The Adaptive Psi Method and the Lapse Rate

Conference Paper *in* Journal of Vision · May 2012

DOI: 10.1167/12.9.322

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The adaptive psi method and the lapse rate.

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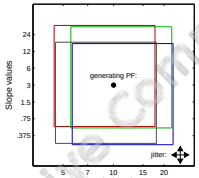
Introduction

The adaptive psi-method (Kontsevich & Tyler, 1999): following each trial the psi-method derives a posterior probability distribution across (discrete) values of the threshold and slope parameters based on all previous trials and a user-provided prior distribution. The stimulus intensity to be used on the next trial is then selected such that the expected entropy in the posterior distribution is minimized. The Psi-method uses a fixed assumed value for the lapse rate and this can be expected to lead to bias in threshold and slope estimates when the generating value of the lapse rate does not match the assumed value.

Methods

PF used: $\psi(x;\alpha,\beta,\gamma,\lambda) = \gamma + (1 - \gamma - \lambda) \times F_W(x;\alpha,\beta) \qquad F_W(x;\alpha,\beta) = 1 - exp\left(-\left(\frac{x}{\alpha}\right)^{\beta}\right)$

α = 10, β = 3, γ = 0.5, and λ = 0, 0.025, or 0.05.



4 priors were used (left). All were uniform within range shown.

Standard Psi method assumed λ = 0.025.

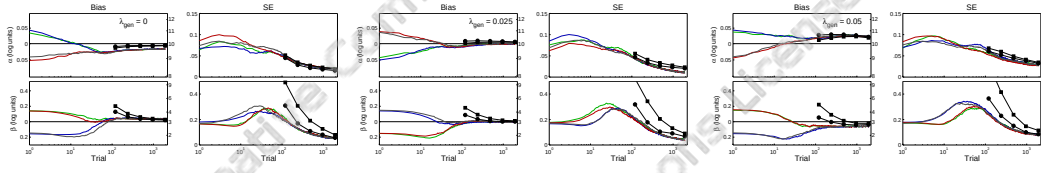
Parameter estimates were derived by Bayesian method (as in K&T, 1999): marginal means across posterior.

Parameter estimates were also derived by Maximum Likelihood (ML) method with free lapse rate.

SEs: square root of average squared deviation of estimate from true, generating value.

Psi method, psi⁺ method, ML fits performed by the Palamedes Toolbox (Prins & Kingdom, 2009).

Standard Psi

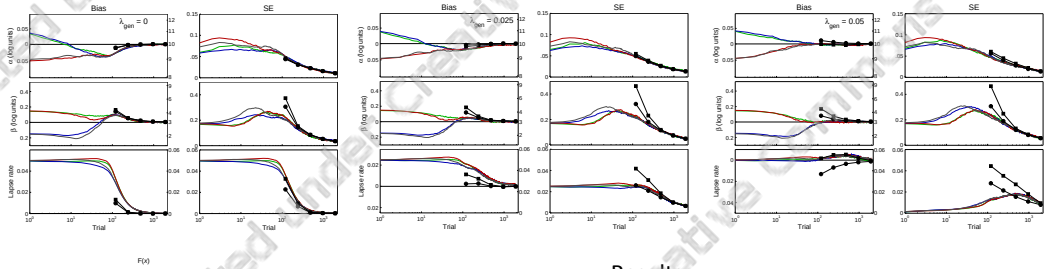


Results:

Bayesian fit results in bias when actual lapse rate deviates from that assumed by Psi method.

ML fit with free lapse rate results in bias due to serial dependencies (Prins, 2012; also see Kaernbach, 2001).

Possible solution I: Include lapse rate in posterior distribution: Psi⁺



Results:

Bias is reduced.

Parameter estimates eventually converge on true, generating values, but only after high number of trials.

Sessions contain lengthy consecutive stimulus presentations at very high intensities.

Possible solution II: 'Asymptotic Performance Lapse Estimation' (APLE; Prins, 2012):

Use standard Psi, but add observations at asymptotic performance intensity (API, here: F_W = 0.9999), and fit model which assumes F = 1 at API.

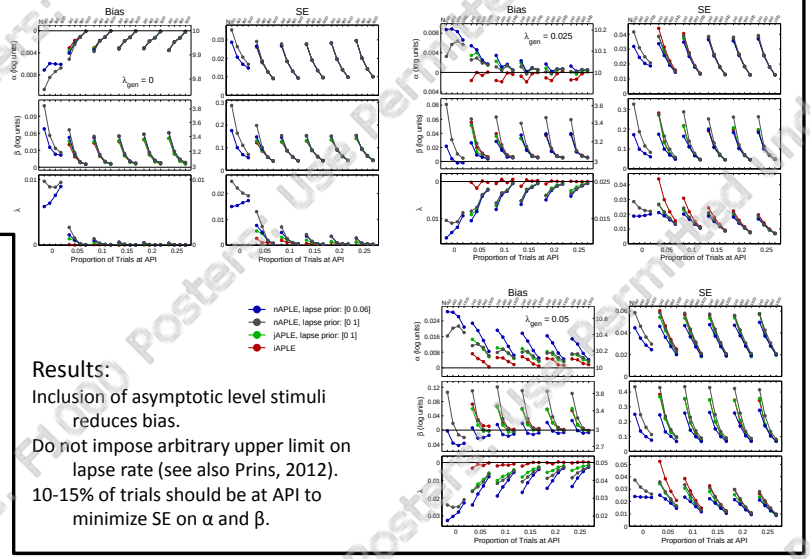
Two versions: jAPLE ('joint-APLE') and iAPLE ('isolated-APLE').

jAPLE: $\psi(x;\alpha,\beta,\gamma,\lambda) = 1 - \lambda$ when $x = API$

$\psi(x;\alpha,\beta,\gamma,\lambda) = \gamma + (1 - \gamma - \lambda)F(x;\alpha,\beta)$ otherwise.

iAPLE: two-step procedure: use performance at API to estimate λ, then estimate α and β from the other, Psi-controlled observations using λ fixed at value estimated at API.

Also included in Figure: ML fit with free lapse rate (e.g., Wichmann & Hill, 2001): nAPLE ('non-APLE').



Results:

Inclusion of asymptotic level stimuli reduces bias.

Do not impose arbitrary upper limit on lapse rate (see also Prins, 2012).

10-15% of trials should be at API to minimize SE on α and β.

Summary

Standard Psi method leads to bias when assumed and generating lapse rate do not match, even when data are fitted post-hoc by ML method with a free lapse rate.

Bias is reduced with proposed Psi⁺ method with eventual convergence on generating parameter values.

Bias also reduced when very high stimulus intensities are added to standard Psi.

Consider using proposed fitting methods jAPLE and iAPLE.

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