Shape-Induced Distortion of Spatial Judgements

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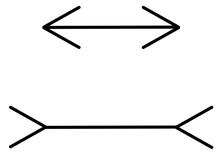
INTRODUCTION

Spatial judgements can be distorted by context, as evidenced by numerous visual illusions.

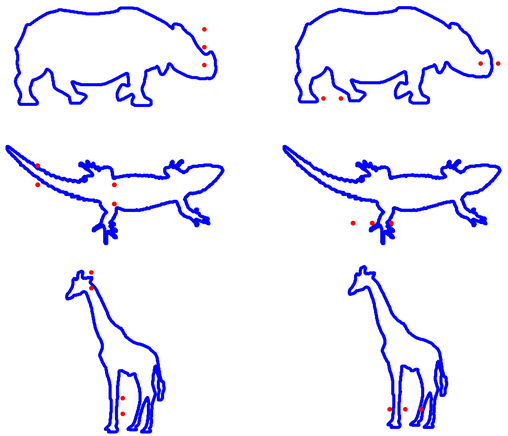


Müller-Lyer, FC (1889)

Titchener (1901)

Here we demonstrate a new spatial illusion in which the presence of a natural shape deforms the surrounding space. This distortion is predicted by theories in which shape is represented neurally as a series of spatial deformation processes (Grenander et al 2007, Oleskiw et al 2010, Elder et al 2013).

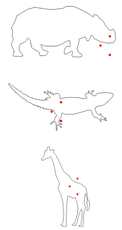
Which pair of dots appears closer together?



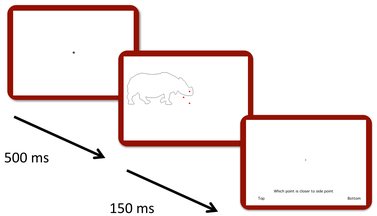
METHODS

The stimulus consisted of an animal outline and 3 dots forming a right isosceles triangle with two equilateral short sides and one long base side. The triangle was oriented so that the base was either horizontal or vertical. The location of the triangle relative to the shape was drawn randomly from a regular lattice. The triangle was always centred at fixation, so that the position of the animal shape varied from trial to trial. Subjects were asked to indicate which of the two equilateral sides appeared shorter. 3 subjects completed 10 blocks each for 3 different animal shapes.

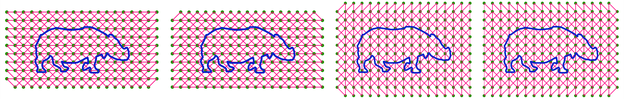
Example Stimuli



Procedure

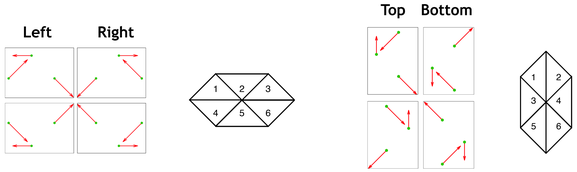


Horizontal Tessellation **Vertical Tessellation**



Each trial judgement was ascribed to a displacement in the perceived relative location of each of the 3 dots:

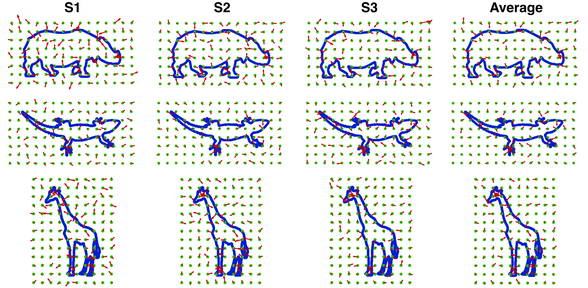
Which base dot appears closer to the apex dot?



These displacements were then summed over trials to yield a **deformation vector map**.

RESULTS

Deformation Vector Maps

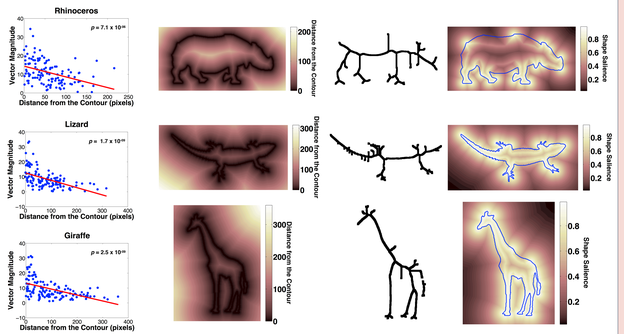


Observation: The magnitude of the deformation is largest near the contour.
However, qualitatively, the deformation appears to be largest near salient features of the shapes.

Definition:

Shape salience $= \exp\left(-\lambda \max\left(d_c, d_s\right)\right)$, where $d_c =$ distance to contour, $d_s =$ distance to skeleton

Avg Def. Vector Mag. vs Dist. From Contour | **Distance Transform** | **Skeleton** | **Shape Salience**

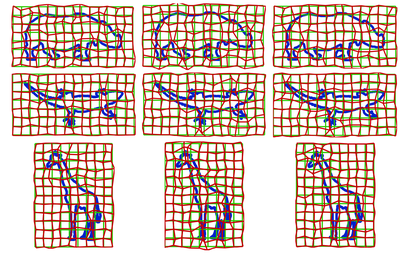


Deformation Vector Magnitude: Proportion of Variance Explained

Stimulus	Distance to Contour	Shape Salience
Giraffe	24.3%	33.6%
Rhino	15.8%	16.3%
Lizard	26.6%	33.7%

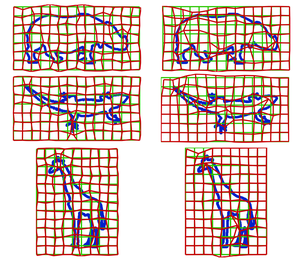
RESULTS

Psychophysical Deformation Maps



In the formlet theory (Oleskiw et al 2010, Elder et al 2013) shape is the outcome of a sequence of localized deformations of an embryonic shape (e.g., an ellipse)

Average Psychophysical Deformation | **Formlet Deformation** | **Smoothed Regression Results**



p = .06

p = .001

p = .09

CONCLUSIONS

- Outline shapes distort perceptual space.
- This distortion is largest near salient features of the shape.
- The magnitude of this perceptual distortion correlates with deformations predicted by the formlet theory of shape (Oleskiw et al 2010, Elder et al 2013).

REFERENCES

Grenander, Ulf, Anuj Srivastava, and Sanjay Saini. "A pattern-theoretic characterization of biological growth." Medical Imaging, IEEE Transactions on26.5 (2007): 648-659.

Elder, J. H., Oleskiw, T. D., Yakubovich, A., & Peyré, G. (2013). On growth and formlets: Sparse multi-scale coding of planar shape. *Image and Vision Computing*, *31*(1), 1-13.

Oleskiw, T. D., Elder, J. H., & Peyré, G. (2010). On growth and formlets: Sparse multi-scale coding of planar shape. *2010 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)* (pp. 459-466). Presented at the 2010 CVPR.