PSYCHOPHYSIOLOGY
Vol. 24, No. 4

Printed in U.S.A.

Methodology

Editorial Policy on Analyses of Variance With Repeated Measures

J. RICHARD JENNINGS

This is the first in a series of occasional editorials intended to keep the readers of *Psychophysiology* aware of various methodological issues that arise in our research. The new editor of the *Journal*, Michael Coles, has asked me to act as Methodology Editor and to address these issues specifically.

In the present case, the issue concerns the question of the sphericity assumption which is discussed in the Vasey and Thayer article appearing in this issue of *Psychophysiology*. The sphericity assumption is usually violated when more than two measures are taken from the same individual at closely spaced points in time. Such measures tend to be highly correlated and the correlation is typically higher for points closer to each other in time. Over the last 10 years, as Vasey and Thayer note, the problem of violating the sphericity assumption has been brought to the attention of the *Journal*'s readers. Editorially, associate and consulting editors have frequently asked for corrections for analysis of variance terms derived from degrees of freedom accumulated across numerous repeated measures. Previously, however, the editorial board has not adopted a consistent stance that *all* analyses using repeated measures take account of the likely violation of the sphericity assumption. The Vasey and Thayer paper suggests that such a consistent stance is overdue.

In practice, two procedures are available for resolving violations of the sphericity assumption. First, multivariate analyses of variance may be employed. These are not limited by the sphericity assumption. Alternatively, univariate repeated measures analyses of variance may be corrected for violation of the sphericity assumption. Typically, this involves determining the significance of an analysis of variance term using degrees of freedom reduced by multiplication with a proportion termed the "epsilon correction." Alternate forms of the correction attributed to Greenhouse-Geisser and Huynh-Feldt are frequently applied and routinely provided by, for example, BMDP package programs.

Most readers should be able to obtain advice in applying these corrections or in using multivariate analyses of variance. Thus, it will now be the policy of the *Journal* to require that papers that employ repeated measures designs include a specific statement indicating how the violations of the sphericity assumption have been dealt with using either multivariate analyses of variance or univariate analyses with corrected degrees of freedom. In the latter case, the correction factor and the nominal degrees of freedom should be included.

I have asked three well known psychophysiologists to comment briefly on the Vasey and Thayer paper and more generally on the importance and relevance of the issue raised for their particular specialty. Drs. Cohen, Ruchkin, and Fridlund are primarily research scientists rather than statisticians. In their comments on the Vasey and Thayer paper, they elaborate on the importance of the policy for their speciality areas, on the availability of programs implementing appropriate analyses, and on the practical impact on significance levels. I hope these comments underline the importance of the new editorial policy for the readership.

The opinions of the Associate Editors of the *Journal* were also solicited. The editors were generally very supportive and anticipated little difficulty in implementing the policy. Some interesting points were raised, however. First, the editors were concerned with the burden imposed upon the investigator who does not have ready access to programs for multivariate analysis or epsilon corrections. Second, correcting for nonhomogeneity of variance-covariance matrices was noted as only one of many statistical problems worthy of our attention. Other problems mentioned were inadequate use of post-hoc tests, executing large numbers of statistical tests thus increasing experiment-wise er-

Address requests for reprints to: J. Richard Jennings, Western Psychiatric Institute and Clinic, University of Pittsburgh, 3811 O'Hara Street, Pittsburgh, PA 15213.

ror, an overemphasis on rejecting the null hypothesis rather than concern about effect size, and insufficient emphasis on replication of findings. Third, investigators might be cautioned against subverting the policy by running multiple analyses testing only two levels of a factor at a time (thus, avoiding the necessity for correcting for nonhomogeneity but inflating the experiment-wise error) or by running both MANOVA and repeated measures ANOVA and choosing the result most favoring the investigator's view. Fourth, questions were raised about how to handle missing data when using MANOVA or computing epsilon corrections, and whether corrections are needed when running trend analyses which have low degrees of freedom in the numerator. Finally, alternatives to the reporting guideline for epsilon corrections given in this editorial were considered.

Comments are welcome from those trying to follow the policy and anticipating difficulty or from those with answers to any of the problems raised. Any investigator without access to software to implement the policy may write to me for a FORTRAN program for epsilon computation and an explanation of its use.

J. RICHARD JENNINGS
Western Psychiatric Institute and Clinic
University of Pittsburgh
Pittsburgh, PA 15213