Confidence in perceptual discrimination and detection

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1 Objective

The current study aims to compare the cognitive processes that govern perceptual discrimination and perceptual detection. Specifically, we wish to:

1. Replicate the finding that metacognitive sensitivity for NO responses is lower than for YES responses in detection (Meuwese, van Loon, Lamme, and Fahrenfort, 2014; Kanai, Walsh, and Tseng, 2010; Higham, Perfect, and Bruno, 2009; Maniscalco and Lau, 2011).
2. Estimate the goodness of fit of an unequal-variance SDT model to perceptual detection data, and compare it to the fit of models that assume a qualitative difference between confidence in absence and confidence in presence.
3. Replicate the results of Zylberberg, Barttfeld, and Sigman (2012) for perceptual discrimination. Namely, show that confidence is mostly influenced by evidence for the selected direction within a short time window around 200 milliseconds after stimulus onset.
4. Test the generality of the results of Zylberberg et al. (2012) to perceptual detection, where, by definition, no evidence can be collected to support a NO decision. Examine the contribution of signal variance.

2 Materials and Methods

2.1 Participants

10 healthy participants will take part in the experiment. Each participant will perform four sessions of 600 trials each, in blocks of 100 trials. Each session will consist of 3 discrimination blocks

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interleaved with 3 detection blocks.

2.2 Experimental Procedure

The experimental procedure for this study will largely follow the procedure described in Zylberberg et al. (2012), experiment 1.

Participants will observe a random-dot kinematogram for a fixed duration of 700 ms. In discrimination blocks, the general direction of motion will be one of two opposite directions with equal probability, and participants will report the observed direction by pressing one of the two respective arrow keys on a standard keyboard. In detection blocks, the general direction of motion will be one of two opposite directions on half of the trials, and completely random on the other half. Participants will report whether there was coherent motion by pressing one of two other arrow keys on a standard keyboard.

In both types of blocks, following a decision participants will indicate the degree to which they considered their response to be correct ("confidence"), reporting on a continuous scale going from chance to complete certainty. To avoid response bias in confidence reports, the scale will be vertical or horizontal in agreement with the type 1 task, and its polarity will be set to agree with the type 1 response. For example, following an down arrow press, a vertical confidence bar will be presented where 'guess' is at the center of the screen and 'certain' is at the lower end of the scale.

To control for response requirement, for 5 subjects the dots will move to the right or to the left, and for the 5 other subjects they will move upward or downward. Whereas the first group will make discrimination judgments with the right and left keys and detection judgments with the up and down keys, this task to response mapping will be reversed for the second group of subjects.

The number of coherently moving dots (called the "motion coherence") will be adjusted the keep participants' performance at around 70% accuracy for detection and discrimination tasks independently. This will be achieved by following these steps once every 20 trials:

- Take the mean accuracy of the last 20 trials $\hat{x}$.
- If $\hat{x} > 0.8$, decrease the coherence level by 3%: $c \leftarrow c - 0.03$
- If $\hat{x} < 0.6$, increase the coherence level by 3%: $c \leftarrow c + 0.03$
- Else, continue.

Stimuli for discrimination blocks will be generated using the exact same process reported in Zylberberg et al. (2012). Stimuli for detection blocks will be generated using a similar process, with the only difference being that on a random half of the trials coherence will be set to 0% (see figure 1).

Subjects will receive no feedback for their performance. At the end of each experimental block (100 trials), subjects will be asked to estimate the number of correct responses they have made.

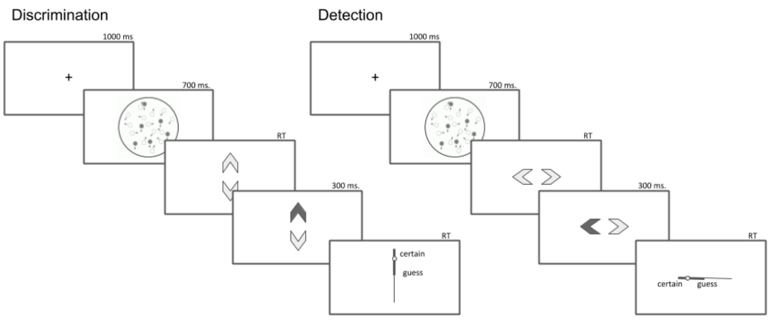

Fig. 1: Task design.

2.3 Transparency

All code and materials for this project are publicly available on github.com/matanmazor/detectVsDiscrimRDK. The current document is uploaded to the Open Science Framework before data acquisition. To time-lock registration with respect to data acquisition, experimental randomization will be achieved using the pre-RNG approach (Mazor, Mazor, and Mukamel, 2017).

3 Analysis and Predictions

3.1 Reverse Correlation

3.1.1 Discrimination

For discrimination blocks, reverse correlation analysis will follow the procedure described in Zylberberg et al. (2012).

3.1.2 Detection

Reverse correlation will be used to contrast trials in which the the participant identified a signal (a YES response) from trials in which they did not identify a signal (a NO response). Additionally, reverse correlation will be applied separately to confidence judgments in YES and NO responses. For detection blocks, reverse correlation analysis will be performed on a) the absolute value of the vertical motion energy, b) the mean motion energy in all directions and c) the variance in the motion energy in all directions.

3.2 Receiver Operating Characteristic (ROC) Curve

3.2.1 Response Conditional ROC curves

Based on previous reports of low metacognitive sensitivity for judgments about absence (Meuwese et al., 2014; Kanai et al., 2010; Higham et al., 2009; Maniscalco and Lau, 2011), we expect to find a difference between the response conditional ROC curves for the detection, but not for the discrimination task. Specifically, we predict that for the detection task the area under the ROC curve for NO responses will be lower than the area under the ROC curve for YES responses.

3.2.2 zROC curves

We predict that the zROC curve for the discrimination task will follow a straight line parallel to the identity line, adhering to the assumption of two unimodal signal and noise distributions of equal variance.

For the detection task, we will compare the fits of a linear regression model and a model that allows the two parts of the curve on each side of the decision point to have different slopes. The first option reflects the family of equal and unequal variance SDT models, and the second option reflects the assumption that confidence in absence is qualitatively different from confidence in presence, regardless of decision criterion.

3.3 Response Times

For each subject, response times will be contrasted for the detection and the discrimination tasks using a nonparametric test. The same test will be applied to contrast response times for YES and NO answers within the detection task, to test the predictions that NO responses are generally slower.

A Spearman correlation coefficient will be computed to quantify the within-subject association between confidence and response times for the discrimination task and for YES and NO answers in the detection task, separately. We hypothesise that the correlation should be negative for discrimination and for YES responses, but that this negative correlation will break for NO responses.

3.4 Global accuracy estimates

Global accuracy estimates will be contrasted between detection and discrimination blocks.

References

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