Changes in decisional criteria and bias during perceptual learning

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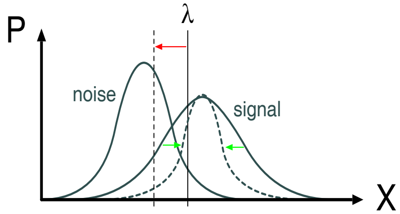
Introduction

Theories of perceptual learning typically concern themselves solely with changes in perceptual sensitivity as a function of experience (see Fahle & Poggio, 2002, for a review). In addition, the methods used to investigate perceptual learning typically assume that observers are either unbiased or that decisional biases are negligible or constant across time (e.g., Dosher & Lu, 1999). However, it is altogether possible that decisional influences may be at work (e.g., Ahissar & Hochstein, 2002).



Signal detection theory (e.g., Green & Swets, 1966) provides an approach to characterizing the various ways in which changes in performance could occur in a perceptual learning task. One possibility is that practice could lead to either a shift or a narrowing of the distribution of perceptual evidence (as in, e.g., Dosher & Lu, 1999; see narrowing in figure, right). A second possibility is that practice could produce a shift in the decisional criterion (λ in figure, right), with additional possibilities suggested by the combinations of these factors.

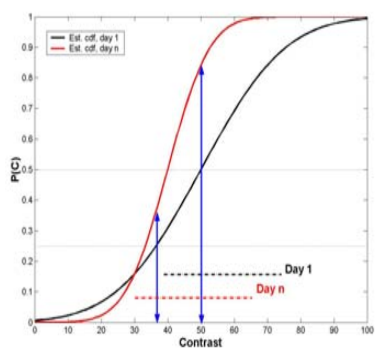
To our knowledge, there has been no systematic consideration given to the possibilities of decisional influences on perceptual learning. However, last year we (Copeland & Wenger, 2003) presented an initial investigation that provided evidence for the presence of *liberal shifts* in response criteria, in perceptual learning of contrast detection and discrimination. The present study extends the previous one by (a) replicating critical effects and (b) introducing a way of estimating
the impact on sensitivity, with a sole focus on contrast detection.

Method

The present study used a *detection task* that involved variations on the *method of constant stimuli* used in Copeland and Wenger (2003). The stimuli in this task were a set of monochromatic Gabor patches that varied only in amplitude (contrast). Observers were presented with a range of contrasts; equal numbers of target-present and target-absent (no contrast) stimuli were presented, and observers were required to give either a positive or negative response. The contrast range used in each session was shifted to follow changes in observers' performance (see figure right). A total of nine naïve observers were tested.

Detection thresholds were estimated for each observer, in each session, by fitting a linear form of the Weibull cdf. Threshold was defined as the contrast for which accuracy exceeded .79. The estimated cdf for the initial session was used to select two contrast levels, corresponding to the 25th and 50th percentile of this cdf. Hit rates for these two levels of contrast were estimated from the data for each of the subsequent sessions. The false alarm rate in each session was used with these estimated hit rates to estimate the signal detection theory measures of discriminability and bias.

The possible impact of strategy shifts on sensitivity is estimated by determining a hypothetical sensitivity that assumes that a mirror effect for the changes in hits and false alarms.



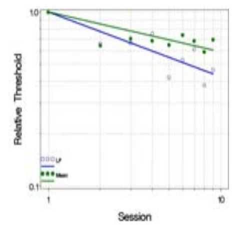
Results

Summary of performance changes for all nine observers. Arrows indicate statistically reliable changes.

Obs	DT	Slope	hit_{50}	hit_{25}	fa	d'_{50}	d'_{25}	c_{50}	c_{25}
DT	↓	↑	↑	—	—	↑	—		—
EN	—	↑	—	—	↓	↑	↑		—
KK	↓	↑	↑	—	—	↑	—	↓	—
KE	↓	↑	↑	—	↑	—	—	↓	—
KR	—	↑	↑	—	—	↑	—	↓	—
LF	↓	↑	↑	↑	↓	↑	↑	↓	—
RJ	↑	↑	↓	↓	↓	—	—	↑	↑
JV	↓	↑	↑	↓	—	—	↓	↓	—
RS	—	↑	—	—	↑	↓	↓	—	↓

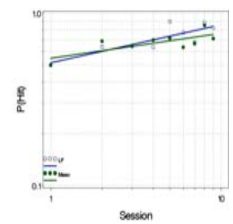
1

5 of 9 observers showed reliable decreases in detection thresholds. Blue: Observer LF. Green: Mean for the five observers.



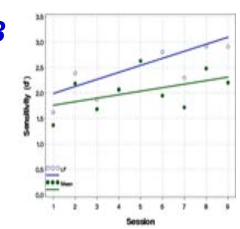
2

6 of 9 observers showed reliable increases in hit rates. Blue: Observer LF. Green: Mean for the six observers.



3

Only 3 of the 5 observers who showed reliable decreases in threshold showed reliable increases in sensitivity. Blue: Observer LF. Green: Mean for the 5 observers.



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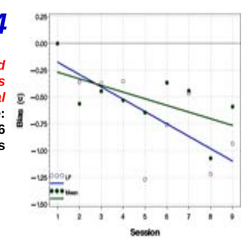
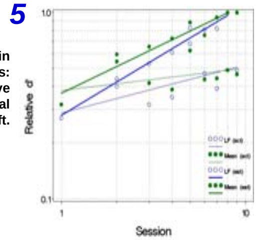
All of the observers who showed decreases in threshold or increases in hit rates showed reliable liberal shifts in response criterion. Blue: Observer LF. Green: Mean for the 6 observers



5

Hypothetical sensitivity. Thin lines: measured *d'*. Thick lines: estimated *d'* that would have been obtained without the liberal shift.



Conclusions

1) A reliable liberal shift in response bias was obtained for each observer who showed a reliable improvement in contrast detection. These results are consistent with those reported last year (Copeland & Wenger, 2003), and suggest that the possibility of decisional influences deserves both theoretical and methodological attention.
2) An estimation of sensitivity without strategy changes showed that observers may perform better without them by up to ca. 45%.
3) Future work focuses on the application of this method to other perceptual tasks, and on an extension of the hypothetical sensitivity estimates to bias estimates.

References

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