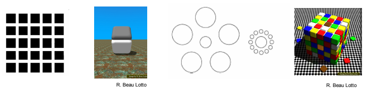
Color-motion asynchrony depends on stimulus predictability

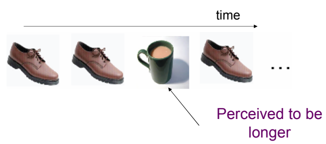
Thomas C. Sprague and David M. Eagleman

Department of Neuroscience and Department of Psychiatry, Baylor College of Medicine, Houston, TX

1. Introduction

Illusions are a powerful tool for understanding the relationship between a neural code and the corresponding percept (Eagleman 2001). The perception of luminance, form, color, motion, temporal order, duration, and simultaneity are all subject to investigation through use of perceptual illusions.

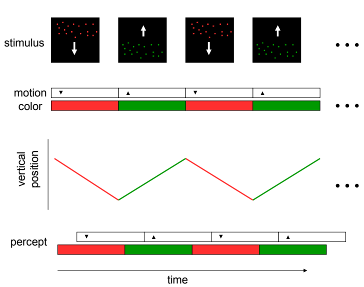




Predictable stimuli have been suggested to have a diminished neural response (Pariyadath & Eagleman 2007). Can manipulating the predictability of a stimulus (and thus the neural response) directly influence perception?

2. Perceptual "asynchrony" for color and motion

When two stimulus attributes change together, they are perceived as changing asynchronously.



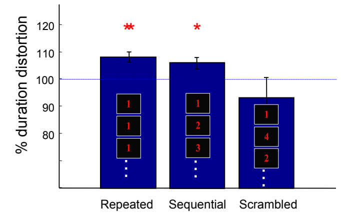
Color is perceived as changing before motion

This illusion is observed only for correspondence judgments in which a subject must bind the color and direction of motion. Temporal order judgments are not subject to color/motion asynchrony (Nishida & Johnston, 2002)

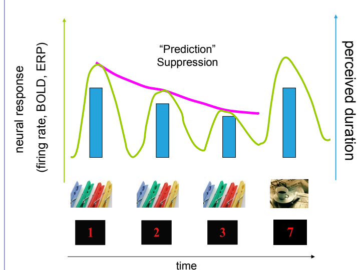
(Moutoussis & Zeki, 1997)

3. Prediction suppression

Manipulations of stimulus predictability have been shown to manipulate the perceived duration of a stimulus (Pariyadath & Eagleman 2007, Pariyadath & Eagleman, *under review*).



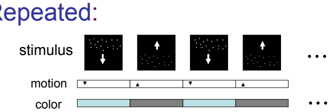
Repetition, a strong case of predictability, leads to diminished neural responses as measured by fMRI BOLD signal, ERP, and single cell firing rates (Grill-Spector *et al*, 2006)



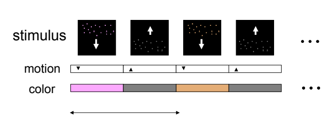
4. Can predictability change the color/motion asynchrony?

By alternating between gray and either a repeated or random isoluminant color, we can determine the effect of predictability on the color/motion asynchrony

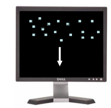
Repeated:



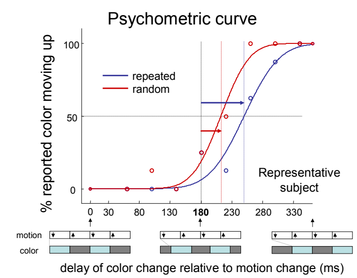
Random:

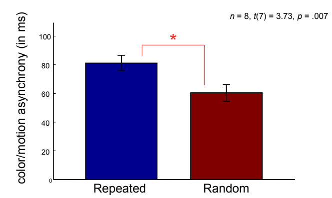


5. Behavioral results



"Which direction are the colored squares moving?"

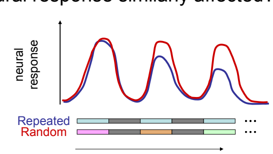




Color/motion asynchrony is **reduced** when the stimulus is *less predictable*.

6. What explains the reduction in asynchrony?

We have shown that increasing the predictability of a stimulus changes its perceptual binding properties. Is the neural response similarly affected?

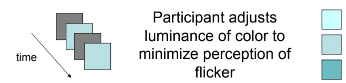


Hypothesis: Color/motion asynchrony is in part caused by neural repetition suppression, which can be tested using functional neuroimaging (fMRI)

7. Imaging methods

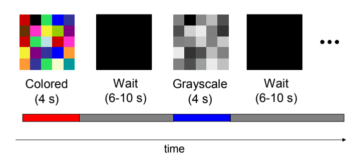
1. Find isoluminant colors

Heterochromatic flicker fusion (30Hz) – a color is rapidly alternated with a gray square so that luminance, but not color, flicker is readily visible



2. Color-responsive regions

Color localizer – subjects passively view isoluminant colored and grayscale patterns.

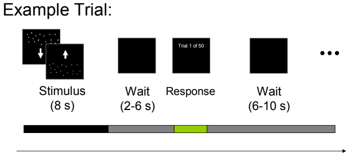


Regions which show greater BOLD signal in response to the colored stimulus than to the grayscale stimulus will be used for later region of interest analysis.

3. Color/motion asynchrony task

- Conditions: Repeated and Random colors
- Color/motion offsets: 0, 100, 200, 300, and 400 ms (T = 800ms)
- Repetitions: 5 per phase offset per condtion
- 2 conditions x 5 color/motion offsets x 5 reps = **50 trials**
- Hemodynamic response is slow – must allow ~6 seconds for return to baseline
- trials presented in random order with random wait time before response given (2-6 s) and after response before next trial (6-10 s)

Example Trial:



EPI sequence (TR = 2s, 37 slices, voxel size = 4x4x4mm) using 3T Siemens TRIO fMRI scanner at the Human Neuroimaging Laboratory

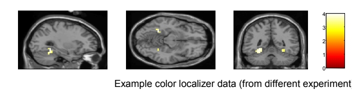
8. Subject pool and behavioral testing

Subjects were drawn from the local Texas Medical Center and Rice University communities. Currently, 15 subjects (6 female) have participated. Technical difficulties were experienced with 4 of these subjects which resulted in a loss of color localizer data.

All subjects also ran the original behavioral version of the task (Panel 4 & 5), randomly either before or after the scanning session. This data may be used for correlation with the fMRI BOLD signal amplitude.

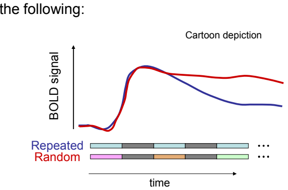
9. Plans for fMRI analysis

We will use the color functional localizer to determine which regions showed a greater BOLD response for the colored patterns than for the uncolored patterns. These regions will be defined as our regions of interest (ROIs).



Example color localizer data (from different experiment)

We will then plot & compare the time course of the BOLD response in these regions to the Repeated and Random conditions of the color/motion asynchrony task. If our stimulus leads to repetition suppression in the Repeated condition, the BOLD response ***may*** look like the following:



Conclusions

We have shown that a common perceptual illusion can be modulated through the careful adjustment of stimulus predictability

We have designed and are currently running an fMRI experiment to determine whether repetition suppression plays a role in this illusion

This paradigm provides an opportunity to link a particular change in neural response to a specific, quantifiable change in the perception of a stimulus

References

D.M. Eagleman, *Nature Reviews Neurosci.* **2**, 920 (2001).
K. Grill-Spector, R. Henson, and A. Martin, *Trends in Cognitive Sciences* **10** (1), 14 (2006).
K. Moutoussis and S. Zeki, *Proc R Soc Lond B Biol Sci* **264** (1380), 393 (1997).
S. Nishida and A. Johnston, *Curr Biol* **12** (5), 359 (2002).
V. Pariyadath and D. M. Eagleman, *PLoS ONE* **2** (11), 1264 (2007).
V. Pariyadath and D. M. Eagleman, (Under review).

This work was partially supported by NSF REU Grant DMS-0755294.

www.eaglemanlab.net