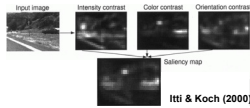


Goal: To construct a comprehensive theoretical framework to explain mechanisms of bottom-up (exogenous) and top-down (endogenous) attentional control

Attentional Control Strategies

Exogenous (Itti & Koch, 2000)

Attention guided to distinctive or locally-contrasting visual features, such as abrupt onsets or color singletons.



Feature-Based Endogenous (Wolfe, 1994)

Attention guided to task-relevant local features.

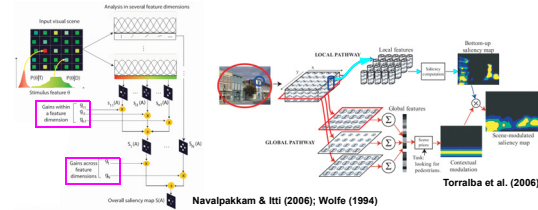


Scene-Based Endogenous (Torralba, Oliva, Castelhano, & Henderson, 2006)

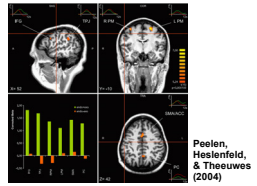
Attention guided to task-relevant regions based global scene gist.

Theories Versus Data

Theories of attentional control generally assume distinct mechanisms and integration of strategies.



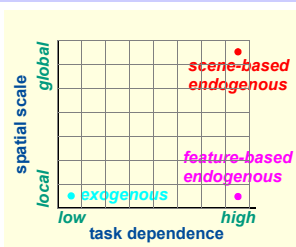
However, neuroimaging suggests that endogenous and exogenous control do *not* involve distinct neural systems (e.g., Rosen et al., 1999; Peelen et al. 2004)



Further, exogenous cues can be suppressed (Pashler, 1988).

A Unified Theory

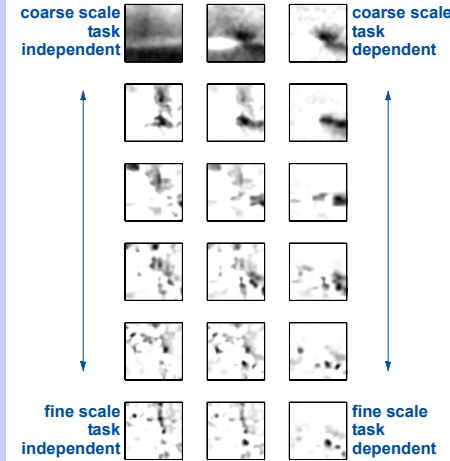
Rather than conceiving of these strategies as three distinct and unrelated mechanisms, we define a continuous control space that encompasses the three strategies and offers insight into their relationships.



We posit that attentional control at a particular instant for a particular task is defined by a single point in the space.

Example: Saliency Maps over Control Space

Task: search for car



Our Framework

Input: images of real-world scenes and stimulus displays

Output: saliency map

Given current goals, model must determine appropriate control parameters (spatial scale, task dependence).

Given control parameters, model can configure a processing pathway.

Processing Pathway

Image

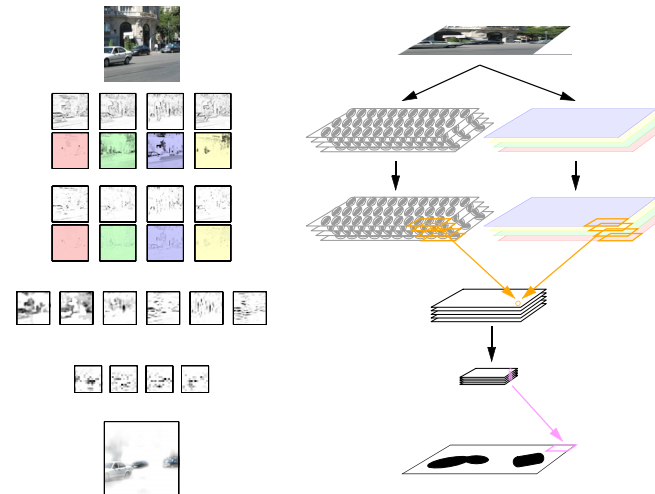
Feature extraction (Gabor, RGBY filtering)

Contrast enhancement (center-surround differencing)

Dimensionality reduction (subsampling and PCA)

Association (rank-limited linear transform)

Saliency Map



A Unified Theory of Exogenous and Endogenous Attentional Control

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Implementation

Spatial Scale

- Vary diameter of overlapping receptive fields
- For each receptive field, dimensionality reduction and association occur along parallel channels

Task Dependence

- Task: target object in visual search
- For each task and spatial scale, train a task-dependent pathway.
- Task-independent pathway response is *average* of responses of task-specific pathways.
- To vary degree of task dependence, interpolate between task-specific and task-independent pathways.

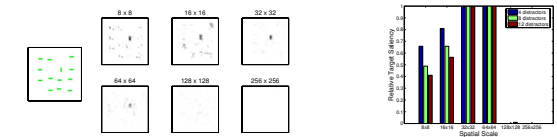
Phenomena

1. bottom-up saliency

Model can identify regions of texture discontinuities.

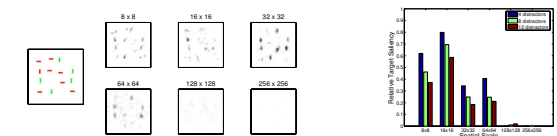
2. simple feature search

Assuming RT inversely related to relative saliency of target, search time independent of number of elements in display.



3. conjunction search

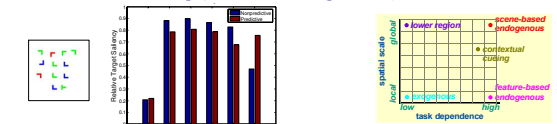
Assuming RT inversely related to relative saliency of target, search time increases monotonically with number of elements in display.



4. scene gist

5. lower region figure-ground (Vecera et al., 2002)

6. contextual cueing (Chun & Jiang, 1998)



Consequences of Theory

In our theory, attention is not a low-level phenomenon but is intricately linked to visual experience and object knowledge.

The pathway that computes attentional salience can overlap with pathways that perform object recognition.

Theory suggests limited ability to direct attention to task-relevant objects, where limit arises from finite neural hardware.