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# The Distinction of Positive and Negative Symptoms
## The Failure of a Two-Dimensional Model

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The distinction of positive and negative symptoms in describing schizophrenic patients has become popular. It presupposes that symptoms cluster in two dimensions, fitting together not only theoretically but empirically. Factor analysis of three published studies of 93, 62 and 52 schizophrenic patients and a large pooled sample showed that more than two distinct dimensions are required to categorise symptoms in schizophrenia. This result is consistent across methods and samples, and with previous literature. The added dimensionality resulted from a splitting of the positive symptom domain into more distinct factors.

Measures of positive and negative symptoms have become a popular means of assessing the status of individuals with schizophrenia; there is also a growing interest in the nature of the particular properties being assessed. In the simplest interpretation, distinguishing between positive and negative features refers to a latent two-dimensional model of symptoms in schizophrenic patients. For instance, Crow (1985) views positive and negative symptoms as reflecting two dimensions of pathology. A number of theoretical reasons have been used to justify the distinction between positive and negative. One reason is based purely on the content of the symptoms – that negative symptoms depict a deficit of functions while positive symptoms reflect an excess of functions (Hughlings Jackson, 1931; Andreasen, 1982, 1988). Negative symptoms encompass a general withdrawal of cognitive/social functioning (Thiemann *et al*, 1987); positive symptoms include a general increase in odd perceptions, formal thought disorder, hallucinations, and delusions.

Another argument for the distinction is that the two dimensions appear to represent cohesive clusters of symptoms, with different symptoms lying within one group or the other, fitting together not only theoretically but empirically. Indeed, most scales of negative symptoms demonstrate, at the least, a moderate amount of internal consistency (Thiemann *et al*, 1987). However, Andreasen & Olsen (1982) report, in addition to a high internal consistency for negative symptoms, a lower consistency for positive symptoms.

While theoretically a distinction can be made between the two types of symptoms, there are also empirical reasons for dividing them, since they do demonstrate independence and a divergence of relations with other variables. Most reported correlations between measures of positive and negative symptoms are near zero, suggesting that the two dimensions are independent (Crow, 1985; Walker *et al*, 1988). A patient with schizophrenia exhibiting one individual symptom within one of the clusters would likely exhibit other symptoms also within the cluster (cohesiveness), but may or may not possess indications on the other dimension (independence). Further, the two sets of symptoms can be discriminated by their relations to outside factors (Crow, 1989), for example in differential diagnosis (Sommers, 1985), and medication may be more effective for positive symptoms than for negative symptoms ( Johnstone *et al*, 1983; Kane & Mayerhoff, 1989). Prognosis shows the same pattern, with good prognosis being related to positive symptoms and poorer prognosis and outcome related to a negative syndrome (Pfohl & Winokur, 1982, 1983; Johnstone *et al* 1987; Lindenmayer *et al*, 1986; Pogue-Geile, 1989). On the other hand, large ventricles (Andreasen *et al*, 1990) and deficits in brain metabolism (Volkow *et al*, 1987) may be associated with negative symptoms, but these associations do not appear with positive symptoms. All of these reported associations are, however, controversial and have not been consistently replicated.

A major analysis strategy to identify and validate underlying dimensions involves principal-component or factor-analytic techniques. This approach directly addresses issues of the empirical cohesiveness of sets of symptoms and the independence of dimensions. A two-dimensional model of the positive/negative distinction would predict two independent factors in measures purported to index positive and negative symptoms. Three studies (Andreasen & Olsen, 1982; Bilder *et al*,1985; Liddle, 1987) looked specifically at scales assessing positive and negative symptoms in their factor analyses. There were some basic inconsistencies in the make-up of the factors from the three studies because of the differing methods. For instance, Andreasen & Olsen (1982) differed by



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not rotating their factors to an interpretable unique solution, and Liddle (1987) allowed his factors to be correlated while the other two studies did not. Small sample sizes may have also contributed to the inconsistencies, since the largest of the three studies included only 52 patients. However, one consistent finding for all three studies was that three or more distinct factors were required to account for the data purported to be measuring two dimensions, positive and negative symptoms. Thus, a two-dimensional model did not seem to account for the data.

We undertook the present study to determine whether two or more dimensions were involved with the symptoms previously referred to as positive and negative and, if necessary, to estimate the number of underlying dimensions. We used three different factor-analytic techniques in order to validate our findings across methods. Principal components, principal factors, and maximum likelihood were used to assess the number of underlying dimensions and their properties which occur in two widely used measures of positive and negative symptoms. In order to assess the reliability of our findings, we replicated the same analysis on three different, moderately sized samples. Further, we pooled the results from the different samples in order to achieve the most stable estimates available. Our rationale was that if the samples were large enough to provide repeatable results, then their combined estimates would be at least large enough for a stable solution.

Both factor analysis and principal-components analysis are multivariate techniques based on observed patterns of correlations between variables. As such, they are sensitive to sample variations in each correlation occurring by chance. Even with a sample of only 52 subjects, a zero population correlation can yield an observed $r$ within a range of plus or minus 0.273 approximately 95% of the time. Given the 45 unique correlations involved in a ten-symptom table of intercorrelations, the inaccuracies can be compounded and be severe. Rules of thumb for minimum sample sizes for reasonable hypothesis tests abound for multivariate analyses and usually suggest between 10 and 20 subjects per variable: for ten symptoms in an analysis, the minimum would range from 100 to 200 subjects. Comrey (1978) has proposed an absolute minimum sample size of 200 for stable estimates in factor analysis. Guadagnoli & Velicer (1988) point out, however, that the simple structure (saturation of the symptom by a single factor) is the most important consideration.

## Method

The subjects for this investigation were participants in three brain-imaging studies conducted at the University of Iowa Hospital and Clinics: one study using computerised tomography (CT study, Andreasen *et al*, 1991) and two using magnetic resonance imaging (MRI), one referred to as simply the MRI study (Andreasen *et al*, 1990), and the other, at a mental health clinical research centre, the MH-CRC study (in progress). All subjects in the CT and MRI study were diagnosed as schizophrenic using DSM-III criteria (American Psychiatric Association, 1980), while DSM-III-R criteria (American Psychiatric Association, 1987) were used in the MH-CRC study.

There were 110 schizophrenic patients who participated in the CT study, 55 in the MRI study, and 62 in the MH-CRC study. Patients who participated in more than one study were retained only in the most recent study. Consequently, the number of subjects reported in this investigation are 93 (54 men, 39 women) for the CT study,

Table 1
Demographic and clinical information on schizophrenic patients participating in three imaging studies

| | Study | | |
|---|---|---|---|
| | CT | MRI | CRC |
| Age | | | |
| mean | 31.48 | 33.31 | 31.29 |
| s.d. | 10.58 | 9.55 | 9.30 |
| *n* | 93 | 52 | 62 |
| Education: years | | | |
| mean | 12.47 | 13.31 | 12.11 |
| s.d. | 2.33 | 2.69 | 2.27 |
| *n* | 93 | 51 | 62 |
| Employment | | | |
| employed (%) | 19 | 25 | 18 |
| unemployed (%) | 71 | 71 | 79 |
| student (%) | 9 | 4 | 3 |
| *n* | 93 | 52 | 62 |
| Age of onset: years | | | |
| mean | 21.46 | 21.64 | 21.51 |
| s.d. | 4.87 | 4.36 | 6.41 |
| *n* | 93 | 52 | 58 |
| No. of previous admissions | | | |
| mean | 4.43 | 6.55 | 4.16 |
| s.d. | 4.24 | 5.79 | 4.81 |
| *n* | 93 | 51 | 62 |
| Duration of stay in hospital: months | | | |
| mean | 21.40 | 12.12 | 11.18 |
| s.d. | 47.24 | 21.89 | 17.95 |
| *n* | 93 | 49 | 55 |
| median | 6 | 4 | 3 |
| Mini-Mental Status Exam: score | | | |
| mean | 31.02 | 28.12 | 27.64 |
| s.d. | 4.51 | 3.00 | 3.31 |
| *n* | 88 | 42 | 50 |
| Treatment history: | | | |
| neuroleptics | 87 | 94 | 71 |
| antidepressants | 33 | 44 | 35 |
| tranquillisers | 15 | 25 | 27 |
| lithium | 31 | 54 | 28 |
| electroconvulsive therapy | 26 | 37 | 15 |

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52 (34 men, 18 women) for the MRI study, and 62 (46 men, 16 women) for the MH-CRC study. Subjects who were mentally retarded or had a serious medical or neurological illness were excluded from the studies. Since schizophrenics often have substance-abuse problems, subjects with a history of alcohol or drug abuse were included in the studies.

The Scale for the Assessment of Positive Symptoms (SAPS) and the Scale for the Assessment of Negative Symptoms (SANS) were used to assess symptoms. Positive symptoms used in this analysis consisted of global ratings of the severity of hallucinations, delusions, bizarre behaviour, and positive formal thought disorder. Negative symptoms consisted of global ratings of the severity of affective flattening, alogia, avolition, anhedonia, and attention. Global ratings were based on ratings of individual items which, taken together, reflect the severity of the symptom. All ratings were based on a six-point Likert scale: none present (0), questionable, mild, moderate, marked, and severe (5). Reliability studies for the SAPS and SANS have been reported by Andreasen & Olsen (1982) and Andreasen (1982). High inter-rater reliability and internal consistency were found for the SANS (above 0.70) whereas internal consistency for the SAPS was less than 0.40.

## Results

Demographic and clinical information for subjects in all studies is reported in Table 1. Means and standard deviations for the nine SANS and SAPS variables are shown in Table 2. The response distributions were positively skewed, with most patients showing only moderate to low ratings for the symptoms. However, the data were sufficiently distributed along the scale so that outliers did not produce spurious correlations. The skew in the data would tend to attenuate the correlation coefficients. This, in turn, may increase the potency of variable-specific or unique variance and reduce the importance of any major factors.

Table 2
Mean scores (s.d.) for SANS and SAPS variables, by study

| | CRC | MRI | CT | All |
|---|---|---|---|---|
| Affective flattening | 2.48 | 2.63 | 3.08 | 2.79 |
| | (1.24) | (1.24) | (1.19) | (1.24) |
| Alogia | 2.23 | 2.13 | 1.91 | 2.06 |
| | (1.49) | (1.48) | (1.63) | (1.55) |
| Anhedonia | 3.05 | 3.60 | 3.45 | 3.37 |
| | (1.31) | (1.49) | (1.32) | (1.37) |
| Attention | 1.58 | 1.88 | 2.43 | 2.04 |
| | (1.58) | (1.76) | (1.51) | (1.63) |
| Avolition | 3.29 | 3.46 | 3.71 | 3.52 |
| | (1.50) | (1.28) | (1.19) | (1.32) |
| Bizarre behaviour | 0.92 | 2.17 | 0.97 | 1.26 |
| | (1.39) | (1.61) | (1.46) | (1.56) |
| Positive formal thought disorder | 1.40 | 2.08 | 1.35 | 1.55 |
| | (1.63) | (1.56) | (1.35) | (1.52) |
| Delusions | 2.60 | 3.62 | 3.46 | 3.24 |
| | (1.56) | (1.27) | (1.46) | (1.50) |
| Hallucinations | 1.76 | 2.35 | 2.94 | 2.43 |
| | (1.80) | (1.91) | (1.90) | (1.93) |

Initially, we were interested in two related questions. First, are there two or more dimensions present in the data, and second, what number of dimensions best describe the observed correlations?

### Principal-components analysis

Selecting eigenvalues greater than unity is a common criterion for deciding the number of dimensions in a principal-components analysis (Tatsuoka, 1971; Cliff, 1988). Eigenvalues are directly proportional to the variance accounted for by a factor and are, in a principal-components analysis, related to the number of variables. Since each variable adds one to the total of the eigenvalues, choosing factors with values greater than one excludes unique and trivial factors. Consistently for all three samples, the first three eigenvalues met the criterion while the fourth lay well below, clearly suggesting that a three-component model fits the data.

### Principal factors

For the iterated principal-factors analyses, we used a criterion based on the eigenvalues relative to the total amount of common variance (Gorsuch, 1974). Using the squared multiple correlations as initial estimates, three factors were found sufficient to account for the common variance in the CRC and MRI data. Only two factors were necessary for the CT data. When alternative initial estimates were used (e.g. maximum $r$, internal consistency from the individual items) more factors were required for all samples. After rotating these larger solutions, it was found that the factors subsequent to the third were fairly specific to only one symptom. However, when we rotated solutions based on three factors, all three samples produced fairly consistent factor patterns. This would suggest that the squared multiple correlations may have been poor starting points, seriously underestimating the common variance, particularly in the CT sample. Thus, even with the possible underestimation, two of the three studies indicate a three-factor solution is required. When alternative initial communality estimates are used, it is clear in all three samples that a two-factor solution is an oversimplification of the data.

### Maximum likelihood

As a third method of determining the number of factors, we performed maximum-likelihood factor analyses. It should be noted that the probabilities of the $\chi^2$ values shown in Table 3 are only approximations given the sample sizes and the skewed data. The first row of Table 3 tests for the presence of any common factors and is included only for the sake of completeness. The null hypothesis of no common factors can clearly be rejected. The next hypothesis of interest, that two or fewer factors can suitably account for the data, is tested by the second row in Table 3. The $\chi^2$ values for the two-factor solution are all large, with corresponding low probabilities indicating a substantial and significant departure from the two-dimensional hypothesis. Thus, this hypothesis can also be rejected for all three of the study samples. Tests for the specific presence of a third

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Table 3
Maximum-likelihood significance tests for the three studies

| | CRC | | MRI | | CT | |
|---|---|---|---|---|---|---|
| | $\chi^2$ (d.f.) | $P<$ | $\chi^2$ (d.f.) | $P<$ | $\chi^2$ (d.f.) | $P<$ |
| No common factors | 189.00 (36) | 0.0001 | 193.53 (36) | 0.0001 | 258.02 (36) | 0.0001 |
| Two or fewer factors | 34.03 (19) | 0.018 | 31.87 (19) | 0.032 | 31.39 (19) | 0.037 |
| A third factor | 12.82 (7) | 0.077 | 17.49 (7) | 0.014 | 21.65 (7) | 0.003 |
| Three or fewer factors | 21.21 (12) | 0.047 | 14.39 (12) | 0.276 | 9.74 (12) | 0.639 |

factor reached significance for both the MRI and CT samples as indicated in the third row of tests. Referring to the last row in Table 3, the hypothesis that three or fewer factors adequately account for the data appears reasonable for these two samples. The CRC data, on the other hand, failed to reveal a specific three-factor solution. However, results for this sample also suggested that two factors were insufficient. This indicates that the variance was more dispersed beyond the second factor for this particular sample.

### Composite analysis

Having seen that the two-dimensional model was deficient in explaining the data and that a three-factor model fits well in most cases, we proceeded to find a stable estimate of the factor pattern. As can be seen from Table 2, the samples appear to differ in mean scores on the symptom scales. Indeed, a discriminant analysis with sample as the grouping factor proved significant ($F(18, 392) = 5.27$, $P<0.0001$, based on Wilks' lambda). Consequently, we did not ignore the sample differences by calculating simple overall correlations for the subsequent factor analysis on the combined study sample. Rather, after testing for the homogeneity of the within-sample variance–covariance matrices and finding no significant difference at a liberal alpha ($\chi^2 = 107.13$, d.f. $= 90$, $P>0.10$), we based subsequent analysis on correlations from the pooled within-sample variance–covariance matrix.

Table 4
Varimax rotated factor loadings from the pooled covariances of the three studies ($n = 207$)

| | Factor | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Avolition | 0.82 | 0.16 | 0.01 |
| Anhedonia | 0.81 | −0.01 | 0.01 |
| Affective flattening | 0.79 | 0.07 | 0.18 |
| Alogia | 0.73 | 0.46 | 0.00 |
| Attentional deficit | 0.72 | 0.21 | 0.16 |
| Positive thought disorder | 0.07 | 0.86 | 0.12 |
| Bizarre behaviour | 0.22 | 0.70 | −0.01 |
| Delusions | −0.03 | 0.11 | 0.83 |
| Hallucinations | 0.22 | −0.02 | 0.78 |

As a final stage we repeated the principal-components analysis on the pooled correlations. Again, three factors had eigenvalues greater than unity and were extracted. The factor pattern after rotation is shown in Table 4. The overall pattern resembles that from the individual prior analyses. The first factor is clearly a negative symptom factor with the appropriate factor loadings greater than 0.72 and all other loadings less than 0.22. The second factor is dominated by the global ratings for positive thought disorder and bizarre behaviour. However, alogia also has a substantial loading. The final factor appears with large loadings on delusions and hallucinations, and virtually no loadings elsewhere. Thus, our analyses indicate a three-factor model is required and that this third factor derives from a separation of what has been previously called a single factor, positive symptoms, in the two-dimensional model.

## Discussion

We found that more than two dimensions were required to account for the patterns of symptoms in our data. The only exception arose in one iterated factor analysis involving one of the samples. Even in this case, when we used alternative initial communality estimates, more than two factors were needed to reach a final solution. Furthermore, finding a two-factor model inadequate is consistent with previous research in this area by Andreasen & Olsen (1982). Even though their study discusses a strong bipolar general factor, several factors were required to explain their data and, as mentioned before, these factors were not rotated to an interpretable unique solution. Bilder *et al* (1985) and Liddle (1987) also report more multidimensionality than the simple two-factor model suggests.

In another study which addressed the latent structures of the positive and negative symptoms, Lenzenweger *et al* (1989) contrasted a unidimensional model with the two-factor model suggested by Crow (1980). The unidimensional model tested was unrestricted and could reflect either a single bipolar or a generalised 'severity–liability' dimension. In their analysis of latent structures using 220 patients,

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Lenzenweger *et al* (1989) found that the model with two underlying dimensions fits far better than did a single-dimensional model. However, of particular interest to us was their finding that a two-dimensional model still showed a significant lack of fit ($P<0.004$, calculated from their tabled $\chi^2=60.41$, d.f. = 34 in their Table 4, p. 68). This further reinforces our findings, since the significant lack of fit for their data indicates that more than two dimensions are required. Further, it extends the number of methods under which it can be seen that the two-dimensional model fails to provide an adequate description of the data. Thus, it would seem that a simple two-dimensional model for positive and negative symptoms is an oversimplification and that at least one more extension must be made.

The additional dimensionality in our three sets of data results from splitting the positive-symptom domain. This would explain the lower internal consistency observed in scales of positive symptoms. Our findings indicated that hallucinations and delusions comprised one dimension which was independent of (i.e. orthogonal to) a factor containing bizarre behaviour and positive formal thought disorder. While these two dimensions appeared to be the weakest factors in our study, this was probably due to the sparsity of variables measuring these symptom clusters. Factor analysis, either exploratory or confirmatory, is extremely sensitive to the number and kind of variables inserted in the analysis. Development of new symptom scales and subsequent studies of this nature need to pursue locating other symptoms which also help define and distinguish these two dimensions. It would also be of value to investigate the two types of positive symptoms in terms of their divergent relations to other variables and treatments.

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