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A premature consensus: are happiness and sadness truly opposite affects?

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Abstract Within the debate on the structure of affect, a consensus began emerging in the last decade regarding the bipolarity of happiness–sadness. We argue that this consensus is premature. Focusing on the psychometrics of momentary affect, particularly happiness and sadness, and using a simulation study, a large-scale data set, and 2 experiments manipulating affect, we plot a map of affective space that departs from the consensus. One key departure is the finding that happiness and sadness are not bipolar opposites. Another is that nonuniform skewness plays a major role in studies of affective structure, but can be addressed with appropriate analyses.

Keywords Affect · Bipolarity · Circumplex · Mood · Structure

In the on-going quest toward mapping the structure of affective space, there has been a periodic oscillation between two opposing views. The first represents the intuitively compelling notion that affective space is composed of a bipolar dimension of valence and an orthogonal unipolar dimension of activation or arousal. The second, and more surprising view, is that affective space is best represented as two separable dimensions, one for negative affect or activation (NA) and one for positive affect or activation (PA).

Authors whose work represented either side of the affective structure debate (e.g., Feldman Barrett & Russell, 1998; Russell, 2003; Watson & Tellegen, 1999) have offered suggestions for a structural model of affect that would render the bipolarity-independence argument obsolete. This consensual structure consists of a two-dimensional space, defined by two orthogonal dimensions with items uniformly distributed in a circular pattern. In the spirit of consensus, the identity of these two dimensions (which was the stiffest bone of contention in the affective structure debate) is now seen as more of a matter of choice for individual researchers (Yik, Russell, & Feldman Barrett, 1999). Some may wish to employ the set of dimensions historically identified with the bipolarity view (i.e., a pleasantness or valence factor and an orthogonal activation factor). Others may wish to employ the set of dimensions historically identified with the independence view (i.e., positive activation and negative activation). As these two sets are simply a 45° rotation of each other, they essentially define the same space (cf., Yik et al., 1999).

To arrive at a consensus, several factors in the measurement of moods and the labeling of the affective space have been discussed: the items chosen to represent latent affect factors; the time frame of the moods measured (momentary vs. not; Russell & Carroll, 1999a, 1999b; though see Watson & Tellegen, 1999); and the establishment of a common language (at the urging of bipolarity proponents, Watson and Tellegen have adopted the term Pleasantness for a general bipolar dimension of moderate-activation feeling states, and have replaced the terms positive and negative affect with positive and negative activation). Once these are considered, major partisans seem to agree that happy and sad are opposite affects. Russell and Carroll (1999a, p. 6) point out

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that "bipolarity has not been challenged at the level of such specific items as happy and sad." Watson and Tellegen (1999, p. 602) seem to concur regarding the bipolarity of happy versus sad affect in self-report data, "More generally speaking, our map shows that oppositely-valenced moderate-arousal terms, such as 'happy' ... versus 'sad' ... mark a bipolar dimension."

Work from several authors (e.g., Schimmack, 2001; Larsen, McGraw, & Cacioppo, 2001) has questioned the consensus, and the present work sets out to do so as well. In the present investigation, we examine, in greater detail, the particular case of the relationship between momentary happiness and sadness. Choosing to focus on this case has both specific and broad purposes. Specifically, our purpose is to examine the pair of mood states that comprise one of the most intuitive of bipolar semantic pairs. Broadly, our purpose is to point out (a) the risk of relying on such intuition in answering an empirical question, and (b) the need for a careful examination of all the implications of the reemerging consensus about affective structure.

We present an argument for the separability of happiness and sadness, a canonical pair of intuitively-bipolar items, by systematically evaluating the effects of skew in a set of simulations and a large-scale empirical demonstration as well as show that both exploratory and confirmatory factor analytic techniques properly locate happy and sad in affective space, not as bipolar opposites but rather as only somewhat negatively correlated. Furthermore, in two experiments, we will show that happy and sad as well as more reliable cluster composites representing Positive and Negative Activation can be manipulated separately. We will demonstrate how all these converge to support a view of separability of affect dimensions, and specifically, of the separability of happiness and sadness.

Overview of current studies

Green, Goldman, and Salovey (1993) argued that observed low negative correlations between *happy* and *sad* are due to insufficient control for measurement error, or to insufficient consideration of item format. Their suggested way to handle this problem is the use of CFA, which can partial out the measurement errors associated with idiosyncratic scales, and yield a correlation between their two latent constructs. The latent relationship they found was very negative (e.g., −.84 in Study 1), and they concluded that measurement errors mask the true bipolar structure of affect ratings.

Russell and Carroll (1999a) focused their attention on how measurement characteristics, particularly item formats, modify the observed correlations between mood items (see also Meddis, 1972). Their analysis notes a continuum of item formats, from strictly bipolar to strictly unipolar. Russell and Carroll note that the bipolar items are inappropriate for testing bipolarity, because they impose the bipolar construal on the respondents. Ambiguous items and unipolar ones were deemed appropriate; however, Russell and Carroll argue that the use of less-than-bipolar item-formats results in bivariate distributions (of putative bipolar opposites) that are not bivariate normal, and that therefore yield low correlations. Accordingly, they suggest that the gold standard for a bipolar correlation cease to be the unattainable −1.0, and instead be adjusted according to the response format used in a study: the more unipolar the format, the lower is the standard for concluding bipolarity.

Russell and Carroll (1999a) correctly note that simple product–moment correlations are not ideal for examining affective structure. However, because the literature is full of correlational studies, many of them challenging the bipolarity argument, they chose to focus their analyses on the correlation coefficient, noting the caveat that investigators must attend to the effect of item-format (which is closely linked to the effect of skew). We concur with these authors that correlations remain somewhat informative but also that they are flawed indicators by themselves. In Study 1, we use simulated data to demonstrate the utility (albeit partial) of correlations. Russell and Carroll (1999a; see also van Schuur & Kliers, 1994) do not see exploratory factor analysis (EFA) as an appropriate method for addressing skewed data, and instead favor using other techniques, particularly ones that account for measurement error. With our simulations, we demonstrate that EFA is an adequate approach to address such skew-ridden data plagued with considerable measurement error. Specifically, the simulations help validate the robust ability of factor analysis to recreate the true structure of a skewed item space.

Study 2 uses a large empirical data set in which we apply the lessons learned from Study 1. In that, we review the problem of item skew, and demonstrate that skew affects items in a nonuniform manner, and therefore distorts the observed affective space in particular ways. We then use correlational results as well as both EFA and CFA in a demonstration of the separability of happiness (or positive activation) and sadness (or negative activation).

Finally, in Study 3, we report the results of two experiments in which we manipulate affect and demonstrate the separable reactivity of happiness and sadness, as well as their partial independence from the energetic and tense arousal dimensions.

Study 1

Overview

The simulation study was designed to examine the effect of skew on correlational and factor-analytic solutions. We generated multiple sets of data with known structure in order to analyze the effects of varying sample size, of using bipolar versus unipolar scales, and of introducing skew, on the measurement of psychological states such as moods. Structural analyses of these data sets were done using correlations, conducting EFA, and utilizing the Very Simple Structure criterion (Revelle & Rocklin, 1979) to determine the most interpretable number of factors.

Method

The basic model for all items followed classic test theory: observed score X is the sum of a true score and an error score ($X = T + E$). To generate two-dimensional data, we generated two independent true scores (T_1 and T_2) sampled with replacement from a random normal distribution with mean 0 and standard deviation of 1. The score for each item, i, was thus found as $X_i = L_{1i}(T_1 + wE_1) + L_{2i}(T_2 + wE_2)$. The loadings ($L_1$ and L_2) for the items on the two true score dimensions (T_1 and T_2) were generated so as to create circumplex items (items with equal communalities that are distributed uniformly along a circle in a two-dimensional space; for more information, see http://bc.barnard.edu/ ~ erafaeli/happy-sad-appendix.htm).

Results

Analyses were conducted using the public-domain statistical and data handling computer system R (R Development Core Team, 2004; http://www.r-project.org/). Further information can be found in the online appendix.

We submitted each of 18 simulated samples (3 numbers of items [16, 36, or 72] × 3 sample sizes [200, 800, 3,200] by × items formats [bipolar vs. unipolar]) to maximum-likelihood principal factoring factor analysis. To examine the factorial structure of the resulting items, we used the Very Simple Structure (VSS; Revelle & Rocklin, 1979) algorithm that is designed to detect the most interpretable number of dimensions. The VSS criterion is a goodness-of-fit index of how well a "simplified" structure matrix reproduces the original correlation matrix. A simplified matrix of complexity n has had all but the n largest (absolute value) loadings per item replaced by 0. Unlike most goodness-of-fit criteria, VSS does not necessarily increase as the number of factors increases and in simulations has been shown to peak at the correct number of factors (Revelle & Rocklin, 1979). VSS is a particularly appropriate algorithm when the expected complexity of the structure for each item (the number of factors on which an item has large loadings) is small (e.g., 1 or 2).

We simulated data samples of varying sizes and various numbers of items, all with known properties (a two-dimensional structure). We distorted the underlying structure in these data sets by adding in skew and random error, and by converting the data to discrete rather than continuous item responses. Most importantly, we added nonuniform skew to the data sets. The skew and error levels introduced were similar to those found in empirical data sets (such as the one described below in Study 2). In all cases, using EFA analysis and applying the VSS criterion allowed us to recover the two-dimensional structure of the data. This study demonstrated the utility of EFA and of the VSS criterion in recovering the true structure of unipolar (and bipolar) items affected by error, constrained response format, and skew. It also demonstrated how considering Pearson correlations within the context of an entire set of correlations offers a useful view of item associations.

Study 2

Next, we applied the simulation's findings to a data set obtained from a very large sample of participants who had completed a comprehensive mood questionnaire.

Method

Participants

A total of 3,896 participants were randomly selected from an Introductory Psychology experimental pool at Northwestern University over 9 years (1989–1998). Participants received course credit for participation.

Materials

The Motivational States Questionnaire (MSQ) is composed of 72 items, which represent the full affective range (Revelle & Anderson, 1996). The MSQ consists of 20 items taken from the Activation–Deactivation Adjective Check List (Thayer, 1986), 18 from the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) along with the items used by Larsen and Diener (1992). The response format was a 4-point scale that corresponds to Russell and Carroll's (1999a) "ambiguous—likely—unipolar format" and that asks the respondents to indicate their current standing ("at this moment") on a scale ranging from 0 (*not at all*) to 3 (*very much*).

The original version of the MSQ included 70 items. Intermediate analyses (done with 1,840 participants) demonstrated a concentration of items in some sections of the two-dimensional space, and a paucity of items in others. To begin correcting this, three items from redundantly measured sections (*alone*, *kindly*, *scornful*) were removed, and five new ones (*anxious*, *cheerful*, *idle*, *inactive*, and *tranquil*) were added.

Procedure

The data were collected over 9 years, as part of a series of studies examining the effects of personality and situational factors on motivational state and subsequent cognitive performance. In each of 38 studies, prior to any manipulation of motivational state, participants signed a consent form and filled out the MSQ.

Results

Overview

We report the results in four steps. First, we report the raw correlations of all 75 items with happy and sad. We find that sad is not the opposite of happy, as other items serve as better candidates for bipolarity. We also find that the picture is less clear with finding the opposite of sad. Second, we conduct an EFA to locate happy and sad in a two-dimensional space, and examine the sufficiency of this two-factor solution using VSS. This analysis yields factor loadings in a Cartesian space, and also suggests specific item clusters representing different parts of the affective domain to be examined using confirmatory techniques. Third, we convert the items' Cartesian coordinates (obtained in the factor analysis) into polar coordinates. This allows an examination of skew as a function of items' angular location, and shows that item skew varies systematically by location. Finally, we conduct a CFA of a subset of the items suggested by the second step; this analysis shows that the aggregation of items into six observed clusters and the use of latent factors confirms the partial independence of positive and negative activation clusters.

Step 1—Correlational Results: What are the Opposites of Happy and Sad? Study 1 demonstrated that Pearson correlations, though obviously attenuated by factors such as skew and measurement error, do provide meaningful information, especially when used in a within-study comparison of all correlations. We therefore begin the results section with these comparisons, this time of item correlations with happy and sad. Although happy and sad are thought to be semantic opposites, it has previously been established that the two are not correlated perfectly negatively (e.g., Russell & Carroll, 1999a). This is said to be a consequence of using two unipolar response scales, which curtail the strength of the negative association; nonetheless, if the two items are indeed opposites, the strongest negative correlate of one (i.e., happy) should be the other (i.e., sad), and vice versa. Examining the patterns of correlations shows this is not the case (middle right-hand panel in Fig. 1; a larger scale version is at http://bc.barnard.edu/~erafaeli/happy-sad-appendix.htm). Happy and sad correlate −.23 (SE = 0.015, with 3,873 cases). Happy has stronger negative correlations with 15 other items than it has with sad, 12 of which were significantly stronger. Because the large differences in skew among these items lowers the Pearson correlation, we also examined polychoric correlations between happy and the other MSQ items (see also Tellegen, Watson, & Clark, 1999a). Polychoric correlations estimate the underlying Pearson correlation assuming a bivariate normal distribution divided into (perhaps) unequal regions. Thirteen items had stronger negative polychoric correlations with happy than did sad, 10 of which were significantly stronger. Using polychoric correlations is a more lenient test of the hypothesis that sad and happy are bipolar opposites but once again indicates it not to be the case.

As was the pattern of correlations for simulated items, the correlations of real items with happy and sad is much more consistent with an angular separation of about 120° than it is with 180°. A visual representation of this angular separation as well as of items that are indeed bipolar opposites (active and inactive, bottom panel) or ones that are indeed orthogonal (happy and nervous, top panel) helps illustrate this further. To formally test this hypothesis, we did a series of EFAs to locate the 75 MSQ items in a Cartesian coordinate space, reported next.

Step 2—Factor Analytic Results: What are the Loadings of Happy and Sad? Three separate EFAs were done: (1) on the 70 items from the original MSQ, $N = 1{,}840$; (2) on the 72 items from the MSQ-R, $N = 2{,}056$; and (3) on the 67 items from both the MSQ and MSQ-R, $N = 3{,}896$. All three used Maximum Likelihood Factor Analysis using the R computer system on the item correlation matrices. The results from all three were practically identical in terms of the observed loadings on the overlapping 67 items (coefficient of congruence for the overlapping 67 items >.99 for Factors 1 and 2). For simplicity, we report item loadings from the 67 item complete set with loadings for the additional eight items taken from the appropriate sub-analysis.

Using the VSS criterion for the optimal number of interpretable factors (Revelle & Rocklin, 1979; as we did in the simulation) we found that for item complexities of 1 or 2, the optimal number of factors was 2 (for Complexity 1) or 3 (for Complexity 2) for the three analyses. The two-factor solution (see http://bc.barnard.edu/~erafaeli/happy-sad-appendix.htm) is consistent with the analyses of Feldman Barrett and Russell (1998), Thayer (1967, 1987), and Watson (1988) and allows for an examination of the question at hand: the relation of happy to sad in affective space.

Step 3—Polar Coordinates and Skew: What are the Locations of Happy and Sad, and How are They Affected by Skew? To examine the items for possible bipolarity, it is useful

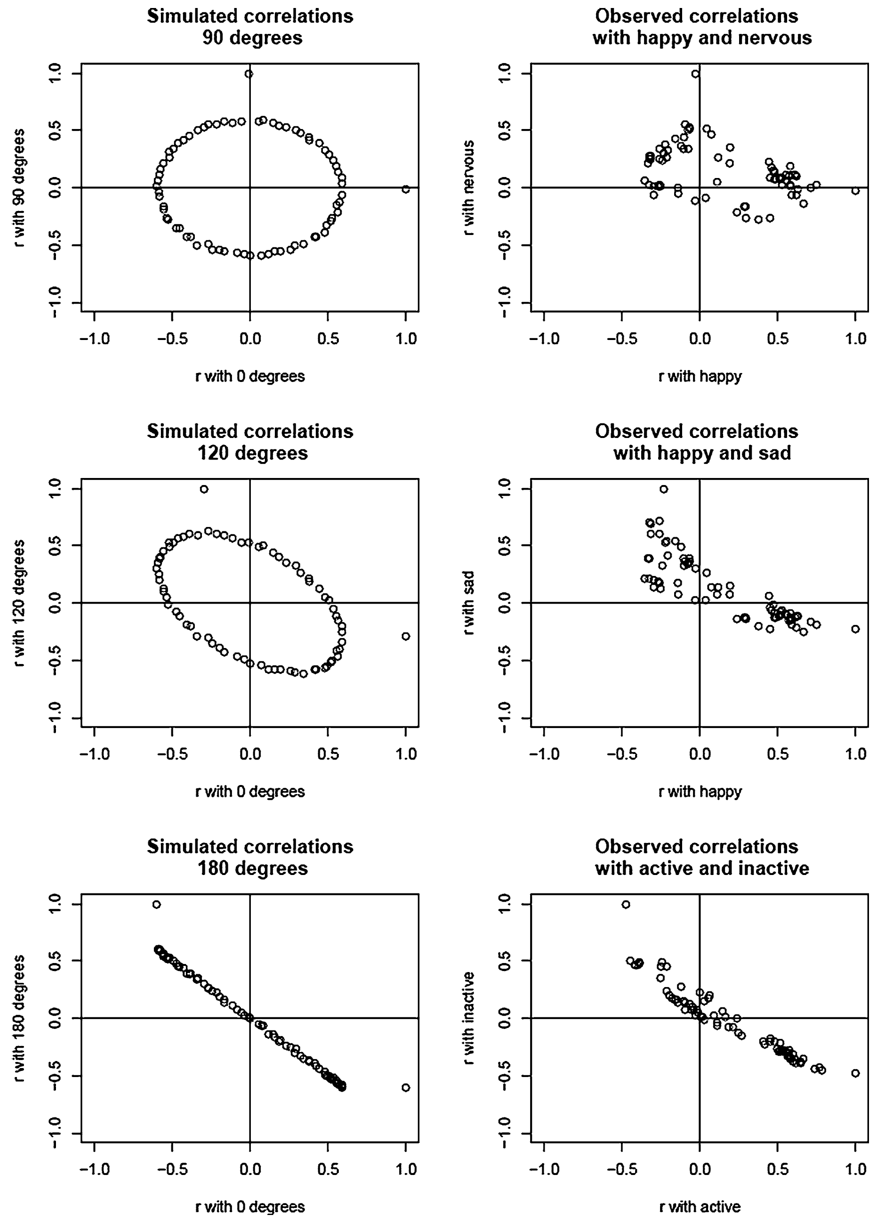

Fig. 1 Correlations of all simulated (Study 1, *left*) and real (Study 2, *right*) items with pairs of markers at 90° (top), 120° (middle), and 180° (bottom)

to organize them in terms of their angular separation and vector length. Factor loadings may be translated into polar coordinates by recognizing that an item's communality in two space is its vector length and that the angular separation of an items from Factor 1 is the arccosine of the loading on Factor 1 corrected for unreliability of the item (in this case, the communality) multiplied by the sign of the loading on Factor 2:

$$\text{Angle} = \text{arccosine}\left(\frac{F_1}{\sqrt{F_1^2 + F_2^2}} \times \text{sign}(F_2)\right)$$

(Note that angle is expressed in radians. To convert to degrees, multiply by $360/2\pi$.)

Russell and Carroll (1999a) suggested that happy and sad are bipolar opposites but fail to correlate more strongly because of their opposite patterns of skew. Two analyses bear on this question. First, we can find the angular separation between the two items (see http://bc.barnard.edu/~erafaeli/happy-sad-appendix.htm for the factor loadings, communalities, and angles of our items, in counterclockwise order of angular location). As expected, we find happy (at 354°) and sad (at 114°) to be separated by 120°, and not the 180° required of bipolar opposites.

Second, we can examine the relationship between angular location and item skew. Figure 2 presents the level of skew in any item as a function of it angular location. Clearly, skew is systematically related to angular location.

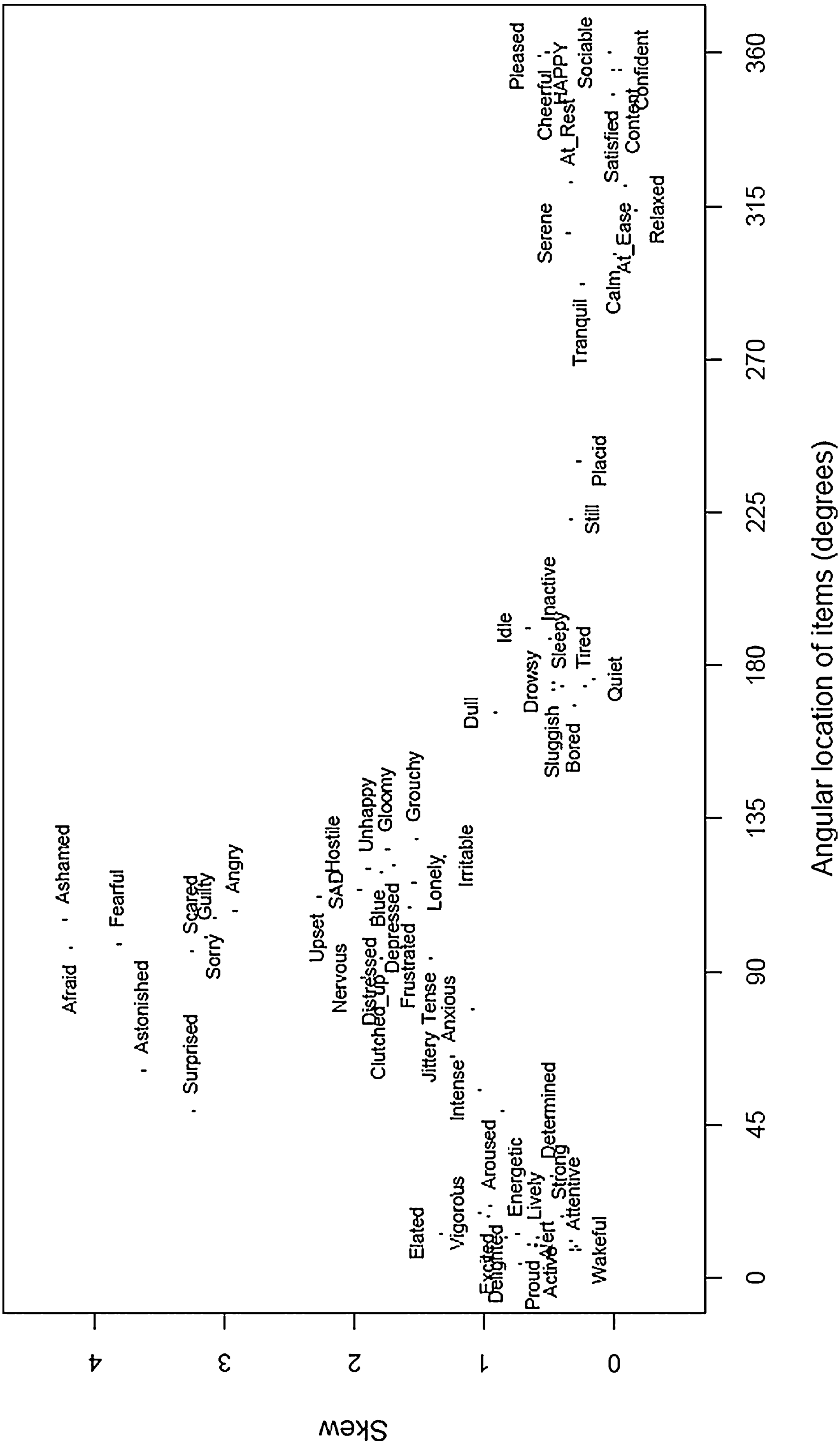

Fig. 2 Study 2: Item skew as a function of angular location

Although most items are only slightly skewed (the overall median is 0.74), the cluster of items at roughly 90° (e.g., *ashamed*, *afraid*, *fearful*, *scared*, *guilty*) is very positively skewed. A few items (*relaxed*, *at ease*, *calm*) are slightly negatively skewed. *Happy*, like most items in its vicinity, is characterized by little skew (0.23). *Sad*, in contrast, is characterized by considerable skew (1.96), though not as much as items that reflect high tense arousal (e.g., *scared*: 3.25; *afraid*: 4.18).

Step 4—Confirmatory Factor Analysis: Would the Results Differ if Items were Aggregated and Latent Factors were Examined? One argument against the preceding analyses could be that they rely too heavily on particular items, which could be strongly affected by random or systematic error. To address this possibility, we identified six clusters of items (chosen on the basis of similar angular location) and subjected this subset of items to CFA and structural equation modeling. Two clusters assessed the constructs of Positive Affect/happiness and Negative Affect/sadness, and four captured the constructs of High and Low Energetic Arousal and High and Low Tense Arousal (Thayer, 1986). The bipolar structure of Energetic Arousal was clear with latent correlations of −.59 between the High and the Low Energetic Arousal clusters. Less clear was the bipolar structure of Tense Arousal with latent correlations of only −.38 between the High and the Low Tense Arousal clusters. What was clear, however, was that the Positive and Negative Affect latent clusters had an even weaker correlation, of only −.36.

Brief discussion

The results from the empirical study reinforce the simulation results. The pattern of Pearson and polychoric correlations with happy and sad suggests they are not bipolar opposites but rather separated by 120° in a two-dimensional affective space. It is useful to compare the patterns of correlations of other items with the putative bipolar pair of happy and sad with truly bipolar pairs (e.g., active and inactive) or truly independent (happy and nervous; right-hand panels of Fig. 1). It is also useful to compare the observed results with the simulated results (left-hand panel of Fig. 1).

We used two additional procedures to evaluate the relationship of happy and sad taking into account measurement error. The first, EFA, examines the structure of the shared variances between many pairs of items. The second, structural equation modeling, examines the structural relationships between the common parts of specific sets of items. When the loadings from an EFA of the 67 items available for all participants are examined, the locations of happy and sad in affective space are made very clear. By converting the (Cartesian) loadings to polar coordinates, the angular separation of happy and sad is 120°, showing neither bipolarity (180°) nor independence (90°). There *are* many pairs, however, that can be seen as bipolar (e.g., active and inactive, 186°). The EFA results suggests that in terms of angular separation, happy is most negatively related with measures of inactivation such as sleepy (181) or drowsy (179). Similarly, the CFA results suggest that high and low energetic arousal are bipolar opposites.

Study 3a and 3b

The psychometric evidence for separability of happy and sad seems fairly clear. We next examine whether a similar separability of happy and sad could be shown by manipulating affect.

Method

Participants

In these two studies, 164 and 160 participants were randomly selected from an introductory psychology subject pool. These are two groups of participants whose data is also included in Study 2. However, the data reported here were collected later in the experimental sessions and were not previously analyzed. Participants received course credit for participation.

Materials

The MSQ was used in these studies as in the earlier one.

Procedure

After completing a consent form and the initial MSQ (used in Study 2 but not in the present analyses), participants were randomly assigned to viewing one of four film clips, each lasting just over 9 min. The clips used were as follows: (1) *Sadness*: taken from a *PBS Frontline* episode (May 1985) depicting the allies' liberation of Nazi concentration camps; (2) *Threat*: taken from the 1978 film *Halloween*; (3) *Neutral*: taken from a *National Geographic* film depicting animals in their natural habitat, grazing; and (4) *Happiness*: taken from the 1989 film *Parenthood*. Immediately after watching the clip, participants completed the MSQ again. In both studies, participants subsequently completed additional questionnaires and cognitive processing tasks, which will not be discussed here. At the conclusion of the study, those participants who had viewed the distressing clips (1 or

2) were shown a brief clip from the movie *Parenthood* at the request of the institutional review board. All were given a comprehensive debriefing.

Results

Means and standard deviations for each of the six affect scales (PA, NA, high and low energetic arousal, and high and low tense arousal) are presented in Table 1. MANOVA tests conducted for each study indicated that the four movie conditions did lead to changes in the affective scores as a group (Study 3a: Wilks test = 0.33, approximate $F[18, 430.4] = 11.3$, $p < .001$; Study 3b: Wilks test = 0.41, approximate $F[18, 410.6] = 8.5$, $p < .001$). We followed this up by conducting one-way ANOVAs for each affect scale; the F values for these are presented in Table 1. Similar ANOVAs were conducted for the single items *happy* and *sad*; these too are presented in the table. All affect scores as well as the two items differed according to the movie condition, with the exception of low energetic arousal scores in Study 3a. The effects were much more pronounced for the PA and NA scores than for the energetic or tense arousal scores.

Plots illustrating the effects of the movie condition on the different affect scales and on the items *happy* and *sad* are at http://bc.barnard.edu/~erafaeli/happy-sad-appendix.htm. Compared to the Neutral film, the Happy film elevated PA and happiness and reduced NA and sadness scores, and the Sad film did the reverse. However, the Threat film only reduced PA, and did not elevate NA. Indeed, in Study 3b, it showed a trend toward *reducing* NA. Similarly, its effect on the single-item scales was to reduce happiness (but do nothing to sadness) in Study 3a, and to *reduce* sadness (with a trend toward reducing happiness as well) in Study 3b. As a consequence, the PA and the NA levels, and the happiness and sadness levels, of the four films do not maintain a monotonic negative rank order. As can be seen in Table 1 (and in the appendix figures) the single *happy* and *sad* items yielded results that are almost identical to those of the PA and NA clusters.

To further understand PA, we compared it to the closely related EA scale. As we noted in the SEM analyses in Study 2, described earlier, PA is very strongly related to EA; thus, we would expect the two to respond similarly to mood inductions. This was the case, but only partly so. Specifically, the Happy film that affected PA also elevated EA scores. However, the Sad film had a negative effect exclusively on PA and not on EA; and the Threat film decreased PA, while tending to actually increase EA. The picture is even more interesting when we compare the response of NA and TA. Though these two scales were strongly related in SEM analyses in Study 2, they responded quite differently to the mood inductions. Specifically, although the Sad film

Table 1 Means and standard errors of affect scales in each of the mood manipulation conditions

	Sad mean, (*SD*)	Threat mean, (*SD*)	Neutral mean, (*SD*)	Happy mean, (*SD*)	ANOVA
Study 3a					$F(3, 157)$
Positive affect	− 0.60 (0.52)	− 0.34 (0.59)	0.19 (0.96)	0.67 (0.80)	22.7**
Negative affect	1.07 (0.99)	− 0.26 (0.55)	− 0.25 (0.63)	− 0.50 (0.39)	44.5**
High energetic arousal	− 0.30 (0.73)	− 0.06 (0.85)	− 0.12 (0.80)	0.43 (0.92)	6.3**
Low energetic arousal	0.15 (0.83)	− 0.14 (0.82)	0.14 (0.90)	− 0.18 (0.91)	1.8
High tense arousal	0.29 (0.92)	0.36 (0.95)	− 0.30 (0.51)	− 0.34 (0.49)	9.1**
Low tense arousal	− 0.35 (0.75)	− 0.45 (0.76)	0.24 (0.79)	0.50 (0.61)	14.7**
Single items					$F(3, 163)$
Happy	− 0.64 (0.62)	− 0.28 (0.80)	0.16 (1.07)	0.69 (0.92)	18.9**
Sad	1.22 (1.05)	− 0.32 (0.64)	− 0.33 (0.63)	− 0.50 (0.48)	50.7**
N	41	41	41	41	
Study 3b					$F(3, 150)$
Positive affect	− 0.70 (0.40)	− 0.16 (0.82)	0.07 (0.77)	0.85 (0.81)	29.6**
Negative affect	0.77 (0.96)	− 0.29 (0.70)	− 0.09 (0.75)	− 0.45 (0.62)	19.5**
High energetic arousal	− 0.23 (0.63)	0.05 (0.85)	− 0.27 (0.87)	0.49 (0.88)	8.2**
Low energetic arousal	− 0.22 (0.76)	− 0.16 (0.75)	0.46 (1.04)	− 0.10 (0.87)	5.2*
High tense arousal	0.31 (0.79)	0.29 (1.06)	− 0.29 (0.73)	− 0.34 (0.53)	7.4**
Low tense arousal	− 0.64 (0.57)	− 0.17 (0.82)	0.29 (0.76)	0.55 (0.73)	9.8**
Single items					$F(3, 154)$
Happy	− 0.65 (0.62)	− 0.16 (0.99)	0.02 (0.89)	0.86 (0.87)	21.2**
Sad	1.00 (1.02)	− 0.50 (0.61)	− 0.05 (0.80)	− 0.56 (0.58)	34.0**
N	42	37	43	38	

*$p < .01$. **$p < .001$.

increased NA and TA, the Happy film affected the former but not the latter, whereas the Threat film affected the latter and not the former.

Brief discussion

The results of Studies 3a and 3b were consistent with each other and show the complex pattern of relationships between positive and negative activation and energetic and tense arousal. In particular, they strongly suggest that changes in happy and sad moods are not always reciprocal. These results are similar to those reported by Larsen et al. (2001) and Larsen, McGraw, Mellers, and Cacioppo (2004), who have shown that although mixtures of happy and sad are unlikely to be observed in normal conditions, they are particular likely to be seen during or following more emotionally intense situations (e.g., after watching the movie "Life is Beautiful," while moving out of a dorm at the end of a year, or on graduation day from college) or following feedback of "disappointing" winnings (e.g., winning \$5 but not winning \$12). Techniques of measurement that go beyond simple self-report of mixed emotion have been discussed by Schimmack (2005), who has used response time measures to evaluate emotional states mixing pleasure and displeasure. These two studies also help understand both the similarity and the difference between valenced scales (such as PA and NA) and arousal scales (such as EA and TA). Specifically, the movie manipulations used had a stronger effect on the affective versus the arousal components of mood. Thus, although PA and EA are strongly related, these studies revealed instances in which they are not synonymous. The same can be said for NA and TA, which responded differently to the mood inductions.

Overall discussion

With the help of 3,894 real participants (and thousands of simulated ones) we have demonstrated that the consensus regarding the structure of affect and particularly the relationship between happy and sad is premature. Rather than bipolar opposites, happy and sad reflect separable but not independent constructs.

One of the problems of mapping the structure of mood has been the reliance on simple correlations (Russell & Carroll, 1999a). Though we agree that this reliance has been a hindrance, we provided evidence for the continued, though limited, utility of the correlation coefficient. We demonstrated the robust ability of EFA to (re-)create order in the affective space. Finally, we explored a problem (*nonuniform* skew) that was overlooked by Russell and Carroll (1999a) in their discussion of response format effects, and that has received only limited attention from other authors (also see Schimmack, Böckenholt, & Reisenzein, 2002; Tellegen et al., 1999a).

Nonuniform skew, along with various sources of error, contributes to low communality and poses a real challenge to simple correlations, by attenuating them, and not in a uniform way. There are different ways to correct for such attenuation, including correcting for poor reliability caused by various factors, or using factor loadings to correct for several sources of error variance by assessing angular distance. Green et al. (1993) conducted a CFA in hope of correcting for low reliability. Conceptually correct as it is, this approach opens the door to several sources of error, as explained earlier and as demonstrated by Schimmack et al. (2002). Next, we explain why we recommend using the angular distance approach.

Using factor loadings to map the angular locations of items in a two-dimensional affect space (and to assess the angular distance among pairs of them) provides a very robust estimate of the true relationship among pairs of items. Factor loadings and communalities (and their polar coordinate equivalents, angular location, and vector length) are computed by considering the interrelations of an item with all other items (in our case, 74 additional items). This takes into account the common variance each item has with all other items in the space, in effect situating the item based on multiple anchors. By situating items in this fashion, we can obtain a more precise estimate of the true relationships among them than by merely computing pair-wise correlations, even if we correct these for attenuation.

Both the simulation and the empirical studies support this statement. What appear to be important relationships for situating an item in the affective space are not only the most positive or most negative correlations, but also the weakest correlations. These weak relationships identify the items that are on hyperplanes of one another. This idea is reminiscent of Campbell and Fiske's (1959) notion of discriminant validity: a major part of a construct's identity are those discriminant constructs to which the construct is *not* related, along with the convergent constructs to which it is strongly related. That information is not lost in EFA.

After demonstrating the utility of factor analysis, factor loadings, and angular distance, we turned to the problem of skew. As was noted by Nunnally (1967) and Russell and Carroll (1999a), skew has a strong effect on correlations. Specifically, the greater the difference between two negatively correlated items in item skew, the smaller (in absolute value) the correlation between them. However, although the magnitude of the correlation is affected by skew, the correct angular location can still be recovered by factor analysis. Additionally, Russell and Carroll's (1999a) implicit assumption regarding skew is incorrect. It is not an inevitable byproduct of unipolar item formats. Instead, a specific range of items (those tapping high tense arousal or negative affect) is particularly plagued by skew (for a similar report with daily rather than momentary feelings, see Tellegen et al., 1999a). As a consequence, the correlations of items in this range, particularly with putative bipolar opposites, are greatly attenuated, whereas the correlations of other items, using the same item format, are much less attenuated (e.g., compare alert–sleepy with tense–calm).

It is possible that the attenuation effects due to skew might be a bigger problem with relaxed participants than with the ones for whom some tension is induced. Our participants completed the MSQ under normal circumstances, and were not under any identified stress. Their tendency to report low scores on the tense arousal items may be the reasons for the skewness of those items. We expect that had our participants been under greater stress, their responses to High Tense Arousal items would have been distributed with less of a skew. Of course, beyond some level of stress it is possible that fatigue would set in, and with it a skew on another quadrant of items (most likely, positive skew on the High Energetic Arousal items, or negative skew on the Low Energetic Arousal ones). Still, at some level of stress, the skewness of items in all quadrants may be balanced at some uniform level (of positive skew).

A similar point, regarding the variable structure of affect, was raised by Cacioppo and Berntson (1994), Feldman (1995a), Watson et al. (1999), and Reich, Zautra, and Davis (2003). For example, Watson and his colleagues suggested that positing a fixed and precise "structure" of affect ignores important variations in the structure in different contexts and across different time frames. Although we suggest that our structure is quite robust, we agree that variability in the structure is both possible and important to study. One approach to this question examines the structure of affect as a function of time-of-day. In other work (Bonanno, Coifman, & Rafaeli, 2005; Rafaeli, Rogers, & Revelle, submitted for publication; cf. Feldman, 1995b) within-person structure has been shown to differ between participants.

Conclusions

According to an intuitive view of moods, they should be measured and modeled "... with terms that have the best chance of actually being used by individuals ..." (Green & Salovey, 1999, p. 304). Indeed, "happy" and "sad" are widely used terms, and in most individuals' intuition, clearly opposite to each other. Affect researchers who often differ in their positions (e.g., Russell & Carroll, 1999a; Tellegen et al., 1999a, p. 301) all seem to accept this consensus, and have adopted these as the poles of an overarching bipolar dimension.

Our findings argue against such a consensus. Instead, they demonstrate that happiness and sadness require a two-dimensional model of affect to be fully understood. As we have shown, this calls into question some of the assumptions and suggestions of Russell, Green, and their colleagues. Additionally, our findings are only partly consistent with Tellegen, Watson, and their colleagues' hierarchical models of affect (e.g., Tellegen et al., 1999a, 1999b). Their description of the lower rungs of the hierarchy (where PA and NA each divide into basic emotion dimensions, requiring additional factors to account for the variance) is consistent with the structural model we find. In contrast, our data question the utility of a higher level happiness–sadness factor.

Unlike other researchers (e.g., Green & Salovey, 1999; Tellegen et al., 1999a, 1999) our argument is not for or against circumplex structure per se. As can be seen in the simulation study, circumplexes are partly artifacts of items selection. A circumplex assumes the following: (a) two dimensions; (b) items of equal communalities; (c) equally spaced items; and (d) equal length of any pair of two dimensions cutting through the space (Acton & Revelle, 2002). Our empirical data meet only criterion (a), but our conclusions regarding happiness and sadness are unaffected by the remaining criteria. Whether affective space is circular or ellipsoid, the intuitive expectation that "happiness–sadness" would form a straight axis through the space is unsupported. We strongly believe that a premature consensus regarding the structure of affect, particularly regarding the sufficiency of a bipolar, evaluative happiness–sadness dimensions will lead to continuing confusion in the study of affect.

In the last decade, authors supporting the bipolarity view of affect have argued that mis-measurement masks the true bipolar structure of affect. Although these authors choose to focus on the psychometric analysis and often refrain from considering functional or biological underpinnings and external correlates, it is important to note that by now, an extensive literature strongly supports the separable view. The interested reader may wish to see a recent review by Carver (2001), and consult Meyer and Shack (1989) for a demonstration of external correlates, Davidson (1993), Fowles (1980), and Gray (1994) for discussions of biological substrates (also see Heller, 1990, 1993, for a dissenting view), Cacioppo and Gardner (1999) for attitudinal and behavioral outcomes, and Rafaeli, Drejet, Ehrlich, Teicher, & Bodkin (submitted for publication) and Watson and his colleagues (e.g., Clark, Watson, & Mineka, 1994; Watson et al., 1999) for implications to psychopathology.

Together with these sources of evidence, we call for caution in moving toward a consensus on the structure of affect, one that will offer an enduring solution for investigators who have been wary of the pitfalls of accepting one dimensional solution or the other. Specifically, using affect rating scales with unipolar items tapping all parts of the two-dimensional space, seems to us to be the most promising (and least restrictive) option for researchers interested in affect measurement. Indeed, as Feldman Barrett and Russell (1998) suggest, using such measures will provide precise and comprehensive information, and yet will not miss out on important, if counterintuitive, findings such as the separability of happiness and sadness.

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