This Week's Citation Classic

Cattell R B. The scree test for the number of factors.
Multivariate Behav. Res. 1:245-76, 1966.
[University of Illinois, Urbana-Champaign, IL]

The problem of when to stop factoring in the use of factor analysis has been variously conceived. This paper names five features of a test for a number of factors that would be appropriate if factors are to be considered as real influences rather than merely statistical derivatives. It shows by numerically made-up examples that if the principal axis factors are plotted in succession there is a sharp point on the curve where the descent suddenly becomes linear. [The *Science Citation Index*® (*SCI*®) and the *Social Sciences Citation Index*® (*SSCI*®) indicate that this paper has been cited in over 350 publications since 1966.]

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"During the 1940s and 1950s, it had been an uphill fight trying to convince psychologists that factor analytic designs of experiment would open the door upon which they had beaten in vain with the classical bivariate type of instrument. I soon discovered that part of their reluctance was a general belief that factor analysts could not agree among themselves in their results. These sources of disagreement arose from psychologists looking at the same correlation matrix and taking out quite different numbers of factors, as well as from failure to achieve an objective technique in rotation. The first problem was particularly serious, and it seemed to me that until this difficulty was met, the whole object of factor analysis, namely, to reach objectively the dimensions of personality or anything else, was vitiated.

"I had given much thought to theoretical approaches to this problem,[1-3] which I had hoped would have solved it for us. I decided to attack the problem in a bold or brutal empirical fashion. That is to say, I made out—backstage as it were—a number of imaginary studies with different numbers of factors in them, with quite particular loadings, from which I generated a correlation matrix such as an experimenter would normally start with. This putting of a model into a literal numerical form I have since been calling *plasmode*. I then factored these correlation matrices in the way one normally would and began to look for various signs in the principal axis 'latent roots' extracted, and various other characteristics, to see if I could find anything that would have told me that I had the number of factors which I knew the problem contained (from backstage). To my delight, a very simple finding presented itself, namely, that if I plotted the principal components in their sizes, as a diminishing series, and then joined up the points all through the number of variables concerned, a relatively sharp break appeared where the true number of factors ended and the 'detritus,' presumably due to error factors, appeared. From the analogy of the steep descent of a mountain till one comes to the scree of rubble at the foot of it, I decided to call this the *scree* test.

"It seemed that from the point of practical operations in factor analysis the problem was solved, but it could well have been that with very different data and circumstances from my own examples the rule would be found not to work, so I began groping for a theoretical basis. The second half of the article describes my consideration of certain alternative possible theoretical bases for this effect.

"This article is actually one of half a dozen in which I have felt forced to try to get a solution without the aid of a professional statistician. An undue number of psychologists seem to find what I want to write on these occasions to be too statistically recondite for them to pursue, and most statisticians feel that my disregard of the proper sequences of statistical exposition justifies their professional contempt. Nevertheless, as the number of citations shows, and as I know from correspondence, psychologists and others have found the scree test extremely useful and in most cases quite reliable.[4] One welcomes the new advance into practicable programs for factor number by the maximum likelihood method, which has come about in the last decade and solves several other problems."

1. **Kaiser H T.** The application of electronic computers to factor analysis. *Educ. Psychol. Meas.* 20:141-51, 1960.
2. **Thurstone L L.** *Primary mental abilities*. Chicago: University of Chicago Press, 1938. 121 p.
3. **Bartlett M S.** Tests of significance in factor analysis. *Brit. J. Psychol. Stat. Sect.* 3:77-85, 1950.
4. **Hakstian A R, Rogers W T & Cattell R B.** The behavior of number-of-factors rules with simulated data. *Multivariate Behav. Res.* 17:193-219, 1982.