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How Much Is Personality Structure Affected If One or More Highest-Level Factors Are First Removed? A Sequential Factors Approach

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Abstract

Rotations of 1 to 12 factors were compared by Goldberg's "bass-ackward" method, with or without initially holding constant one or more principal components. Two sets of data were employed: ratings by 320 undergraduates using 435 personality-descriptive adjectives, and 512 Oregon community members' responses to 184 scales from 8 personality inventories. Holding constant none or one or three initial factors made relatively little difference to the resulting structure. On the whole, that structure was not strongly hierarchical: allowing an additional dimension usually resulted in a new substantive dimension rather than in the splitting of an old one.

Keywords

personality factors; bass-ackward method; personality scales; adjective self-ratings; general factor of personality

1. Introduction

In a recent paper (Loehlin & Goldberg, 2014) the "bass-ackward" scheme (Goldberg, 2006) was applied to two large data sets. It was concluded that the relations among 1, 2, 3, ..., 12 sequentially extracted factors conformed more to a list than to a hierarchical arrangement. In a pure hierarchical scheme, a new factor is always derived from the splitting of an old factor, and factors do not persist for long as one extracts more of them. In a pure list scheme, each additional factor is a new one, and once emerged, factors tend to persist indefinitely.

In hierarchical views of personality, the trait at the top has attracted considerable recent attention. The notion of a general factor of personality (GFP), analogous to *g* in the

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cognitive domain, has been controversial: authors have ranged from considering it a basic dimension for human evolution (Rushton, Bons, & Hur, 2008) to an artifact of test construction (Ashton, Lee, Goldberg, & de Vries, 2009). However, even if a predominantly list view of personality organization prevails, the first factor may still be of special interest. Several authors have examined a first principal component or first principal factor from the intercorrelations of a battery of personality trait measures. Such a dimension has been shown to be predictive of occupational criteria (van der Linden, Nijenhuis, Cremers, & van de Ven, 2011—although see Schermer, Carswell, & Jackson, 2012); substantially heritable (e.g., Loehlin & Martin, 2011; Veselka, Schermer, Petrides, & Vernon, 2009), and generalizable across different personality inventories and levels within them (Loehlin, 2012a).

Apart from questions about the nature of a first factor, what are the consequences for *other* personality factors if one elects to begin by removing such a dimension—whether one labels it a “general factor of personality” or not? For example, several recent investigators have examined personality structure after minimizing the influence of a first factor, considered to represent an evaluative dimension (e.g., Bäckström, Björklund, & Larsson, 2009; Pettersson, Turkheimer, Horn, & Menatti, 2012). And one need not stop at one factor. Kuusinen (1969), working in the Semantic Differential tradition, factored the correlations among 47 bipolar personality rating scales after partialing out scales representing the three dimensions of Evaluation, Potency, and Activity.

Some recent papers (Loehlin 2012b, 2013; Loehlin & Martin, 2013) have examined what happens when one extracts a first principal component and then rotates the remaining factors, without any special assumptions about the nature of the first factor. In different cases, the number of supplemental factors ranged from two to five, but this varied with the data sets involved, and depended on traditional criteria of “how many factors”—eigenvalues greater than one, scree tests, or the like. The question arises: What happens if one does not decide a priori or by some statistical criterion on the number of factors past the first, but treats the data to a sequential-factors (“bass-ackwards”) analysis in which varying numbers of factors are rotated? This was the approach undertaken in the present investigation.

This approach was applied to two large data sets. One is the responses of 320 college students to 435 common English adjectives describing personality traits (Goldberg, 1990). The other starting point was 184 scales from 8 standard personality inventories that were completed by some 500 members of the Eugene-Springfield (Oregon) community sample (Gruca & Goldberg, 2007). In both cases, a sequential-factors analysis in which all factors are rotated was compared to one in which the first principal component was held constant, and subsequent factors rotated. Questions: Will holding the first factor constant affect the relationships among subsequent factors—for example, will it simplify or complicate them? Will starting with adjectives or scales make a difference? Will all or most of the same factors emerge? Will the results look more like lists or hierarchies?

Finally, this approach was extended to the initial removal of three components. According to proponents of the Semantic Differential, there is more than one major connotative dimension on which judged objects or concepts vary. The three dimensions of Value, Activity, and

Potency are typically identified (Osgood, Suci, & Tannenbaum, 1957). If it is worthwhile to look at the consequences for personality structure of removing a first factor, it may also be worthwhile to look at the consequences of removing three.

2. Method

The data gathering procedures are described in detail in the original publications (Goldberg, 1990; Grucza & Goldberg, 2007). They are summarized briefly here.

2.1 Participants

The sample for the adjective ratings consisted of 320 undergraduates in a psychology class who rated themselves; 316 of them also rated someone of their same age and sex whom they liked (Goldberg, 1990). These 636 sets of ratings provide the basis for the analyses in this paper.

The participants in the sample providing the scale scores were adult community residents of a broad age range who agreed to complete a number of personality questionnaires by mail over a several-year period (Grucza & Goldberg, 2007). The number of participants for individual inventories ranged from 680 to 857; 514 individuals with relatively complete data over the period were used for the present analyses.

2.2 Measures

For the student sample, 7-point rating scales were used. Four midscale response options were provided—*average or neutral, it depends on the situation, don't know, and term unclear or ambiguous* (Goldberg, 1990).

For the community sample, the lowest-level scales available from each inventory were taken as the starting point—these were variously labeled in the different inventories as subscales, facets, clusters, basic scales, etc.; 184 such scales were used. Respondents with more than 10% missing scores (which usually meant missing one or more inventories) were eliminated from the sample; the missing scale values from the remaining participants were replaced by mean values for the scale.

2.3 Analyses

The factor analyses involved were carried out as principal component analyses rather than strict factor analyses, for the advantages of computational economy, avoidance of Heywood cases, and the ability to calculate factor scores directly rather than having to estimate them. With large initial matrices, such as the ones involved in this study, the two methods tend to give closely similar results. Likewise, orthogonal rotations were used throughout, rather than oblique rotations. Again, with large initial matrices, the results for orthogonal and oblique rotations tend to be similar. For example, in comparisons involving 5 factors and 75-variable matrices, factor scores based on five different extraction methods, including principal components, were correlated on average from .950 to .996; and factor scores from oblique and orthogonal rotations were correlated on average from .991 to .995 (Goldberg, 1990).

For each of the two data sets, scales and adjectives, three different versions of the analysis were compared. The first simply involved rotating 1, 2, 3, 4, etc., principal components. (This was the analysis of Loehlin & Goldberg, 2014.) The next retained the first principal component as representing a general factor and rotated the remaining 2, 3, 4, etc. This was then extended to holding constant three principal components and rotating those remaining. (For economy, we will hereafter usually just refer to the components as “factors.”) Inter-level correlations were calculated via factor scores either directly or via the shortcut calculation described by Waller (2007). For practical reasons, the analyses in this paper will be presented just to 12 factors. Preliminary analyses indicated that this should be more than adequate to cover replicable factors at these sample sizes (Loehlin & Goldberg, 2014).

3. Results and Discussion

The basic results are presented in Figures 1 through 6. Figures 1 and 2 present the results for adjectives and scales when all the factors are rotated at each level. These are taken from Loehlin and Goldberg (2014), and are reproduced here for comparison purposes. Figures 3 and 4 present the results when the first factor is held constant and the remaining factors rotated. Figures 5 and 6 present the results when holding constant three factors. In all of the figures, successive rows in the diagram represent the extraction of increasing numbers of factors. In each row, each factor is represented by the three adjectives or scales that have the highest loading on it. If that loading is negative, a minus sign is appended. Correlations of .30 or more between the factor scores of factors in adjacent levels of the diagrams are shown by lines of varying thickness, depending on the magnitude of the correlation. Negative correlations are indicated by dashed lines. The factors at each level are aligned below the factor in the level above with which they are most highly correlated.

3.1 Rotating all factors

The rotation of all factors, shown here in Figures 1 and 2, was the topic of the earlier paper (Loehlin & Goldberg, 2014); the results are only briefly summarized here. The typical picture presented by Figures 1 and 2 is one of a list structure—i.e., at each level the factors of the preceding level persist, and a new one emerges—usually, but not always, with modest contributions from one or more of the existing factors. Occasionally, a hierarchical effect occurs: as between Levels 5 and 6 in Figure 1, where the simple/unintelligent factor splits into an easy-going factor and (reversed) an intellectual one, or between Levels 7 and 8 in Figure 2, where Conscientiousness divides into achievement and control factors. However, for the most part a relatively simple persistence of existing factors and addition of a new one marks each step. That is, the structure mostly conforms to the list rather than the hierarchical pattern.

Both diagrams exhibit factors resembling the Big Five. Both have Extraversion, Conscientiousness, Agreeableness, and Intellect/Openness factors, although sometimes with slightly different emphases. A major difference between Figures 1 and 2 is that in the latter a substantial Neuroticism factor is present as the first factor, whereas in Figure 1 the first factor (quarrelsome, irritable, temperamental, etc.) looks more like the negative pole of Agreeableness. Neuroticism does not appear as such in that diagram, although the fifth and

tenth factors, which feature such traits as Happy-go-lucky and Carefree, may represent opposites of the depression and anxiety characteristic of Neuroticism.

3.2 Holding one component constant

What happens when the first principal component is held constant as representing a general factor, and 1, 2, 3, etc., of the remaining factors rotated? Figure 3 shows the results for the adjectives. Clearly, the holding out of a general kindness-unkindness factor has left the remaining results somewhat more complex. Only the timid/passive/meek and the religious/moralistic/moral factors persist at the .90+ correlational level all the way down after their initial emergence, although emotional/moody/temperamental does after Row 6. Several dimensions resembling the Big Five are recognizable, but not identical with their Figure 1 counterparts. For the Extraversion factor, factor 2, the shyness aspects are weaker, and the aggressive and domineering aspects more evident. Conscientiousness and Intellect factors, 3 and 5, are apparent, but Conscientiousness emerges somewhat later, and Intellect changes character in the last two rows. Agreeableness appears to have been largely absorbed by the kind/helpful/unkind of the general factor. Changes of direction occur more often: the 3rd factor switches from its organized to its disorganized end three times down the column, as does the 7th factor, formal/informal.

Figure 4 shows the results for the scales when the first factor is held constant. The first few factors are considerably simplified, and there is more persistence down the columns than in Figure 2 (55 inter-row correlations above .90, as compared with 46 in Figure 2). As in Figure 2, there is a split of the Conscientiousness factor after Row 7 into control and achievement factors. Again there are a patience/gentleness/compliance factor, an intellect factor emphasizing aesthetics, and a sincerity/modesty factor emerging at Row 7. The general factor is more of a broad Extraversion factor (sociability, dominance, self-acceptance) than in the other figures, but even here we find a separate sociability/warmth factor as factor 4.

3.3 Holding three components constant

Does holding constant more than one component make a difference? For comparison with the Semantic Differential (Kuusinen, 1969), 3 components were held constant. Figure 5 provides the results for the adjectives, and Figure 6 for the scales.

On the whole, it appears that the general properties of the diagrams remain similar to those of Figures 1 to 4, in that most factors, once they emerge, persist fairly consistently down the diagram, and that the new factor at each step typically receives minor contributions from one or two factors at the preceding level—although once in a while a new factor emerges *de novo*, or is the result of a major split.

3.4 Two indices of simplicity

Table 1 provides a summary of two indices of a diagram's simplicity—first, a large number of correlations between adjacent levels that exceed +.90, represented in the Figures by thick vertical lines, and second, a small number of appreciable across-column correlations, represented by slanted lines. Thus, on the whole, list structures will tend to rank as simpler

than hierarchical ones. The two criteria of simplicity are, of course, not independent, in the sense that if a factor at one level correlates above .90 with one at the next level, it cannot well have very large correlations with factors orthogonal to that one.

First, it is evident that all the diagrams may be considered simple by these standards. There are 66 vertical lines in each figure; a large majority of these in all cases exceed $\pm .90$ (the range is 70% to 85%). There are 204 potential off-line correlations in even the most constrained of the figures (5 and 6); only 20 and 21 are above $\pm .30$.

Second, no very sharp divisions are evident in Table 1 between the diagrams based on adjectives and those based on scales, or between those with 0, 1, or 3 factors held constant. The most complex diagram for the adjectives, in terms of relatively few .90+ correlations and relatively many .30+ off-column correlations, is Figure 3, with one factor held constant. For the scales, it is Figure 2, with none.

General Discussion

On the whole, the factors after exclusion of a general factor (Figures 3 and 4) look a good deal like the factors in the original Figure 1 and 2 analyses. In both Figures 1 and 3, for example, there is an orderly/organized/precise factor, a formal/informal factor, and a religious/moralistic/moral factor, and most of these are visible in Figure 5 as well. Similarly, in both Figures 2 and 4 there is a gentleness/patience/compliance factor, a closeness/warmth factor, a perfectionist/ambitious/diligence factor, and a sincerity/modesty/orderliness factor, again for the most part also recognizable in Figure 6. For both adjectives and scales, the five-factor level can be related to the Big Five: the precise/organized/perfectionist factor to Conscientiousness; compliance/compassion and sympathetic/warmth factors to Agreeableness; the intelligence/ideas/aesthetic factors to Intellect/Openness. Neuroticism and Extraversion are somewhat more complex, with quarrelsomeness, dominance, sociability, moodiness, emotionality, shyness, and anxiety splitting up in somewhat different ways in the various analyses. As one proceeds further down the diagrams, additional recognizable factors emerge: formal/informal, religious/moralistic, sincerity/modesty, and so on. Kuusinen (1969), in looking at personality factors after partialing out Evaluation, Potency and Activity, reported factors of morality, self-confidence, rationality, unpredictability, tolerance, and sociability-factors clearly overlapping with although not identical to those in Row 9 of Figure 5.

Does the initial extraction of three components make a difference over the extraction of one? Not very much. Looked at from a Semantic Differential perspective, there may be connotative dimensions additional to Evaluation in considering persons as well as in considering objects in general. From an evolutionary perspective, there may be routes to successful reproduction beyond the main one captured by a general factor of personality. In both cases, however, the first and largest component would be expected to be heavily loaded with evaluation. Should the investigator try to remove the evaluative component, or should he or she focus upon it? The answer will be different depending on one's perspective. Social desirability is surely an important factor in mate choice, but might have nuisance value in studying personality structure. The same issues are present in the case of additional

dimensions of mate preference or connotative meaning. Fortunately, the choice in either case seems not to have drastic effects on the structure remaining.

How do the adjective- and scale-based diagrams compare? As we have seen, the structures are generally similar, and the factors obtained show resemblances but are not identical. On the whole, starting with adjectives or with scales appeared to make a bigger difference than starting with or without the exclusion of one or more general factors.

What about the comparison of Figures 1 to 3 and 2 to 4, the rotation of all factors versus the extraction of a general factor as an initial step? No dramatic differences either way emerged from these analyses. For the adjectives, the structure appeared to be somewhat simpler without the extraction of a general factor; for the scales, after removing one. As noted in the earlier paper, adjectives are likely more vulnerable to verbal associations than are scales; it might be that the removal of a general factor was more disruptive in the case of the adjectives. However, further research would be necessary to clarify this.

In short, the initial removal of one or more highest-level factors did not affect in a major way the structure among those remaining, whose structure continued largely to resemble a list rather than a hierarchy.

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- 1 to 12 personality factors rotated with 0, 1, or 3 initial factors held constant.
- 636 student ratings on 435 adjectives and scores of 512 adults on 184 scales.
- Effects slight for initial factors held constant, modest for adjectives vs. scales.
- Results suggest that personality structure not strongly hierarchical.

Figure 1.

One to twelve orthogonally rotated adjective-based factors. The three adjectives with highest absolute loadings are shown for each factor. Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations.

(Reprinted from Loehlin & Goldberg 2014.)

Figure 2.

One to twelve orthogonally rotated scale-based factors. Titles of the three scales with highest absolute loadings are shown for each factor (abbreviated if necessary). Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations. (Reprinted from Loehlin & Goldberg, 2014.)

Figure 3.

Adjective-based general factor, plus one to eleven orthogonally rotated supplemental factors. The three adjectives with highest absolute loadings are shown for each factor. Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations.

Figure 4.

Scale-based general factor, plus one to eleven orthogonally rotated supplemental factors. Titles of the three scales with highest absolute loadings are shown for each factor (abbreviated if necessary). Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations.

Figure 5.

Three adjective-based factors held constant, and one to nine factors rotated. The three adjectives with highest absolute loadings are shown for each factor. Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations.

Figure 6.

Three scale-based factors held constant, and one to nine factors rotated. Titles of the three scales with highest absolute loadings are shown for each factor (abbreviated if necessary). Thickness of lines reflects magnitude of correlations between adjacent levels—dashed lines represent negative correlations.

Table 1
Two indices of diagram simplicity

Figure and basis	Factors held constant	Vertical	Off-column
		$rs > \pm .90$	$rs > \pm .30$
1. adjectives	0	56	19
2. scales	0	49	29
3. adjectives	1	46	35
4. scales	1	55	19
5. adjectives	3	51	20
6. scales	3	54	21