Comment

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We are very pleased for the opportunity to comment on this provocative paper by Professor Young. While we agree that the promise offered by the extensive research efforts on the bootstrap over the past decade has not been fully realized in practice, there is evidence to suggest that the use of bootstrap methods is making significant inroads into the applications literature of the biomedical sciences. A lag period between theoretical development and incorporation into practice is expected as newer methods trickle into the various areas of application. Young's expectations for the timing of this transfer from theory to practice may simply be unrealistic when viewed in historical context. As practicing biometricians in the biopharmaceutical sciences, we will address, at least in part, questions posed by Young as to why the bootstrap methods have been slow to catch on among practitioners. We will also make a few comments on areas that may serve to enhance the practical appeal of the bootstrap and thereby hasten its use in practice.

First, the bootstrap is making the slow journey into the mainstream of statistical curricula and out of the strictly research-oriented seminars and special-topics courses where students may never actually perform any bootstrap computations. Thus, the current cohort of statistics graduate students is probably the first to have such broad exposure to the basic theoretical and practical aspects of bootstrap techniques. This is evidenced by the recent proliferation of theory-oriented texts (e.g., Beran and Ducharme, 1991; Hall, 1992a; LePage and Billard, 1992; Mammen, 1992) and practical texts (e.g., Efron and Tibshirani, 1993; Noreen, 1989; Westfall and Young, 1993) to serve as a foundation on which faculty can base their courses.

Accepting that this transition to mainstream is

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indeed taking place, we then have a delay before some fraction of this newly educated cohort makes its way into other than academic research-oriented positions. This delay is not surprising, as exemplified by now-common methodology for the general linear model where theory was well established in the statistical literature and texts (e.g., Scheffé, 1957; Graybill, 1961; Searle, 1971) before broad evidence of practical application. Also note that there are many results in general linear model theory that have not been embraced in practice simply because they lack practical utility. The general linear model did not really become an integral part of the practicing statistical armamentarium until readily accepted and documented software such as SAS or BMDP were widely available in the 1970's and 1980's. Realistically, we should expect similar delays for the bootstrap, although one could argue that today's population of technical and scientific people are far more computer literate than those of a generation ago, thereby hastening the transition from theory to practice. It is absolutely imperative that the proper applications and limitations of bootstrap methods are clearly conveyed to students and currently practicing statisticians. This clear communication will facilitate a more rapid incorporation of bootstrap methods into routine statistical practice.

Researchers should also recognize that for the practicing statistician there are often significant roadblocks to the deployment of "new" methodology. Roadblocks can be a simple lack of knowledge by individuals who completed their statistical education years ago and have had few opportunities to further their professional development by sifting through the morass of current research literature (at best, these individuals may read a text, when available, or attend a continuing education short course on the topic). As people who "grew up" using the delta method to derive asymptotic standard errors for complicated functions of random variables and have occasionally jackknifed nonlinear least squares parameter estimates to remove first-order bias, we were very interested to follow the development of bootstrap methodology. "Tried-and-true" techniques, like the delta method, frequently serve one's needs quite well, provided that you exercise caution. Hence, there may appear to be little motivation to employ