RF shape channels: The processing of compound Radial Frequency patterns

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INTRODUCTION

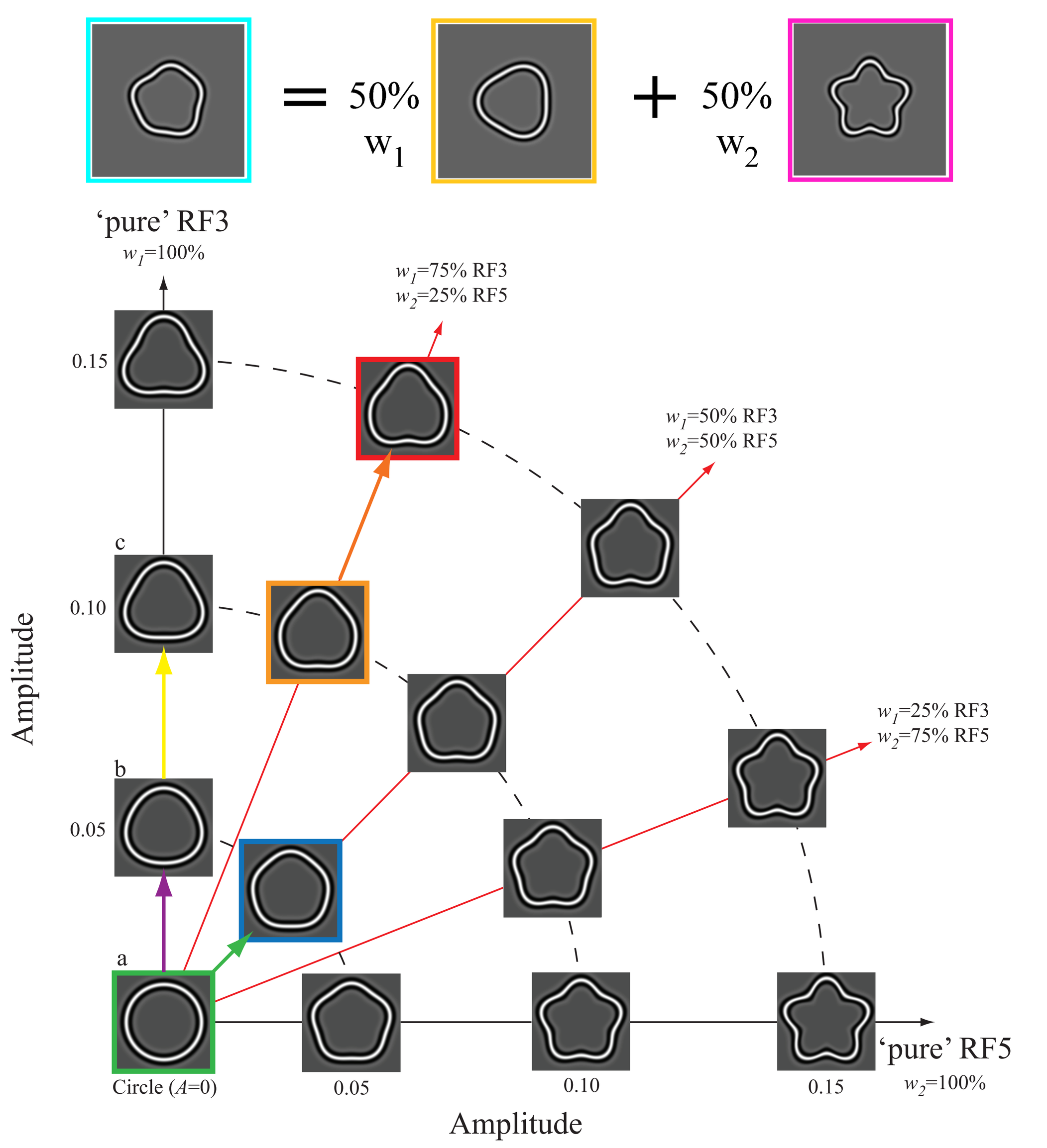
- Radial Frequency patterns (RF) have been extensively used to study intermediate stages of shape perception *(Wilkinson et al., 1998; Loffler, 2008; Schmidtmann et al., 2012)*.
- Combinations of RF patterns can be used to investigate natural shapes like faces or fruits/vegetables.
- Previous studies showed evidence that different RF patterns are processed by different independent narrowly-tuned RF shape channels *(Bell & Badcock, 2009; Bell et al., 2007; 2009, cf. Dickinson et al, 2013)*.

AIMS

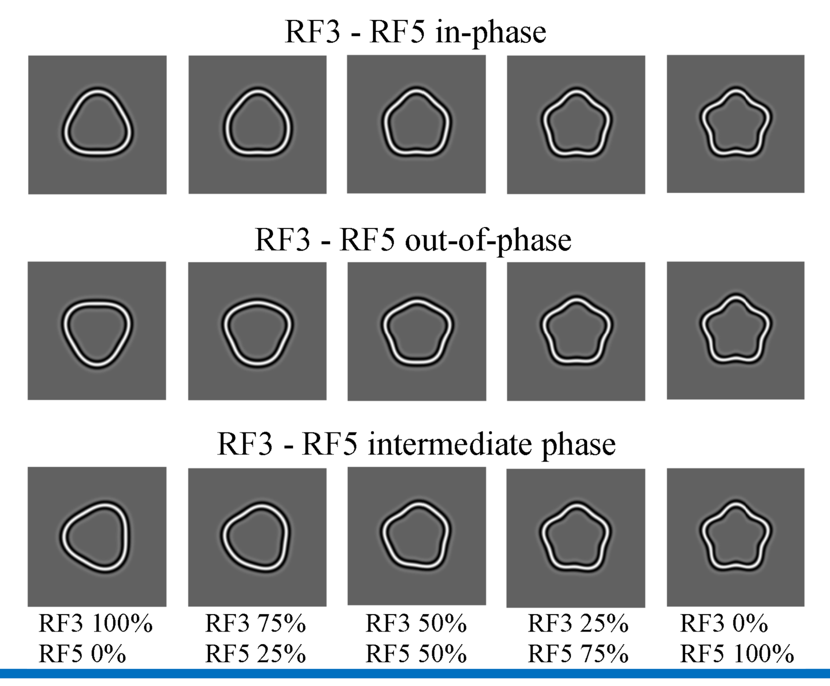
- To test the multiple RF shape channel hypothesis for a wide range of near-threshold and supra-threshold (high modulation amplitude) shapes
- To model summation with a Signal Detection Theory (SDT) Additive and Probability Summation Model (*Kingdom et al., 2015*)

METHODS

$$r(\theta) = r_{mean}(1 + w_1 \cdot A \cdot \sin(\omega_1\theta + \varphi_1) + w_2 \cdot A \cdot \sin(\omega_2\theta + \varphi_2))$$



Fraction of theoretical shape space spanning RF3, RF5 and various morphs of them.



PREDICTIONS

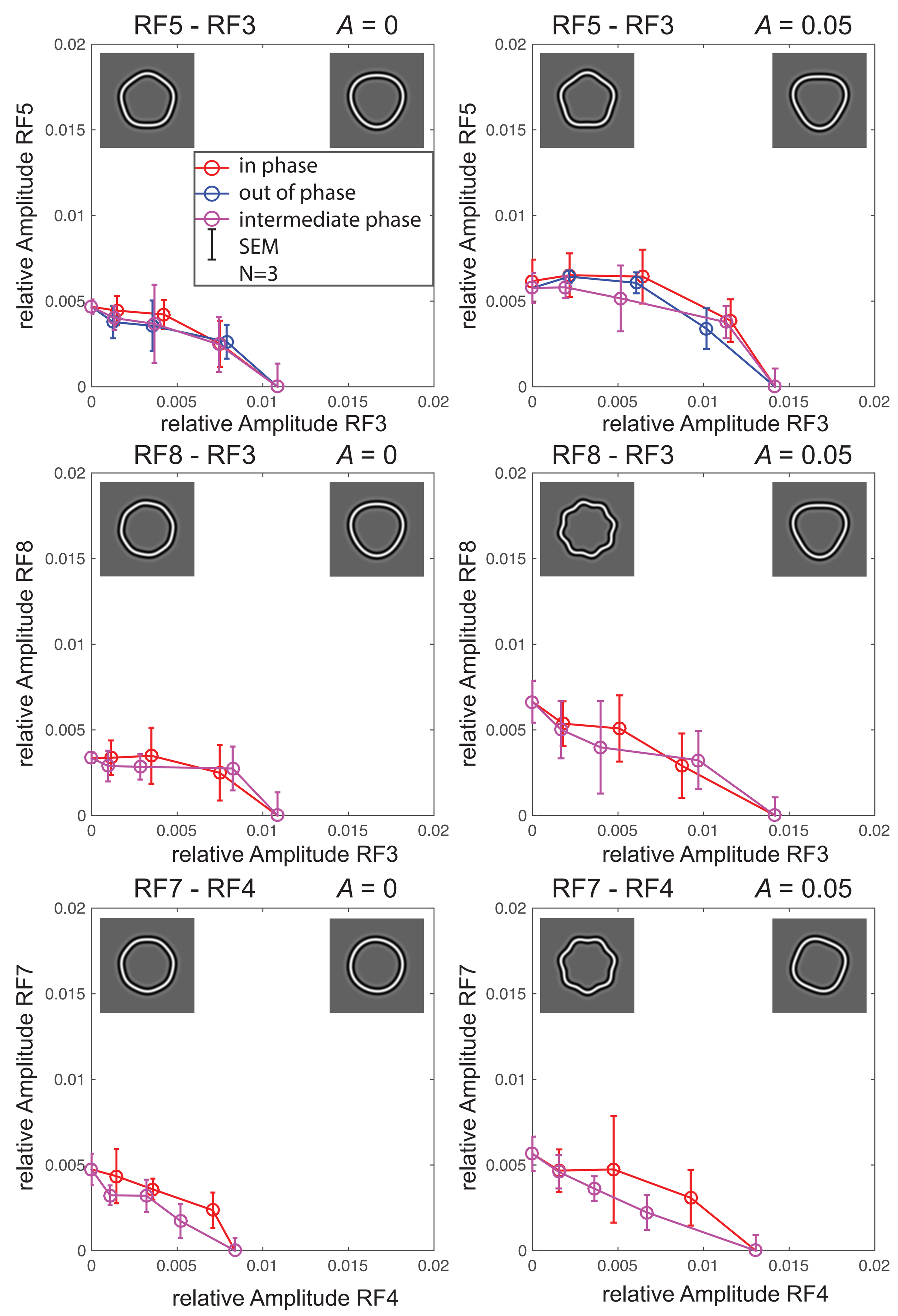
Additive Summation (AS)

If both RF components were processed by a common broadband channel, one would expect a substantial increase in sensitivity as the information from both components would be summed within the same channel.

Probability Summation (PS)

If the two components were processed independently by separate channels, one would expect only a slight increase in sensitivity for the compound compared to the components.

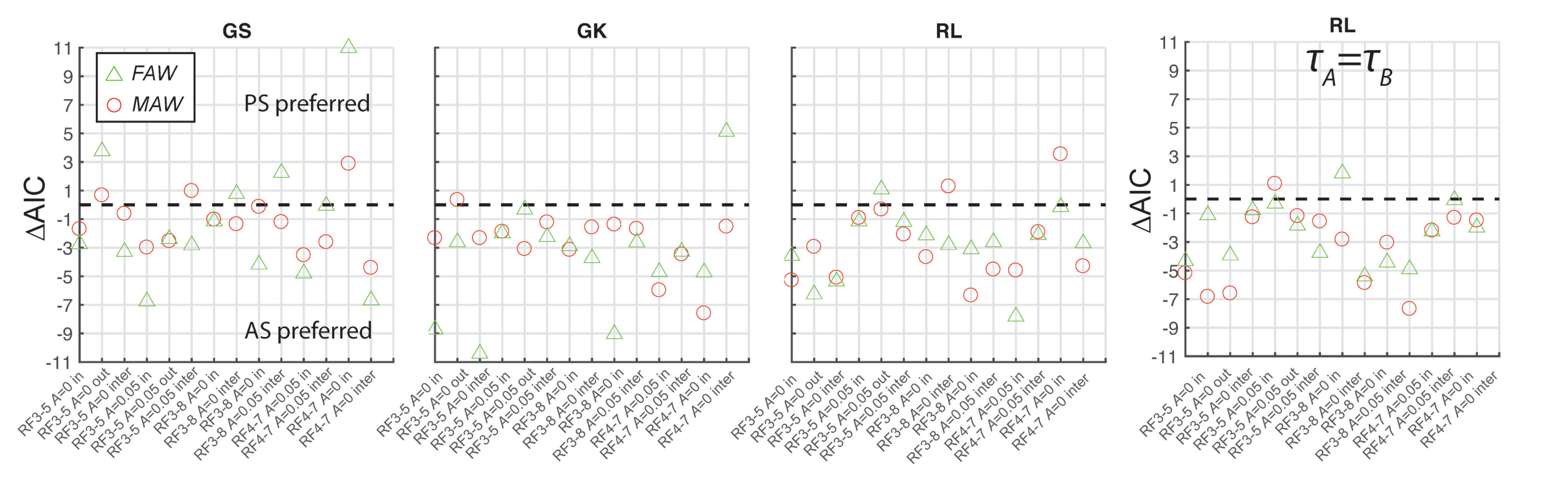
RESULTS



MODEL

- PS / AS model under Signal Detection Theory for a 2-IFC task (*Kingdom et al., 2015*)
- The model calculates the proportion correct based on the PS of *n* signals presented in *n* out of *Q* spatial locations, with all signals having the same *d'*, for a M-AFC (M-AFC) task, under the assumptions of SDT and assuming an unbiased observer.
- PS and AS for unequal stimulus strengths for two summation scenarios termed by Kingdom et al. (2015) 'Matched Attention Window' (*MAW*) and 'Fixed Attention Window' (*FAW*) (the latter term first proposed by Tyler & Chen, 2000).
- The difference in the two scenarios is reflected in the parameter *Q* which indicates the number of channels that are monitored by the observer on each trial.
- In the *MAW* scenario, the observer only attends to those channels that contain a signal in one or other of the forced-choice pair.
- Given that the component and compound shapes were presented in separate blocks, this is a plausible scenario.
- Under this scenario *Q*, the number of channels monitored is the same as *n*, the number of signals.
- Thus for our component data *Q* and *n* both equal 1, while for the compound data *Q* and *n* both equal 2.
- However, given that the observers were naïve as to whether in each block they were detecting a component or a compound, it is also possible that they monitored on all trials both channels – this is the FAW scenario - in which case *Q* is 2 for both components and compounds.
- In the above analyses, we allowed the transducer exponents for the two components to be different.
- However, one could argue that they should be constrained to be equal, so we decided to model one of the naive observer's (RL) data with this constraint.
- Model comparison: Akaike Information Criterion (Akaike, 1974)

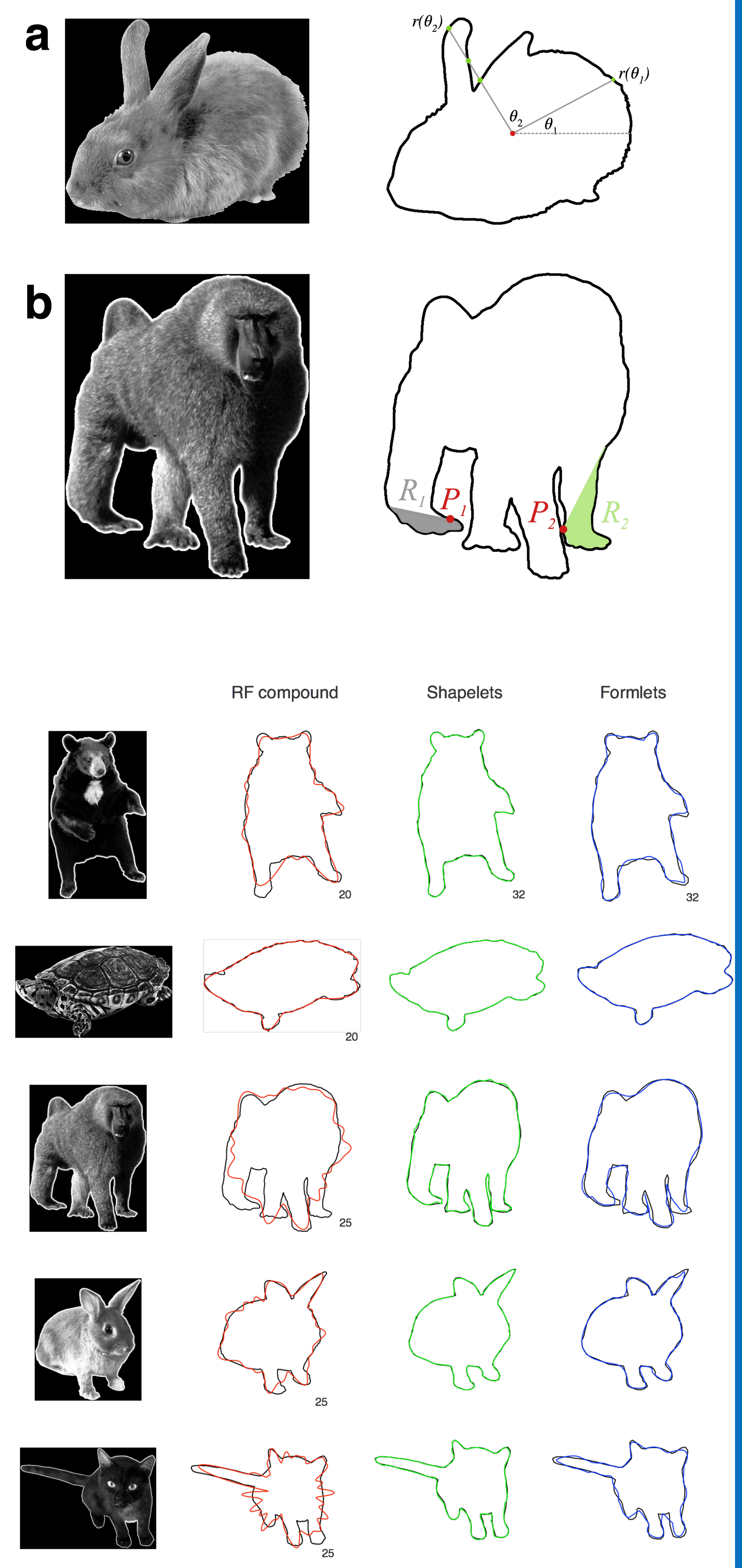
MODEL RESULTS



AS provides the better model fits

RF functions as shape descriptors

Limitations



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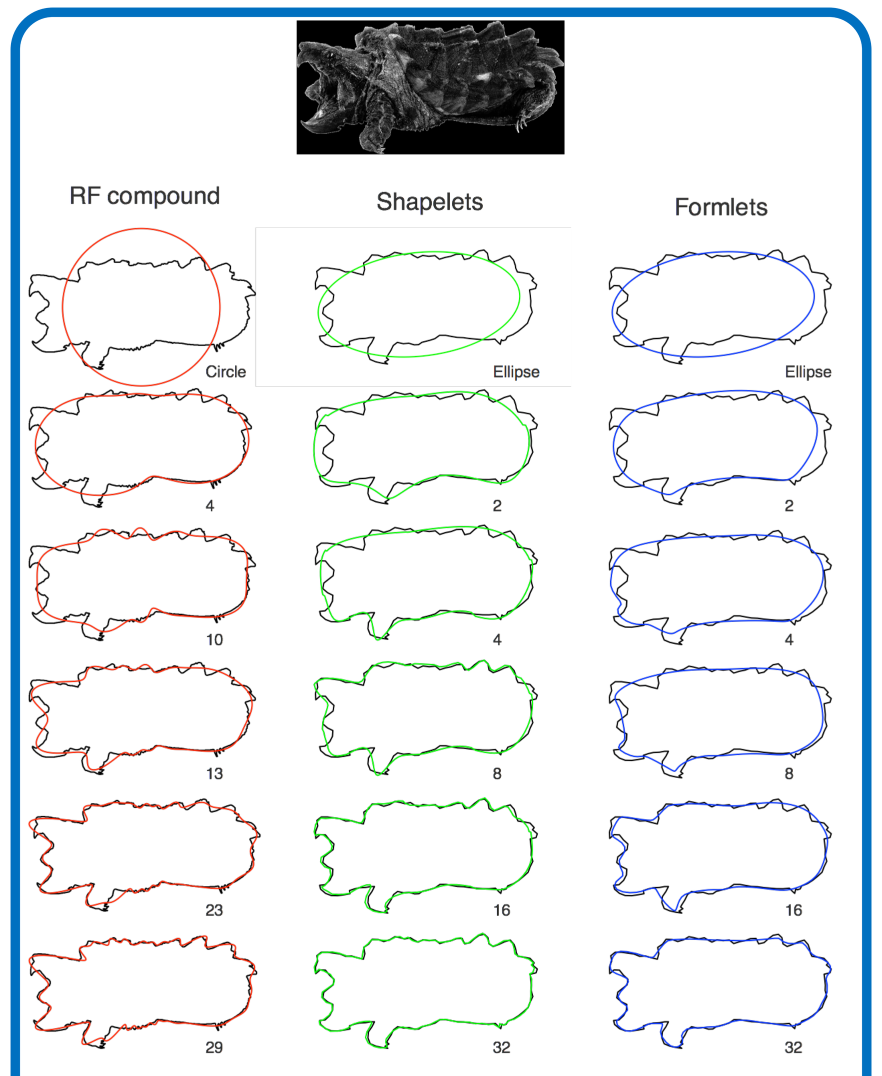

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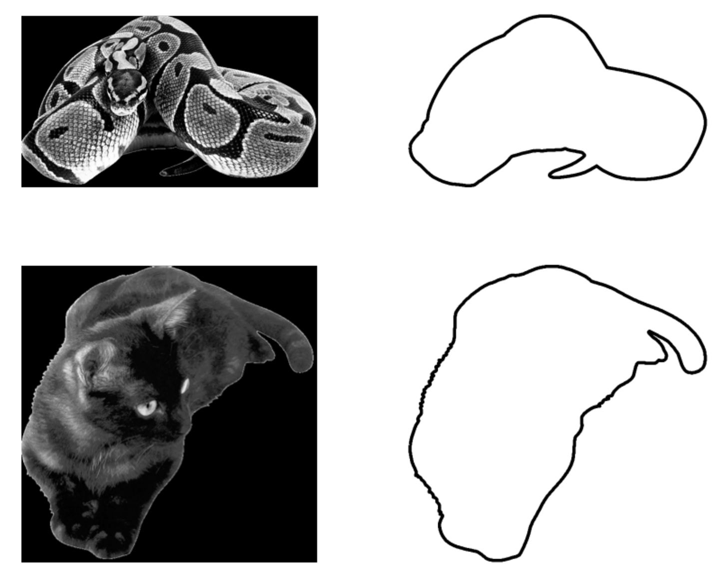
- Simulations show that combinations of RF basis functions can only describe a small subset of shapes.
- due to their mathematical limitations RF basis functions are *not* suited as universal shape descriptors utilized by the visual system



DISCUSSION

Results show that summation of information from different RF components is consistent with AS.

This suggest that the shapes tested here are processed by a broadly tuned mechanism; no evidence for RF shape channels.

Complex shapes are unlikely to be encoded by RF functions, because RF patterns are not suited as universal shape descriptors.

References

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