Why do we prefer looking at some scenes rather than others?

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CENTRAL PROBLEM

What do we do with the large proportion of our waking lives when we are not concerned about satisfying the standard needs for survival and reproductive success (e.g., satisfying hunger, avoidance of harm, sex, etc.) or taking various measures to improve our inclusive fitness?

POSSIBLE ANSWER

We attempt to maximize the rate at which we acquire new but interpretable information. That is, we are infovores.

FUNDAMENTAL BEHAVIORAL OBSERVATIONS and QUESTIONS

- Where we look when we encounter a new scene is decidedly nonrandom. Instead we look at “regions of interest.”

But what defines what is interesting?

- We generally show a preference for novelty, preferring a new book, movie, or conversation than one experienced previously. How could win-shift be implemented in the brain?
- How do we build a motivational system into a real-time perceptual-cognitive system?

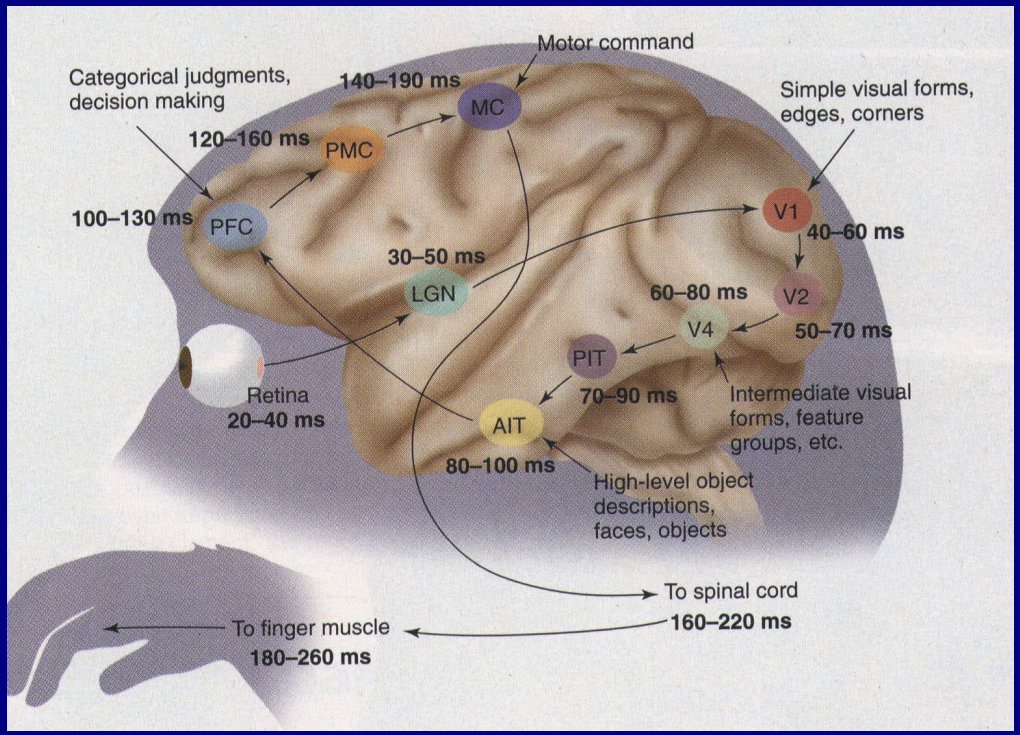
A THEORY OF COGNITIVE AND PERCEPTUAL PLEASURE

Fundamental Neural Observation:
A gradient of endorphin (μ-like) receptors in the ventral cortical visual pathway (Lewis, et al. 1981).

SPARSE

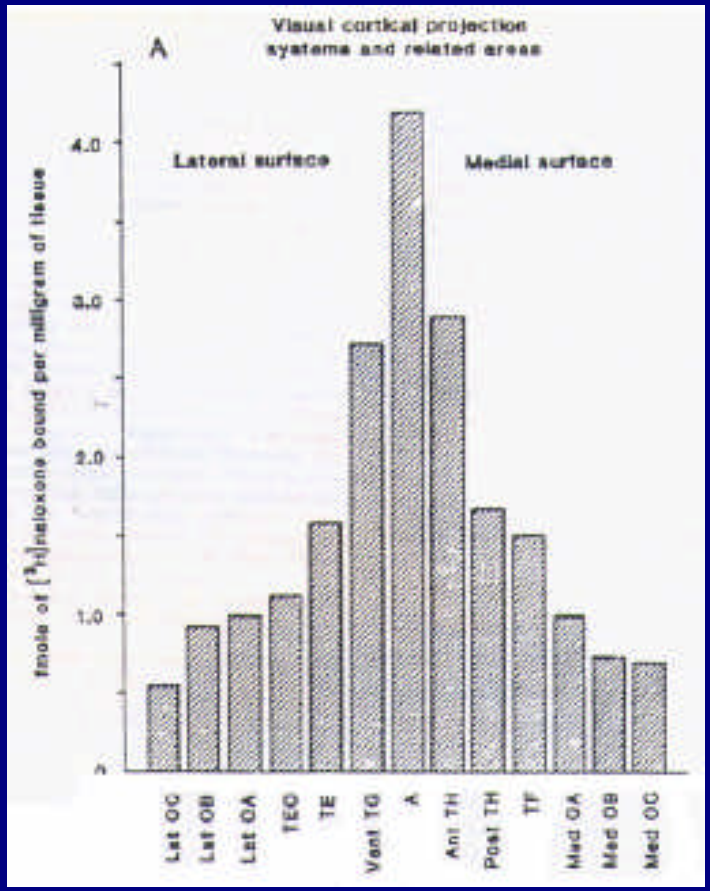
V1
↓
V2
↓
V4
↓
TEO
↓
TE
↓
(LO/Fusif.)
↓

DENSE **Amygdala**



From Thorpe & Fabre-Thorpe, 2001

Gradient of Opiate Receptors



V1 V2 V4 From Lewis et al., 1981

<u>Fundamental Assumptions</u>:

Greater neural activity results in greater endorphin release.

The greater the endorphin release, the more pleasurable the experience.

But what about novelty preferences?

Competitive Learning:

- A majority of cells in TE show decreased firing upon repetition of a stimulus (Miller, Li, & Desimone, 1993; Sobotka & Ringo, 1994).

- Repetition of stimuli in visual priming indexed by reduced fMRI activity in inferotemporal cortex (Buckner et al., 1998; Menon et al., 2000)

Therefore, repetition of stimuli will result in less activity in areas high in endorphin receptors.

Novel inputs that result in extensive interpretation / association maximize endorphin release.

Visual Preference

Novel, highly interpretable stimuli produce high activity in temporal lobe structures and thus high endorphin release, resulting in high visual preference.

- How does visual preference for a scene change as a function of repetition?
- Do differences in initial preference affect the rate of change?
- What factors contribute to a subject's initial preference for a scene?
- What is the neural basis for visual preference?
  Goal: develop imaging and pharmacological methods to directly test this neural hypothesis.

STIMULI

200 Full Color Scenes (approx 15° in width) selected to vary widely on a number of dimensions:

- urban vs. natural
- close-up vs. scenic
- animate vs. inanimate
- cluttered vs. simple

TASK

We collected preference ratings on a 7 point scale for all 200 scenes from 20 subjects.

1 < - - - - - - - - - - 4 - - - - - - - - - - > 7

don't like it — really like it

All images were shown for 1 second

Preferences for a Single Presentation

- Average preference: 3.97 $\pm$ 0.62
- subject variability:

  correlation of subjects' ratings with mean ratings: 0.55 $\pm$ 0.11

What type of scenes are preferred?

Most Preferred Scenes

6.10

6.10

6.00

5.85

5.85

5.85

Least Preferred Scenes

1.65

2.15

2.20

2.20

2.40

2.40

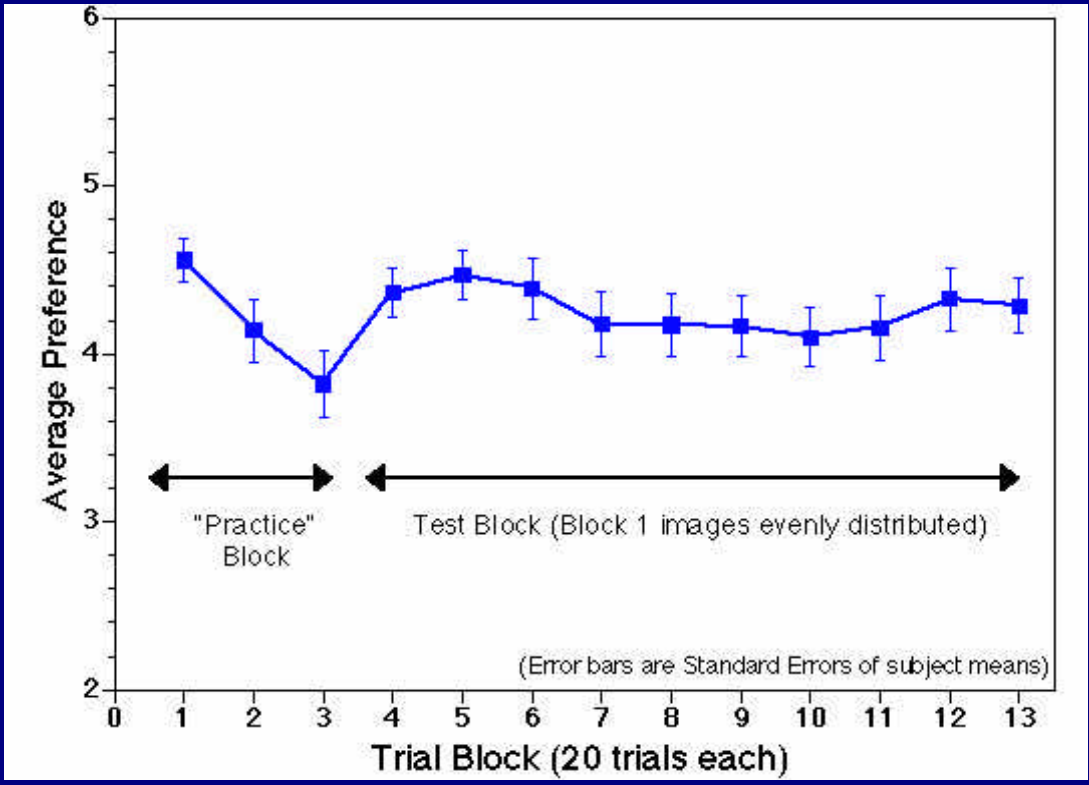
Repetition

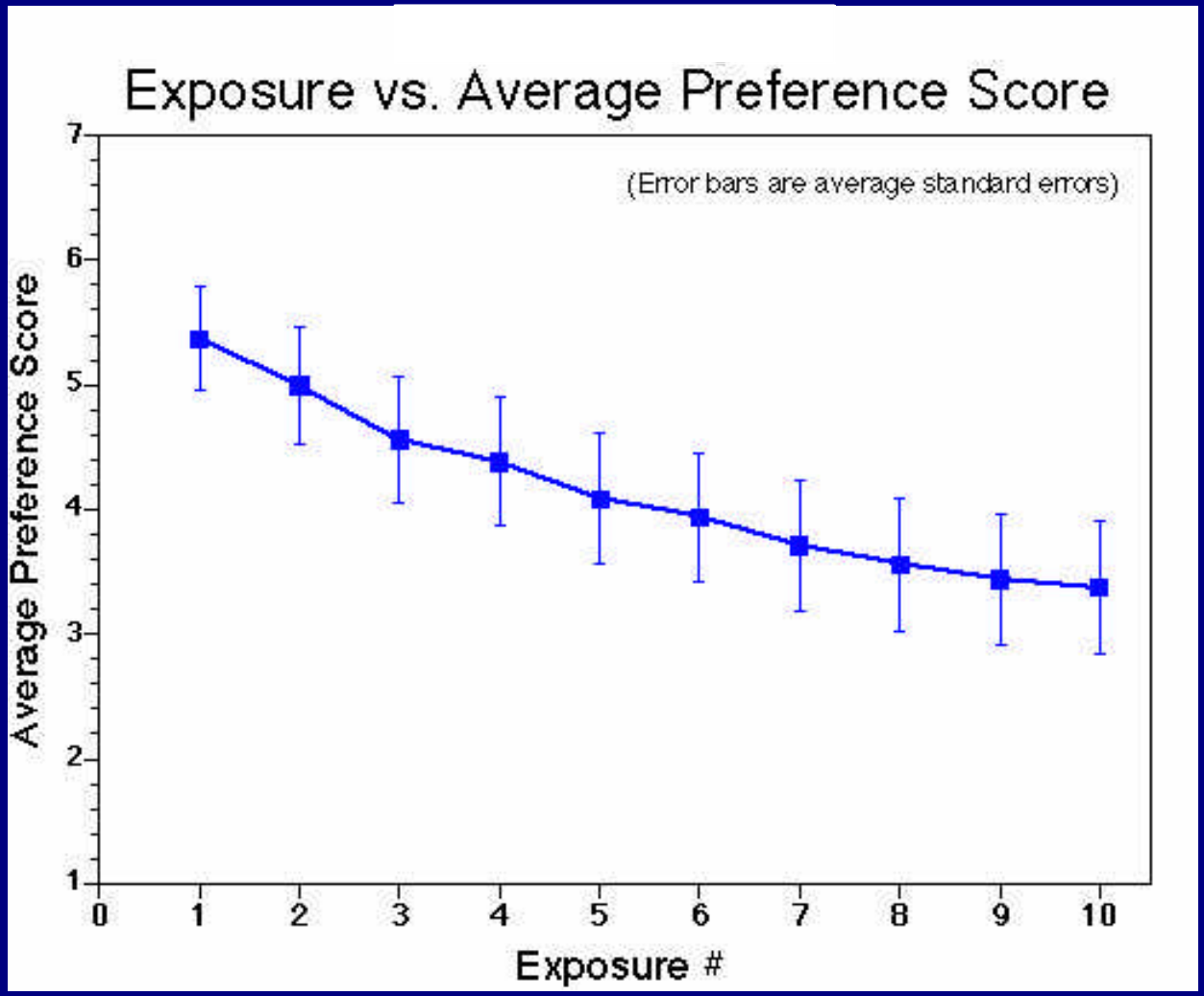
- How does preference for a scene change over repeated presentation?
- Does preference change in a consistent manner for different types of images?

Twenty subjects made preference ratings for subsets of 20 scenes repeated over 10 exposures.

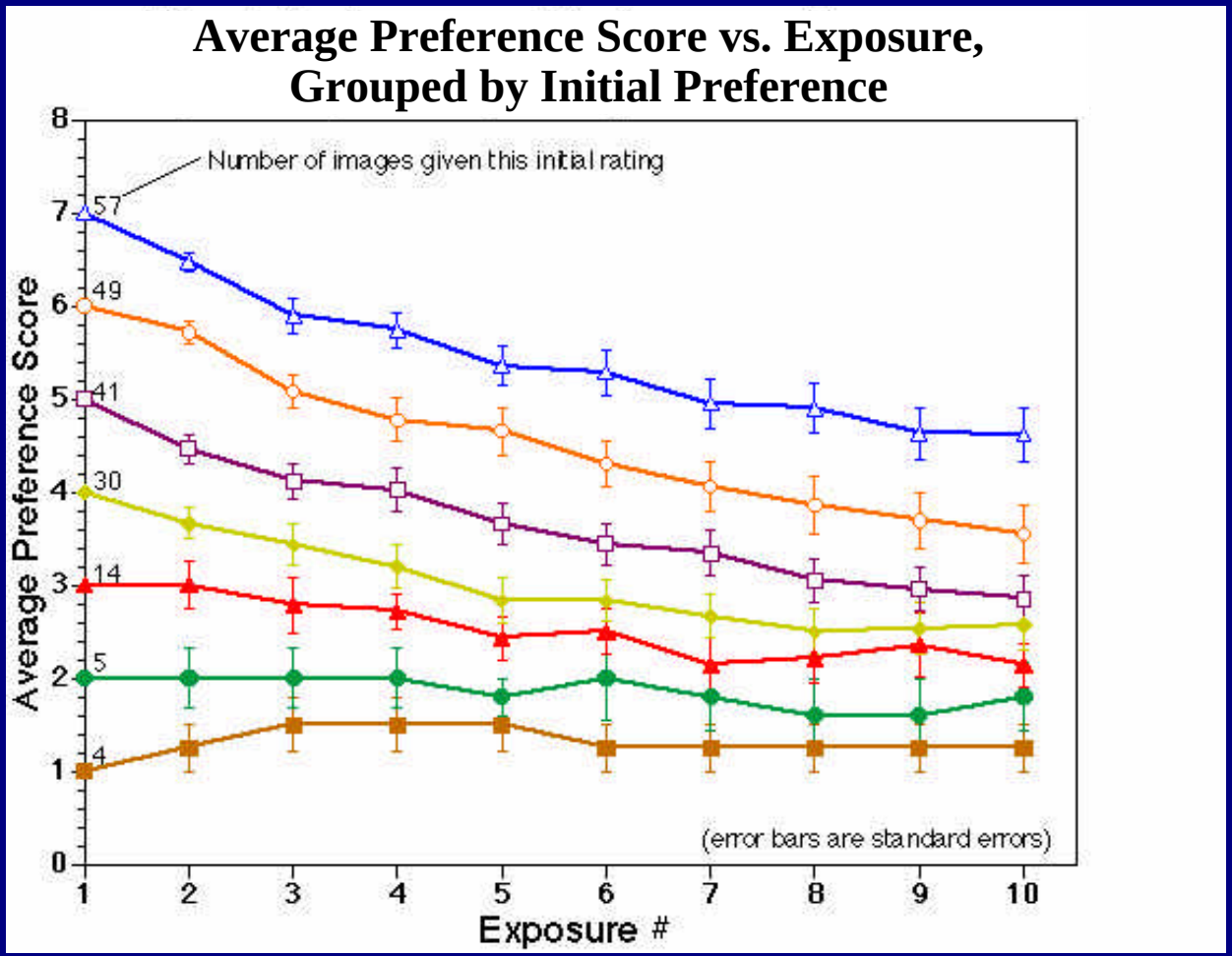
Methodological point:

Novel images must be introduced at a constant rate to avoid "context" effects.




Exposure vs. Average Preference Score
(Error bars are average standard errors)
Average Preference Score
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
Exposure #

Average Preference Score vs. Exposure, Grouped by Initial Preference



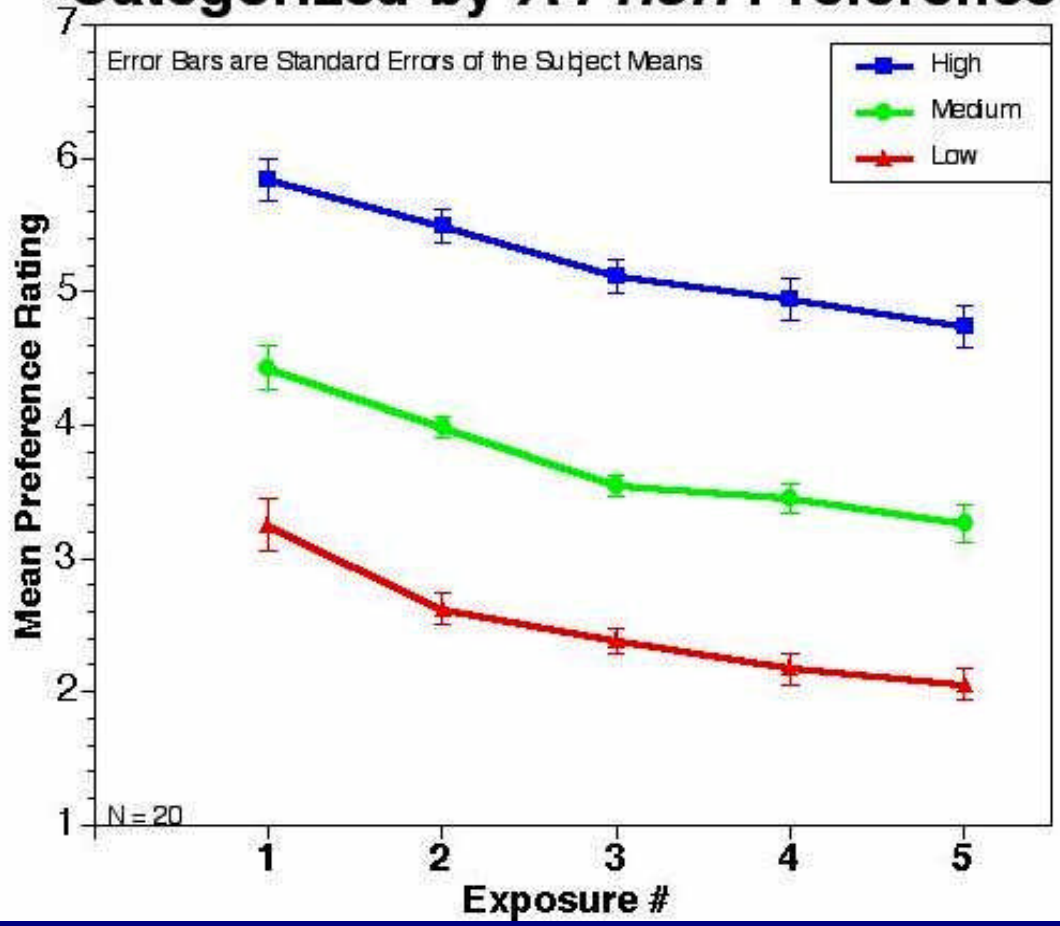
How reliable are these preference ratings?

- Can we increase their reliability by selecting a subset of images?

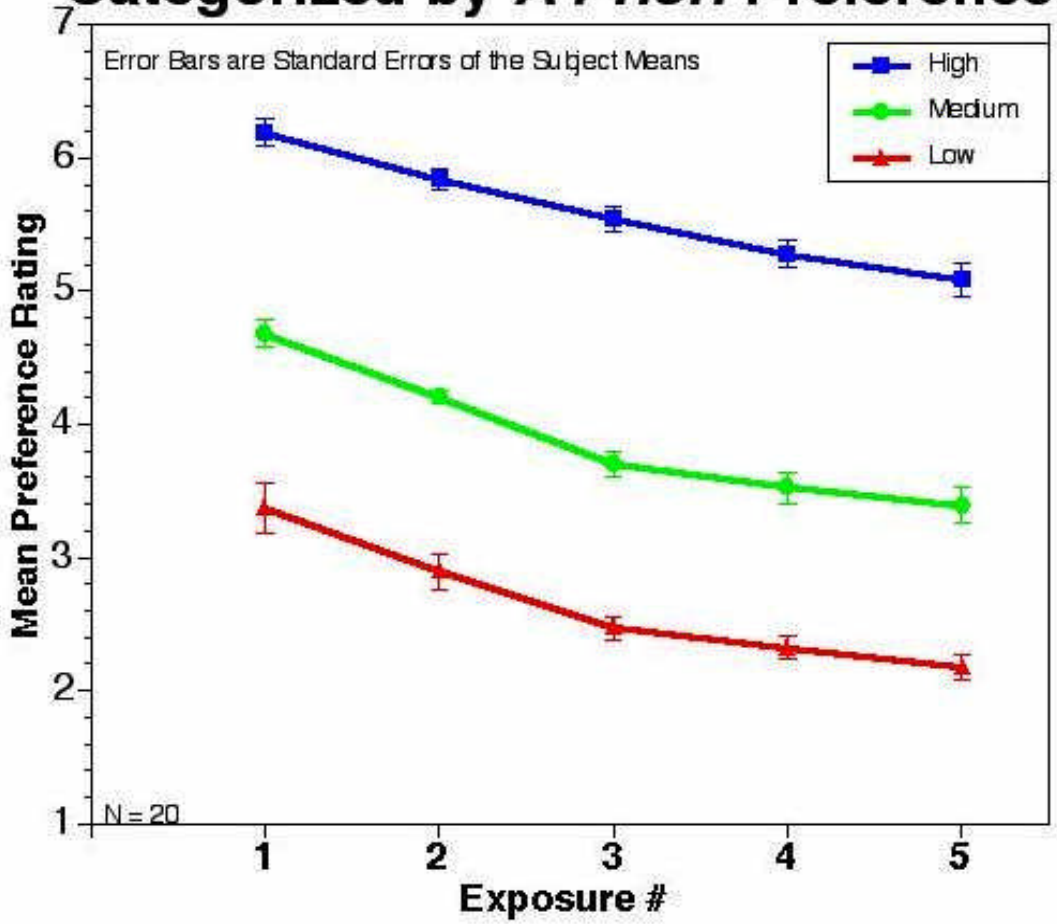
- Can *a priori* preferences predict performance?

We conducted a second set of repetition experiments with a subset of 60 images grouped into High, Medium, and Low preference categories.

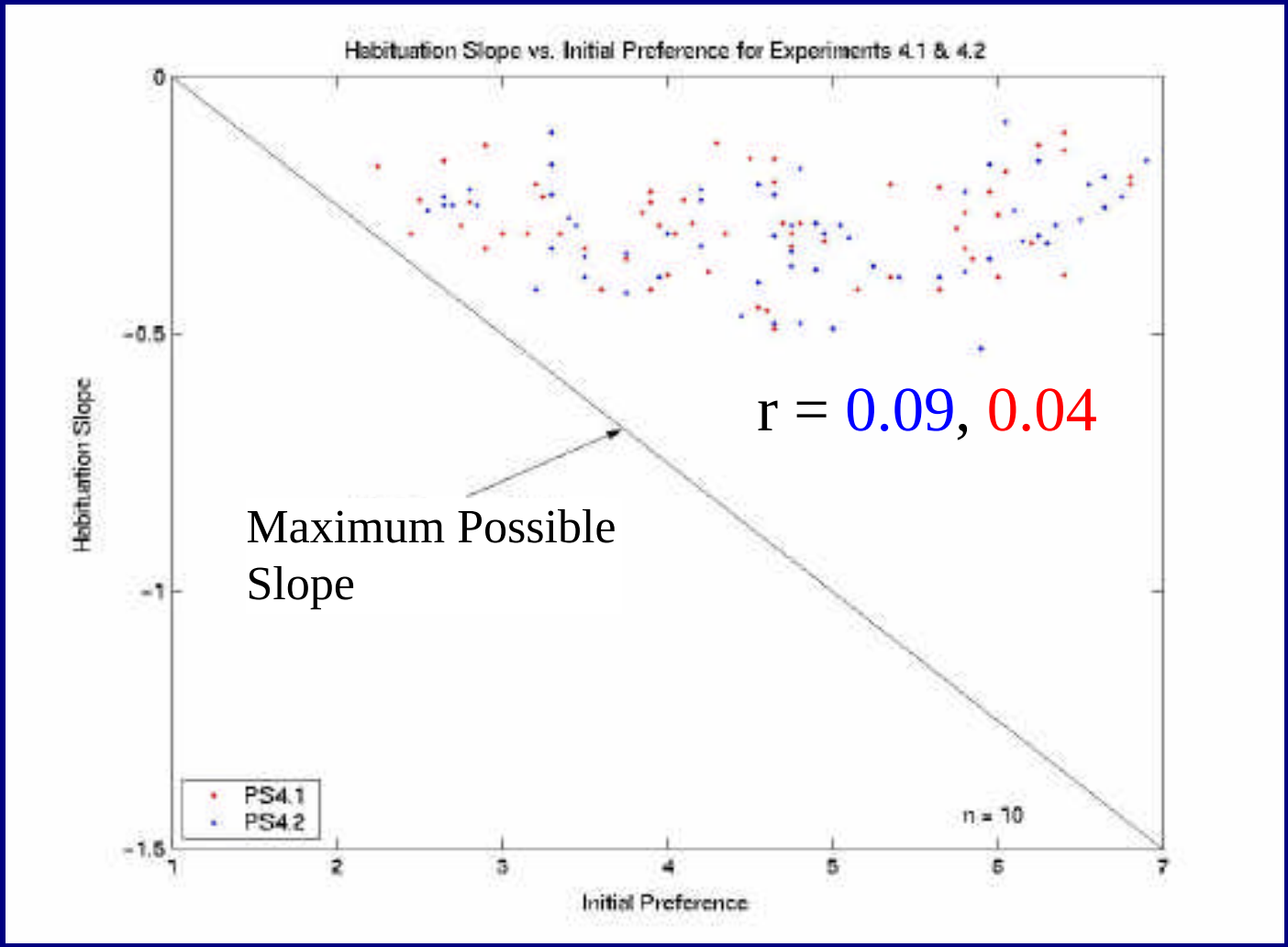
Preference vs. Exposure for Images Categorized by *A Priori* Preference



Preference vs. Exposure for Images Categorized by *A Priori* Preference



Stimulus Analysis: Habituation vs. Initial Preference



Repetition Results

- For relatively long exposures (1 sec), preference declines with repeated presentation.
- This habituation occurs for images with a wide range of *a priori* preference.
- Preference ordering is maintained even up to 10 repetitions.
- Preference is influenced by the local novelty context (contrast effect).

- With a subset of images, the initial preferences and habituation rates are highly reliable.

- The rate of habituation does not depend on initial preference.

Why?

- What factors might explain the initial preference and habituation rates?

Evolutionary Mechanisms of Natural Scene Preference

Stephen Kaplan (1992):

The evolutionary significance of landscape arises from the need to unconsciously assess one's environment quickly while not straying too far from the known.

"In this way preference would help keep the individual in an environment where orientation and access to new information can be maintained easily - quite apart from the particular purposes that individual was pursuing at that moment."

Can factors which indicate the likely survival value of a scene (habitat / locale) predict initial preference and habituation rates?

Factors:

- **Coherence**: How rapidly and easily did you understand what the scene was about?
- **Legibility**: How easily would you be able to determine where you were in the scene and navigate through it?
- **Mystery**: How likely is it that you would obtain different information from changes in your vantage point, or that something new might appear?
- **Vista**: How good is the view? Can you see a wide expanse of area, or for a long distance?
- **Refuge**: Is there a position in the scene where you can go to have a good vantage point without being seen?

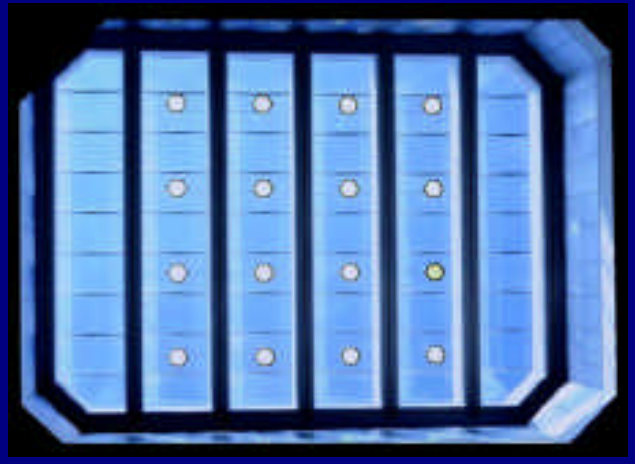
+ **Natural vs. Urban**, ***a priori*** **preferences**,

and initial ratings (for habituation rates)

Coherence

High

Low



Legibility

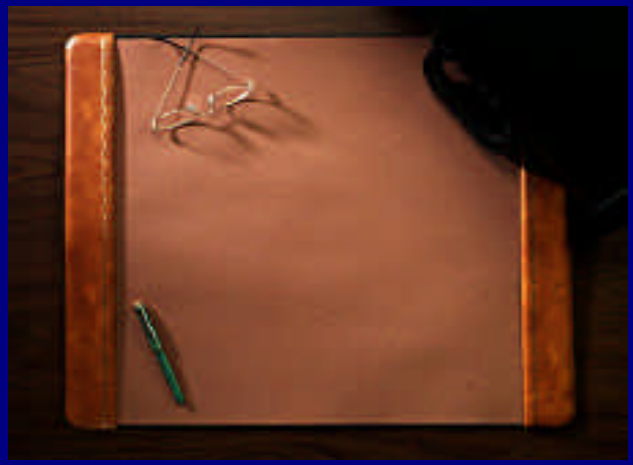
High

Low

Mystery

High

Low



Vista

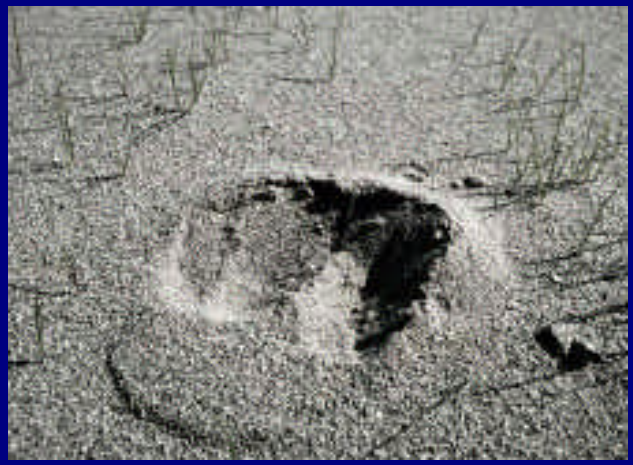
High

Low

Refuge

High

Low



Natural vs. Urban

High

Low

Factor Results

- Mystery, Vista, Refuge, and Natural Vs. Urban correlate significantly with initial preference.

Taken together these factors account for 63% of the variance.

- Initial preference is highly reliable (r = 0.92) across subjects.
- None of the factors consistently correlate with Habituation Slope (weak negative correlation with Legibility & Coherence for one experiment).
- Very highly preferred images show a resistance to habituation.

Conclusions

- Initial preferences for scenes are well predicted by factors which describe the likely evolutionary value of natural settings.
- Habituation rates are independent of these factors and initial preference, although the *most* highly preferred scenes tend to remain highly rated.
- These findings may be accounted for by a neurocomputational theory of perceptual and cognitive pleasure.

fMRI

- **Which brain areas show activity that correlate with initial preference?**

- **Which brain areas show activity that correlate with the change in preference as a consequence of repetition?**

Methods

Event Related fMRI

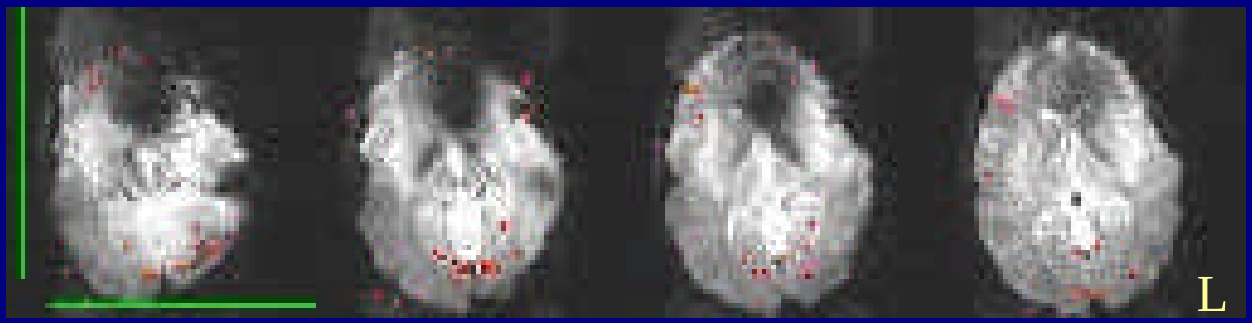
- 3 preference levels x 5 repetitions
- TR = 2.5
- Siemens 3T scanner
- Single subject analysis using multiple linear regression

Collaborators: Mark Cohen, UCLA Brain Mapping Center

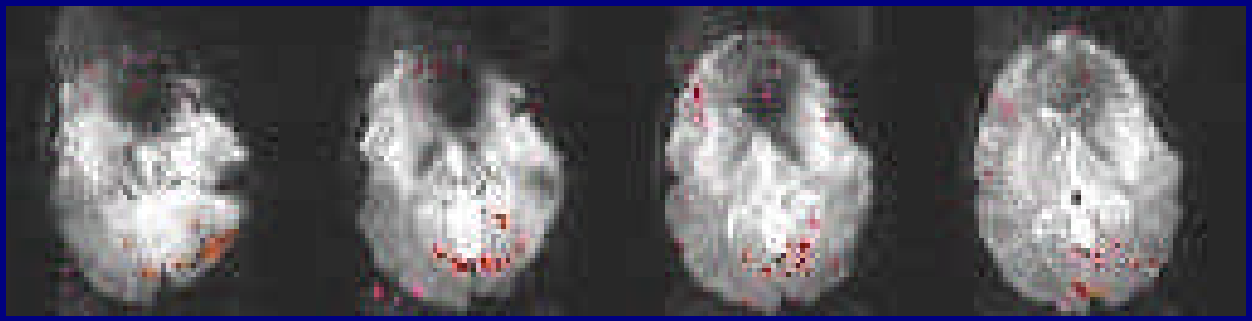
Thanks: David Glahn, Richard Dubois,

Preference

High



Low



High - Low