Endogenous attention and contrast detection in external noise

Rémy Allard & Patrick Cavanagh

Purpose

- Endogenous attention can improve contrast thresholds for low-level tasks such as an orientation discrimination task.
- Endogenous attentional benefits could be mediated by
  - A contrast gain or stimulus enhancement that increases the contrast of the stimulus.
  - Noise exclusion or filter narrowing that reduces the impact of external noise or distractors.
- Ling and Carrasco (2006) found that, for a fine orientation discrimination task in noiseless conditions, endogenous attention improved contrast threshold without improving performance in supra-threshold conditions suggesting that attentional benefit is mediated by a contrast gain.
- In contrast, Lu et al. (2009) found that endogenous attention improved contrast threshold in the presence of local noise and not in noiseless conditions. They concluded that endogenous attentional benefit is mediated, not by contrast gain, but by noise exclusion occurring before the additive internal noise.
- However, we recently found evidence that the spatial and temporal extent of the external noise greatly alters its impact and specifically when the external noise is spatially and temporally coincident with the stimulus, it qualitatively changes the processing (Allard and Cavanagh, 2009). We argue that, since internal noise is expected to be spatially and temporally broad, similarly broad external noise should be used to get an appropriate test of noise exclusion versus contrast gain without triggering a change in the nature and strategy of the stimulus processing itself.
- In the present study, we evaluated the impact of endogenous attention on a detection task in no noise, local noise and broad noise conditions.

Stimuli

- No noise
- Local noise
- Broad noise

Procedure

- The signal, i.e. vertical sine wave gratings, was presented for 59 ms.
- The cue (arrow or circle) and the 8 peripheral circles appeared 236 ms before the signal onset and disappeared 236 ms after the signal offset.
- Localized noise was presented simultaneously with the signal and was static.
- Spatially and temporally broad noise was always present and was resampled every 59 ms.
- Contrast detection thresholds were measured using a 2 interval-forced-choice paradigm
- For the focused, endogenous attention conditions, arrows were always informative of the signal location in the interval containing the signal and pointed to random location in the no-signal interval.

Results

- The similarity of the endogenous attentional benefits in two of the three conditions — no noise and broad noise — suggests that the benefits were mediated by noise exclusion occurring after additive internal noise (see bottom right plot at top of poster). We found no evidence of contrast gain or noise exclusion attentional benefit occurring before the internal noise, which would have produced different benefits in the no noise and broad noise conditions¹ (as in the two top plots at top of poster).
- A different pattern of results was observed with local noise where the attentional benefit was greater than in the broad noise condition. If the attentional benefit observed with local noise was due to a noise exclusion, then it should be the same or even greater in the broad noise case where there was more noise to exclude. However, the opposite result was observed: the attentional benefit is less for broad noise than local noise. To explain this result, we suggest that the local noise induced a qualitative change in processing, narrowing the spatiotemporal properties of the attentional noise-exclusion filter compared to that in place when no external noise is present. This implies that the nature of the filtering changes as the external noise contrast increases, invalidating the logic behind the external noise analysis of attentional benefits. This processing confound can also explain earlier results (e.g. Lu et al., 2009) that had been attributed to noise exclusion occurring before the additive internal noise. Our results suggest that the external noise paradigm should use only spatially and temporally broad external noise in order to match the likely characteristics of the internal noise and leave the filtering characteristics unaffected as external noise contrast is increased.

References


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¹ We cannot exclude the possibility that a combination of a contrast gain and noise exclusion occurring before additive internal noise mediated attentional benefits.