# Attention

## Integration of bottom-up and top down attention

*Suggested reading:*

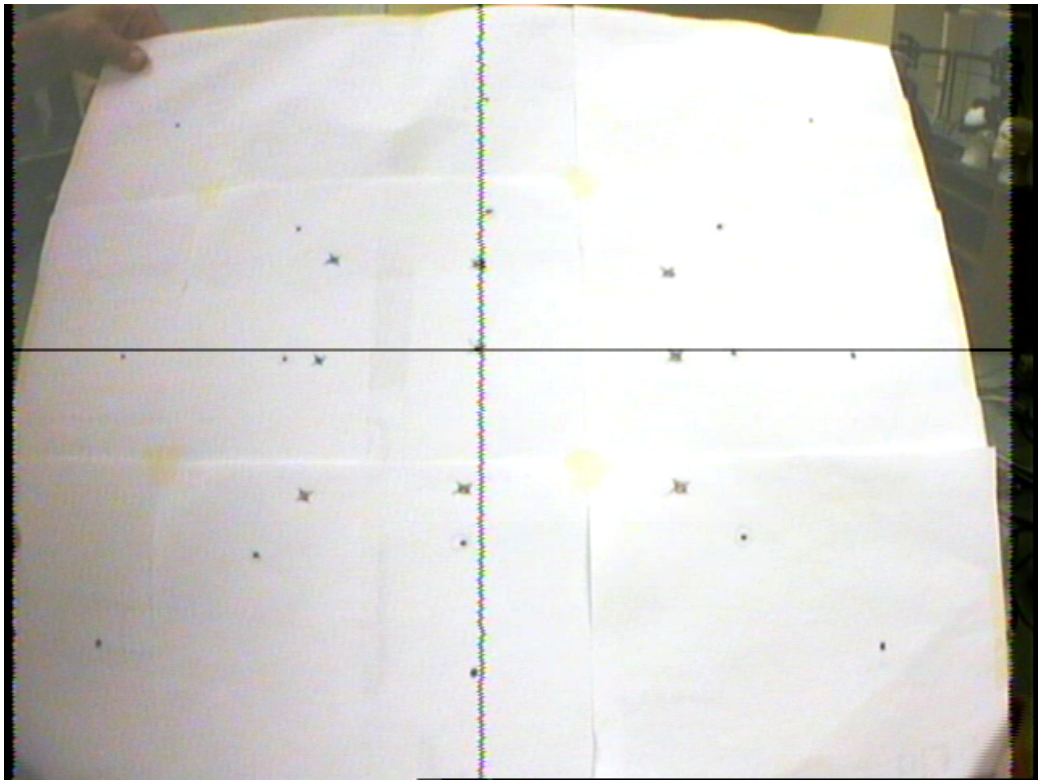
- Hamker, F. H. (2005) The emergence of attention by population-based inference and its role in distributed processing and cognitive control of vision. Journal for Computer Vision and Image Understanding. Special Issue on Attention and Performance in Computer Vision, 100:64-106.



## *Attention: Integration of Bottom-up and Top-Down*

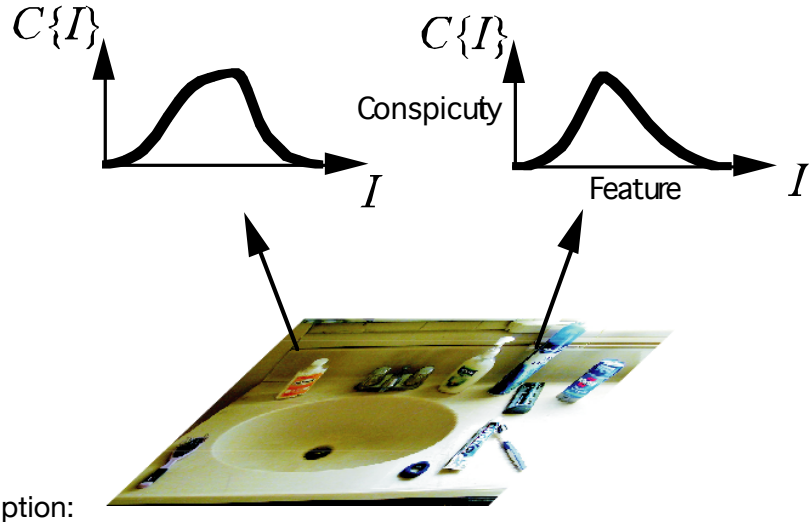
*Contents:*

# Real world visual search

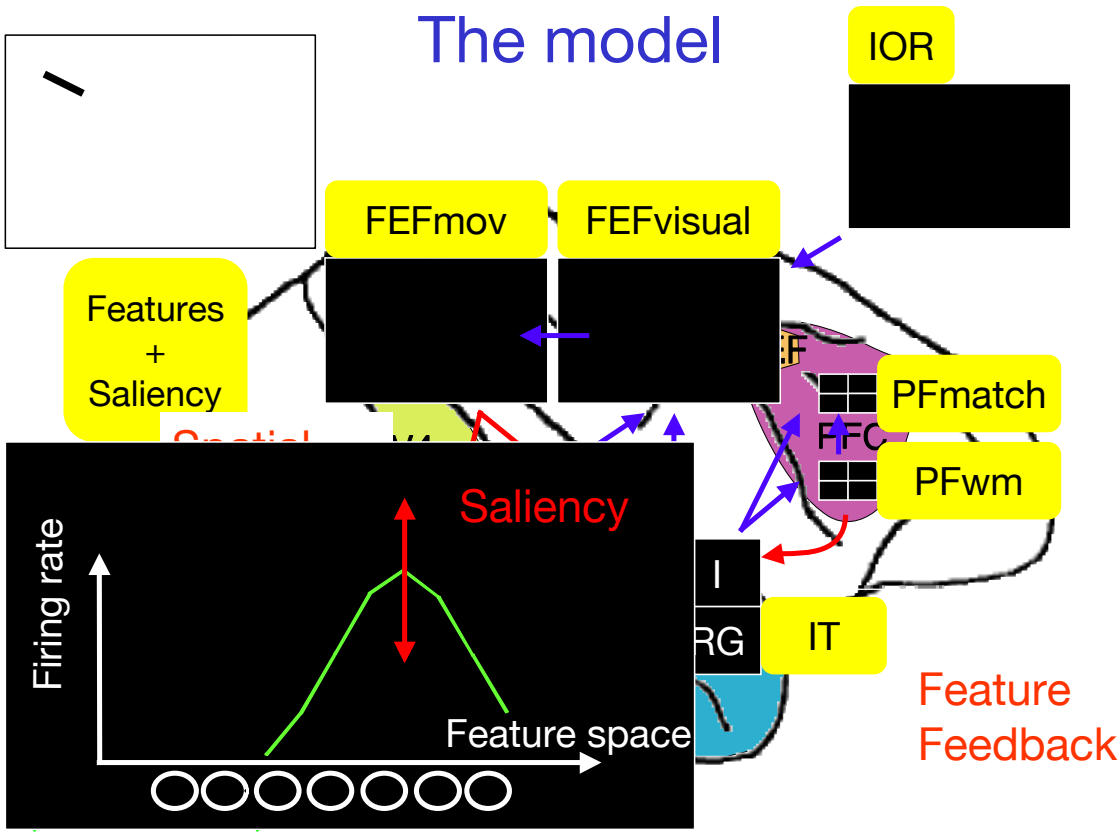




# Population-code

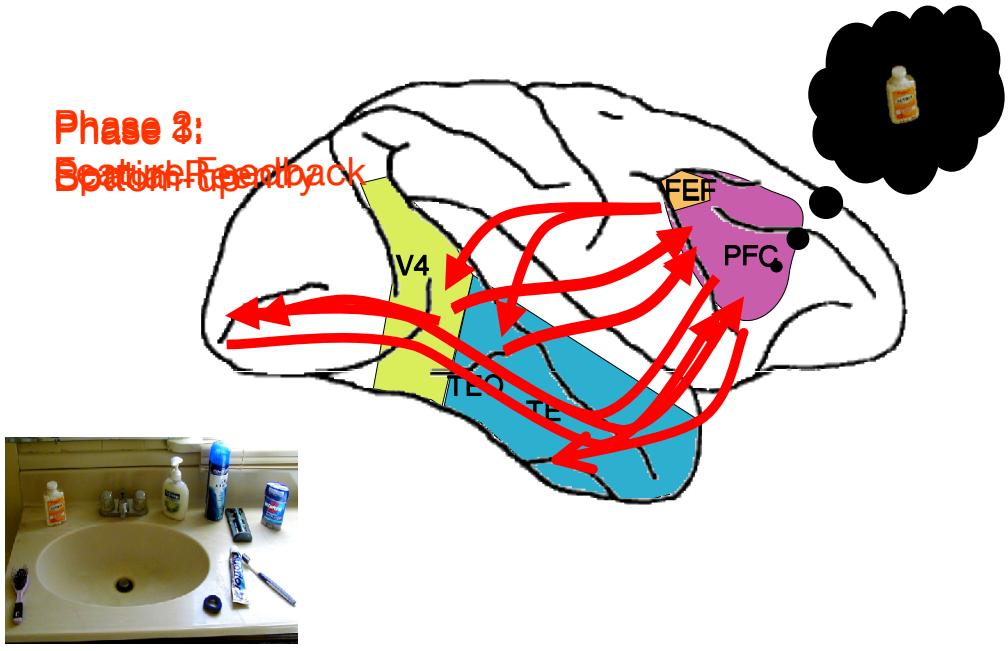



General assumption:
A visual scene is encoded on basis of a population code, where the y-axis represents the feature conspicuity (e.g. in the intensity channel) and the x-axis the encoded feature (e.g. brightness).
Thus, at each location we obtain a population of the conspicuity over the feature values.





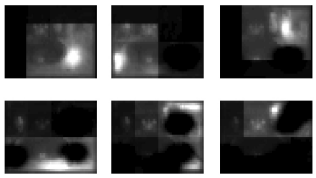

## Three phases of visual perception



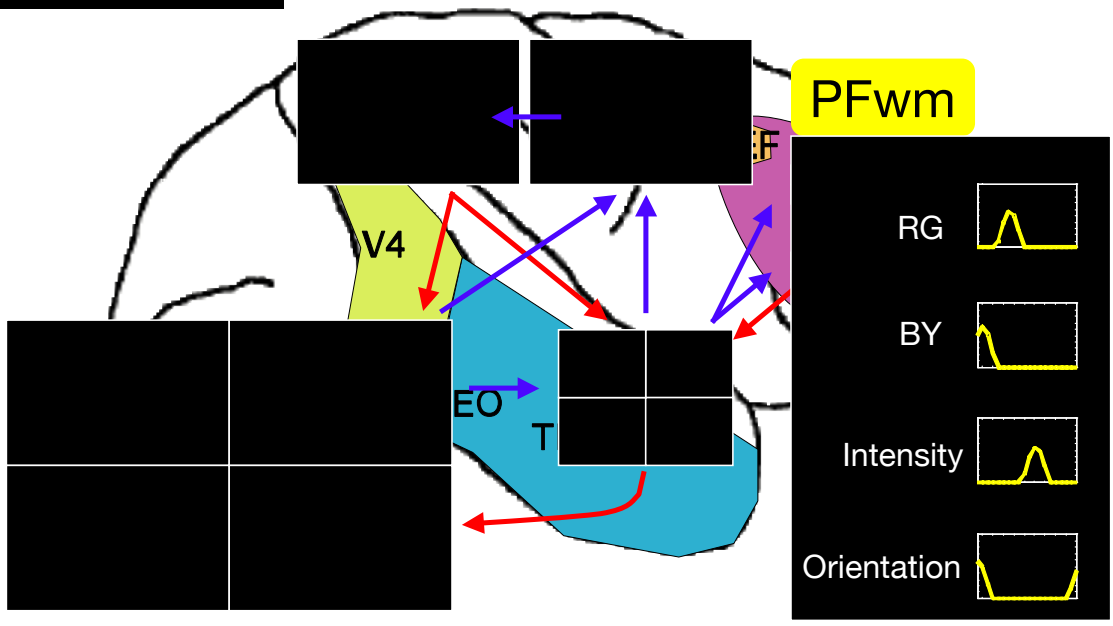
# Search “without Target“

No Target →

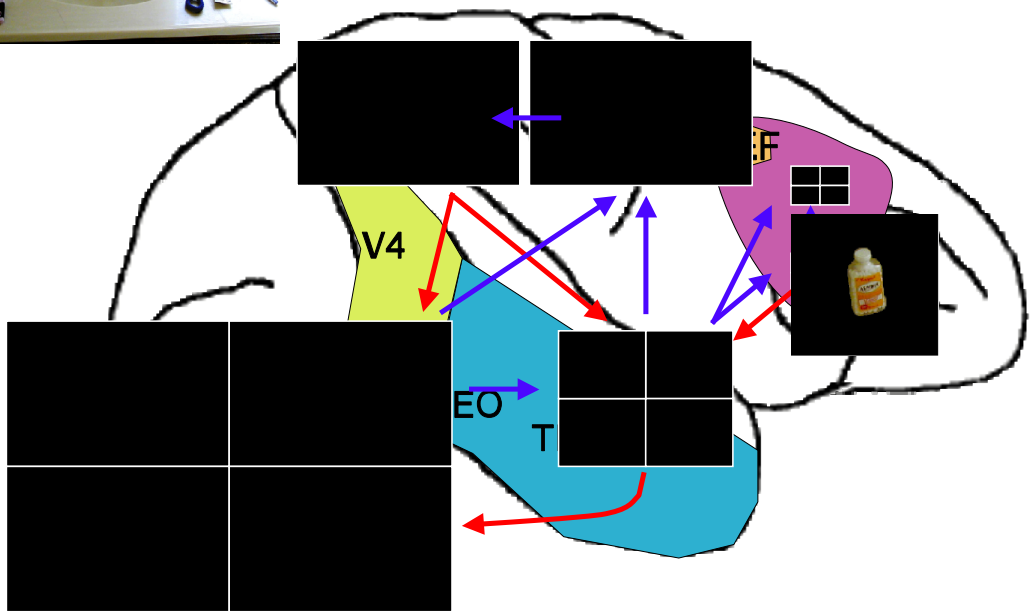
FEFv cells

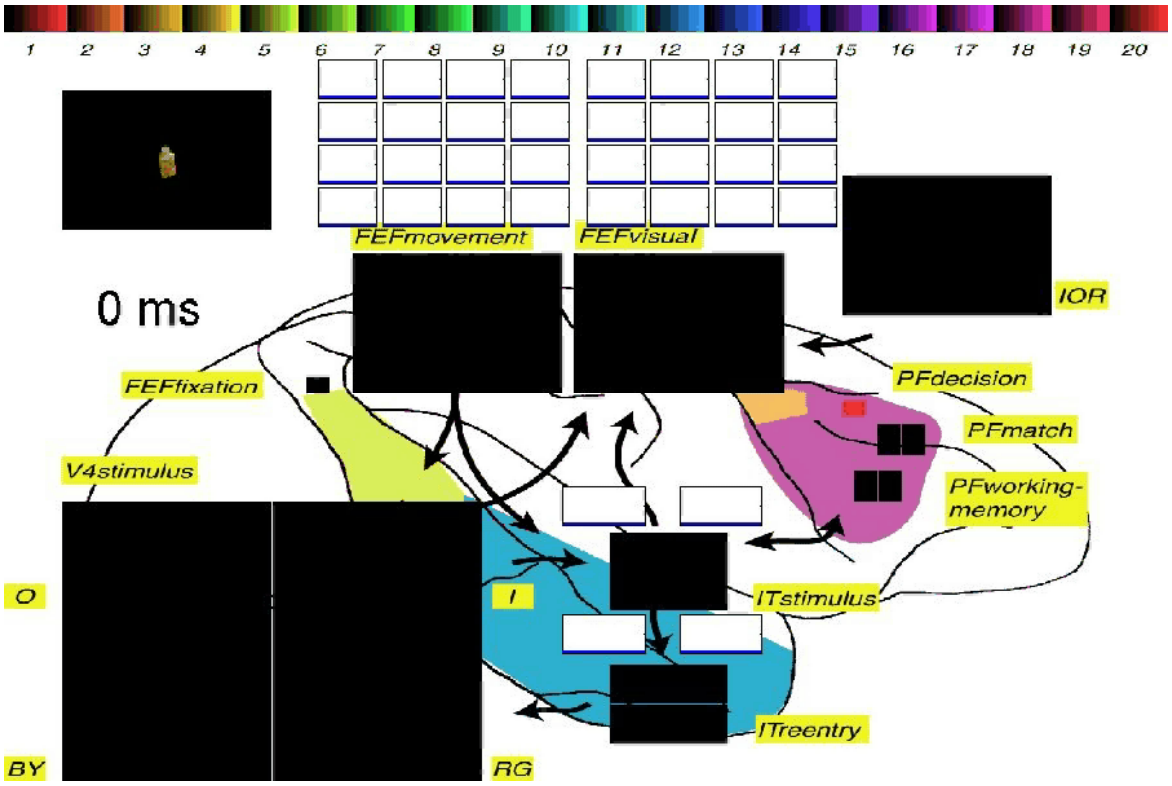


## Memory of the cue

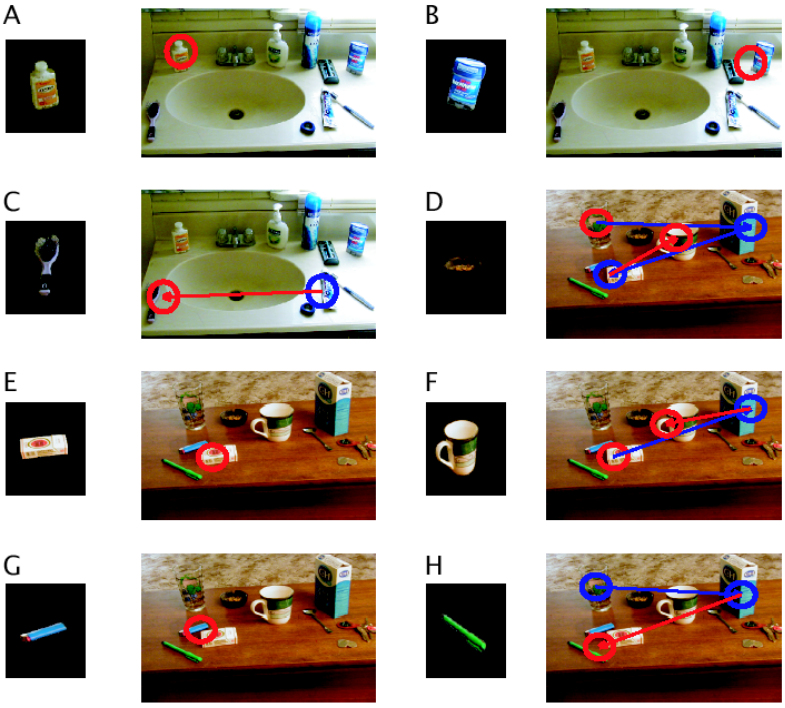


# Goal-directed perception



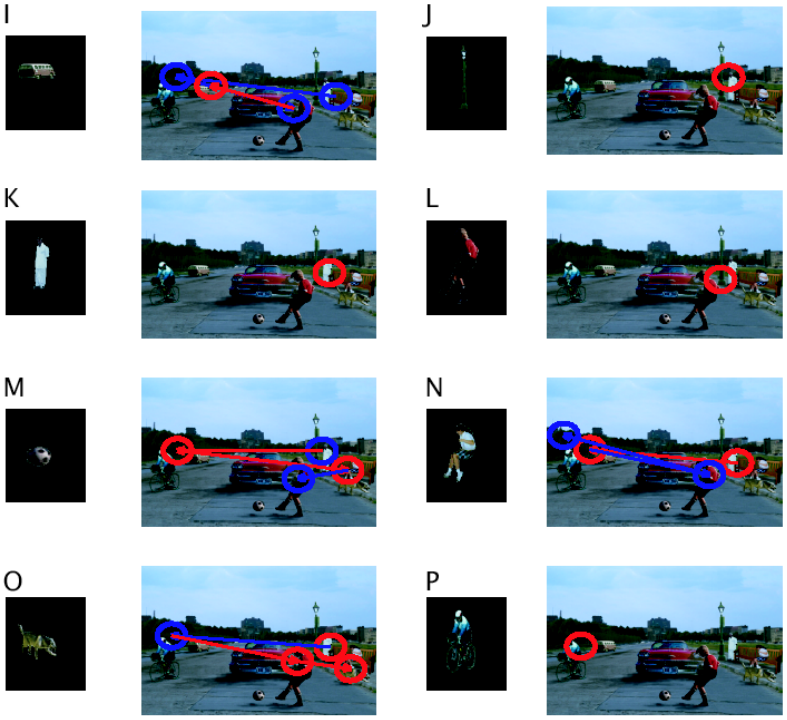



# Object detection performance

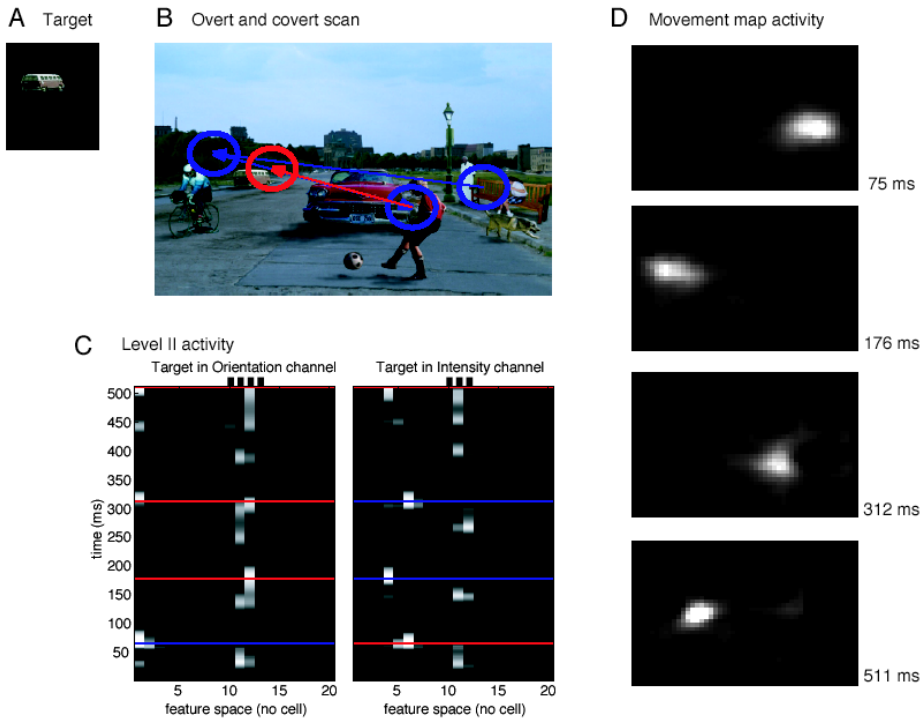





# Object detection performance

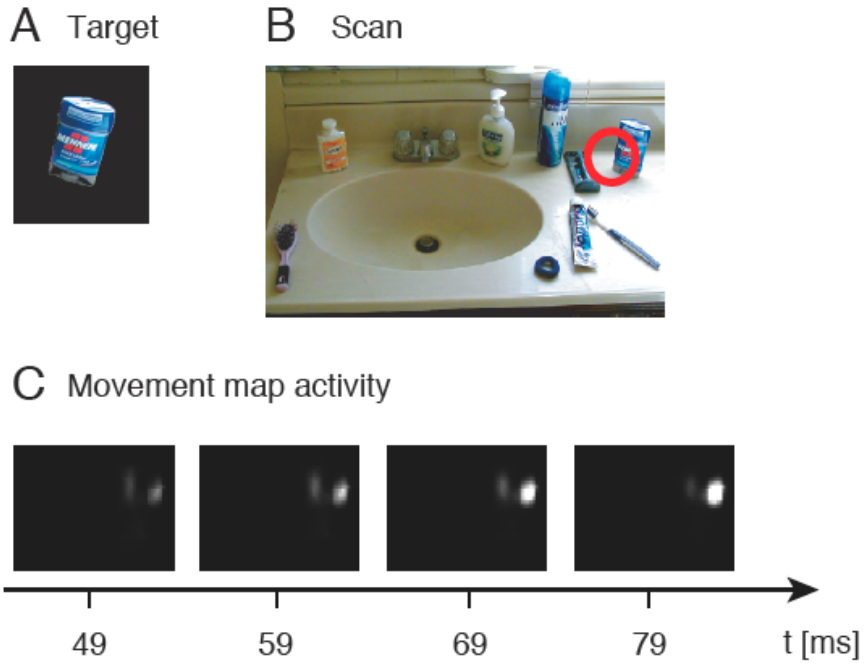


# Overt and covert attention






# Split of spatial attention



# Feature-based attention

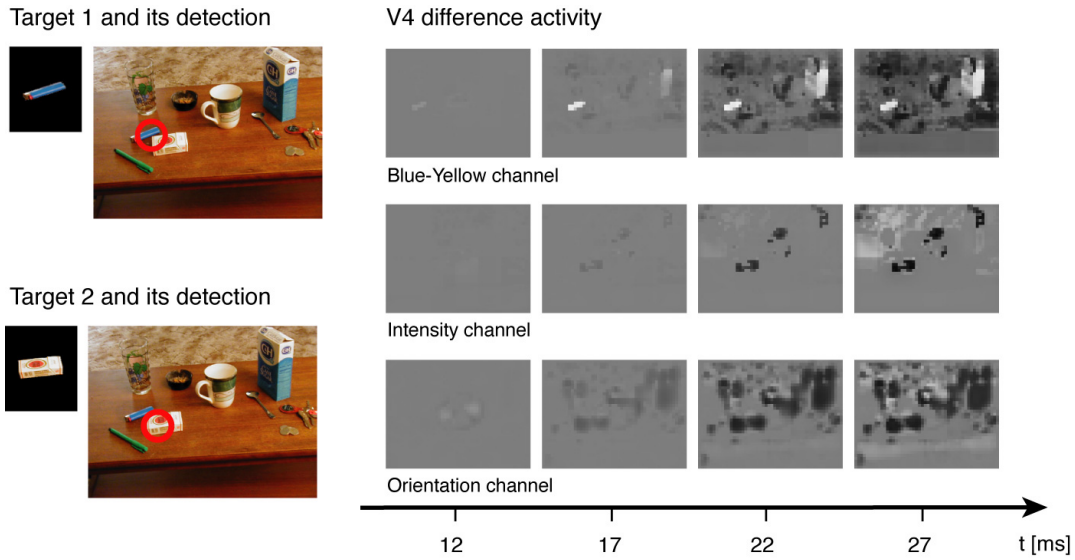
Experimental evidence:

Feature-based attention has been observed in electrophysiological experiments:

- Mazer, J.A., Gallant, J.L. (2003) Goal-related activity in V4 during free viewing visual search. Evidence for a ventral stream visual salience map. Neuron.
- Bichot, N.P., Rossi, A.F., Desimone, R. (2005) Parallel and serial neural mechanisms for visual search in macaque area V4. Science.



# Feature-based attention

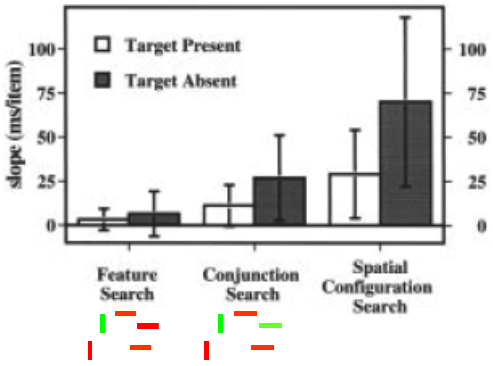


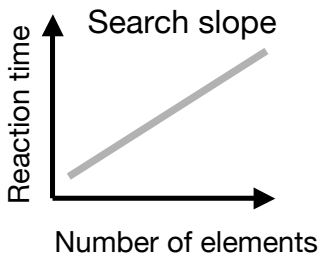

The model predicts that prior to any spatial selection, V4 contains information about potential target objects - feature-based attention.

Hamker, F. H., BioSystems, 2006

# Parallel vs serial search

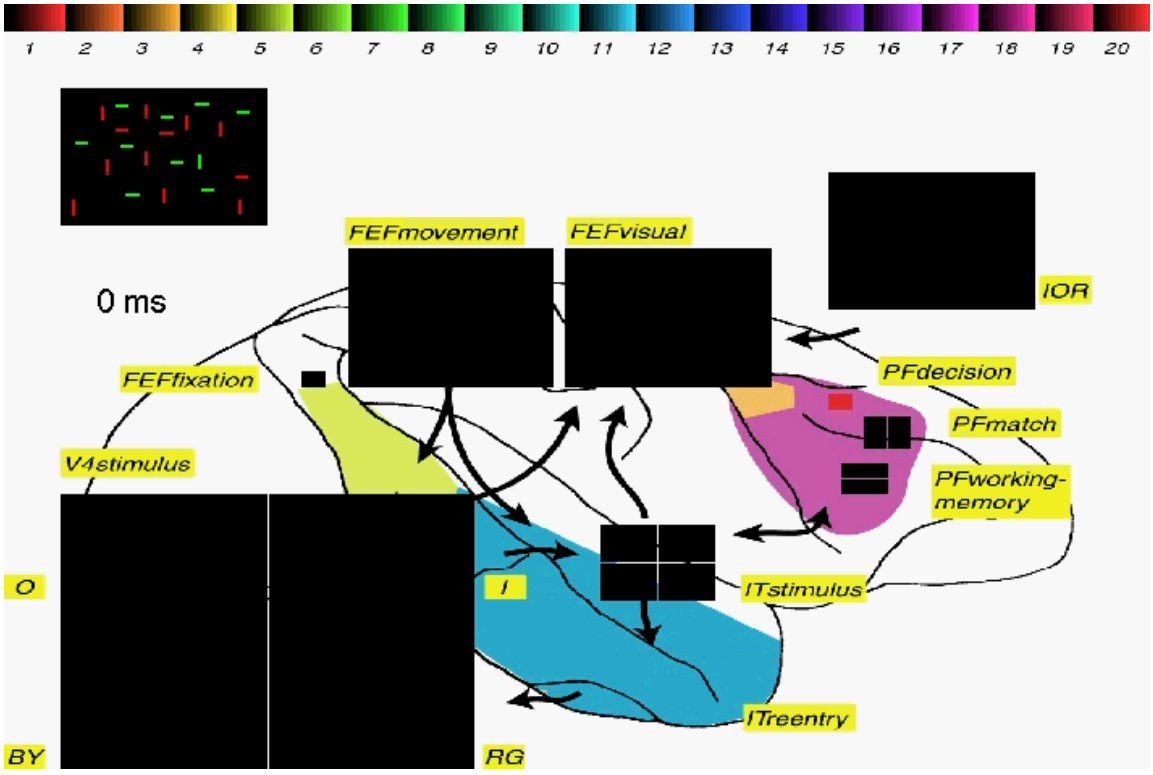
From: Wolfe, J. M. (1998). What can 1 million search trials tell us about visual search. Psychological Science, 9, 33-39.



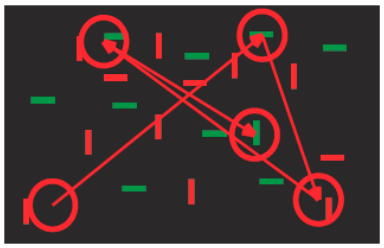




Under the assumption that each item in a scene is analyzed separately, the performance of search can be expressed by the number of scanned items per second. However, the time to complete search shows a high variability in feature and conjunction search (Wolfe, 1998) such that knowing the number of items per second does hardly allow to predict the underlying search mode. In addition, the assumption that each item is visited one after the other predicts a very fast covert scan of the scene of about 30-40 ms per item for which no physiological counterpart has been found yet. There is more evidence for a slow serial component in search (at least larger than 100 ms to shift spatial attention)





# Parallel vs serial search



The model processes stimuli in parallel.

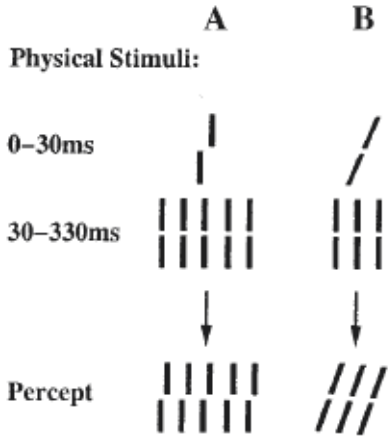
If parallel processing does not allow to detect the object of interest, it switches into a serial search.

Serial selection is much slower than 10-40 ms per item and linked to eye movement planning.



# Feature Inheritance

From: Herzog & Koch (2001) PNAS



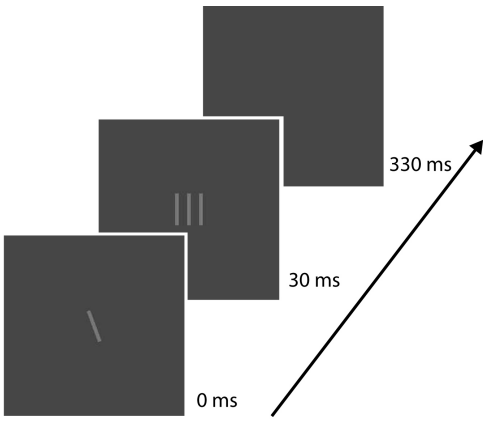

In feature inheritance, the mask inherits a property of the target stimulus. A vernier, a tilted line, or a bar in apparent motion are presented for a short time and followed immediately by a grating comprising a small number of straight elements. The grating is perceived as offset, tilted, or moving.

Claim: Attention is a result of interactions between brain areas.

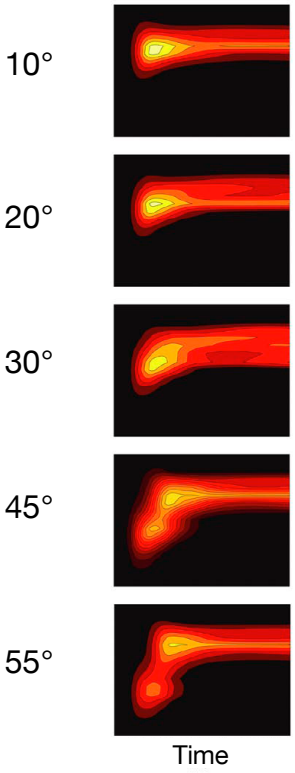
Question: Can this model of attention account for phenomena for which it was not designed for, such as feature inheritance?

# Feature Inheritance

Hamker (2007) Advances in Cognitive Psychology




The figure above shows the original sequence of images presented to the model. The target is visible for 30 ms (simulation time) followed by a grating for another 300 ms. The orientation of the target has been systematically varied (10°, 20°, 30°, 45°, 55°).

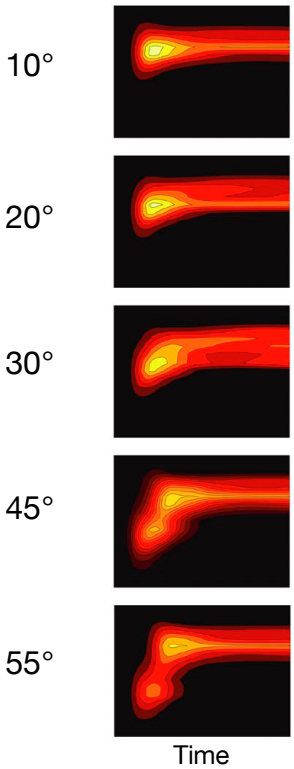



Population activity in IT from target onset to mask offset.

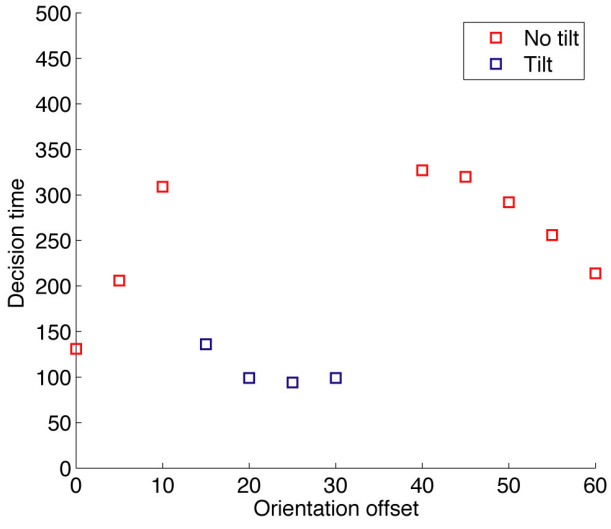
The numbers on the left indicate the orientation offset of the target stimulus with respect to the mask.



# Feature Inheritance in the model

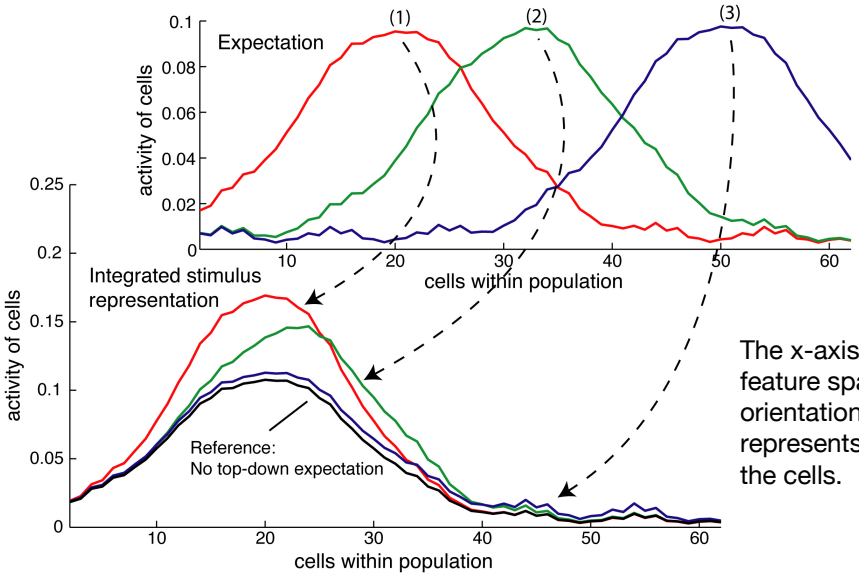



Perceptual decision based on the accumulated sensory evidence. The model predicts the perception of a tilt feature inheritance - depending on the orientation offset.




Temporal integration

## Feature inheritance - Putative mechanism




The x-axis represents the feature space such as orientation, and the y-axis represents the firing rate of the cells.

When the expectation is equal to the observation (1), the conspicuity of the integrated stimulus representation is enhanced as compared to the unmodulated reference. A partial overlap of expectation and observation results in the distortion of the population response into the direction of the expectation (2). When the expectation is much different, the integrated stimulus representation is largely unchanged (3).

Hamker (2007) Advances in Cognitive Psychology

# Discussion

Integration of recognition and attention into a common framework.

Attention improves object recognition, specifically in cluttered scenes.

Feature-specific feedback within the object recognition pathway, gain control and competitive interactions directly enhance the features of interest and guide spatial attention to the object of interest.

The direction of attention and recognition must be an iterative process to be effective.

# Discussion

Attention is a network property. Attention might be an emergent result of the interaction of areas involved in action, planning and perception.

It emerges since high level task descriptions have to be connected to low level scene descriptions.

The planning of an eye movement provides a reentry signal which influences perception

Decision making seems to be a continuous process in the sense that other brain areas are continuously updated