Measuring Subjective Well-Being: Unfolding the Bradburn Affect Balance Scale

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MEASURING SUBJECTIVE WELL-BEING: UNFOLDING THE BRADBURN AFFECT BALANCE SCALE

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ABSTRACT. Factor analysis of the items in the Bradburn Affect Balance Scale has repeatedly shown that the positive and negative affect items are unrelated. Despite this, negative affect scores are routinely subtracted from positive affect scores to derive Affect Balance Scale Scores that apparently provide a valid measure of a sense of well-being. In this paper we offer a resolution to this paradox – and so justify the use of Affect Balance Scale Scores – by showing that the positive and negative affect items each form a single cumulative scale, and that the two cumulative scales taken together form one unidimensional unfolding scale. This explanation is based on a hypothesis by Coombs and Kao (1960) – later proved mathematically by Ross and Cliff (1964) – that when data that are unfoldable in r dimensions are factor-analyzed, r + 1 significant factors will be found. In an empirical test, Bradburn Affect Balance Scale data collected from ten countries in the 1981 and 1990 European Values Study surveys were analyzed. The results clearly support the hypothesis that the data form a single unidimensional unfolding scale, although two of the ten Affect Balance Scale items are not homogenous with the rest.

1. INTRODUCTION

Over the last twenty-five years survey researchers have tried to improve techniques for measuring the perceived quality of life. Of these, Bradburn (1969) was one of the first to analyze self-expressed mood states. Subjects in his study were asked to indicate whether they saw five positive mood states (e.g., 'pleased about having accomplished something') and five negative mood states (e.g., 'bored') as applicable to them. Taken together, these ten questions have become widely known as the Bradburn Affect Balance Scale.

To assign an 'Affect Balance Scale Score' to a subject, the researcher first calculates positive and negative affect scores separately by adding up the number of positive items and negative items the subject deems applicable (both scores will be between 0 and 5), and then subtracts the negative score from the positive. The resulting

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value – which falls between −5 and +5 – is hypothesized to indicate the subject's position along a latent 'perceived quality of life' dimension.

But do all 10 items in fact measure the same latent trait? Factor analysis[1] has been used by Bradburn and others to explore this question with surprising results: the ten mood states seem NOT to form a single bipolar dimension, but rather correspond to two INDEPENDENT factors – one comprising the positive items and the other the negative items. Analyses of large scale surveys carried out in the USA and the UK show that a respondent's score in one affect dimension indeed does not predict his score on the other (Bradburn, 1969: 225; Harding, 1982).[2]

In a study of Affect Balance Scale data collected in 1981, the European Value Study Systems Group (EVSSG) also found two independent factors, one for positive affect and one for negative affect (Harding *et al.*, 1986: 189). Although each of the two scales correlated highly (in opposite directions) with the variable 'happiness', positive and negative affect scores did not correlate with each other and they correlated differently with a number of other external variables (Harding *et al.*, 1986: 197). The Study Group concluded that a feeling of happiness is probably composed of several elements such as positive and negative mood states, and is better predicted by the composite index of the Affect Balance Scale than by either of the two factors separately (Harding *et al.*, 1986: 192). Like Bradburn, they subtracted subjects' negative scores from their positive scores to arrive at their Affect Balance Scale scores without confronting the interpretation problem: how can one justify subtracting apples from oranges?

We are faced, then, with a paradox. On the one hand, if positive and negative affect are independent we cannot interpret their difference score meaningfully. On the other hand, the difference score has proven to be reasonably valid, in that it correlates highly – more highly, in fact, than either the positive or negative affect score separately – with two other well-known indicators of the quality of life: measures of happiness and of satisfaction with one's life (Bradburn, 1969; Harding, 1981; the latter's Affect Balance Scale data came from a 1975 survey ont he 'Quality of Life' in Great Britain). How can this paradox be resolved? How can the difference score between two seemingly unrelated variables – positive and negative affect – function as an apparently valid measure of affect on a single bipolar continuum?

In the next section we review some existing attempts to answer this question. Then we pursue a solution suggested by Van Schuur and Kiers (1994), according to which the finding that positive and negative affect are independent may be an illusion – a statistical artifact known to arise when factor analysis is applied to data that underlyingly conform to the unidimensional bipolar UNFOLDING model. Factor analysis and an unfolding analysis will then both be applied to Bradburn Affect Balance Scale data collected from ten European countries in the European Values Study in 1981 and 1990.

2. A BRIEF REVIEW OF LITERATURE ON MOOD STATES

The measurement of mood states is discussed not only in the literature on the Affect Balance Scale but in many other articles as well. Many authors have assumed that positive and negative mood states should be representable by a single bipolar factor. But in analysing mood state items comparable to those in the Affect Balance Scale – usually with factor analysis – they have usually found two independent unipolar dimensions (see Middis, 1972, and Chamberlain, 1987, for reviews). This finding has led to two different reactions: a) acceptance, and b) puzzlement and an attempt to explain the phenomenon.

Authors who have simply accepted the finding and not questioned its validity have often justified this on grounds that subjects' scores on the positive and negative affect factors correlate differently with additional variables. Holström and Wearing (1984) suggest that the two-factor outcome can be better understood if we compare the measurement of the perceived quality of life to the measurement of intelligence:

> General intelligence tests usually have separate sections dealing with quantitative ability and verbal ability, and results for the sections are considered separately ... However, it is generally found that, if an overall measure of intelligence is required, it is best to combine the two scores. (p. 116)

Other authors, however, have been overtly puzzled that mood states are not bipolar; Brenner (1975), for instance, gives several substantive reasons why positive and negative affect should be negatively correlated. Authors in this camp have tried to explain the lack of correlation by invoking 'response set bias' (Campbell, Converse, and Rogers, 1976), 'extreme response style' (Lorr and Shea, 1979; Lorr and McNair, 1982), 'acquiescence' (Lorr and Wunderlich, 1980), 'circumplex representation' (Russell, 1980), 'change of response format' (Warr *et al.*, 1983), and 'length of time interval in which moods are described' (Diemer and Emmons, 1985). And Diener, Emmons, Larsen and Griffin (1985) found that, once intensity (how strongly each mood item is experienced) was partialled out, positive and negative affect were strongly negatively correlated after all.

3. AN ALTERNATIVE EXPLANATION: FACTOR ANALYSIS AND UNFOLDING – THE MYSTERY OF THE 'EXTRA FACTOR'

Sharing the perplexity of authors in the second camp, Van Schuur and Kiers (1994) have suggested that the problem may lie in the method of data analysis: factor analysis may not be the right technique for analyzing mood state data. More than thirty years ago, Coombs and Kao (1960) observed that when factor analysis is used to analyze data that conform to what Coombs (1964) named the 'unfolding model', the result is an 'extra', artifactual factor. This means that if the latent dimension that underlies mood state data actually has the structure of a unidimensional unfolding scale, the application of factor analysis to this data would lead to the identification of two factors instead of the expected single factor.

The unfolding model is a distance model: that is, it represents the relationship between a respondent and an item in terms of distance along one or more dimensions. Both subjects and items are assigned a position on the dimension(s). Items to which a respondent responds positively (e.g., the subject 'prefers' the item, or – as in the present case – considers it applicable to himself) are assigned a position close to that of the subject, and items to which he responds negatively are represented farther away. Factor analysis, in contrast, is a linear model, in which only the subjects and not the items are located (by means of their factor score) along the latent trait, and their position has a different meaning. In the unfolding model, subjects' positions reflect their optimal point along the latent dimension – the point of maximal preference or the point at which they deem items maximally applicable to themselves. But in the factor analysis model their positions reflect how positive their responses are to the items that maximally represent that factor.[3]

Ross and Cliff (1964) provided the mathematical proof for Coombs and Kao's proposal that an extra factor (or dimension) is found when factor analysis if applied to unfoldable data (i.e., data that can be interpreted as *squared distances*). Their proof applies to the general case in which the distances are obtained from an r-dimensional Euclidean space. The artifact introduced when factor analysis is applied to unfoldable data is most dramatic when the underlying unfolding representation is unidimensional: two factors will then be found. These are typically interpreted as two unipolar scales, but each scale in fact constitutes one half of a single underlying bipolar unfolding dimension.

In principle, of course, factor analysis can lead to the identification of a single bipolar factor. But this factor has a different structure than a unidimensional unfolding scale. The difference can best be appreciated by considering the correlation matrix of all the items. For data that can be represented with one bipolar factor, all items that load highly on the factor will correlate highly with each other, though sometimes in opposite directions. If items with negative loadings are recoded, the negative loadings will reverse to positive and all correlations will then be positive.

But for data that can be represented with a unidimensional unfolding scale, neither property holds. First, recall that items, like subjects, have a position on an unfolding scale, and items to which subjects have similar or identical reactions will be represented as adjacent on the scale. This means that adjacent items, wherever they are positioned, correlate most highly with each other. The items at the extreme ends of the unfolding scale will generally correlate negatively: that is, a positive response to one item implies a negative response to the other. But the negative correlation between end-point items is not necessarily very high, because subjects whose optimal point is somewhere internal on the scale (and these are usually in the majority) will typically respond negatively to BOTH items because they are too extreme, although in different directions.

Second, note that as the distance between the items along the scale increases, the correlation between them will decrease to zero and then begin to rise again, this time with the sign reversed to negative. Since the correlation between two items may range from high (with either a positive or a negative sign) to zero, it is not possible to recode some items so as to make all correlations positive (cf. Davison, 1977). If such a correlation matrix is factor analyzed, at least two significant factors will be found, each of which typically comprises the items on one half of the unfolding scale.

It is plausible that Affect Balance Scale data might be representable along a unidimensional unfolding scale ranging from highly negative affect to highly positively affect. Diener (1994) has indeed suggested this. If so, the mood state items can be ordered from extremely negative to mildly negative to neutral to mildly positive to extremely positive. Subjects mark as applicable to themselves only those items that describe their mood state best. Items describing mood states that are extreme in either direction will not be chosen as often as items that describe more moderate states.

It is crucial to recognize that in an unfolding representation, the *items* are interpreted as differing in the *extent* to which they describe a positive or negative mood. In a factor analysis representation, in contrast, an item's loading on a factor does not indicate directly how positive or negative the item's affect is, but only the extent to which it is an adequate indicator of the underlying 'affect' variable.

The application of the unfolding model to the Affect Balance Scale can be illustrated with a hypothetical data set conforming to the deterministic model for the unfolding of dichotomous data, also known as 'parallelogram analysis' (e.g., Coombs, 1964). Imagine that each subject chooses five of the ten Affect Balance Scale items as applicable. If the data conform to the deterministic unfolding model, they can be displayed in such a way that the items are ordered columnwise from extremely negative to extremely positive, and the subjects are ordered rowwise so that the subject at the top selects only the five leftmost (i.e., most negative) items and the subject at the bottom selects only the five rightmost (i.e., most positive) items.

This arrangement is shown in Table I, where '1' – the so-called 'positive' response – means that the subject considers the item applicable, and '0' – the 'negative' response – means that it is not

TABLE I

Hypothetical data set conforming to the deterministic unfolding model. Each subject gives the 'positive' response to five of the ten items ('pick 5/10 data')

	Items of the entire Affect Balance Scale	Items of the two half-scales	
		Negative affect	Positive affect
Subjects	A B C D E F G H I J	A B C D E	F G H I J
1	1 1 1 1 1 0 0 0 0 0	1 1 1 1 1	0 0 0 0 0
2	0 1 1 1 1 1 0 0 0 0	0 1 1 1 1	1 0 0 0 0
3	0 0 1 1 1 1 1 0 0 0	0 0 1 1 1	1 1 0 0 0
4	0 0 0 1 1 1 1 1 0 0	0 0 0 1 1	1 1 1 0 0
5	0 0 0 0 1 1 1 1 1 0	0 0 0 0 1	1 1 1 1 0
6	0 0 0 0 0 1 1 1 1 1	0 0 0 0 0	1 1 1 1 1

applicable. Note that the 'positive' responses in this data set have the shape of a parallelogram. If we split the data set columnwise down the middle, the two resulting (half) data sets each form a perfect cumulative Guttman scale.

Subjects' scale scores on each of the two cumulative scales are calculated by simply summing the number of positive responses in each scale (this procedure is identical to that used in assigning Affect Balance Scale scores). But how are scale scores assigned in the case of the parallelogram (unfolding) scale? A procedure devised by Van Schuur (1993a) works as follows.

The hypothetical Affect Balance unfolding scale we are considering is a unidimensional latent construct on which the ten items each have a different position (as, of course, do the subjects). In Van Schuur's procedure, each item is seen as occupying a closed interval along the latent dimension. The interval is bounded by two 'item steps': the left-sided item step, or (i_{01}), and the right-sided item step, or (i_{10}). Subjects whose position on the scale falls within this interval give the positive response to the item, while those whose position falls to either the left of the left-sided item step or the right of the right-sided item step give the negative response (see Figure 1).

The model assumes that across items, the '$_{01}$' item steps are ordered in the same way as the '$_{10}$' item steps (e.g., if $i_{01} < j_{01} < k_{01}$

response: 0 1 0

i_{01} i_{10}

Fig. 1. Relationship between the item steps for an item and positive vs. negative responses to that item.

Dichot. response patterns	000	100	110	111	011	001	000
Scale value of subjects	0	1	2	3	4	5	6
Position of item steps		i_{01}	j_{01}	k_{01}	i_{10}	j_{10}	k_{10}

Fig. 2. Unidimensional unfolding scale for dichotomous data, in which three items give rise to six item steps and seven isotonic areas.

then $i_{01} < j_{10} < k_{10}$). This implies unequivocal ordering of the items, as shown in Figure 2.[4]

A subject's response '0' to an item thus has two interpretations within the model: either the subject should be assigned a position to the left of the left-sided item step – in which case he is said to have "passed" ZERO item steps – or to the right of the right-sided item step – in which case he has passed TWO item steps. Which interpretation is correct can only be determined in context.

Let us now consider a few examples of how subjects are assigned a scale value – that is, a position on the scale.

If a subject gives the response pattern 11100 to the items in a five-item scale, he clearly must be represented to the left of the left-sided item steps of the two rightmost items. Counting from left to right along the scale, this subject has passed three item steps: the three left-sided item steps of the three leftmost items. Note that he has NOT passed the right-sided item step for these items; otherwise he would have gotten the value 0 for the items. This subject will therefore be given the scale value 3.

Conversely, if a subject gives the response pattern 00111, he must clearly be represented to the right of the right-sided item steps of the leftmost items. Counting again from left to right along the scale, this subject has passed seven item steps: two item steps apiece for each of the two leftmost items, and the left-sided item step for each of the

TABLE II

A comparison between the Affect Balance Scale scores and the Unfolding Scale scores for a data set that conforms perfectly to a deterministic unfolding scale for 'pick 5/10' data

Negative affect	Positive affect	Affect Balance Scale score	Unfolding Scale score
1 1 1 1 1	0 0 0 0 0	−5 + 0 = −5	1+1+1+1+1+0+0+0+0+0= 5
0 1 1 1 1	1 0 0 0 0	−4 + 1 = −3	2+1+1+1+1+1+0+0+0+0= 7
0 0 1 1 1	1 1 0 0 0	−3 + 2 = −1	2+2+1+1+1+1+1+0+0+0= 9
0 0 0 1 1	1 1 1 0 0	−2 + 3 = 1	2+2+2+1+1+1+1+1+0+0=11
0 0 0 0 1	1 1 1 1 0	−1 + 4 = 3	2+2+2+2+1+1+1+1+1+0=13
0 0 0 0 0	1 1 1 1 1	0 + 5 + 5	2+2+2+2+2+1+1+1+1+1=15

three rightmost items. This subject will therefore be given the scale value 7.

The subject who gives the response pattern 01110 must be represented to the right of the right-sided item step of the leftmost item and to the left of the left-sided item step of the rightmost item. Counting from left to right, this subject has passed five item steps: the two item steps of the leftmost item and the three left-sided item steps of the three middle items. This subject will be given the scale value 5.[5]

Let us now use this procedure to compute the unfolding scale scores of the hypothetical subjects whose data were shown in Table I, and compare the values to the scale scores obtained following Bradburn's method of subtracting the sumscore for the negative affect items from the sumscore for the positive affect items. The result is shown in Table II. Remarkably, the two final sets of scores are in essence identical, differing only by an additive constant of 10!

In summary, if a data set conforms to a unidimensional unfolding scale, factor analysis will find two significant factors that can be interpreted as the two halves of a unidimensional unfolding scale. If each of these two halves conforms to a single cumulative scale, then the procedure of subtracting the sumscore of the first cumulative scale from the sumscore of the second cumulative scale will give a result that is identical, up to a constant, to that of the unfolding scale score.

This, we propose, is the resolution to the paradox we started out with: the reason the Affect Balance Scale Score has proved to be a valid measure of perceived quality of life, even though calculating it has seemed to be a matter of subtracting apples from oranges, is that covertly it is an unfolding scale score, and Affect Balance Scale data is, we have argued, likely to be unfolding data.

When dichotomous data are treated as monotonic transformations of squared distances – which is what we have done in our unfolding analysis – some of the properties found when the data are genuine squared distances in a factor analysis begin to falter; for instance, the number of high eigenvalues may increase even beyond $r + 1$ (or beyond 2 in the case of a unidimensional unfolding scale). Moreover, the form of the correlation matrix is no longer a simplex, as Davison (1977) had shown is the case for data that are treated as squared distances. This can easily be seen in Table I: the correlation between C and H is – 1.00 and increases for CG and for BH and AH. But Post (1992: 51–53) has shown that when data are treated as monotonic transformations of squared distances, some restrictions on the correlation matrix can still be formulated: if there are negative correlations in the matrix, they should be confined to the bottom left and top right sections, and if we go along a row in the matrix from left to right we expect at most two sign changes; from negative to positive and then from positive to negative. For Cliff *et al.* (1988) the differences between squared distances and dichotomous data were large enough to merit making a distinction between 'unfolding' analysis, defined as the analysis of squared distances, and 'parallelogram analysis', defined as the analysis of dichotomous data. This distinction has not yet been adopted in the literature, however (cf. Luo, 1995: 20–21).

Earlier, we mentioned that several other explanations have been proposed for why analyses of mood state data so often find two factors. Can these be reconciled with our interpretation? Though we cannot go into it here, there is reason to think so. In discussing the relationship between factor analysis and unidimensional unfolding, Davison (1977) has dealt with Russell's (1980) explanation in terms of a circumplex representation. And we suspect that explanations invoking response bias and 'acquiescence' may turn out to be special cases of the explanation in terms of partialing out intensity.

Up to now, our effort to reformulate Affect Balance Scale data in terms of a unidimensional unfolding scale has been based on purely theoretical considerations. Let us now turn to a concrete data set to explore whether it is true that the ten affect items form two factors in a factor analysis, that the two factors form two cumulative Guttman scales, and that the two cumulative scales together form one unidimensional unfolding scale.

4. THE DATA

4.1 *The Respondents*

In 1981 and 1990 large surveys were held in the European Community to measure a number of values in random samples of citizens of ten Western European countries. The surveys, designed by the 'European Values Study Systems Group' (EVSSG) near the end of the seventies, included the Affect Balance Scale items. The main goal of the study group was to describe "the broad phenomena of the values of the people living in Europe" (Harding, Phillips, and Fogarty, 1986: x; see also pages xii–xiii of this publication for a description of the questionnaire design and data collection procedures). A total of 12,463 people were interviewed in the 1981 survey and 15,385 in the 1990 survey.[6]

4.2 *The Items*

The Affect Balance Scale items were introduced to the respondents in the following way: "We are interested in the way people are feeling these days. During the past few weeks, did you ever feel (A to J) . . . (response possibilities: yes or no):

1. Particularly excited or interested in something
2. So restless you couldn't sit long in a chair
3. Proud because someone had complimented you on something you had done
4. Very lonely or remote from other people
5. Pleased about having accomplished something
6. Bored

7. On top of the world/feeling that life is wonderful
8. Depressed or very unhappy
9. That things were going your way
10. Upset because somebody criticized you.

For each of the ten items the respondents could indicate, by checking separate boxes, whether it was 'applicable' or 'not applicable'. They were not supposed to check both boxes, but they could ignore the item and not check either box. The resulting possible responses for an item could, then, be interpreted as an ordered three-point index: 'applicable'; 'neither applicable nor not applicable'; and 'not applicable'. In fact, however, respondents rarely used the 'neither applicable nor not applicable' option, so we will ignore it.

The dichotomous data generated by tallying the checks of the 'applicable' box are used to derive Affect Balance Scale scores ranging from -5 to $+5$ for each respondent (see section 1). When respondents' positive affect scores are higher than their negative affect scores (scale score between $+1$ and $+5$), they can be said to have a sense of psychological well-being. Conversely, when their negative affect scores are higher than their positive affect scores (scale score between -1 and -5), they have a sense of ill-being (Bradburn, 1969: 9).

Two other variables were included to allow validation of the Affect Balance Scale score; 'happiness' and 'satisfaction'. The variable 'happiness' was tapped with the question: "Taking all things together, would you say you are very happy (4), quite happy (3), not very happy (2), not happy at all (1), or don't know (9)?"[7] The corresponding question for the variable 'satisfaction' was: "All things considered, how satisfied are you with your life as a whole these days?" (the answer was indicated on a ten point scale ranging from 'dissatisfied' (=1) to 'satisfied' (=10)).

4.3 *Results Reported by the Study Group EVSSG for the Affect Balance Scale Data from the 1981 Survey of Ten European Countries*

At present, only the results from the 1981 survey have been published (Harding *et al.*, 1986: 192). The study group EVSSG found that positive mood states were mentioned approximately twice as often as negative mood states. The most frequently chosen item was E ('pleased about having accomplished something'), mentioned by 68% of the total sample, and the two next most frequent items were A ('particularly excited or interested in something') (48%), and I ('that things were going your way') (45%).

Denmark, Great Britain and Ireland, in this order, were the countries with the highest Affect Balance Scores, whereas France, Italy and Spain had the lowest. If we restrict our attention to the positive affect score, Germany was higher than Denmark, but Germany also had the highest score on the negative affect scale; when the second is subtracted from the first to derive the composite Affect Balance score, the value is close to the European mean. This atypical pattern suggests, according the study group, that German respondents have experienced more kinds of positive and negative mood states than respondents in other countries. Spain showed the converse pattern: both low positive and low negative affect scores.

5. OUR PRELIMINARY DATA ANALYSES: FACTOR-, RELIABILITY-, AND CUMULATIVE SCALE ANALYSIS

5.1 *Factor Analysis*

In reanalyzing the data, we first applied the technique that has been used most often: factor analysis. The results came out as expected: for all ten countries in both the 1981 and 1990 data sets, at least two independent factors were found. The eigenvalues of the first two factors are given in the first four columns of Table III (on p. 10). The two factors were always completely unipolar, with the positive affect items loading highly on one and the negative affect items loading highly on the other. The interpretation of the factors is not changed by doing the analysis (in SPSS) with oblique rotation methods with different degrees of obliqueness, and the factors are always only very modestly correlated. Our factor analysis results therefore simply confirm what has been reported in the literature: the positive and negative affect items are apparently unrelated.

5.2 *Reliability Analysis*

We also carried out a reliability analysis of these data in order to demonstrate the relationship between reliability analysis and unfolding. Recall that the sumscore of the 5 negative affect items for a particular subject is calculated by adding up the number of positive (1) responses to those items. This is equivalent to subtracting from 5 the number of negative (0) responses to the items. This means that the procedure used in deriving the composite Affect Balance Scale score – subtracting the sumscore of positive responses for the negative items from the sumscore of positive responses for the positive – is logically equivalent to the procedure of adding the number of negative responses to the negative items to the number of positive responses to the positive items. If negative responses to the negative items measure the same construct as positive responses to the positive items – something like a 'sense of well-being' – then when we follow this procedure (which is done by simply recoding the negative responses to the negative items from 0 to 1), the reliability of the 10 positive and negative items taken together should be high (e.g., Cronbach's α should be over 0.70). But if the items do NOT measure the same thing – e.g., if the data from two factors rather than a single bipolar factor or a single cumulative scale – the reliability should be low.

When the data were recoded for each of the ten countries in the two time periods, the reliability analysis led to too-low values of Cronbach's alpha in each case (see columns 5 and 6 in Table III). This means that the Affect Balance Scale cannot be seen as measuring a single construct.

Does this also count against the possibility that the data form an unfolding scale? In both factor analysis and reliability analysis, items are assumed to be interchangeable indicators of the same latent concept. In unfolding, however, the items are NOT seen as interchangeable: they are assumed to have different positions along the latent trait. So low reliability does not necessarily mean that the data do not form a homogeneous unfolding scale.

5.3 *Cumulative Scale Analysis*

We next performed cumulative scale analyses on the data (as recoded for the reliability analyses), using Mokken's (1971) nonparametric stochastic procedure, which is publicly available as the MSP-program (Mokken Scaling for Polytomous items; Debets *et al.*, 1988).

Mokken's program uses a 'bottom up' search procedure that allows the researcher to build one or more cumulative scales of maximal length from among the items. In contrast, factor analysis, reliability analysis, and other Item Response Theory procedures are all 'top-down': they begin by analyzing an entire set of items and then discard the worst-fitting items one by one until a scale with good fit is found. A bottom-up search procedure has certain advantages over a top-down procedure (see Mokken and Lewis, 1982; Niemöller and Van Schuur, 1983; and Sijtsma, Debets and Molenaar, 1990, for introductions to this scaling procedure). The notion of 'bad fit' to a scale cannot be restricted to individual items, since a single bad-fitting item affects the fit of all the other items as well. When there are a number of items whose fit is at issue, the homogeneity of all the items is affected and it is too difficult to identify WHICH items should be discarded. In the bottom-up procedure, in contrast, this problem is circumvented: a candidate new item is only added to the scale after its effect on the homogeneity of the existing items in the scale is assessed and found acceptable.

The Mokken scale analyses identified two cumulative scales for all the countries in both 1981 and 1990: one comprising the positive affect items and one the (recoded) negative affect items (see columns 7 to 10 in Table III). The homogeneity coefficients are not very high, however, and for a number of scales (e.g., for Great Britain and Germany) they drop below 0.30 – the lower boundary that is recommended in the literature for Loevinger's coefficient of homogeneity H (e.g., Mokken, 1971). Item J ('Upset at criticism') does not fit well into the best cumulative scales for any of the countries in 1981 and 1990, and item B ('Restless') does not fit well in scales for 1990.

6. RESULTS OF THE UNFOLDING ANALYSES

We performed the unfolding analyses with the computer program MUDFOLD (Van Schuur and Post, 1990).[8] Introductions to the method are given in Van Schuur (1984, 1987, 1988). Using, like the Mokken scaling method, a 'bottom-up' procedure, the program searches for one or more unidimensional unfolding scales that conform to a number of criteria for unfoldability. the procedure

TABLE III

Results of preliminary analyses. For each country, the first two eigenvalues[9] resulting from the factor analyses are given in columns 1 and 2 (1981) and 3 and 4 (1990); the reliability coefficients Cronbach's α's are in columns 5 (1981) and 6 (1990); the coefficients of homogeneity for the cumulative scale with the positive mood state items H(p) and negative mood state items H(n) are in columns 7 and 8 (1981) and 9 and 10 (1990)

	Factor analysis Eigenvalues:				Cronbach's alpha		Mokken scales			
	1^{st}	2^{nd}	1^{st}	2^{nd}	α	α	H(p)	H(n)	H(p)	H(n)
	1981		1990		1981	1990	1981		1990	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Belgium	2.3	2.1	2.3	2.0	0.56	0.58	0.37	0.31	0.40	0.28
Denmark	2.1	1.8	2.2	2.0	0.47	0.55	0.29	0.32	0.32	0.29
France	1.9	1.8	2.3	2.0	0.46	0.51	0.25	0.22	0.31	0.30
Gr. Britain	2.1	1.8	2.3	1.9	0.55	0.63	0.22	0.28	0.27	0.29
Ireland	2.5	2.0	2.6	1.7	0.58	0.65	0.37	0.29	0.34	0.24
Italy	2.2	1.8	2.0	1.8	0.49	0.58	0.27	0.31	0.25	0.25
Netherlands	2.0	1.5	2.0	1.9	0.36	0.49	0.32	0.22	0.30	0.25
N. Ireland	2.5	1.7	2.4	2.0	0.63	0.58	0.31	0.24	0.38	0.31
Spain	2.2	1.7	2.0	2.0	0.38	0.64	0.27	0.28	0.33	0.28
W. Germany	2.1	1.7	2.2	1.8	0.53	0.59	0.28	0.26	0.26	0.29

determines not only which items form an unfolding scale but also the order in which they should be represented.

For the 1981 data from all 10 countries, the program identified one unfolding scale with a sufficiently homogeneous fit consisting of the following eight items in their unfolding order:

D. Lonely

F. Bored

H. Depressed

C. Proud because of compliment

E. Pleased at accomplishment

A. Excited/interested in something

G. On top of world

I. Things going your way.

For the 1990 data there was a slightly different unfolding scale with sufficiently homogenous fit for all 10 countries, consisting of the following nine items in their unfolding order:

H. Depressed

D. Lonely

F. Bored

B. Restless

C. Proud because of accomplishment

A. Excited/interested in something

E. Pleased at accomplishment

G. On top of world

I. Things going your way.

For each country, these scales had a Loevinger's H-value of over 0.30, as shown in Table IV, and they also satisfied a number of other goodness-of-fit criteria for a good unfolding scale, one of which is illustrated shortly.

Two items did not fit into the scale based on the 1981 data; B ('So restless you could not sit long in your chair') and J ('Upset because someone criticized you'); J did not fit into the scale based on the 1990 data either. A possible reason for the bad fit of these items is that they may be worded too restrictively. People who DO in fact feel restless may still say "no" to item B because their restlessness does not express itself in just this way, and people who ARE upset may say "no" to item J because they are upset for a reason other than being criticized.

One of the goodness-of-fit criteria in addition to a Loevinger's H above 0.30 involves visual inspection of the pattern of responses in a "characteristic monotonicity" matrix. This matrix shows the proportion of positive responses to each of the scale items by groups of subjects with increasing scale scores, as illustrated in Table V with Dutch data from 1981. Columnwise the items are arranged in

TABLE IV
Loevinger's coefficients of homogeneity H for the unfolding scales for each of the ten countries for 1981 and 1990

	MUDFOLD analyses	
	H(1981)	H(1990)
Belgium	0.42	0.42
Denmark	0.45	0.47
France	0.41	0.47
Great Britain	0.35	0.42
Ireland	0.38	0.49
Italy	0.36	0.37
Netherlands	0.32	0.40
Northern Ireland	0.43	0.47
Spain	0.36	0.51
West Germany	0.35	0.38

their unfoldable order, and rowwise the subject groups are arranged from low to high scale scores. Subjects' scale scores can in principle range between 1 and 15, but for convenience of exposition these have been collapsed into seven scale score groups of approximately equal size.

The cell proportions in this matrix should conform to the requirement of characteristic monotonicity. This means that the proportions in successive columns from left to right should show a unimodel distribution with the mode moving from top to bottom, and that the proportions in successive rows from top to bottom should also show a unimodel distribution with the mode moving from left to right. Cell values that show a deviation of more than 5% from the expected characteristic monotonicity pattern are given in bold numbers.

Apart from three deviations (cell 1C, whose value of 0.48 is too low rowwise, cell 2E, whose value of 0.50 is too low columnwise and cell 6C, whose value of 0.02 is (marginally) too low rowwise), this matrix, like all those from the other countries, clearly corroborates that the data are unfoldable.

In summary, Affect Balance Scale data collected from respondents in 10 European countries in 1981 and 1990 conform well to

TABLE V

Proportions of 'positive' answers given to items in their unfolding order by Dutch (1981) subjects in different scale value groups (N = 1221)

	N	D	F	H	C	E	A	G	I
p(i)	1221	0.09	0.15	0.19	0.47	0.76	0.57	0.42	0.31
Value 1	152	0.41	0.55	0.63	**0.48**	**0.64**	0.22	0.07	0.05
Value 2	178	0.07	0.15	0.17	0.50	**0.50**	0.24	0.11	0.04
Value 3	313	0.09	0.15	0.19	0.56	0.90	0.50	0.28	0.19
Value 4	211	0.03	0.09	0.13	0.61	1.00	1.00	0.53	0.33
Value 5	241	0.00	0.03	0.05	0.45	0.80	0.79	0.76	0.57
Value 6	61	0.00	0.02	**0.07**	**0.02**	0.65	0.82	0.82	0.75
Value 7	65	0.03	0.00	0.02	0.06	0.20	0.28	0.77	0.82

the unidimensional unfolding model. Despite a few variations, the unfolding order of the items stayed relatively stable between 1981 and 1990.

7. A COMPARISON OF THE UNFOLDING SCALES WITH BRADBURN'S AFFECT BALANCE SCALE

One way to find out whether a measurement instrument is valid is to correlate values obtained with this instrument with values obtained with other commonly accepted instruments. For the data from each country separately, we computed correlations between subjects' MUDFOLD (i.e., unfolding) Scale Scores (MFS), their Bradburn Affect Balance Scores (BBS), and their scores on 'happiness' and 'satisfaction', the two validating variables mentioned in section 4.2; all the data are from the 1981 surveys. The correlations are shown in Table VI. The MFS is based on the eight items of the unfolding scale DFHCEAGI and the BBS is based on all ten mood state items.

For every country the MFS and BBS correlate more highly with each other than with either of the validating variables 'happiness' or 'satisfaction' (compare AB with AE and AF, and AB with BE and BF in Table VI). The BBS (with 10 items) and the MFS (with 8 items) correlate to a roughly similar extent with 'happiness' and

TABLE VI

Correlations between the different variables for ten European countries in 1981

	AB	AE	BE	AF	BF	CD	EF
Belgium	0.66	0.38	0.46	0.42	0.45	0.01	0.55
Denmark	0.63	0.29	0.37	0.40	0.43	−0.03	0.47
France	0.66	0.34	0.39	0.38	0.41	−0.09	0.53
Great Britain	0.70	0.37	0.41	0.41	0.44	−0.09	0.53
Ireland	0.66	0.36	0.39	0.41	0.43	−0.04	0.55
Italy	0.72	0.36	0.39	0.40	0.44	−0.03	0.53
Netherlands	0.62	0.27	0.29	0.28	0.31	0.07	0.44
Northern Ireland	0.73	0.48	0.55	0.53	0.51	−0.14	0.63
Spain	0.74	0.28	0.30	0.34	0.35	0.03	0.52
West Germany	0.81	0.42	0.42	0.47	0.52	−0.04	0.55

A: Unfolding scale score MFS (15-point scale: 1–15)
B: Affect Balance Scale score BBS (11-point scale: −5–+5)
C: Positive affect scale score (6-point scale: 0–5)
D: Negative affect scale score (6-point scale: 0–5)
E: Happiness variable (4-point scale: 4–1)
F: Satisfaction variable (10-point scale: 1–10)

'satisfaction' (compare BE and BF with AE and AF in Table VI). (In fact, the BBS correlates slightly more with 'happiness' and 'satisfaction' than does the MFS, which is surprising since it contains two items ('Restless' and 'Upset') that, according to the unfolding analysis, were not homogeneous with the other Affect Balance Scale items. The differences are small, however.)

Table VI also shows the correlation between scores for Bradburn's 5-item positive affect subscale and negative affect subscale (see column CD). These are almost zero, which is consistent with previous findings by Bradburn (1969) and Harding (1982).

For all practical purposes we may conclude that the Bradburn Affect Balance scale can be interpreted as an unfolding scale in which the two halves (positive and negative affect) each form a cumulative scale. This explanation both justifies the use of Affect Balance Scale scores as a valid measure of perceived quality of life, and explains why, according to factor analysis results, subjects' scores for positive and negative affect are unrelated.

8. DISCUSSION

This paper started out with the observation that although factor analysis has shown that the positive and negative items of the Bradburn Affect Balance Scale are independent, an overall scale score is still computed by subtracting the negative affect sum score from the positive affect sum score. How can this procedure of subtracting apples from oranges be justified?

By now there is a vast literature about this apparent anomaly. Some pragmatically-minded authors simply point out that the resulting scale scores correlate well with other measures of perceived well-being and so appear to be valid. Others have tried to explain away the apparent unrelatedness of positive and negative affect by pointing to aspects of the data collection process (e.g., response bias).

In this paper we advance a different explanation, one based on an observation made by Coombs and Kao more than 30 years ago and discussed periodically ever since in the mathematical psychology literature. According to this explanation, the seeming unrelatedness of positive and negative affect is the (artificial) result of using factor analysis on data that are more appropriately analyzed with an unfolding procedure. The results of our analysis of Bradburn Affect Balance Scale data from the European Values Study in 1981 and 1990 support this explanation.

Our explanation applies not only to mood states but also to a number of content domains. For example, in the political ideology literature, factor analysis has indicated – often to researchers' surprise – that 'liberal' and 'conservative' ideology are two independent factors. It turns out, however, that these factors are the two halves of a unidimensional unfolding scale (Van Schuur and Kiers, 1994). Similarly, factor analysis in research on androgyny has suggested – again surprisingly – that 'masculinity' and 'femininity' are independent factors, but according to preliminary evidence these are also the two halves of a unidimensional unfolding representation (Van Schuur, 1993b).

There are several reasons why empirical researchers have not paid attention earlier to the unfolding explanation for these surprising two-factor outcomes. First, the idea has been promoted in the methodological literature that unfolding analyses can only be carried out on data that are collected as full rank orders of preference (e.g., McIver and Carmines, 1981). This is incorrect, however. In the last decade a number of (mainly unidimensional) unfolding procedures have been developed, generally as a byproduct of parametric Item Response Theory, which are applicable to data that have been collected (or recoded) as dichotomous data (DeSarbo and Hoffman, 1986; Andrich, 1988; Hoijtink, 1991; Andrich and Luo, 1993; Hoytink, 1993). A nonparametric unidimensional unfolding procedure has also been developed recently for multicategorical rating scales (Van Schuur, 1993a); this bears a strong resemblance to the nonparametric item response theory models of Mokken (1971) and Sijtsma *et al.* (1990). Nor does the application of the unfolding model require different items or a different formulation of particular questions.[10] It only assumes a different response process when respondents reply to questions. In short, the unfolding model is applicable to the same kinds of data as factor analysis.

A second reason for the relative unpopularity of unfolding is that unfolding programs have not been available in the standard statistical packages. The only available computer programs for unfolding analysis were based on multidimensional scaling (cf. Carroll, 1980, and Carroll and Arabie, 1980) and these could only handle data from a maximum of 100 subjects, which made them unfit for survey analysis. Fortunately, this situation has changed: good and user-friendly stand-alone personal computer programs for unfolding have become publicly available (e.g., Van Schuur and Post, 1991).

Applied researchers may wonder how they can determine whether their data are best represented with a linear model like factor analysis or with a distance model like the unfolding model. The first step in answering this question is obviously to consider the theoretical assumptions underlying the research: are there substantive reasons to expect one or the other of the two (linear or quadratic, c.q., monotonic versus single-peaked) item-response processes to hold? As a general rule, we expect the linear or monotonic model to hold for the measurement of abilities, and the unfolding model for the measurement of preferences. Sometimes, as in the examples cited above, the outcome of a factor analysis may surprise researchers on substantive grounds, whereas when the same data are analyzed with the unfolding model, the results are readily interpretable. A second step in answering the question of which model to use is to apply a number of diagnostic tests (Post, 1992; Van Schuur and Kiers, 1994).

According to a Dutch proverb, one can make a straight strike with a crooked stick. The Affect Balance Scale has seemed to be just that. Now it turns out that its procedure can be theoretically justified.

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NOTES

[1] The terms 'factor analysis' and 'principal components analysis' will be used interchangeably in this paper by analogy with the default 'factor analysis' terminology in SPSS. The difference between these two models is not relevant for this paper.

[2] According to Headey *et al.*, 1984, the observation that positive and negative affect are uncorrelated was made even earlier, by Jahoda, 1958.

[3] The difference between factor analysis as a linear model and unfolding as a distance model should not be confused with the difference between a linear model and a monotonic model (e.g., a nonparametric cumulative model, or polychoric correlation as a model that is not sensitive to monotonic deviations from linearity).

[4] This assumption also allows us to regard the response pattern 101, for any triple of items in their hypothesized unfolding order, as containing an 'error' (i.e., a violation of deterministic, or perfect, unfolding). The number of response patterns with errors is taken into account in determining the goodness of fit of any candidate unfolding scale (see Van Schuur, 1993a).

[5] In this example, the data are dichotomous, but this way of calculating a subject's position is not restricted to data of this kind. It can also be used with any kind of rating data, such as the well-known 5-point Likert scale (see Van Schuur, 1993a).

[6] The countries and numbers involved in each survey were: Belgium (1145; 2792), Denmark (1182; 1030), France (1200; 1002), Great Britain (1167; 1484), Ireland (1217; 1000), Italy (1384; 2018), The Netherlands (1221; 1017), Northern Ireland (312; 304), Spain (1131; 2637), and (the Federal Republic of) Germany (1305; 2101).

[7] In our reanalysis of the original data, the value scores were recoded so that a high value means a *high* rather than a low amount of happiness.
[8] The computer programs for both MUDFOLD and MSP are available from the interuniversity expertise center ProGAMMA, Grote Rozenstraat 15, 9712 TG Groningen, The Netherlands.
[9] In most datasets only the first two eigenvalues are higher than one. In each case a scree test showed that the first two eigenvalues are much higher than the remaining ones.
[10] But, as Andrich (1994) points out, unfolding analysis does allow the formulation of questions that represent ambivalent attitudes, which are useless in factor analysis. For instance, in addition to questions about extremely positive or negative attitudes to the death penalty, unfolding analysis can make use of questions like "The death penalty is necessary, but I wish it were not".

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