Using Reaction Time to Choose Stimuli Levels in Perimetry

#5511

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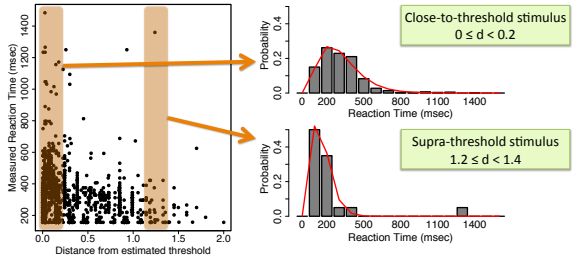
Purpose To improve algorithms for determining thresholds by using reaction times (RT) to influence stimulus levels in static automated perimetry .

Methods The perimetric stimulus simulated in this study was the sinusoidal patches as used by Hot et al[3] (also see poster #5500), with thresholds measured in log-contrast.

Reaction times to stimuli that are near threshold are generally longer than responses to bright stimuli a long distance from threshold[1,2]. Hence, expressing distance from threshold of a stimulus in log units, we collected the following RT data.



RT from 10 runs of 8 subjects: mean of 80 yes responses per run (sd 18).

Fitted truncated gamma (red) for observed reaction time distribution (grey).

A truncated Gamma function was fitted to empirical RT data for ranges of distance from threshold [0,0.2), [0.2, 0.4), ..., [1.4,1.6). The two parameters of each Gamma function were then subject to log-linear regression, giving a truncated Gamma distribution for any particular distance from threshold of

$$\text{Prob}[\text{Reaction Time } t \mid \text{Distance from threshold } d] = \Gamma(t, e^{0.9967 + 0.7412d}, e^{-4.765 + 1.181d}).$$

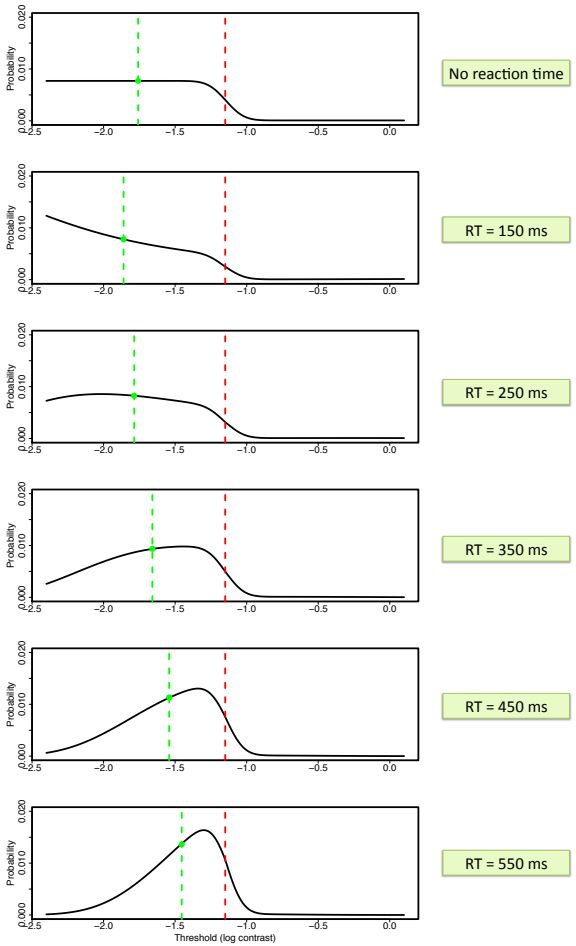
We modified a ZEST[4] procedure to include an extra likelihood component using the above formula. As shown to the right, this altered the probability density function (pdf) over thresholds in different ways after each stimulus presentation depending on reaction times.

The new procedure, dubbed BURTO (Bayesian Updating with Reaction Time Offsets), was tested using computer simulation. We simulated BURTO and ZEST on four populations of 1000 patients, all of whom had

- 3% or 20% false positive and negative rates;
- reaction times sampled from the third author's empirical data as a function of d;
- a Gaussian psychometric function with standard deviation 0.25 log units[3]; and
- true thresholds -2, -1.8, -1.6, ..., 0 log units.

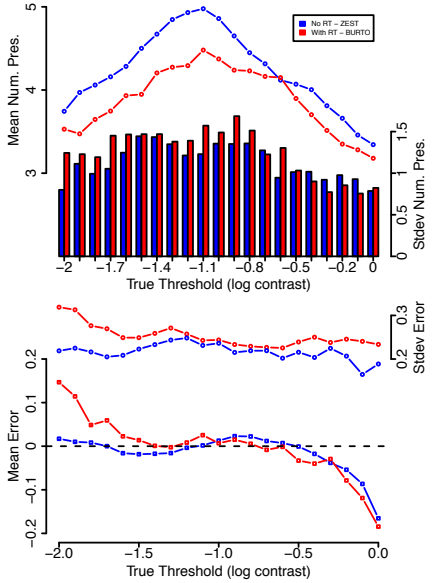
References

1. Wall et al., IOVS 1996, Apr; 37(5): 878-85.
2. Wall et al., Vision Research 2002, Mar; 42(6): 781-7.
3. Hot et al., IOVS 2008, Jul; 49(7): 3049-57.
4. King-Smith et al., Vision Research 1994, Apr; 34(7): 885-912.
5. Turpin et al., IOVS 2007, Apr; 48(4): 1627-1634



The probability density functions (pdfs) used to determine the second presentation of BURTO (green line) when the subject responds "yes" to the first presentation of -1.15 (red line) with various reaction times, RT. A uniform prior pdf is assumed to determine the first presentation.

Results



Number of presentations (upper panel) and measured less true threshold in log units (lower panel) for ZEST (blue) and BURTO (red) for 1000 subjects with 3% false response rates.

Conclusions

BURTO is as accurate as ZEST, except for very low thresholds, and about 10% faster.

Reaction times can be used to improve stimulus placement in clinical perimetry.

Future Work

Customize reaction time functions to an individual based on test history, rather than using population data.

Reduce BURTO's inaccuracies for low threshold values.

Incorporate BURTO into the REMU[5] strategy.

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