Different processing strategies underlie mean orientation discrimination in low and high orientation variance

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**Purpose**

- Discriminating the mean orientation of a set of distinguishable elements is typically assumed to be processed by the same strategy independently of the orientation variance across elements: the observer averages the estimated orientation of many elements processed in parallel.

- A manipulation affecting the estimated orientation of each sample should affect performance in low variance but not in high variance.
- Conversely, a manipulation affecting the averaging process (e.g., number of samples) should affect performance whether the precision of each local estimate comes from the observer (low variance of the pdf) or the stimulus (high variance of the pdf).
- Thus, this model predicts similar performance gain in low and high orientation variations as the number of elements increases.
- We challenged the variance-indifference processing assumption by testing this prediction.

**Experiment 1**

- **Objective**
  - Determine whether similar summation effects occur in low and high variance as predicted by the variance-indifference processing assumption.
- **Stimuli**
  - Orientation SD of the pdf (deg)
    - 0
    - 1
    - 2
    - 3
    - 4
  - Number of samples
    - 1
    - 2
    - 4

- **Task**
  - Discriminate whether the mean orientation of the pdf was tilted clockwise or counterclockwise from vertical.

- **Results**
  - Summation effects were measured as the orientation discrimination threshold with 1 sample divided by the orientation discrimination threshold with 4 samples.

- **Discussion**
  - Summation in high variance shows that observers can efficiently average different orientations.
  - The absence of improvement with extra samples (no summation) when there is no variance suggests that observers are not averaging the estimated orientation of many elements independently processed in parallel as typically assumed.

**Experiment 2**

- **Objective**
  - If different processing strategies underlie mean orientation discrimination for no and high orientation variance, then they should be dissociable. Here we look for a double dissociation by manipulating the presentation time and the number of elements.
- **Stimuli**
  - Baseline
  - 2 Gabor pairs 235 ms
  - 1 Gabor pair 215 ms
  - 2 Gabor pairs 47 ms

- **Results**
  - Double dissociation between mean orientation discrimination in no and high variance

- **Discussion**
  - Results were analogous to the ones of experiment 2
  - The number of samples primarily affected threshold in high variance
  - The presentation time significantly affected performance in the absence of variance but not in high variance.
  - The fact that observers were basing their decision on a single sample (Gabor pair)
  - This double dissociation suggests that different processes underlie mean orientation discrimination for no and high orientation variance.

**Experiment 3**

- **Objectives**
  - Determine if summation occurs in the absence of variance for a task that does not require the comparison with an internal reference. (A noisy internal vertical reference common to all samples could explain the absence of summation in the absence of variance.)
  - Determine if summation occurs in the absence of variance when the observer does not know that all samples have the same orientation. (Observers could have focused on a single Gabor when they knew that they all had the same orientation.)
- **Stimuli**
  - All stimuli were symmetrical relative to the horizontal axis (upper and lower Gabor pairs had opposite orientations).
- **Task**
  - Discriminate whether the upper Gabor pairs were tilted clockwise or counterclockwise relative to the lower Gabor pairs (∴ vs ∵).
- **Procedure**
  - Trials of different variances were interleaved so that the observer did not know the SD of the pdf which forced them to consider all samples even in low variance.
- **Results**
  - Double dissociation between mean orientation discrimination in low and high variance

- **Discussion**
  - Results were analogous to the ones of experiment 2
  - The number of samples primarily affected threshold in high variance
  - The presentation time significantly affected performance in the absence of variance.
  - The absence of summation in low variance cannot be explained by a noisy internal vertical reference common to all samples.

**Conclusions**

- Different processing strategies underlie mean orientation discrimination in low and high orientation variance.
  - In high variance, performance depends on the averaging process which follows coarse orientation estimation of many elements processed in parallel.
  - In low variance, the absence of summation suggests that observers are not averaging the estimated orientations of many identical elements presumably because the estimated orientation precision of each element decreases with the number of elements averaged.
- Factors affecting performance in high variance (e.g. averaging efficiency) may not equally affect performance in low variance as generally assumed when using external noise paradigms.
- The variance-indifferent processing assumption can be violated which limits the application of external noise paradigms.