Two spot increment and decrement summation as a function of spot separation

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This project is a follow on to our published work on spatial summation with adaptive optics correction and retinally-stabilized viewing. Here we examine how increment-increment pairs, decrement-decrement pairs, and increment-decrement pairs sum in detection. The experiment described here follows on pilot work which suggests that there is partial increment-decrement cancellation, beyond that which can be easily explained by residual optical blur. By measuring detection for spot pairs at various separations, we aim to acquire a full dataset that will provide stronger constraints on underlying models.

Subject 11046 has piloted data of the sort described here but only out to spot separations of ~2.4 arcmin. This was not sufficient separation to reveal clear failures of complete summation for the paired spots. The increment-decrement data did show cancellation at smaller separations, with thresholds decreasing as separation increased. We aim to determine whether this pattern replicates in 11046 and whether it is seen in other subjects.

Subject 11002 has piloted data with no separation between the spots, with data revealing some cancellation for increment-decrement pairs, but has not collected data for conditions with non-zero spot separation.

We will run the following conditions in randomized order in each of two sessions for 11002, 11046, and one additional subject who has not participated previously.

Size:

- 7 pixels high by 9 pixels wide (415 pixels/deg)
- 1.01 arcmin high by 1.3 arcmin wide.

Directions:

- Single increment (0°) at 0 separation
- Single decrement (270°) at 0 separation
- Increment-increment (45°) at 7 vertical separations
- Decrement-decrement (225°) at 7 vertical separations
- Incrment-decrement (315°) at 7 vertical separations

Separations:

- 0, 2, 4, 7, 13, 24, and 45 pixels
- 0, 0.29, 0.58, 1.01, 1.88, 3.47, 6.51 arcmin (415 pixels/deg)
- Obtain pixels with 0 and round(logspace(log10(2),log10(45),6))
- Obtain arcmin by multiplying by 60/415.

So, 23 directions/separations in all.

For each direction/separation:

- 12 trials at each of four contrasts
- Contrasts are the highest 4 we used previously
- Run 3 catch trials (0 contrast) for each direction/separation

Add to protocol practice trials at start.

- Each run starts with practice trials
- These are all at highest contrast for direction/separation for that run
- Subject pushes some new button to see a practice stimulus
    - Some new button on controller used to present a practice stimulus
    - No response given
    - Can be repeated as many times as desired
    - Experiment starts when subject pushes current start button
        - No more practice stimuli after experiment start

At start of a session, do one short practice run with "easy" stimulus.

- 10 pixels tall by 12 wide
- Increment/decrement (315°) at 10 pixels vertical separation
- Same four contrasts as with smaller stimulus
- Same practice stimulus protocol as above
- 4 trials/contrast plus 1 catch trial, something like that.
- Data not analyzed

Counting the practice run, we have per session:

- NTrials = 23*(4*12+3) + 1*(4*4 + 1) = 1190

We set our background at 30% of the device maximum, allowing us 100% decremental contrast and 233% incremental contrast relative to this background. This asymmetry is because have found sensitivity to increments lower than sensitivity to decrements in our pilot work.

We will analyze data for each subject separately, and report individual subject data.

We plan to combine all of the catch trials within a session to estimate the false alarm rate for that session, and use this rate to correct the session data for guessing. Thresholds will be determined by fitting a logistic psychometric function to the data, with the slope of the psychometric function constrained to be the same across all conditions in the session. The slope constraint appears reasonable on the basis of our measurements to date, and stabilizes threshold estimates in cases where performance does not reach asymptotic levels. Because we are measuring for both increments and decrements, the contrast range available is limited.

In combining data across sessions, we will use the increment only and decrement only data to normalize each sessions data. This will be done by determining, for each subject, the mean thresholds for these stimuli across sessions, and scaling the data for each session to bring the mean session threshold for these directions into alignment with the across session mean.

One analysis will be to compare the measured thresholds to ideal observer thresholds for same stimuli (Poisson noise limited at the cone excitations, stimulus known exactly). Before comparison, we will scale the decremental contrasts to make the mean decrement only thresholds equal to the mean increment only thresholds, as the ideal observer for this case does not account for any increment-decrement asymmetries in threshold. Ideal observer performance will be scaled to bring into overall alignment with the experimental data. We will also develop computational observers that have arrays of summation units placed after the cone excititaions, and ask whether these can account for the observed data as well as our earlier published summation data.