Tracking Time-Varying Thresholds

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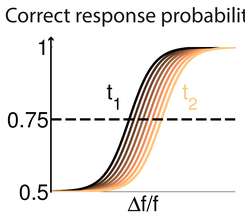
I. Motivation and aims

In order to relate fluctuations of performance to measures of ongoing brain activity, it is necessary to accurately track these behavioral variations over time. Tracking these variations can also reveal phenomena such as habituation, sensitization or learning.



Time-varying thresholds

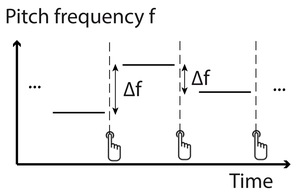
Between two time points t_1 and t_2, the psychometric function shifts along the stimulus axis .

We combine an adaptive staircase procedure with a simple local threshold estimation method to track fluctuations of auditory thresholds over time.

- We assess the tracking performance of this method in a 2-Alternative Forced Choice (2-AFC) pitch discrimination task.
- We investigate the benefit of interleaving multiple, independent tracks within the adaptive procedure. Interleaving decreases the serial correlation of Δf/f between trials.

II. Methods

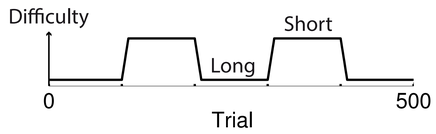
Serial 2-AFC pitch discrimination task



Stimuli were pure tones starting at a pitch frequency of 250 Hz. Participants had to indicate the direction of the pitch change after each tone [1].

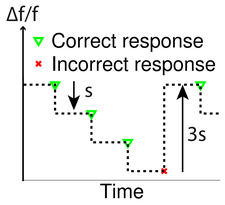
Induction of threshold shifts

To induce variations of performance, tone duration alternated between short (40 ms) and long (320 ms).



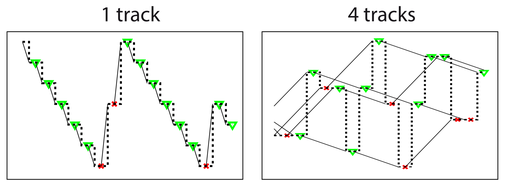
Methods (continued)

Adaptive procedure



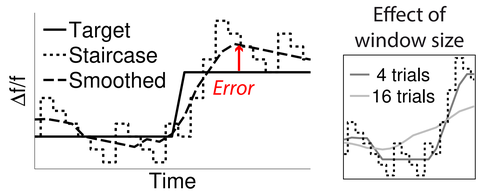
Weighted up-down method [2] targeting the 75% accuracy threshold.

Multiple interleaved tracks

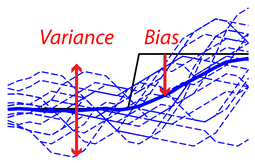


When 4 tracks are interleaved, the response in a trial affects Δf/f 4 trials later [3]. Serial correlation is reduced.

Quantifying estimation error



A moving average of Δf/f provides a smoothed estimate of local thresholds. The **error** is defined as the difference between the local average and the target threshold.



The **bias** and **variance** are defined as the mean and variance of the error over participants (or simulation trials).

Method references

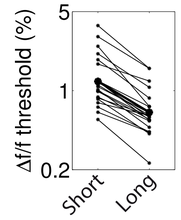
[1] De Kerangal et al., *ARO Psychoacoustics session II*, 2016 (poster)

[2] Kaernbach, *Perception & Psychophysics,* 1991

[3] Leek et al., *JASA,* 1991

III. Results (human participants, n=21)

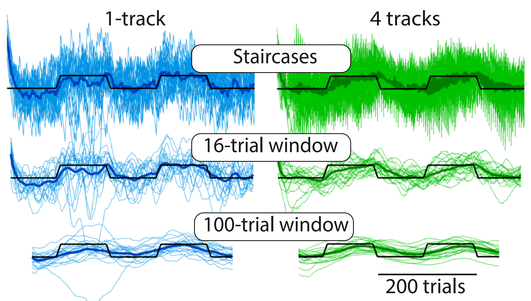
Thresholds as a function of tone



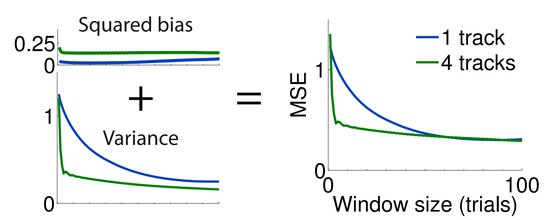
A threshold was obtained by fitting a psychometric function to the subject's accuracy. Thresholds fit separately to short-tone and long-tone trials were different ($p=1.5\ 10^{-11}$, n=21).

Estimation of the time course of the threshold

In light colors the individual time series for each subject, without (top) or with smoothing (lower two plots); in dark colors the time series averaged over subjects; in black the expected target performance.

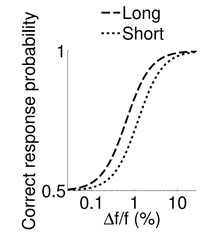


Mean Squared Error (MSE)



IV. Simulations (n=2000)

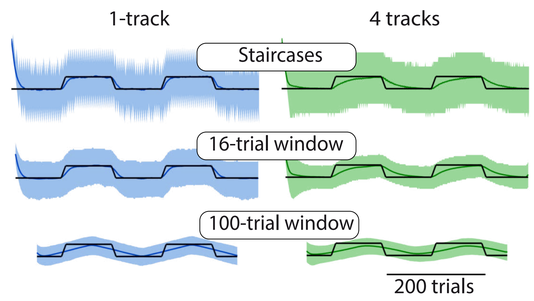
Model response curves



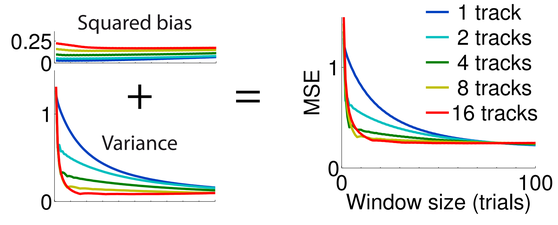
The response of the model is determined by a sigmoid "psychometric" function. The intercept of the function takes two values corresponding to the thresholds measured for short and long tones.

Estimate time courses

In dark colored lines the time series averaged over simulation trials; in colored shades the 95% confidence intervals.



MSE



V. Conclusions

Simulation results are consistent with behavioral results.

(1) Local threshold estimates follow expected variations, with a delay and variability that depend on the number of tracks and size of the averaging window.

(2) For short smoothing windows (required to track fast fluctations) multiple tracks lead to more reliable threshold estimates. Additional advantages are the possibility to investigate serial context effets (less serial correlation), and less predictable difficulty form the subjects' perspective.

Acknowledgements

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