The study of the neuronal encoding of visual categorization with the use of a Kohonen network

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Inferior Temporal (IT) Cortex

•Neurons in the area produce responses that are shape and color selective.

•Neurons in the inferior temporal cortex show a shape selectivity which is invariant to luminance, position, and size.

•Overall shape preference of neurons in the area IT remained the same whether the shapes were defined by luminance, relative motion or texture.

•The shape selectivity of these neurons remained the same with partial occlusion.

•This led to the conclusion that the area IT plays a role in object recognition.

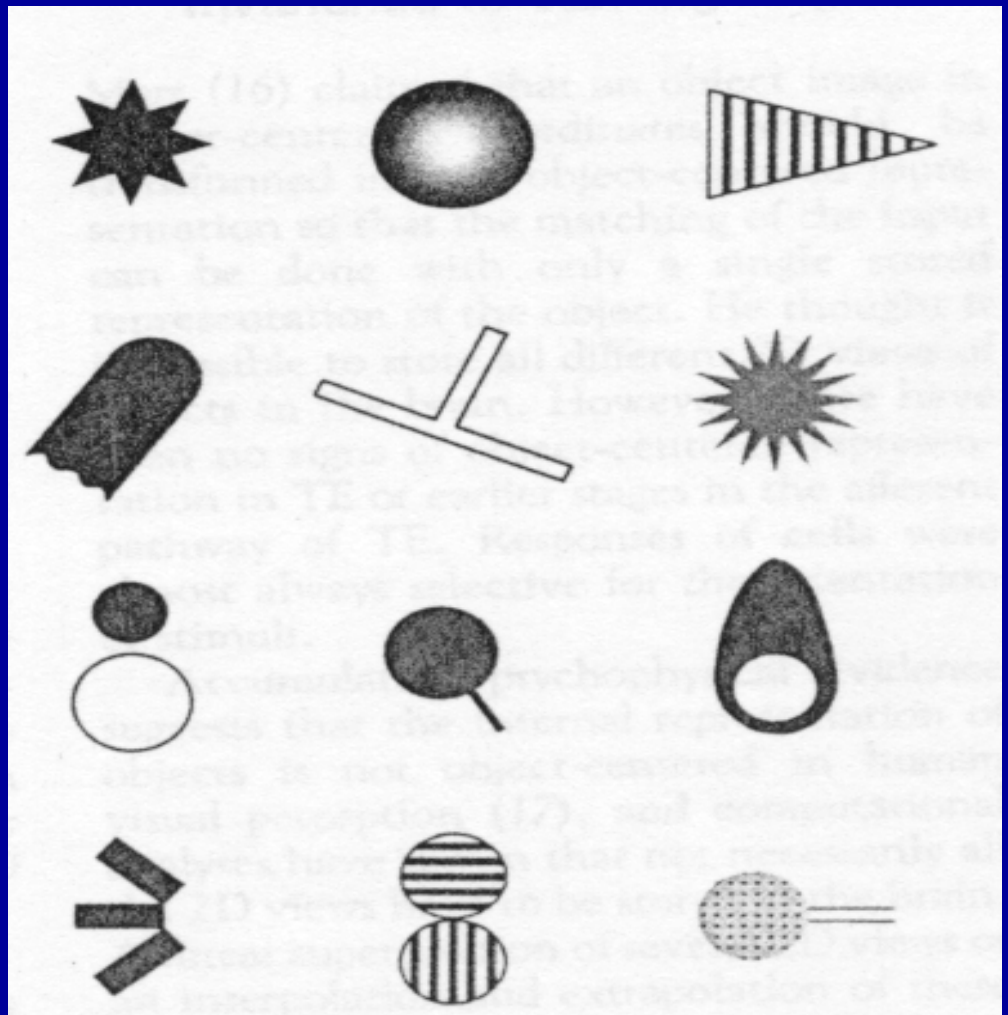

Fig. 2. Twelve examples of the critical features for the activation of single cells in area TE.

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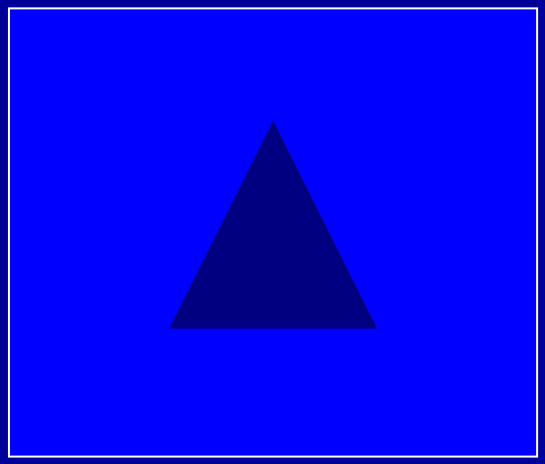
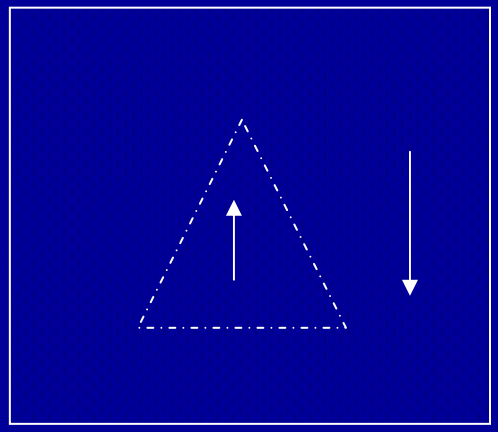
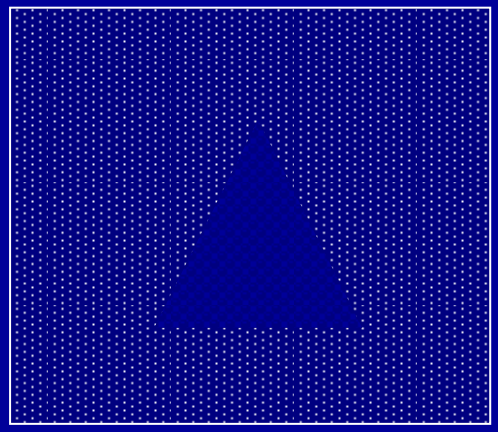
LUM



KIN





TEX

Vogels and Orban (1996) Progress in Brain Research 112: 195-211.

Purpose of this study:

How might the inferior temporal cortex contribute to visual categorization.

Task chosen:

Categorization of tree and non-tree stimuli.

Steps taken:

1)Behavioral testing of monkey capability to categorize tree and non-tree stimuli.
2)Neuronal recording in the inferior temporal cortex during the categorization.
3)Analysis of the neuronal data with the Kohonen network.


PHILIPS

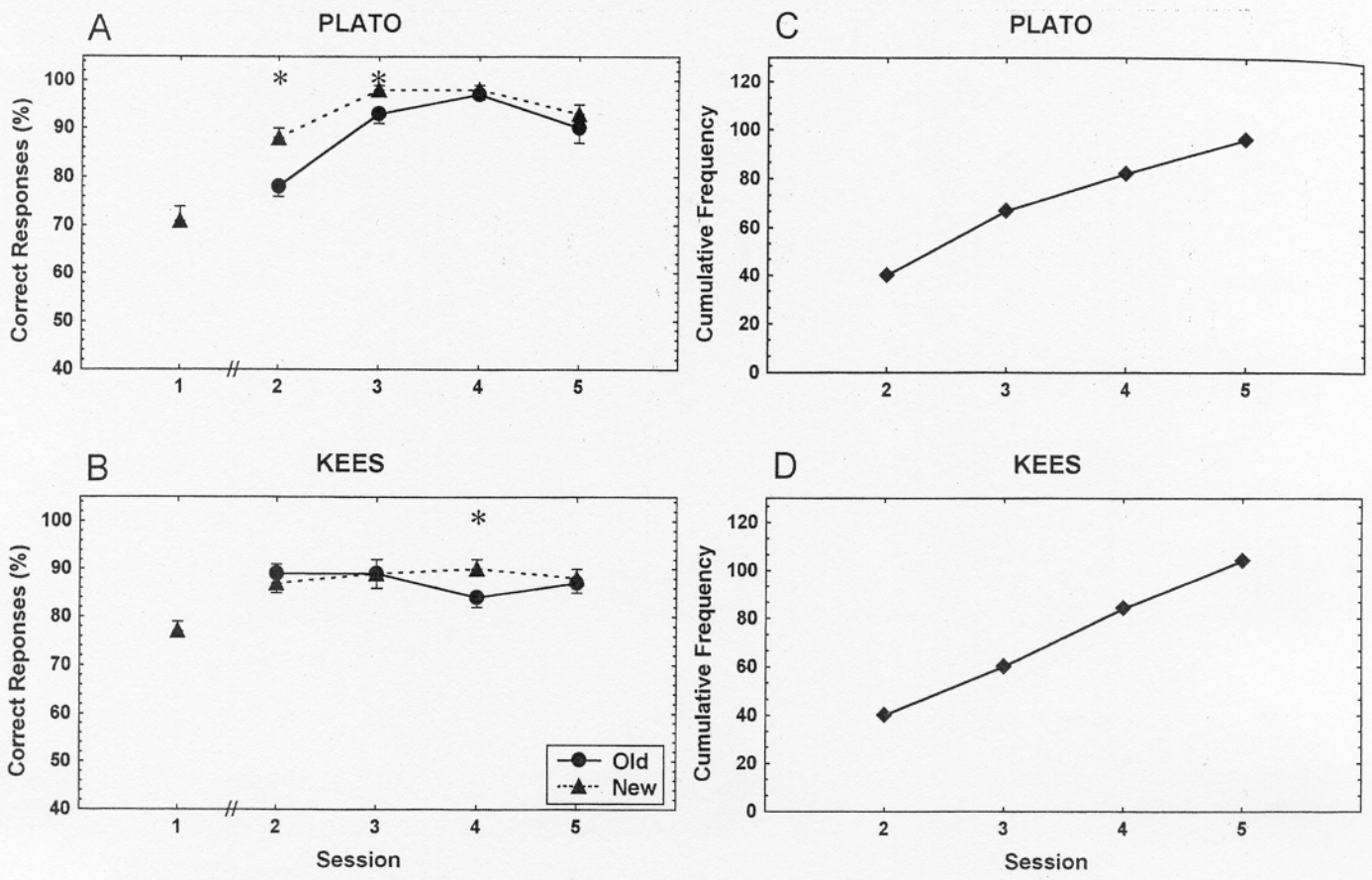


FIG. 7. Performance during training of the tree categorization task. (A,B) Mean proportion of correct responses and SEs in the first five training sessions for new (stippled) and old (full line) stimuli plotted separately for each monkey. Asterisks indicate significant difference (binomial test; $P < 0.05$) between old and new stimuli. For some data points, the SEs are smaller than the symbol size. (C,D) Cumulative number of different (novel) stimuli presented in sessions prior to the one indicated in the figure abscissa.

Vogels (1999) *European Journal of Neuroscience* 11:1223-1238.

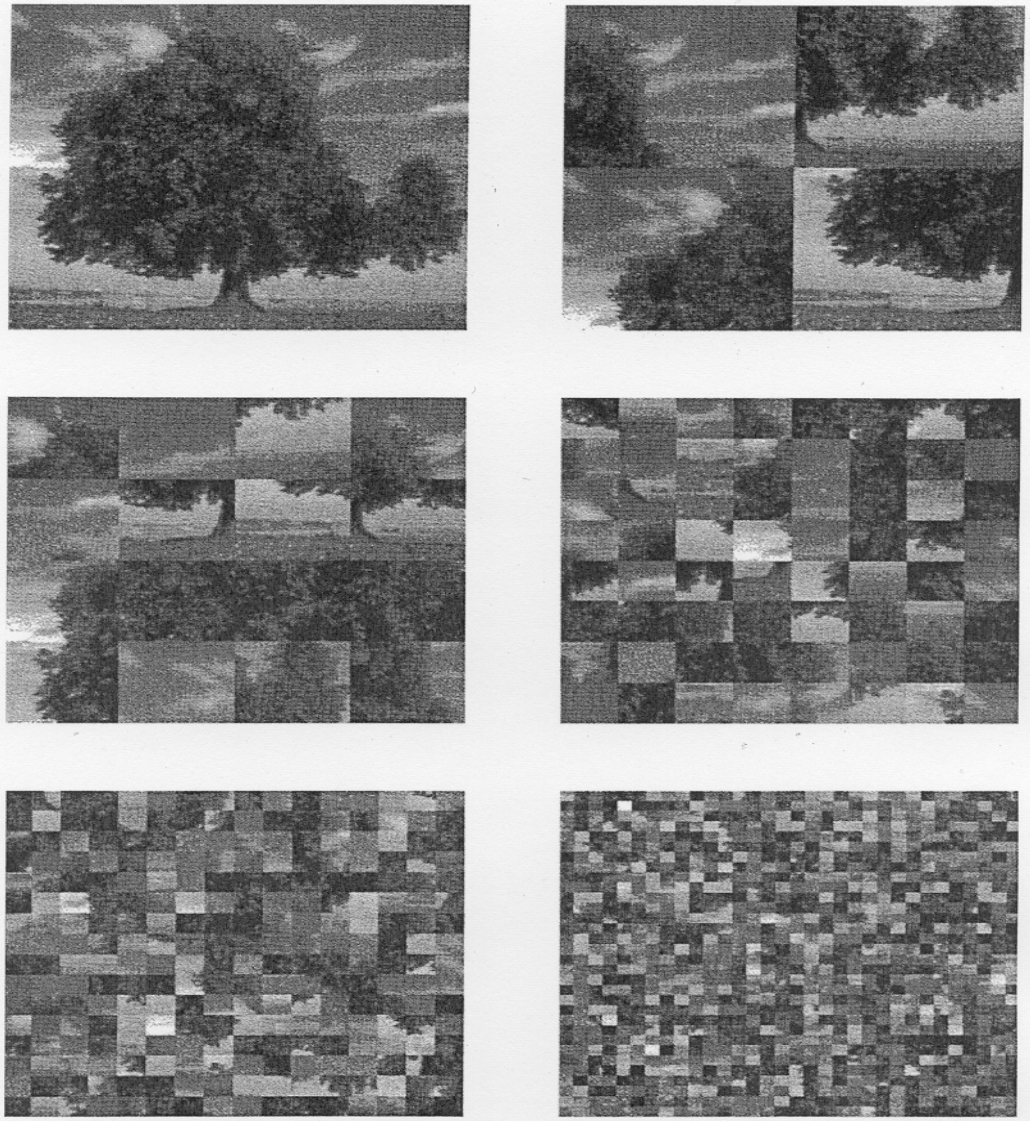


FIG. 5. Black-and-white reproduction of stimuli used in the scrambling experiment. The tree shown in the upper left panel is scrambled using an increasing number of parts sections. The images used in the experiment were in colour.

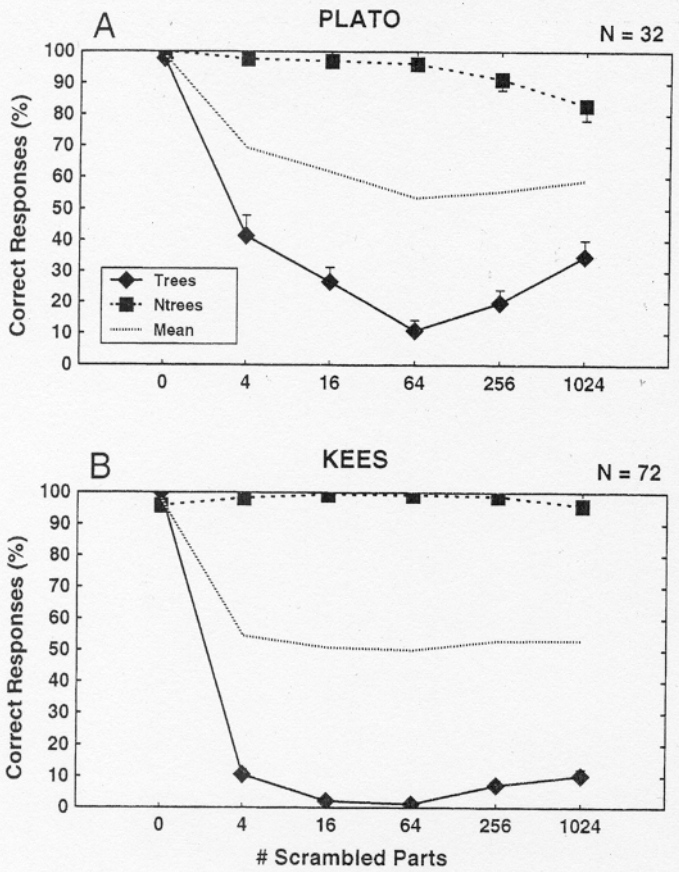
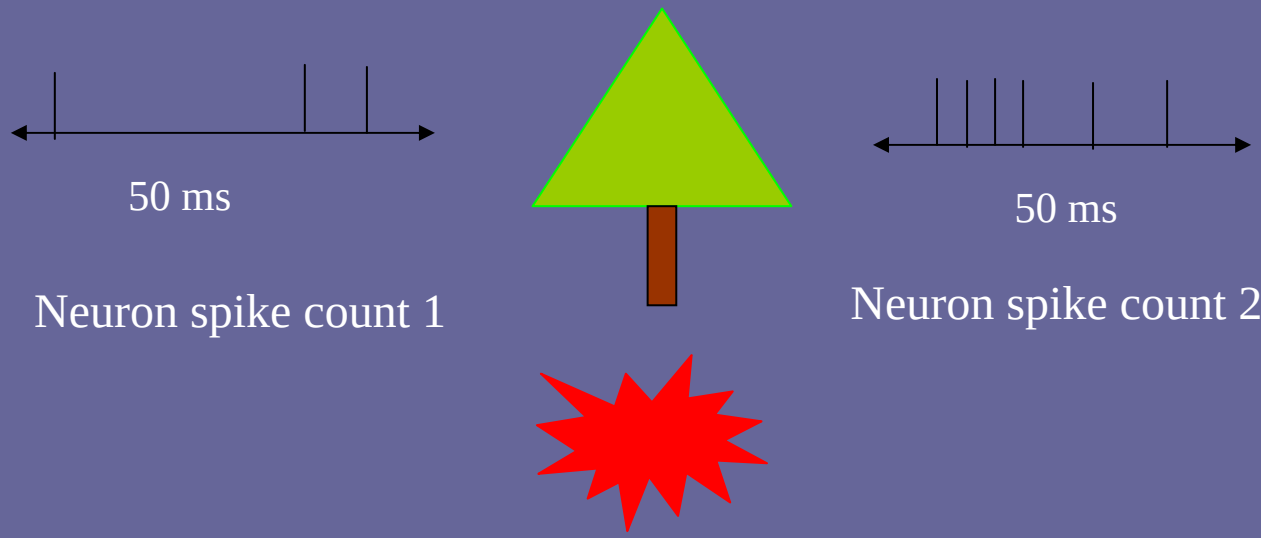


FIG. 9. Effect of stimulus scrambling on the categorization performance. The mean proportions of correct responses are shown for tree (full line), non-tree (stippled line) and both types of stimuli (mean; dotted line) as a function of the number of scrambled parts (see Fig. 5) for each of the two animals. SEs, when larger than symbols, as well as the number of scrambled stimuli, are indicated.

Neuronal Response : Spike counts

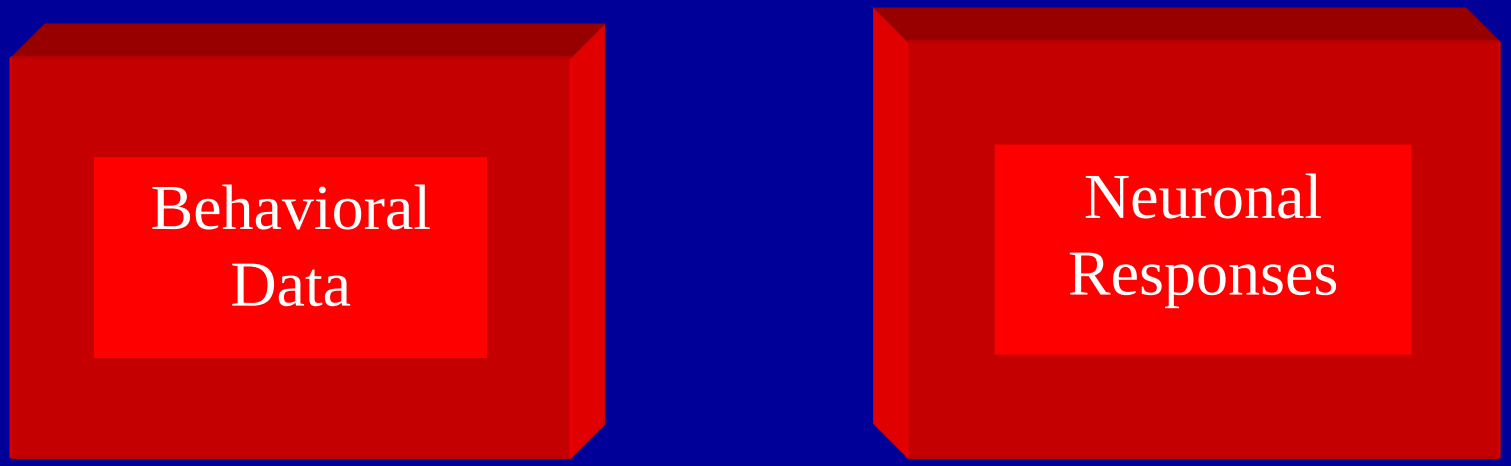


Neuron spike count 1

Neuron spike count 2

Stimulus response = Neuron spike count 2 – Neuron spike count 1

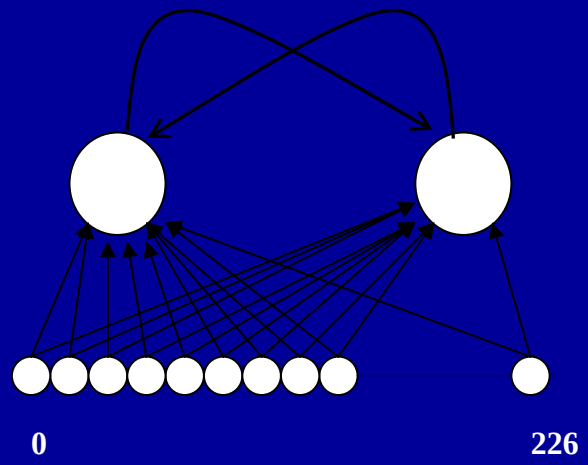
Vogels(1999) *European J of Neuroscience* 11: 1239-1255



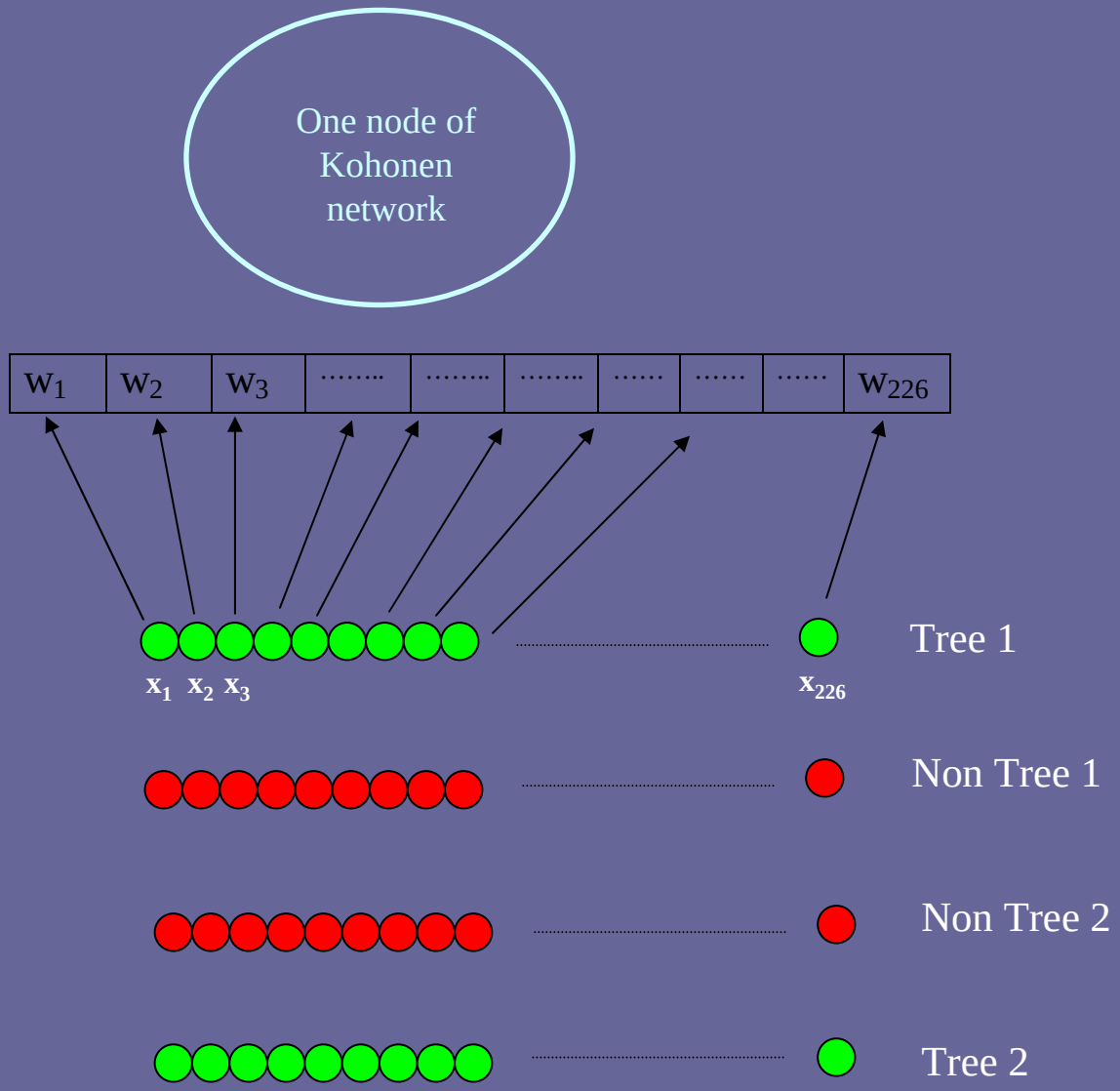
Is there sufficient information in the neuronal data collected in the area IT to account for the categorization performance of the monkey?

Method used to analyze the data

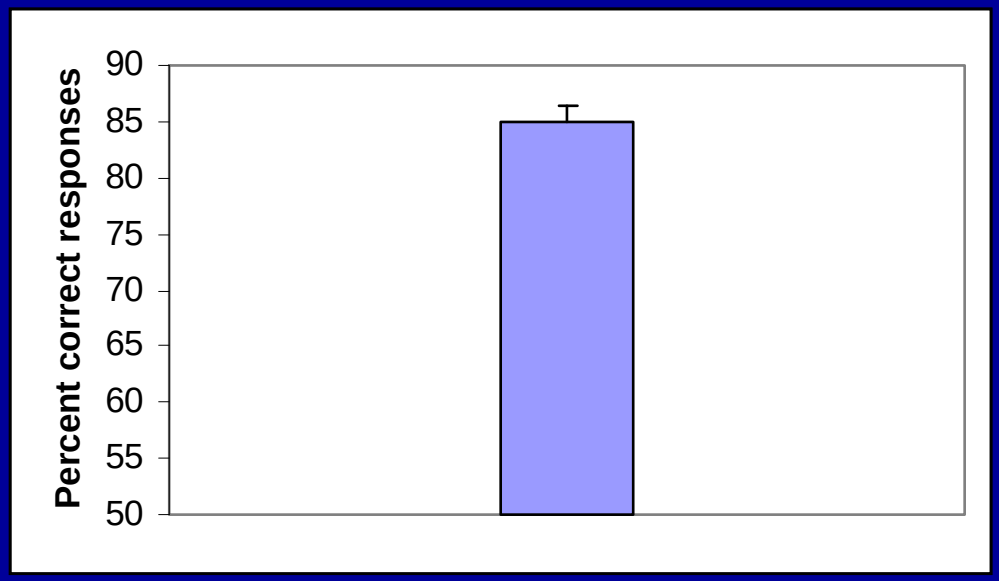
Kohonen network



Each node


One node of Kohonen network
W1
W2
W3
……..
……..
……..
……
……
……
W226
x1 x2 x3
x226
Tree 1
Non Tree 1
Non Tree 2
Tree 2

Success of categorization with a 2 node Kohonen network



Mean = 85.04201
SD = 1.306
Max = 88.35
Min = 83.6842

Identification of neurons crucial to the process of categorization

No neurons responded to all the members of a class. Most neurons responded to a subset of the presented trees and non-trees. A few neurons were category specific and only responded to a few samples of only one category.

Contribution of a type of neuron to categorization was judged by testing the categorization success of the Kohonen network after the ELIMINATION of this group of neurons from the response matrix.

Control provided by the assessment of network performance after the RANDOM elimination of the same number of neurons from the response matrix.

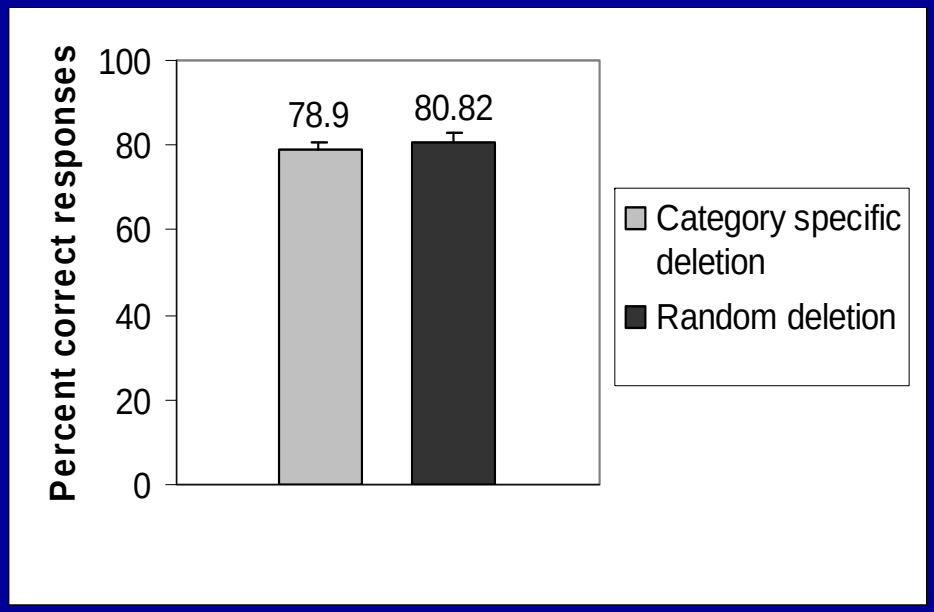
Classes of neurons investigated

Category specific neurons

Neurons which responded to both categories but favored one category. Responded to < 10 samples of the non-favored category (N10 neurons).

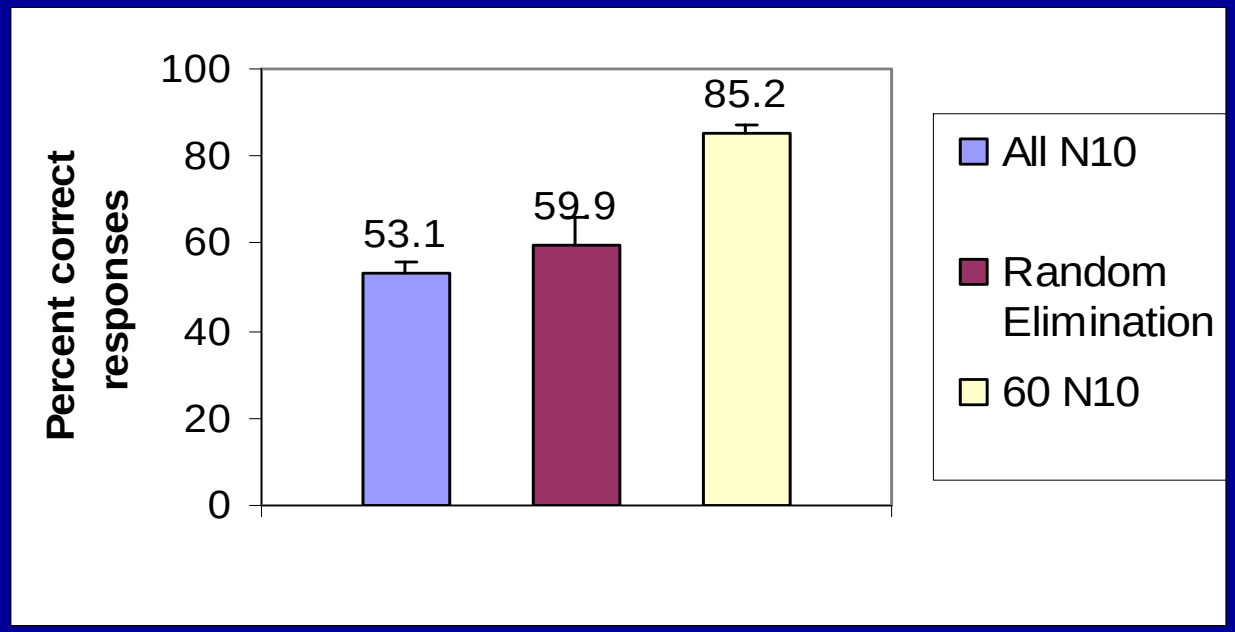
Neurons for which the number of samples of the favored category exceeded the number of samples of the non-favored category by 7 (D7 neurons).

The role of category specific neurons



Slight decrease in performance with deletion of category specific cells is not significantly different from decrease in performance with random deletion of the same number of neurons (57 neurons).

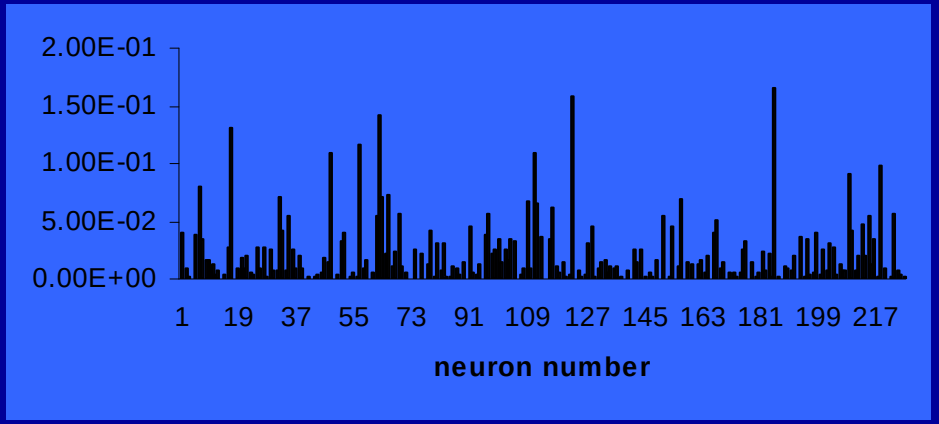
The role of N10 non-category specific neurons



Use of Kohonen network to identify neurons crucial to the process of categorization

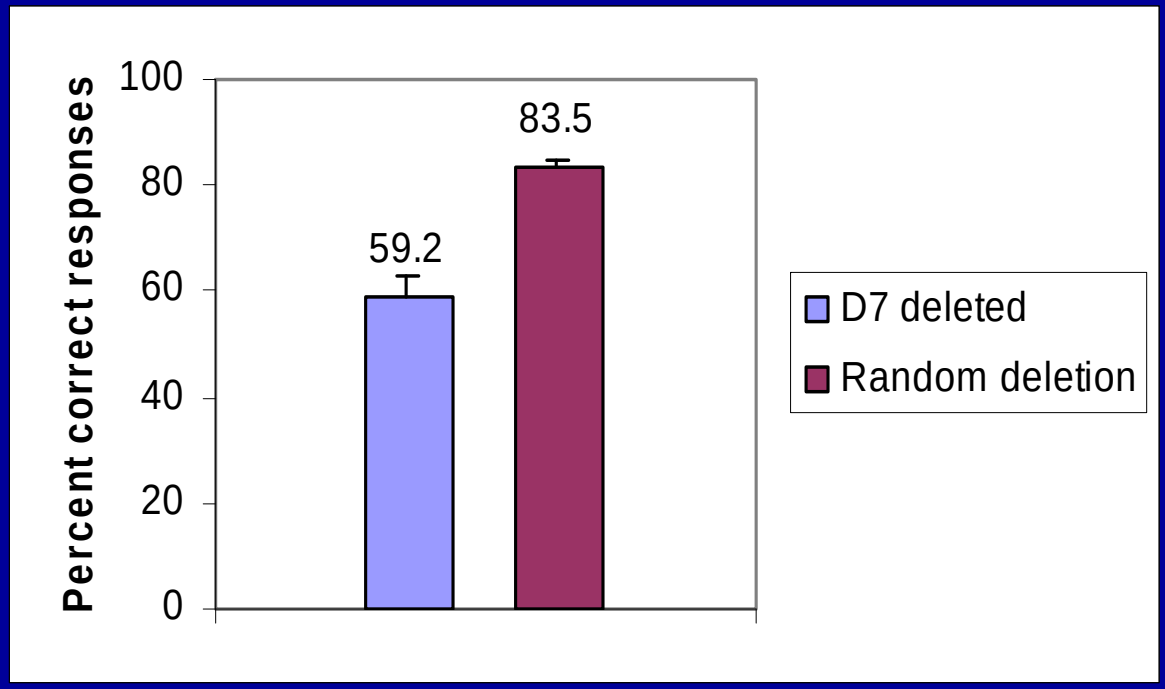
Following training, the weights of the Kohonen network were studied to observe which weights contributed the most to the difference in the weight vectors of the nodes in the Kohonen network.

$(w_{1i}-w_{2i})^2$



The neurons that contributed the most to the difference in the weight vectors of the Kohonen nodes were found to be broadly tuned cells which responded more to one category than the other. The number of their responses to the favored category, exceed the number of their responses to the non-favored category by at least more than seven images (D7 neurons).

Role of D7 neurons in categorization success



Note: Number of D7 neurons < Number of category specific neurons

Conclusion

Analysis of the neuronal response data in the area IT demonstrates that there is sufficient information in the area to account for upto 88% of categorization success in a tree, non-tree discrimination task.

Counter to intuition the group of category specific neurons was not found to be critical for the categorization. Instead, a class of more broadly tuned neurons, which responded to at least seven more samples of one category than the other was found to be essential.