Quantifying environmental constraints on the signaling strategies of Australia's dragons

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Background

To appreciate fully the forces that shape the behaviour of animals, it is necessary to understand the information-processing tasks under evolution-relevant conditions. Knowledge of the environment in which animals operate and the sensory processing demands that mediate behaviour are crucial. Two fundamental questions arise:
1. How are biologically relevant stimuli distinguished from noise?
2. What are the sensory limitations that necessitate a change in behaviour?

A Problem

Animal signals are a useful system to understand sensory & environmental constraints as they have evolved to be effective in the environment in which they are emitted. However, we must consider in more detail the habitats in which signaling takes place. A solution is needed for motion signals that allows for simultaneous consideration of the physical movements of plants, microhabitat structure, environmental variables and animal signals. **Our solution is to use a *virtual lens*.**

Our solution | Use 3D animation to consider *the motion ecology of animals through a* virtual lens

Real world scenes

recreated in a virtual world

can be a powerful tool in sensory biology

Our focus | The territorial displays of Australia's dragon lizards

Introduction

Research into animal motion signalling must address the fundamental questions proposed above. The territorial displays of Australia's dragon lizards, and the richly contrasting environments they inhabit, will show the **important link between sensory systems, environment and motion-based behaviours**.

Questions

One | How does plant motion and the light environment affect detection of lizard displays?

Two | Could lizards change behaviour to minimise environmental constraints?

Approach

- Saliency analysis (artificial neural network) used to analyse animation sequences frame-by-frame
- The salience of lizard movements determined
- Salience scores [0-1] compared to a threshold for detection and the proportion of sequence duration above threshold computed

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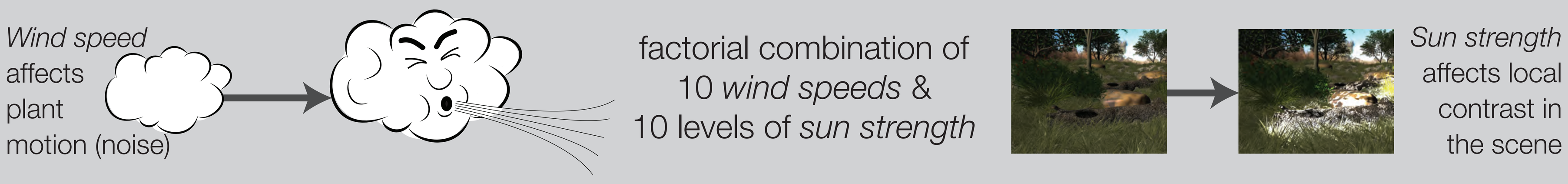
One | Plant motion and the light environment

Short answer: Plant motion constrains the effectiveness of lizard displays, but this is mediated to some extent by the light environment

We created **100 animation sequences** varying in wind speed and sun strength



As receiver attention is not constant, we examined multiple thresholds for response

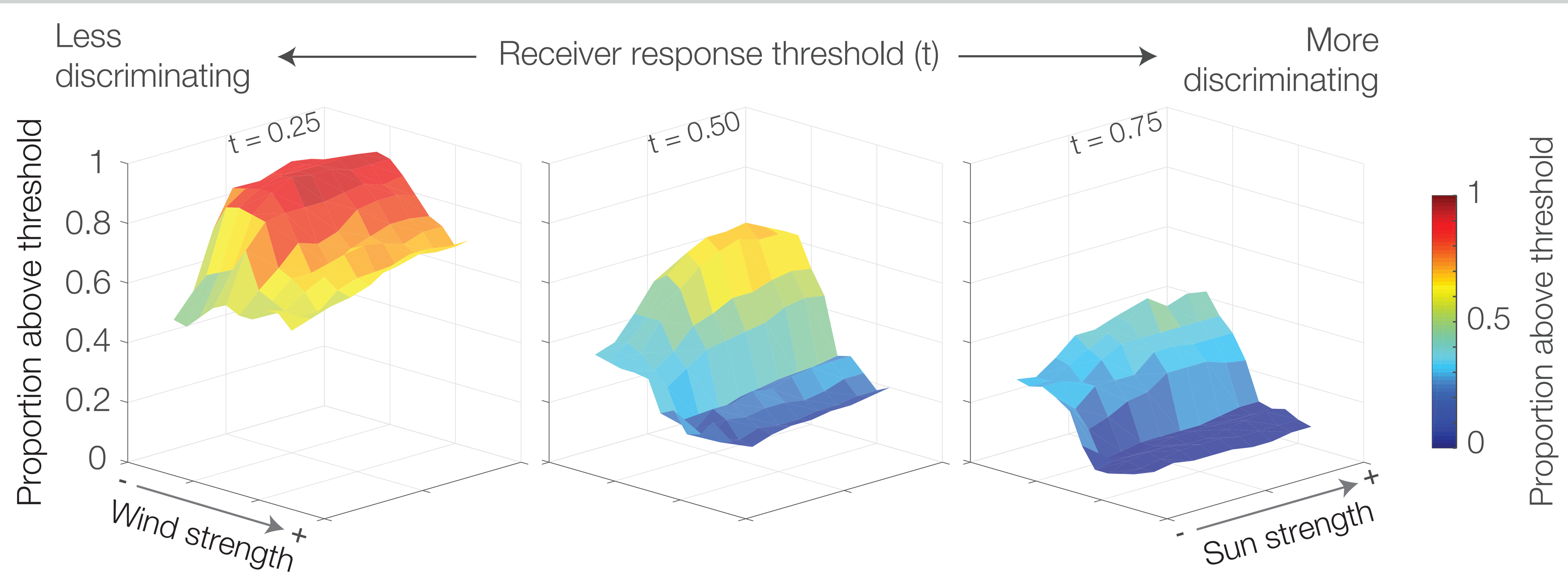
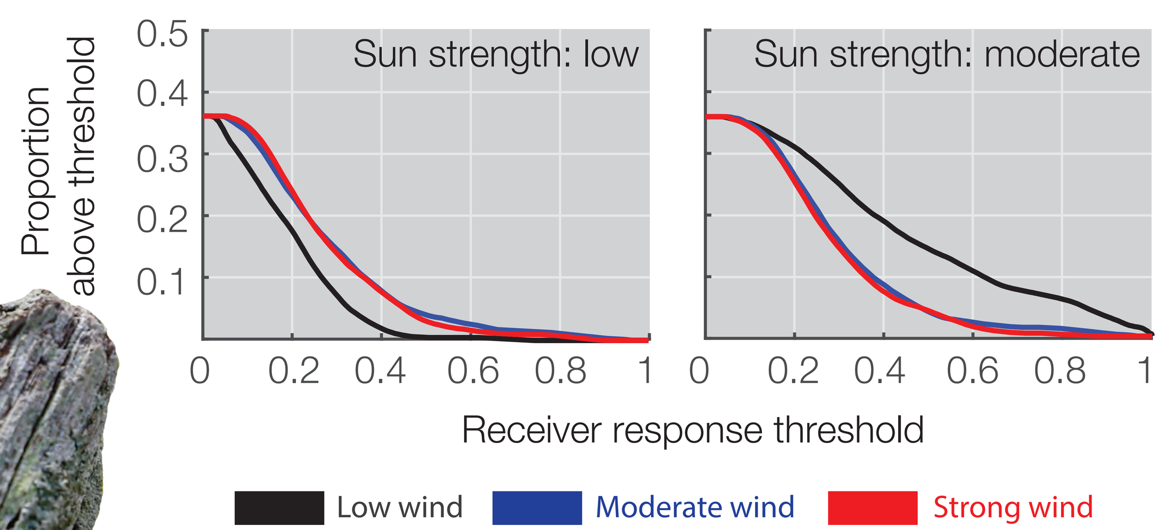
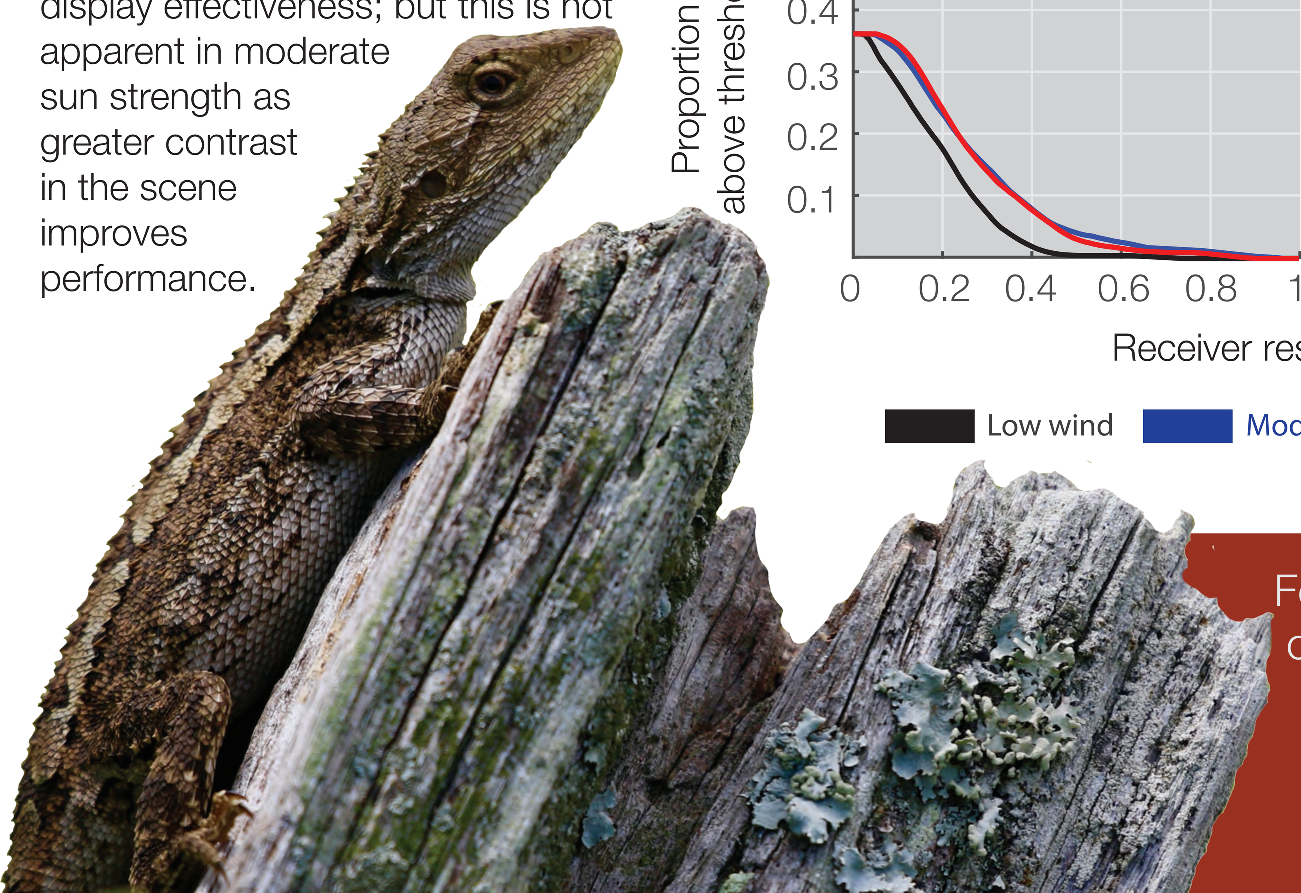


Figure 1 | Proportion of sequence with salience score above threshold for detection for low (left), moderate (middle) and high (right) receiver thresholds. Signal effectiveness declines with increasing wind speed. However, at low wind speeds, performance improves when there is greater contrast in the scene; this is most pronounced at moderate receiver thresholds (middle).

Figure 2 | Proportion above threshold as a function of changing reciever thresholds for response, shown for low and moderate sun strength values. Lines represent **low (black)**, **moderate (blue)** and **strong (red)** wind speeds. At low sun strength, adding plant motion improved display effectiveness; but this is not apparent in moderate sun strength as greater contrast in the scene improves performance.

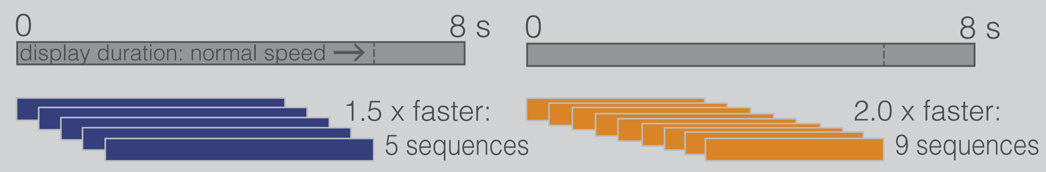




Two | Could a change in behaviour help?

Short answer 1: Signalling faster improves the salience of movements, but reduces the time frame for detection (unless you signal for longer)

Under moderate wind conditions and sun strength, we created multiple sequences at 1.5 & 2.0 times faster than normal speed



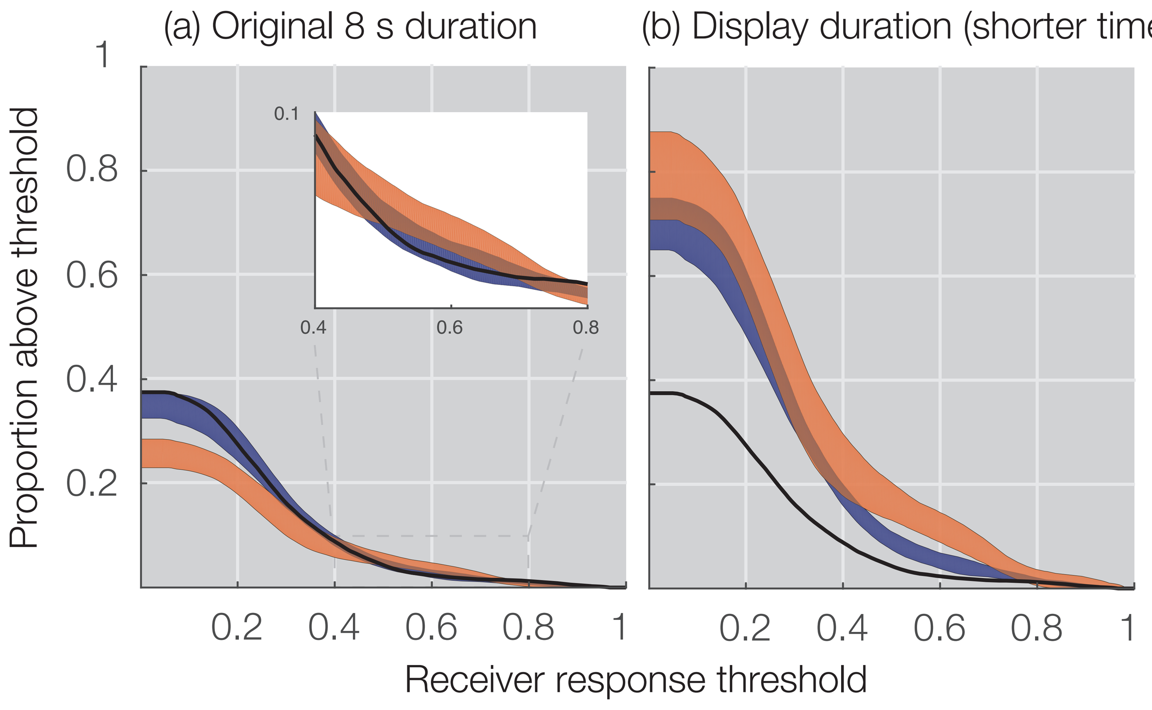


Figure 3 | Proportion above threshold as a function of changing receiver thresholds for response, shown for normal speed (black line), as well as **1.5 x faster** and **2.0 x faster**. Effectiveness varied between animations within a given speed group as plant motion varies. (a) Performance is generally lower due to the reduced time period for detection, although signalling 2x faster might have beneficial outcomes (see inset). Nevertheless, the salience of display movements *per se* improves (b).

Short answer 2: Changing orientation could improve signal effectiveness.

Under moderate wind conditions and sun strength, we created multiple sequences in which the lizard moved in an identical manner but was oriented differently in each case.

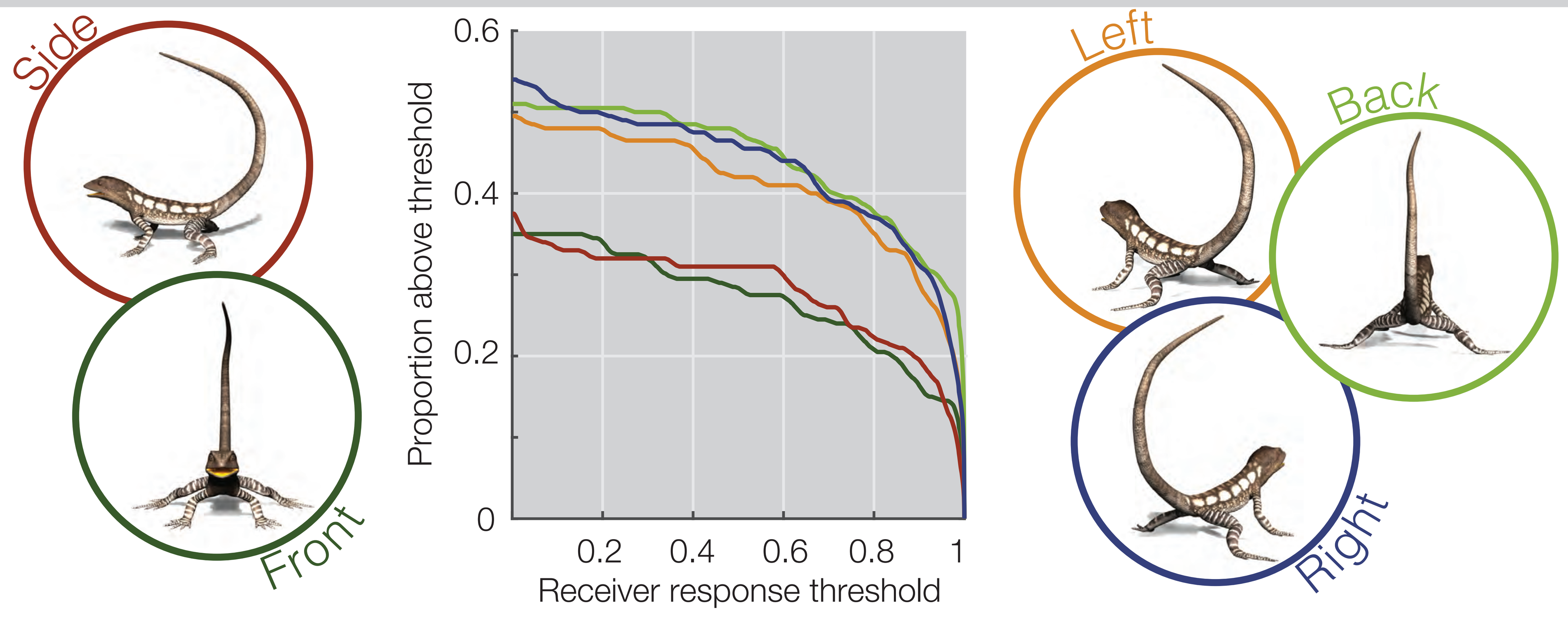


Figure 4 | Proportion above threshold as a function of changing reciever thresholds for response, shown for five different signaller orientations. The effectiveness of movements depend on orientation, which are subject to occlusion by objects in the environment.

For extra content: images & videos

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