On Using PEST

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1 Idea

The goal here is to use an Adaptive Contrast Algorithm to achieve some performance, p_o, on individual optotypes so that we can use the corresponding contrast level during stabilization blocks. The complication is that we can only update the contrast after receiving 6 responses since each trial consists of a line of 6 letters. Here I describe how we can use PEST to collect enough trials over different contrast levels to fit a psychometric function to the optotype data.

PEST needs a binary value at the end of each trial, which can contain up to 6 individual optotypes. A rule to do this is to consider a trial to be correct only if all 6 optotypes are correctly identified.

Let C_N be the number of correct trials after N total trials at some contrast. We can approximate the corresponding number of correctly identified letters as

$$6 \cdot C_N + \beta \cdot (N - C_N)$$

where β is a variable denoting the number of correct letters identified in an incorrect trial. So on any trial $\beta \in [0, 5]$.

At this contrast the PEST performance is given by $p_p = C_N/N$ and the actual optotype performance is given by

$$p_o = \frac{6 \cdot C_N + \beta \cdot (N - C_N)}{6N}$$

Because of the ambiguity of β we cannot directly calculate a p_p that will give us a desired p_o. But we can approximate it then use the collected trial performances to fit a psychometric function to the performance on the actual optotypes.

Algebra to estimate a pest performance p_p that will put us near p_o:

$$\begin{aligned}
p_o &= \frac{6 \cdot C_N + \beta \cdot (N - C_N)}{6N} \\
p_o &= \frac{(6 - \beta)}{6}\frac{C_N}{N} + \frac{\beta}{6} \\
p_o - \frac{\beta}{6} &= \frac{(6 - \beta)}{6} p_p \\
\frac{6p_o - \beta}{6 - \beta} &= p_p
\end{aligned}$$

Given that we want a desired optotype performance $p_o = .75$, the trial performance for different values of β is then

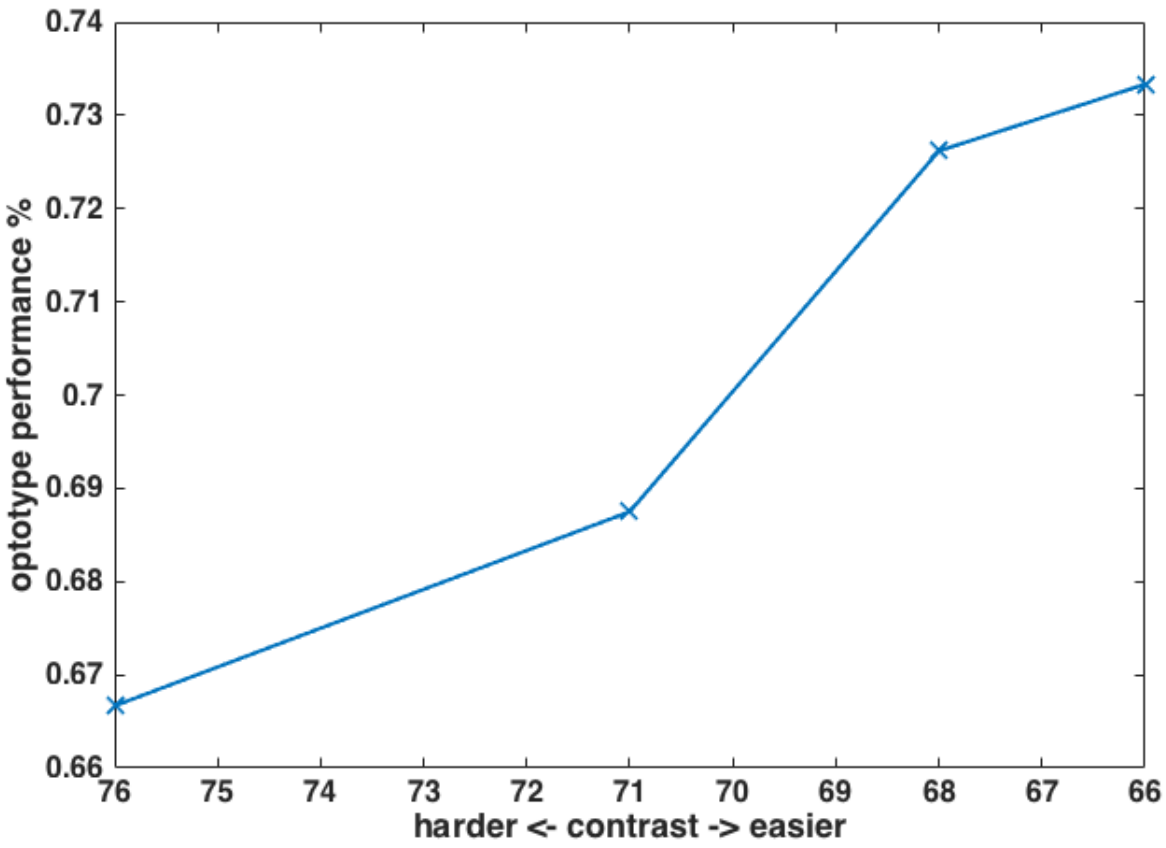
$$\beta = 3 \Rightarrow p_p = .5$$
$$\beta = 4 \Rightarrow p_p = .25$$
$$\beta = 5 \Rightarrow p_p = -.5$$

This obviously covers a wide range of trial performances so let's say that we use $p_p = 0.25$ in an experiment. If we reverse this process we can look at the variability of the p_o:

$$p_p = 0.25 \Rightarrow$$
$$\beta = 3 \Rightarrow p_o = .625$$
$$\beta = 4 \Rightarrow p_o = .75$$
$$\beta = 5 \Rightarrow p_o = .875$$

2 Data

50 trials using PEST with a desired performance of 25%, linear step size, and an initial contrast of 76 resulted in the following performance at different contrasts:



It didn't quite get to 75% optotype performance but I probably just stopped the trials too early.

The graph below shows how the pest level difficulty changed over the trials (up is easier). Blue circles denote "correct trials" and red x's are "incorrect trials".