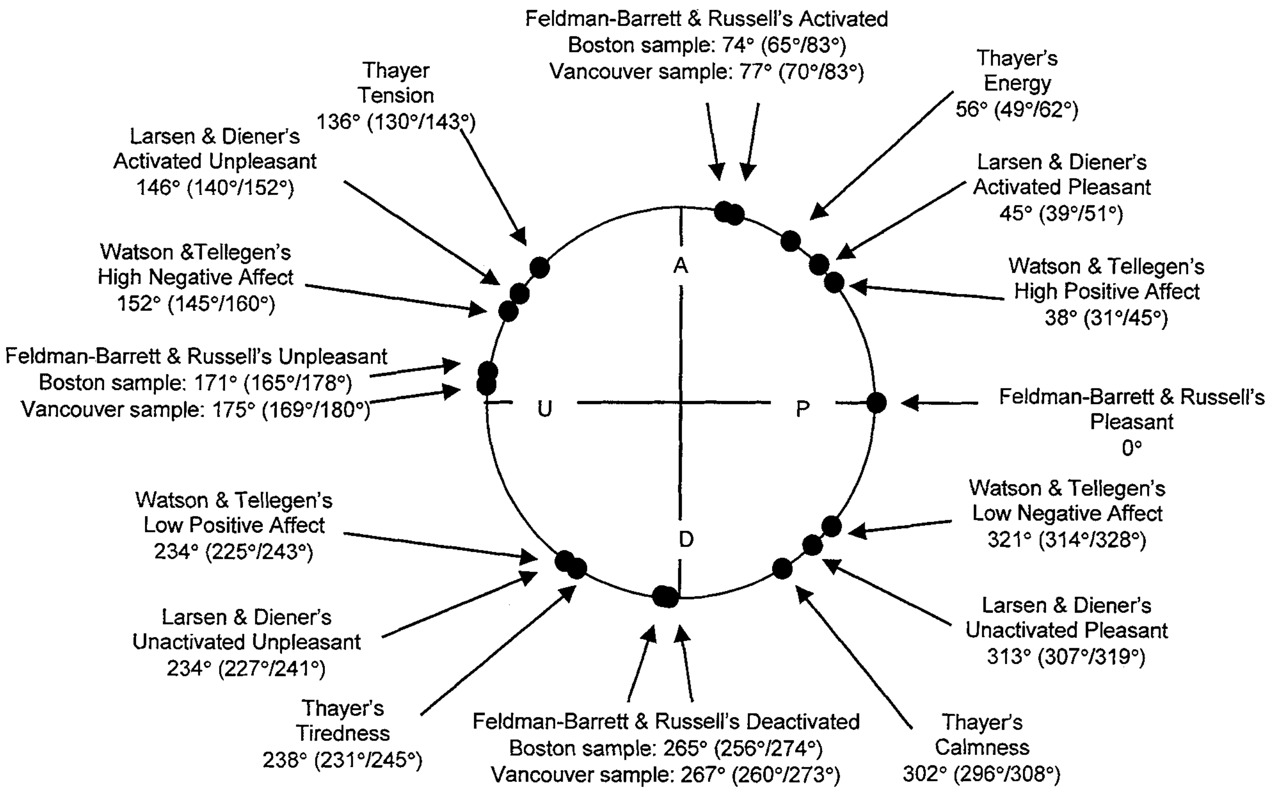

Figure 6. A circumplex representation of 16 affect constructs by means of CIRCUM. A = Activated; D = Deactivated; U = Unpleasant; P = Pleasant. In this representation, two separate analyses are shown superimposed on one another. In both analyses, Pleasant was designated the reference variable and its angle was fixed at 0°; communality estimates were constrained to be equivalent for all variables. Figures given are estimates of polar angles (with the 95% confidence interval). *N*s = 198 (Boston) and 217 (Vancouver).

in Figure 6. Pleasant was fixed at 0°. CIRCUM estimated the remaining angles on the circle for each variable, as well as a 95% confidence interval for each angle. The angles obtained are likely precise: The confidence intervals are small, and when angles for three variables (Unpleasant, Activated, and Deactivated) were estimated from independent samples, the results differed by 4°, 3°, and 2°. In contrast, other scales that, according to the 45° hypothesis, would be identical differed by up to 19° from each other. No large differences occurred in the Unpleasant Deactivated quadrant. However, noticeable differences did occur within the other three quadrants. Thayer's (1989) Energy did not fall within the confidence interval of Watson and Tellegen's (1985) High Positive Affect, Thayer's Tension did not fall within the confidence interval of Watson and Tellegen's High Negative Affect, and Thayer's Calmness did not fall within the confidence interval of Watson and Tellegen's Low Negative Affect.

Further, the CIRCUM results on this matter were similar to those results from the structural equation models shown in Figure 5. Thayer's (1989) constructs are closer to the vertical activation axis; Watson and Tellegen's (1985) and Larsen and Diener's (1992) constructs are closer to the horizontal pleasantness axis. Together, these results showed that the hypothesized equivalent constructs are not interchangeable, even though they are highly correlated. In other words, variables fell at various angles within the space, not only at multiples of 45°. We suggest that finer measurement will show that variables can be defined at any angle around the circle. The 45° rotation hypothesis is but a first approximation.

Nevertheless, the circumplex model fit the data only moderately well. The circumplex too is but an approximation. One explanation to account for the marginal levels in the fit indexes is that CIRCUM is not able to estimate systematic error in the present data sets. Present and past findings show that affect scales can include substantial amounts of systematic as well as random error (Green et al., 1993). Removing the systematic errors may be necessary to pinpoint the underlying structure. Another (complementary) possibility is that additional substantive dimensions account for some of the variance in the original affect scales. Still another possibility currently being explored in our laboratory is a nonlinear relation between manifest and latent variables (Carroll, Russell, & Reynolds, 1998).

Discussion

Scales of 16 differently named variables drawn from four different conceptualizations were examined in two studies of self-reported current affect. We found empirical support for each of the four original two-dimensional structures separately. More important, the four separate structures also fit comfortably into one integrated structure, still of only two dimensions. The original four structures thus have more in common than the names of the variables would suggest. Here we discuss (a) methodological implications, (b) the interpretation of the proposed integrated structure, (c) controversies about the structure of current affect, and (d) progress in the study of affect.

Methodological Implications

The integration hypothesis portrayed in Figure 2 was well supported in two sets of data. This empirical support is at odds with results reported by Burke et al. (1989) and by Hutchison et al. (1996). The difference may stem from Burke et al.'s focus on a single response format and Hutchison et al.'s focus on manifest variables, in contrast to the present focus on latent constructs indicated by multiple manifest variables. One clear message from the present results is that correlations among manifest variables do not fully reveal underlying structure. For example, in every case studied, the manifest variable (scores obtained directly from a single response format) was less related to the overall structure than was its corresponding latent construct. These results underscore Green et al.'s (1993) call for multiple response formats and structural equation modeling.

We also found that the use of unipolar dimensions, even latent ones, underestimated the underlying relations. In every case studied here, bipolar latent constructs were more fully explained by the two-dimensional space than were the separate unipolar counterparts. Interestingly, all the scales proposed by authors of the structures of Figure 1 were unipolar in format, with the exception of Mehrabian and Russell's (1974) semantic differential scales. For routine assessment of affect (although not for a test of bipolarity), bipolar response formats should be considered.

Interpretation and Naming

What is the proper interpretation of this integrated two-dimensional structure? We suggest that it is a description of current affective states that are grounded in pleasantness and activation. Positive affect (the entire right half of Figure 2) consists of a range of states that vary in level of activation. Negative affect (the entire left half) consists of a range of states that vary in level of activation. Activation (the entire top half of Figure 2) consists of states that vary in pleasantness, as does deactivation (the entire bottom half). Every affective state has both pleasantness and activation components.

In defining *affect,* some writers implicitly or explicitly omit certain regions of Figure 2. For instance, there is a vertical corridor down the center of Figure 2 that is neutral in pleasantness and that may seem less affective (just as some colors seems less colorful than others). Similarly, deactivated affective states seem less affective than do activated ones. Nevertheless, we believe that a person's temporary affective state can fall at one and only one point in this space, including inside the neutral corridor and the deactivated half. If so, no region of the space can be omitted if we are to have a complete representation of affect.

It has been argued that an account such as that just outlined mixes apples and oranges, in that positive and negative affect are mental states whereas activation is a physical (or physiological) state. We disagree. First, as did many of our predecessors, we are approaching both pleasantness and activation on the level of how people experience and report them. The structures seen in Figures 1 and 2 and the scales used by Larsen and Diener (1992), Russell (1980), Thayer (1989), and Watson and Tellegen (1985) are all based on self-reports and thus capture a person's state as that person represents it to himself or herself. On our view, the distinction between affect as mental and activation as physical is unwarranted. Both are based in neural processes. Both have an experiential counterpart to those neural processes.

The most striking difference among the four models of Figure 1 is the way in which the variables are named and conceptualized. Each set of labels provides a plausible interpretation of the full structure, but because the four have now been demonstrated to be so overlapping, we can legitimately call for a common set of labels and concepts. Our data do not tell us directly how to interpret the common integrated structure, but we offer our suggestion so that discussion can lead to a consensual set of terms.

Consider first the horizontal dimension of the emerging common structure of Figure 2. Russell (1980), Watson and Tellegen (1985), and Larsen and Diener (1992) have all interpreted this dimension (assuming needed reorientation and rotation) as pleasant versus unpleasant. Thayer (1989), in contrast, offered Calm–Energy versus Tense–Tiredness. Calm–Energy is a pleasant experience, but calm energy fails to capture the full generality of the horizontal axis. Calm energy is one possible state that would fall here, but so would many other pleasant states. When a person's state falls on the right-hand side of the horizontal axis of Figure 2, we do not know that the person has the specific state of calm energy, but we do know that the person has described the state as medium in activation and as pleasant. The full set of items in this region of the space supports this more general interpretation. Similarly, Tense–Tiredness is an unpleasant experience, but other kinds of unpleasant states (medium in activation) would fall on the left-hand side of the horizontal axis. We also believe that Pleasant versus Unpleasant is a more felicitous concept than Calm–Energy versus Tense–Tiredness in lending itself to integration with other areas of psychology and in communicating with others. For instance, we are confident that naive raters would have an easier time making judgments on a scale of Pleasant versus Unpleasant than Calm–Energy versus Tense–Tiredness in a great variety of domains.

Now consider the vertical axis. Russell (1980) and Larsen and Diener (1992) have agreed in labeling this axis as activation versus deactivation. Because Thayer's (1989) empirical results yielded two dimensions rather than one, he was compelled to define two activation concepts—hence tension and energy—and the vertical axis was labeled Tense–Energy versus Tired–Calmness. Presumably, if the horizontal axis is reconceptualized as pleasantness, the vertical axis could revert to Thayer's original concept of activation versus deactivation. In other words, as Thayer assumed, what tension and energy have in common is activation and what tiredness and calmness have in common is deactivation.

The major alternative conceptualization of the vertical axis is Watson and Tellegen's (1985) suggestion of engagement versus disengagement with the external environment. We know of no evidence in support of their interpretation and point to extensive evidence that this dimension correlates with biological indexes of activation (e.g., Lang, 1978; Lang et al., 1992; Thayer, 1989). In addition, the concept of engagement is somewhat vague. On

Watson and Tellegen's interpretation, the state of joy would be high in engagement, the state of calm low in engagement; indeed, engagement would be exactly what differentiates the two. But a calm person can be engaged, and a joyous person disengaged, from their surroundings. Similarly, on Watson and Tellegen's interpretation, the state of nervous tension would be high in engagement, the state of sadness low; but again, a tense person might be disengaged, a sad person highly engaged, with their surroundings. Perhaps engagement is best thought of as a possible correlate of the vertical axis rather than as its interpretation.

Next, consider those vectors at roughly the diagonals in Figure 2. Following Larsen and Diener (1992), we suggest that this set of variables collectively be straightforwardly labeled as various combinations of pleasantness and activation. For 45°, Russell's (1980) label of excitement and Thayer's (1989) of Energy are too narrow (states other than excitement and energy fall here as well), and Watson and Tellegen's (1985) label of Positive Affect is too broad and too vague (other regions of the space are positive as well). The concept of positive is also problematic (see Larsen & Diener, 1992). Previous labels for variables near 135°, 225°, and 315° were also either too narrow, too broad, or problematic.

Controversies

One vexing traditional problem has been whether certain dimensions of affect are independent of, or the bipolar opposites of, one another. This persistent debate has recently flared once again (Green et al., 1993; Russell & Carroll, 1999; Tellegen et al., 1994; Watson & Clark, 1997). The proposed structure of Figure 2 reconciles at least some of the (apparent) differences. When random and systematic measurement errors are taken into account, the two principal axes are each bipolar and are each almost fully independent of the other.

A second controversy has been simple structure versus the circumplex. Simple structure occurs when items fall into tight clusters with gaps between the clusters. A circumplex occurs when items fall at any place along a circle. Again, the sampling of items within the domain is the key point. The analyses here lent support to a circumplex, although figures also show some remaining gaps. The controversy between simple structure and the circumplex can thus be translated into an empirical question: Can items be generated that fill those gaps, or are they intrinsically empty spaces? Whereas the 45°-rotation hypothesis might have suggested gaps between the variables (empty spaces at angles not multiples of 45°), our results show vectors not exactly at 45° and that fill at least some of the gaps. If variables are combinations of varying degrees of pleasantness and activation, it is hard to find a rationale for precluding some combinations, and so the assumption of inherent gaps remains to be demonstrated or justified.

A third controversy has concerned the proper rotation of the axes. Our two-dimensional structure of Figure 2 is anchored by the pleasantness and activation axes. Mathematically, any two nonredundant dimensions within the space would do as well, and thus the evidence we offer here does not speak to the question of rotation. Thus, our map in and of itself does not imply that pleasantness and activation cause other affective states or even that pleasantness and activation are more basic than other potential rotations of the axes. Rather, the choice between competing rotations must be made on the basis of a range of other empirical and conceptual considerations. Larsen and Diener (1992) and Reisenzein (1994) have provided conceptual arguments for the primacy of pleasantness and activation dimensions. Our data do make one contribution to this debate. By showing the essential equivalence of the four structures of Figure 1, our studies undermine arguments for one rotation over another based entirely on the kind of correlational data reported here—and debates about rotation have centered on just such data.

Progress in the Study of Affect

Like continental drift, progress in the psychology of affect is not always apparent to the naked eye. We believe that progress has been made and that further progress is imminent.

We see progress in the shift from accounts that focus on either activation alone or pleasantness alone to accounts that consider these two simultaneously. The orthodoxy of behaviorism at one time tainted the study of anything as subjective as happiness and sadness, leaving activation as the more acceptable topic. And yet Thayer's (1989) extensive research program on activation contained a strong but implicit pleasantness dimension. Conversely, any study of verbally reported experiences was overwhelmed by a first factor contrasting pleasant and unpleasant experiences. And yet Watson and Tellegen's (1985) extensive research on positive and negative affect contained a strong activation dimension. The simultaneous emphasis on both pleasantness and activation is progress because any attempt to define one of these dimensions inevitably encounters the other.

One structure that emphasizes both dimensions is Larsen and Diener's (1992). Their structure was an explicit statement of the often repeated assumption that various previous structures were interchangeable after a 45° rotation. An empirical demonstration of that hypothesis was made possible by Green et al.'s (1993) methodological breakthrough that allowed better control of random and systematic errors of measurement. Our version of their integrated model is portrayed in Figure 2. This structure, with two bipolar dimensions independent of each other, allows a conceptual integration of various previous models, helps clarify such vexing controversies as that over bipolarity and independence, and serves as the foundation for verbal measures of current affect.

Empirical results obtained here lead to further refinements of the structure of Figure 2. The division of the full space into eight vectors separated by multiples of 45° was found to be arbitrary. Actual scales descriptive of this space vary slightly in their place within that space. For example, Watson and Tellegen's (1985) Positive Affect, Thayer's (1989) Energy, and Larsen and Diener's (1992) Pleasant Activated, although highly interrelated, are not identical. These three variables fall at slightly different places on the perimeter of the two-dimensional pleasantness–activation space (as suggested by separate structural equation models and indicated by the nonoverlapping confidence intervals from the CIRCUM analysis). For most practical purposes, these three scales are almost interchangeable, and yet the small but telling differences among them point the way to further progress in the conceptualization of the pleasantness–activation space. The differences are meaningful and predictable: Thayer's scales have a larger component of activation, Watson and Tellegen's a larger component of pleasantness. Larsen and Diener's scales have about equal doses of pleasantness and activation. These differences are not surprising given the origin of each of these dimensions, but it nonetheless shows that vectors can be created at many different angles in Figure 2, not just at multiples of 45°. Pleasantness and activation can be combined to varying degrees rather than in quantum leaps. The 45°-rotation hypothesis is but a first approximation to which the circumplex offers an alternative perspective.

Nevertheless, the circumplex of Figure 6 is, in turn, still an approximation. The indexes of goodness of fit of the specific circumplex model were modest, and so we must seek further refinements in the description of affect. The same conclusion follows from the analyses summarized in Tables 8 to 10, in which the amount of variance in the latent constructs accounted for by the pleasantness and activation axes were, although huge, always less than 100%. For unipolar constructs, variance explained ranged from 53% to 90%, with a mean of 72%. For bipolar dimensions, variance explained ranged from 73% to 97%, with a mean of 84%.

There are a number of reasons that the two-dimensional pleasantness–activation circumplex failed to account for 100% of the variance in other dimensions and failed to fit the data perfectly. Here are the two most obvious. First, although we used the best technique that we know of to control random and systematic measurement error, error variance common to the several response formats used was not eliminated. As conceptual models improve, finer measurement models are required. Progress beyond the circumplex of Figure 6 requires further progress in measurement techniques. Second, there are substantive dimensions of affect beyond pleasantness and activation (Russell, 1978; Smith & Ellsworth, 1985).

We thus offer the circumplex of Figure 6 as an improvement on the 45°-rotation hypothesis but still only an approximation. The 16 variables included here had been constructed to capture vectors at multiples of 45° from one another, and the results did conform to that pattern somewhat. And yet the circumplex suggests that other variables can be created that fall at any angle within the pleasantness–activation space. The circumplex has the potential to unite previous structures and to incorporate still further dimensions. Of course, we cannot unilaterally declare a consensual structure. Only further exchange will reveal how acceptable our proposal is. We believe that this circumplex can help go beyond interminable disputes over labels and rotation and that it warrants very serious consideration by the field.

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