

Using SAS/PC for Higher Order Factor Analysis in Research

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Abstract

Many researchers do not run higher order factoring because either they must exit the traditional statistical packages to complete the necessary analyses or they do not know the procedures for the analyses. This paper describes the procedures for higher order factoring, presents an illustrative sample data set with interpretation, and provides the SAS/PC program for the final solution.

Using SAS/PC for Higher Order Factor Analysis in Research

Researchers often run first-order factor analysis. However, many do not proceed with higher order factoring. Perhaps this circumstance is because of one or two potential difficulties. First, many researchers do not know the procedures for higher order analysis. Second, one has to exit the statistical packages to do portions of the higher order analysis. This paper provides a description of the procedures to do higher order factoring along with a SAS/PC program for the final solution of higher order factoring.

When one does a first-order factor analysis with promax rotation, an interfactor correlation matrix is produced. The interfactor correlation matrix can be factored just as the intervariable correlation matrix can be. This method is called second-order factor analysis. Kerlinger (1984) wrote that "while ordinary factor analysis is probably well understood, second-order factor analysis, a vitally important part of the analysis, seems not to be widely known and understood" (p. xiv).

Second-order factors are extracted from the interfactor correlation matrix and rotated to the varimax criterion. Second-order factors such as these are often interpreted. However, Gorsuch (1983) argued that interpretation at this stage of the analysis is not desirable:

Interpretations of the second-order factors would need to be based upon the interpretations of the first-order factors that are, in turn, based upon the interpretation of the variables. Whereas, it is hoped that the investigator knows the variables well enough to interpret them, the accuracy of interpretation will decrease with the first-order factors, will be less with the second-order factors, and still less with the third-order factors. To avoid basing interpretations upon interpretations of interpretations, the relationships of the original variables to each level of the higher-order factors are determined. (p. 245)

Gorsuch (1983, p. 247) and Cattell and White (Cattell, 1978) suggested one way to avoid "interpretations of interpretations" is to postmultiply the first-order factor pattern matrix times the orthogonally rotated second-order factor pattern matrix. The first-order promax rotated factors, therefore, are postmultiplied by the second-order varimax rotated factors, and the product matrix is then rotated to the varimax criterion. The multiplication of the two factor pattern matrices will yield the factor pattern matrix directly relating second-order factors to the original variables. This is a common procedure for doing higher order analysis. In principle, higher order factoring could go on indefinitely if one started with enough variables and each factor analysis were oblique. In practice, solutions beyond the second-order are rare. The decision at any stage for orthogonal rotation terminates the higher order factor sequence (Loehlin, 1992).

One can use SAS IML to multiply the first order factors and the second order factors. For the last step of the analysis, one must rotate the product matrix. The Program Description section that follows provides the SAS/PC program for the final varimax rotation.

Program Description

Input

```
data pat(type=factor);
  _type_='PATTERN';
  Input _Name_ $ q1-qn;
  Cards;
  Factor1 (list all the factor loadings for q1-qn separated by a space)
  Factor2 (list all the factor loadings for q1-qn separated by a space)
      etc.
  FactorK (list all the factor loadings for q1-qn separated by a space)
  ;
proc factor rotate=varimax;
run;
```

Output

The output will be the standard rotated factor pattern matrix. The final rotated product matrix is the desired solution for the higher order factor solution. It is important to realize that researchers often want to analyze data with higher-order factor analysis because various levels of analysis give different perspectives (Gorsuch, 1983). As Thompson (1990, p.579) explained, "The first-order analysis is a close-up view that focuses on the details of the valleys and peaks in mountains. The second-order analysis is like looking at the mountains at a greater distance, and yields a potentially different perspective on the mountains as constituents of a range."

Tables 1 and 2 present sample first-and-second order varimax rotated factor pattern matrices. Then matrices are calculated from a sample of $n=822$ subjects who responded to a Part A, General Climate Factors (40 Questions), of the Charles F. Kettering Climate Profile (Howard, Howell, & Brainard, 1987) that is reported to have eight subscales of five questions each for the following areas: respect, trust, high morale, opportunity for input, academic and social growth, cohesiveness, school renewal, and caring. See Figure 1 for a listing of the instrument questions for the CFK scale. The results of Table 1 show that the first-order solution yielded five distinct factors. The two items that are factorially complex are included at the bottom of Table 1 only to give the factor loadings for all 40 items. Table 2 shows that two second-order factors emerged from the higher order solution (Johnson, 1990). The three items that are factorially complex are also listed. The four items that did not have a pattern coefficient greater than 0.30 in absolute value are not listed.

The first second-order subscale focuses on cognitive-managerial components of organizational climate, while the second subscale focuses on the affective-experiential features

of organizational climate. The first subscale is a composite mainly of growth, cohesiveness, renewal, and caring items while the second subscale is composed of respect, trust, morale, and input items. The higher-order analysis shows that the first-order subscales group into larger conceptual domains. This second-order analysis clearly defines a solution that is different from the first-order solution. Both perspectives are very useful in facilitating an understanding of the data.

References

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TABLE 1
FIRST-ORDER VARIMAX ROTATED FACTOR PATTERN MATRIX

Item No./ Scale Name		Factor				
		1	2	3	4	5
32	Renewal	0.619	0.367	0.072	0.262	0.200
33	Renewal	0.704	0.389	0.185	0.165	0.079
34	Renewal	0.692	0.269	0.168	0.140	0.142
35	Renewal	0.739	0.303	0.158	0.108	0.154
36	Caring	0.802	0.277	0.181	0.138	0.119
37	Caring	0.788	0.301	0.181	0.122	0.050
38	Caring	0.820	0.225	0.137	0.148	0.179
39	Caring	0.761	0.235	0.154	0.170	0.169
40	Caring	0.828	0.273	0.192	0.151	0.051
18	Input	0.160	0.425	0.340	0.106	0.395
20	Input	0.243	0.451	0.368	0.167	0.329
21	Growth	0.283	0.558	0.164	0.265	0.280
22	Growth	0.265	0.645	0.241	0.175	0.238
23	Growth	0.364	0.620	0.271	0.208	0.088
24	Growth	0.341	0.678	0.225	0.163	0.103
25	Growth	0.334	0.628	0.148	0.191	0.169
26	Cohesiveness	0.356	0.575	0.236	0.107	0.175
27	Cohesiveness	0.390	0.564	0.320	0.139	-0.007
28	Cohesiveness	0.298	0.635	0.164	0.252	0.117
29	Cohesiveness	0.373	0.611	0.162	0.233	0.180
31	Renewal	0.415	0.581	0.238	0.080	0.052
8	Trust	0.150	0.255	0.641	0.321	0.043
9	Trust	0.194	0.140	0.566	0.359	0.196
10	Trust	0.186	0.060	0.502	0.176	0.239
11	Morale	0.148	0.237	0.622	0.299	0.208
12	Morale	0.163	0.251	0.691	0.216	0.021
13	Morale	0.126	0.172	0.609	0.250	0.193
14	Morale	0.164	0.402	0.601	0.153	0.076
15	Morale	0.172	0.285	0.612	0.124	0.170
1	Respect	0.108	0.151	0.096	0.616	0.125
2	Respect	0.154	0.160	0.259	0.555	-0.011
3	Respect	0.038	0.158	0.150	0.601	0.122
4	Respect	0.121	0.104	0.243	0.655	-0.012
5	Respect	0.142	0.120	0.406	0.537	0.047
6	Trust	0.186	0.052	0.359	0.479	0.230
7	Trust	0.204	0.188	0.152	0.624	0.183
16	Input	0.260	0.183	0.300	0.169	0.686
17	Input	0.140	0.234	0.210	0.224	0.711
19	Input	0.246	0.455	0.232	0.078	0.495
30	Cohesiveness	0.502	0.598	0.246	0.120	0.049

Note. - Salient items were items with pattern coefficients greater in absolute value than 0.42.

TABLE 2
SECOND-ORDER VARIMAX ROTATED FACTOR PATTERN MATRIX

Item No./ Scale Name	Factor	1	2
21	Growth	0.336	-0.139
22	Growth	0.481	-0.121
23	Growth	0.644	0.069
24	Growth	0.699	-0.019
25	Growth	0.585	-0.114
26	Cohesiveness	0.599	-0.124
27	Cohesiveness	0.737	0.151
28	Cohesiveness	0.557	0.013
29	Cohesiveness	0.568	-0.091
30	Cohesiveness	0.843	-0.011
31	Renewal	0.775	-0.025
32	Renewal	0.549	-0.184
33	Renewal	0.793	-0.075
34	Renewal	0.644	-0.156
35	Renewal	0.730	-0.220
36	Caring	0.769	-0.154
37	Caring	0.843	-0.090
38	Caring	0.690	-0.242
39	Caring	0.637	-0.186
40	Caring	0.833	-0.067
1	Respect	-0.293	-0.373
2	Respect	-0.115	0.577
4	Respect	-0.261	0.666
5	Respect	-0.216	0.613
7	Trust	-0.232	0.325
8	Trust	0.030	0.588
9	Trust	-0.171	0.402
11	Morale	-0.102	0.379
12	Morale	-0.120	0.561
13	Morale	-0.134	0.362
14	Morale	0.267	0.362
16	Input	-0.300	-0.507
19	Input	0.156	-0.455
3	Respect	-0.345	0.422
6	Trust	-0.338	0.328
17	Input	-0.406	-0.530

Note. - Salient items were items with pattern coefficients greater in absolute value than .30.

FIGURE 1
INSTRUMENT QUESTIONS FOR THE CFK SCALE

Respect

1. In this school even low achieving students are respected.
2. Teachers treat students as persons.
3. Parents are considered by this school as important collaborators.
4. Teachers from one subject area or grade level respect those from other subject areas.
5. Teachers in this school are proud to be teachers.

Trust

6. Students feel that teachers are "on their side".
7. While we don't always agree, we can share our concerns with each other openly.
8. Our principal is a good spokesman before the superintendent and the board for our interests and needs.
9. Students can count on teachers to listen to their side of the story and be fair.
10. Teachers trust students to use good judgment.

High Morale

11. This school makes students enthusiastic about learning.
12. Teachers feel pride in this school and in its students.
13. Attendance is good; students stay away only for urgent and good reasons.
14. Parents, teachers, and students would rise to the defense of this school's program if it were challenged.
15. I like working in this school.

Opportunity for Input

16. I feel that my ideas are listened to and used in this school.
17. When important decisions are made about the programs in this school, I, personally, have heard about the plan beforehand and have been involved in some of the discussions.
18. Important decisions are made in this school by a governing council with representation from students, faculty, and administration.
19. While I obviously can't have a vote on every decision that is made in this school that affects me, I do feel that I can have some important input into that decision.
20. When all is said and done, I feel that I count in this school.

Continuous Academic and Social Growth

21. The teachers are "alive;" they are interested in life around them; they are doing interesting things outside of school.
22. Teachers in this school are "out in front," seeking better ways of teaching and learning.
23. Students feel that the school program is meaningful and relevant to their present and future needs.
24. The principal is growing and learning, too. He or she is seeking new ideas.
25. The school supports parent growth. Regular opportunities are provided for parents to be involved in learning activities and in examining new ideas.

Cohesiveness

26. Students would rather attend this school than transfer to another.
27. There is a "we" spirit in this school.
28. Administration and teachers collaborate toward making the school run effectively; there is little administrator-teacher tension.
29. Differences between individuals and groups (both among faculty and students) are considered to contribute to the richness of the school; not as divisive influences.
30. New students and faculty members are made to feel welcome and part of the group.

School Renewal

31. When a problem comes up, this school has procedures for working on it; problems are seen as normal challenges; not as "rocking the boat."
32. Teachers are encouraged to innovate in their classroom rather than to conform.
33. When a student comes along who has special problems, this school works out a plan that helps that student.
34. Students are encouraged to be creative rather than to conform.
35. Careful effort is made, when new programs are introduced, to adapt them to the particular needs of this community and this school.

Caring

36. There is someone in this school that I can always count on.
 37. The principal really cares about students.
 38. I think people in this school care about me as a person; are concerned about more than just how well I perform my role at school (as student, teacher, parent, etc)
 39. School is a nice place to be because I feel wanted and needed there.
 40. Most people at this school are kind.
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