Nothing more than a curve?
A common mechanism for the detection of radial and non-radial frequency patterns

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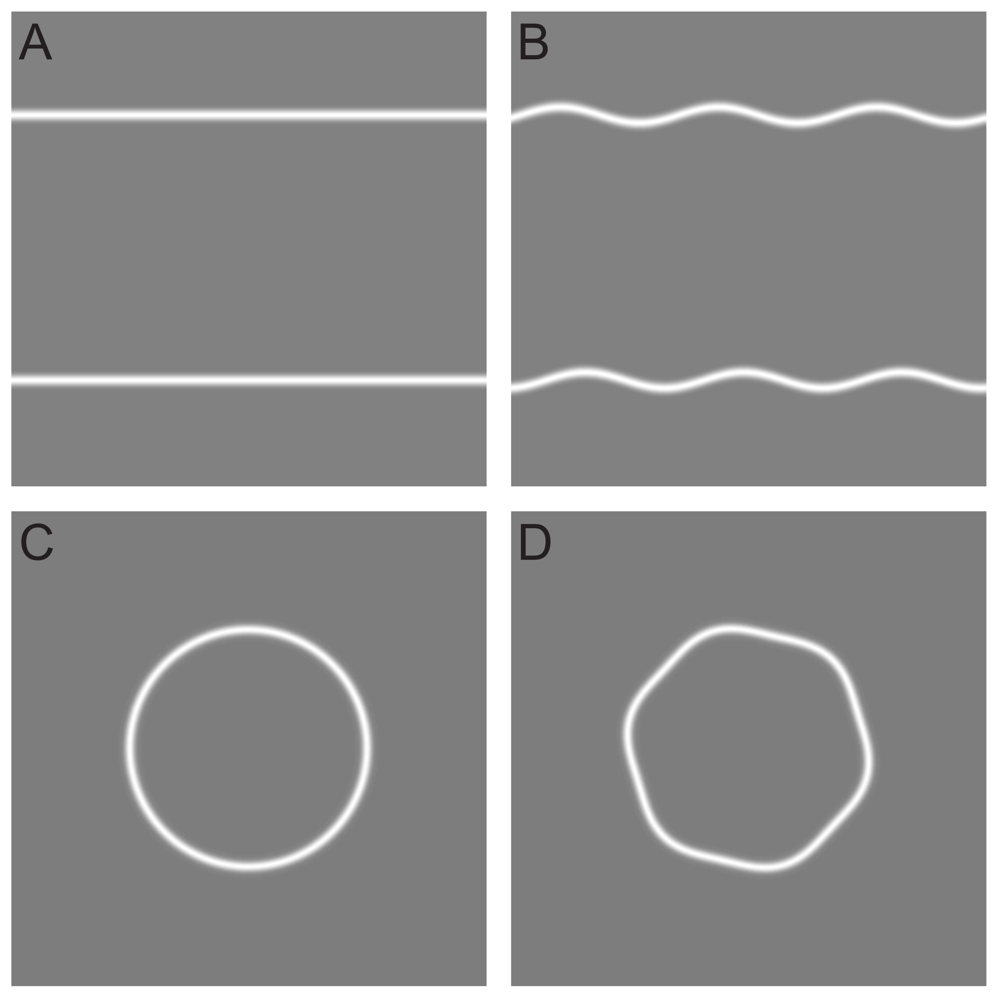
BACKGROUND

Radial Frequency (RF) patters are sinusoidal modulations of a radius in polar coordinates (*Wilkinson, Wilson, & Habak, 1998*).
Theoretically, RF pattern detection (discrimination against a circle) could be realized by either local filters matched to parts of the pattern, or by a global mechanism operating on the scale of the entire pattern. Wilkinson et al. (1998) argued that the high sensitivity for the detection of RF patterns could not be explained by the analysis of local orientation or curvature, but instead suggested pooling of local information into a global representation of the shape.
However, recent evidence questions the global processing of RF patterns (*Baldwin, Schmidtmann, Kingdom, & Hess, 2016*).

AIM

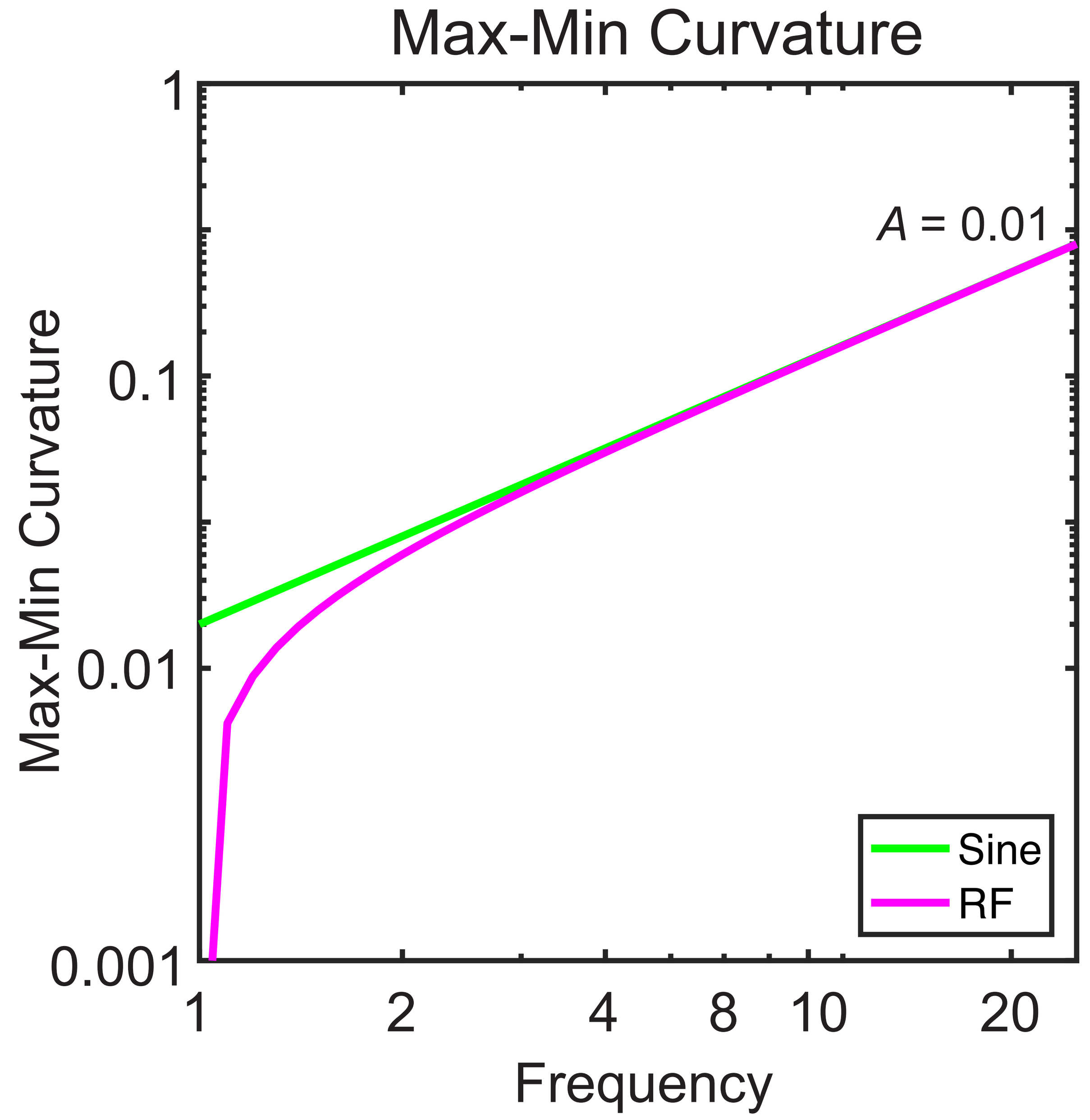
This study aims to challenge the current view on RF detection and suggests a model based on the detection of local curvature to account for the pattern of thresholds observed for both radial and non-radial (e.g. modulated around a straight line) frequency patterns.

STIMULI

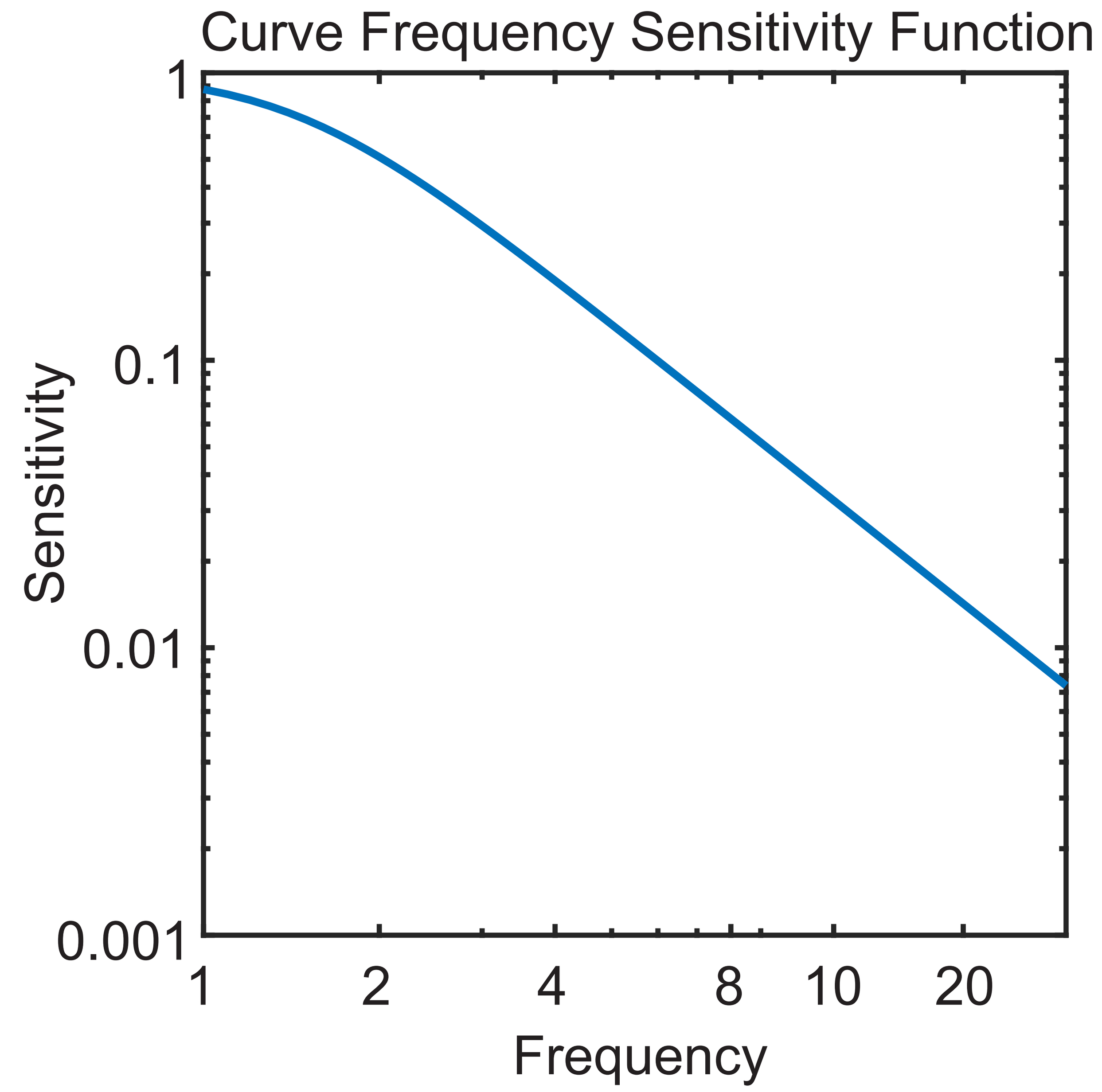


Detection thresholds for Radial (RF) and non-radial (Sines) patterns were measured in a 2-AFC. Twelve frequencies were used: 1, 2, 3, 4, 6, 8, 10, 12, 14, 16 18 and 20. The Figure shows stimulus examples of with a high modulation amplitude (supra-threshold) and a frequency of 6.

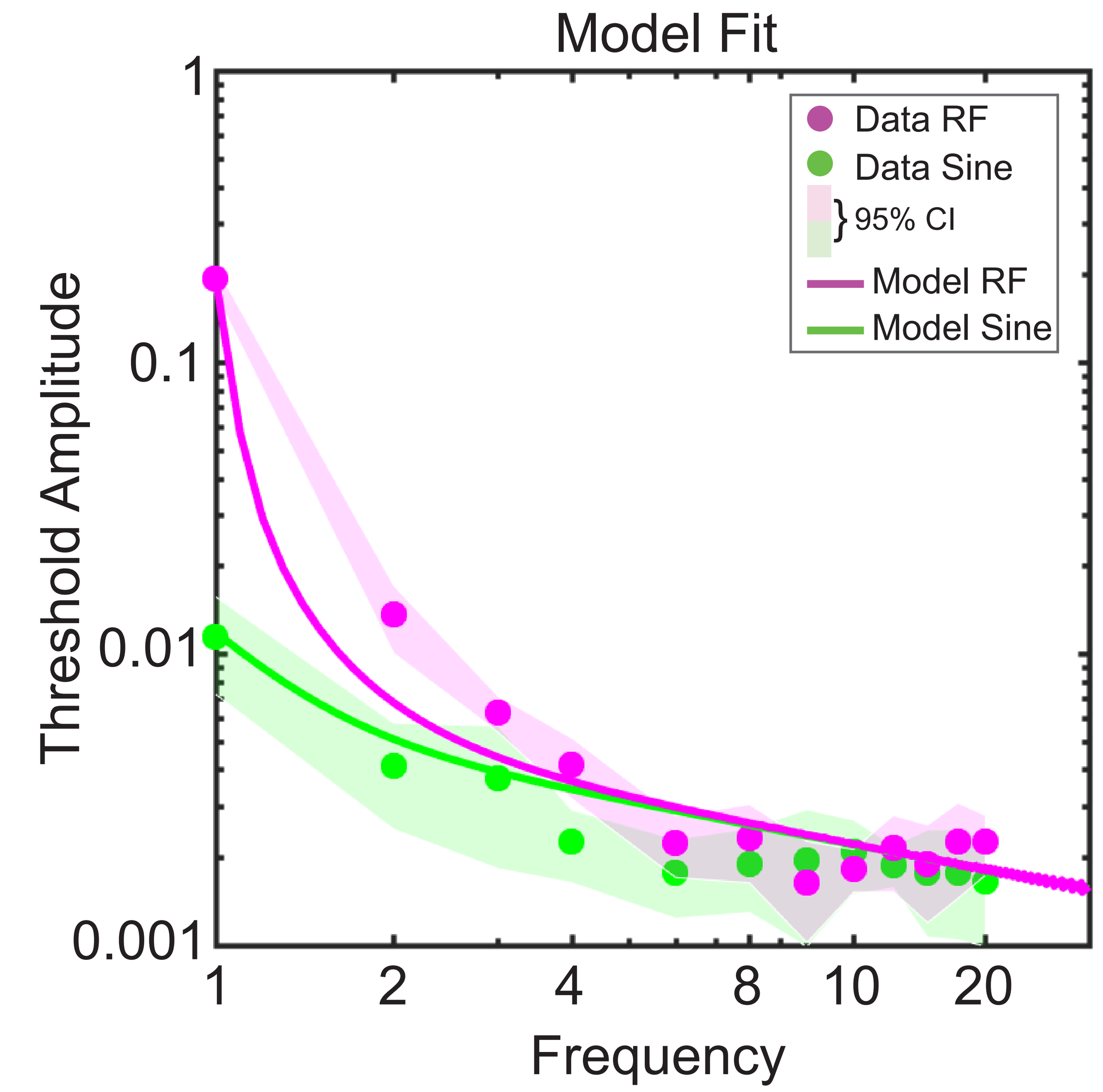
MODEL



The Figure shows a metric defined by Max-Min curvature for RF patterns and Sines as a function of frequency for different modulation fixed amplitudes (*A*=0.01) in log-log coordinates.
RF (magenta): Max-Min curvature increases with increasing frequency. The metric is characterized by an initial non-linear increase and a subsequent linear increase.
Sines (green): the metric is characterized by a linear increase with increasing frequency.



The model assumes a Curve Frequency Sensitivity Function (CSFF), which is characterized by a flat followed by declining response (sensitivity) to curvature as a function of modulation frequency. The decline in response to curvature at high modulation frequencies embodies the idea of a perceptual limitation for high curve frequencies.



Data

RF (magenta): Detection threshold decrease with increasing number of frequency and plateau at a frequency of ~ 6.
Sines (green): The initial decrease in thresholds is much shallower compared to RF patterns. Thresholds for frequencies between 5 - 20 do not significantly differe between RF patterns and Sines.

MODEL

The CSFF explains the initial decrease in detection thresholds for low RFs followed by the asymptotic thresholds for higher RFs (*Wilkinson, Wilson, & Habak, 1998*) and similarly accounts for results with non-radial frequency patterns (*Mullen, Beaudot, & Ivanov, 2011; Prins, Kingdom, & Hayes, 2007; Tyler, 1973*).

CONCLUSION

In summary, our model suggests that the detection of shape modulations for non-radial and radial frequency patterns is processed by a common curvature-sensitive mechanism that is independent of whether the modulation is applied to a circle or a straight line and that therefore radial frequency patterns are not special.

NSERC CRSNG

Wilkinson, Wilson, & Habak, 1998, Vision Research
Baldwin, Schmidtmann, Kingdom, & Hess, 2016, Vision Research
Mullen, Beaudot, & Ivanov, 2011, Journal of Vision
Prins, Kingdom, & Hayes, 2007, Vision Research
Tyler, 1973, Journal of Physiology