THE FACTOR-WHEEL METHOD OF ROTATION FOR Q-TECHNIQUE RESEARCH

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Anticipating advances in 'objective' methods of factor rotation with increases in computer technology, Thompson (1962) felt there was still a need for new 'judgmental' methods and expressed the hope that these would keep pace with the others. In retrospect, it would appear his hopes have not materialized to any great extent, perhaps because of the failure to visualize the computer as an aid to judgmental methods as well as to those with set mathematical criteria. The present paper outlines a judgmental method of factor rotation, designed for use with Q technique, which would never have been feasible without computers.

Objective, or 'analytic,' factor rotation is perhaps best typified by Thurstone's (1947) simple structure criterion as incorporatedinto Kaiser's (1958) varimax solution (of which oblique solutions are only variations). Judgmental rotation on the other hand is a method commonly used by Stephenson (1953) in dependency analysis, where any number of criteria for rotation can be derived from hypotheses to be tested, each being unique to the problem studied. Either of these two methods makes possible the selection of certain points in factor space which have the special distinction of being designated

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as factors. The two methods applied to the same problem will likely give different results, but despite their differences they have in common the imposition of an external orientation to the data. It is not the test items, but the relationships among variables that determine where rotation will terminate. Factors are never 'seen' until they have been located. Only then are factor arrays[1] calculated so that it can be discovered what the factors actually look like. Factor arrays at other points of rotation are ignored. The factor wheel method, although similar to Stephenson's in that it is judgmental, takes an internal orientation to the data, using many factor arrays, or at least the items most typical of them, as the means for choosing factor positions.

A few years ago, it was quite difficult to construct four or five factor arrays. Obviously, the computer has alleviated that problem, and now it is simple to calculate as many factor arrays as may be desired, even one for each degree of rotation. In fact, carrying this process to an absurd extreme, a factor array could be made for every infinitesimal amount of rotation, and the successive factor 'pictures' would then resemble the frames of a motion picture film. Scanning from one to the next in rapid fashion, one could see 'themes' in the data as they gradually emerged, became clear, and then disappeared back into a more unintelligible mixture of ideas. At this point, however, a new difficulty would arise --that of evaluating so many factor arrays. We are rescued from overwhelming complexity by virtue of the fact that item positions, and thus themes also, change much more slowly than the precise computer

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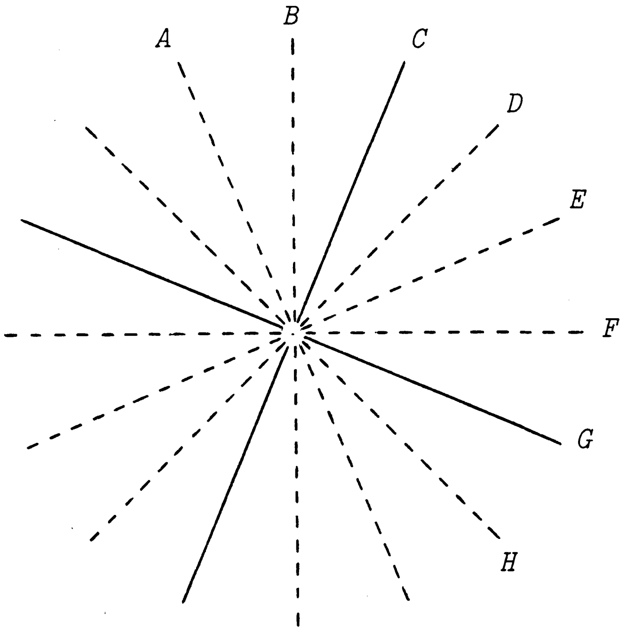
(1) A factor array is a list of test items which are arranged in order to show a picture of the factor. Items that are characteristic of the factor are at the top of the list, and those that are uncharacteristic of the factor are at the bottom of the list. For a discussion of the calculations involved in composing factor arrays, see Creaser (1955), Schlinger (1969), or Stephenson (1953).



FACTOR A+	*FACTOR B+*	*FACTOR C+*	*FACTOR D+*
sociable	sociable	sociable	intelligent
friendly	friendly	friendly	sociable
outgoing	outgoing	outgoing	friendly
ignorant	bold	intelligent	bright

FACTOR A-	*FACTOR B-*	*FACTOR C-*	*FACTOR D-*
unsociable	unsociable	unsociable	ignorant
unfriendly	unfriendly	unfriendly	unsociable
reserved	reserved	reserved	unfriendly
intelligent	shy	ignorant	dull

FIGURE 1. Factor wheel showing extreme items for factor arrays at each 22.5^{o} of rotation of a hypothetical problem (continued on next page). The undivided lines refer to the positions of the unrotated factors. The letters outside the wheel are for identification while factors are being selected.

FACTOR E+	*FACTOR F+*	*FACTOR G+*	*FACTOR H+*
intelligent	intelligent	intelligent	intelligent
bright	bright	bright	unsociable
quick	quick	quick	unfriendly
sociable	smart	unsociable	bright

FACTOR E-	*FACTOR F-*	*FACTOR G-*	*FACTOR H-*
ignorant	ignorant	ignorant	ignorant
dull	dull	dull	sociable
slow	slow	slow	friendly
unsociable	stupid	sociable	dull

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calculations of varimax would lead us to believe. Examining factor arrays for each 5^{o} of rotation is quite adequate and not at all impossible to judge. That is the essence of the factor wheel method, which is so-called because, if viewed graphically, the factor axes, spaced at equal intervals of rotation, criss-cross one another like the spokes of a wheel. Such an arrangement for a hypothetical problem, with only a few representative axes, is shown in Figure 1.

An investigator attempting to locate factors from such a factor wheel would probably have in mind a criterion of simplicity, not the simplicity of relationships among variables as in Thurstone's simple structure, but the simplicity of concepts which, it could be argued, is the sine qua non of a factor. With the factor wheel, it is possible by direct inspection to pick out any simple concepts that may exist in the data. For example, factor array B, in Figure 1, contains only socially-related items in the extreme positions, whereas factor array F gives prominence to intellectual items. Each of these is pure in itself and devoid of contamination by peripherally-related or unrelated ideas, whereas other factor arrays are mixtures of these two clearer concepts. In accordance with the definition of simplicity, therefore, the rotated axes would pass through points B and F. The themes associated with these two points would become the factors found by the study; the matrix of factor loadings accepted would be that which produced these arrays, i.e., the pattern of loadings would be dependent upon the factor arrays selected.

Matrices of rank greater than two can still be rotated with the factor wheel, but practical problems are soon encountered. With three factors, the usual sequence of rotation is factor A with B, A with C, and B with C, and then the process is repeated since each subsequent rotation affects the factor loadings determined by previous rotations. Since rotations are judgmental, there is a break in the computer processing between each rotation, and the data must then be resubmitted. With four factors, there are six rotations plus repeating, and ten rotations with five factors. All of this requires close access to a computer, or at least to a terminal. Since remote terminals are becoming more common, the factor wheel method could become of increasing utility.

THE FACTOR WHEEL VS. SIMPLE STRUCTURE

Since varimax and other approximations to simple structure are usually part of the programmed package for factor analysis, it is often assumed that the solution, rather than being arbitrary and the outgrowth of a philosophical point of view, is some sort of absolute mathematical truth. Actually, the interpretation of Q factors rotated to simple structure can be ambiguous, and Cattell (1952: 98), a strong advocate of simple structure rotation with R technique, has stated that the method is not entirely applicable to Q.

Findings with the factor wheel method have been found to differ from those produced by the simple structure criterion. The first comparison of the two methods involved the reanalysis of a previous study (Creaser, 1960) in which Q sorts of study skills and attitudes were factored and originally rotated to simple structure. One of the resulting factors was designated 'The Anxious Student.' Some years later, when the data was reevaluated by means of the factor wheel, a much clearer picture of anxiety was revealed at a considerable rotational distance from the simple structure solution. Thus, simple factor structure did not insure conceptual clarity, at least in this instance.

Several subsequent studies have shown discrepancies, varying in amount, between the factor wheel and varimax solutions. The most pronounced involved the Myers-Briggs Type Indicator, with 45^{o} separating the factors identified by varimax from those picked out by the investigator. To determine if support could be found for the admittedly subjective selections from the factor wheel, the factor arrays located by the two methods were submitted for evaluation to seven other psychologists. These judges were not told how the two lists of items had been derived, but merely that each represented a possible personality factor. They were then instructed to pick out the one that seemed the 'simplest,' the 'purest,' the one 'showing the least conflict or complexity of ideas.' The two competing arrays for one of the factors are shown in Table 1.

The judges were given a very precise definition of what to look for, a definition that undoubtedly had the same meaning for each of them. The instructions could have been more vague, such as 'pick out the list you feel represents a factor.' In that case, however, we would have been testing how well the judges agreed on the definition of a factor rather than which list demonstrated the most of a certain quality. If there are to be any hopes of agreement, the judges must have the same frame of reference in making their selections. In this study, the judges were unanimous in choosing the factor wheel array as most closely meeting the criterion: This set of items is consistent in reflecting good relationships with people, whereas the varimax listing has some of the same items but mixed with one or two unrelated ideas.

These results do not prove the factor wheel in-

TABLE 1
Arrays for Comparing Factor Wheel and Varimax

Factor Wheel	Varimax
As a guest, I enjoy joining in the talk of the group.	As a guest, I enjoy joining in the talk of the group.
At a party, I like to help get things going.	I am a naturally good mixer, not quiet or reserved in company.
At parties, I always have fun.	I usually get on better with imaginative people than with realistic people.
I am naturally a good mixer, not quiet or reserved in company.	If I were a teacher, I would rather teach courses involving theory than fact.
People close to me know how I feel about most things even if I don't have any special reason for telling them.	I like the word 'figurative' better than the word 'literal'.
In the matter of friends, I tend to seek broad friendships with many different kinds of people.	At parties, I always have fun.

trinsically better than varimax in any absolute sense, but they do indicate that the two methods are independent and can be used for different purposes. The results might also stimulate curiosity concerning the factor arrays generated by criteria other than varimax.

From a theoretical standpoint, the rotation of axes is the most interesting feature of factor analysis. It is also the most controversial. Since, in some respects, all points of rotation are mathematically equal, there are those who contend that no rotation is necessary. Others insist that, in order to advance science, all rotation should be done 'blindly' according to some abstract criterion. Still others find that judgmental methods make rotation more meaningful and flexible. For Q technique research, it is hoped that the factor wheel will be useful in this latter respect.

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