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Assessing the Variability of Psychometric Functions

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The quality of psychophysical threshold measurements hinges on the availability of error estimates for the estimated parameters. To obtain the latter is particular difficult in work with patients and in situations where data are not stationary (e.g. due to learning). Bootstrapping (Efron & Tibshirani, 1993) provides a general and elegant way to estimate standard errors for arbitrarily complex summary statistics like those specifying the complete shape of a psychometric function, or, more generally, like function parameters in a nonlinear fit. The surprisingly simple idea of the bootstrap is to generate sets of virtual data by resampling (with replacement) the original data. In psychophysics the original data set are the responses collected in a session; the sets of resampled data have the same size as the original and consist of the same responses except that some responses have been omitted and others have been doubled. Using the Bayesian fit routine of Treutwein & Strasburger (1999) to fit a template psychometric function to the original data set, best estimates for threshold, slope, and guessing and lapsing rate are obtained, the variability of which are of interest. With the same fit routine applied to the sets of virtual data, distributions of these parameter values are obtained. The variances of these distributions are the ideal bootstrap estimates of the standard error of the corresponding parameters estimated from original set. Data from Monte-Carlo simulations demonstrate that the bootstrap distributions of the estimated parameter values are highly similar to the distributions of repeated (simulated) measurements. Data from psychophysical experiments further show the applicability of this method to real-world data.

Efron, B. & Tibshirani, R. J. (1993) *An Introduction to the Bootstrap*. Chapman & Hall, New York.

Treutwein, B. & Strasburger, H. (1999) Fitting the Psychometric Function. *Perception & Psychophysics*, *61*, pp. 87–106.