Slide 1

Investigation of the perirhinal cortex

1. Capacity for recognition
2. Model of perirhinal processes

I’m going to divide my presentation into two parts. They are obviously related (as you will soon see).

Slide 2

Recognition in neural networks

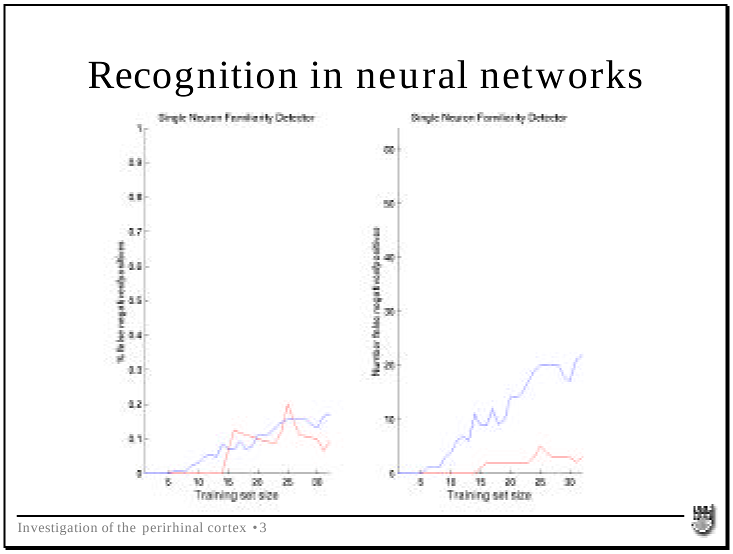
Hebb rule: $w_j \leftarrow w_j + \frac{1}{N} x_j$

Activation rule: $h = \sum_{j=1}^{N} x_j w_j$

Output: $y = sign(h - 0.5)$

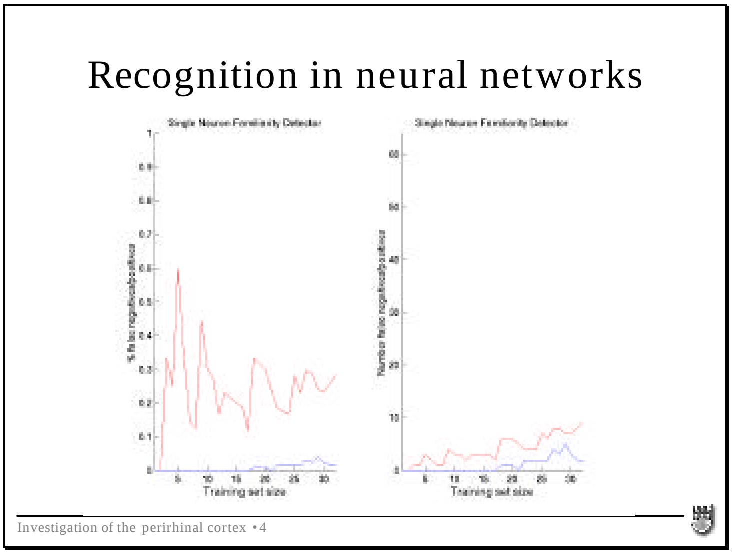
- In the first part of my project, I looked at ways of modeling recognition in a neural network.
- Rafal Bogacz proposes a “familiarity detector” using basic Hebbian learning.
- N is the number of inputs
- w’s are the weights.
- Assume binary input (i.e. either –1 or 1).
- Now, without any noise h will 1 for a stored pattern.
- For a novel pattern, on average h will be 0.
- Therefore, we can get a pretty good approximation with the output function.
- If noise is small enough, then the neuron behaves as a familiarity detector: +1 for familiar patterns and –1 for novel patterns.
- What is the capacity of this? Well, I won’t provide a proof, but the idea is that the more patterns we store, the more noise we get. Assuming we want very low error rate (1%), the stored capacity is 0.046N.
- Advantages: does not extend the basic neural net mechanisms. Has a sound theoretical foundation. Simple and easy to use. I think that last one is perhaps the most important.
- The authors then go on this whole spiel about “déjà vu” and so on.
- They also use this recognition model and extend it to the perirhinal cortex. In theory this is good, but I think they have a problem right at the start.
- Problems: does not work well in practice! This model is too simple to fit our real needs.

Slide 3



- I ran a little simulation using uniformly distributed data.
- Blue = false positives
- Red = false negatives
- As predicted, the network collapses at 0.046N.
- Issues to consider:
  1. This data behaves REALLY nicely. This does not happen in real life.
  2. There is a tradeoff between recognition of novelty and recognition of familiarity.
- Most stimuli are familiar. Therefore, it is important for familiarity to work. On the other hand, novelty detection may be important for survival.

Slide 4



- Then I did some other studies looking at variants of threshold rates. In this example, I optimized it based on the total error.
* I propose basing recognition on self-organized feature maps – they are clearly more robust and perhaps can lead to a better model. I hypothesize that it is a better model, but definitely lacking.

Slide 5

Recognition

1. Identification.
2. Judgement concerning prior occurrence.
   a. when it was encountered
   b. how many times
   c. context of occurence

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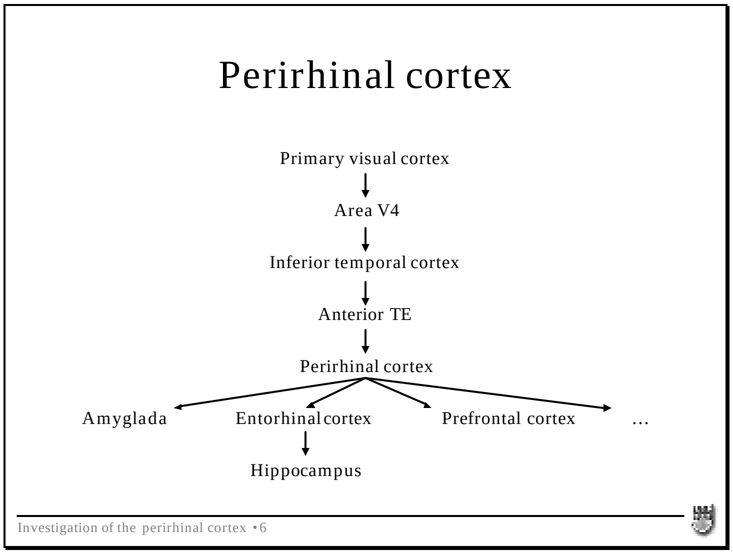
- Strong evidence that hippocampus is involved in identification and the perirhinal cortex is mostly responsible for the second.
- We won't look at context – no evidence that functionality is located in perirhinal cortex.
- The reason why perirhinal cortex is such a strong candidate is that there is a high proportion of *repetition-sensitive* neuron responses.

Slide 6



- Not very good at anatomy, but I do know it is located in or bounded by the anterior temporal cortex. You’ll have to excuse me.

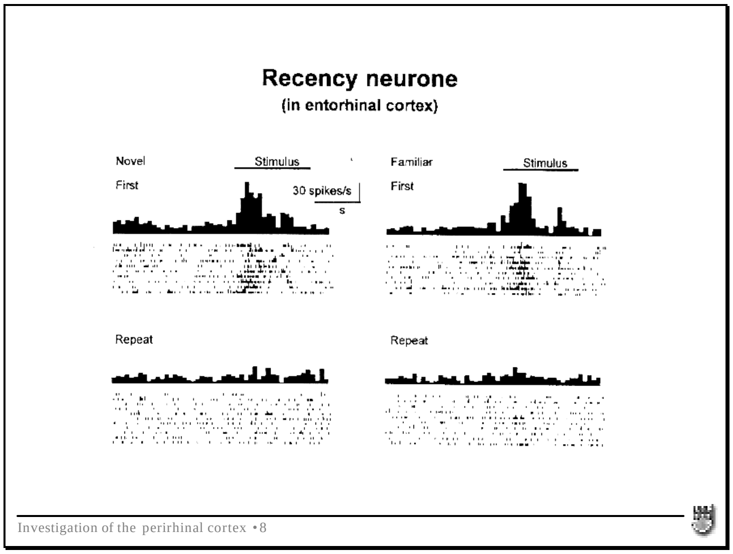
Slide 7

Studies on perirhinal cortex

- Serial recognition task.
- Some neurons demonstrate information in memory held longer than 24h.
- Visually responsive neurons.
- Three different classes:
  1. Recency (19%)
  2. Familiarity (37%)
  3. Novelty (38%)

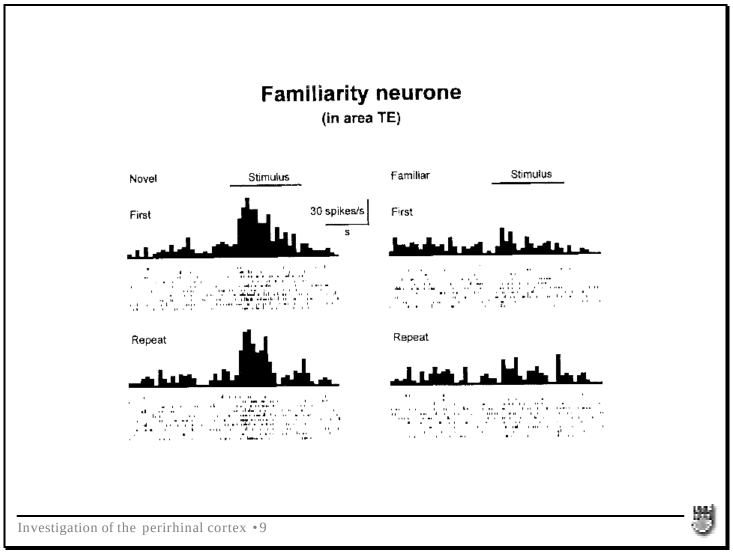
- Obviously, won't have time to go through all the experiments on recognition in the perirhinal cortex and other regions of the brain. i.e. we won't have a chance to look at these experiments critically. Very interesting, though.
- The experiments we're done using a serial recognition task.
- Memory span: longest interval following initial presentation of stimuli for which representation results in a significant change in activity.
- About 63% of the neurons in the rhinal cortices were responsive to visual stimuli.
- 93% of the differentially responsive neurons (via repetition) differed significantly on recency, familiarity, or both.
- What is important is the decrement in response.
- Best to let the pictures do the talking.

Slide 8



Recency neurone
(in entorhinal cortex)
Novel
Stimulus
First
30 spikes/s
s
Familiar
Stimulus
First
Repeat
Repeat

Slide 9


Familiarity neurone
(in area TE)
Novel
Stimulus
First
30 spikes/s
s
Repeat
Familiar
Stimulus
First
Repeat
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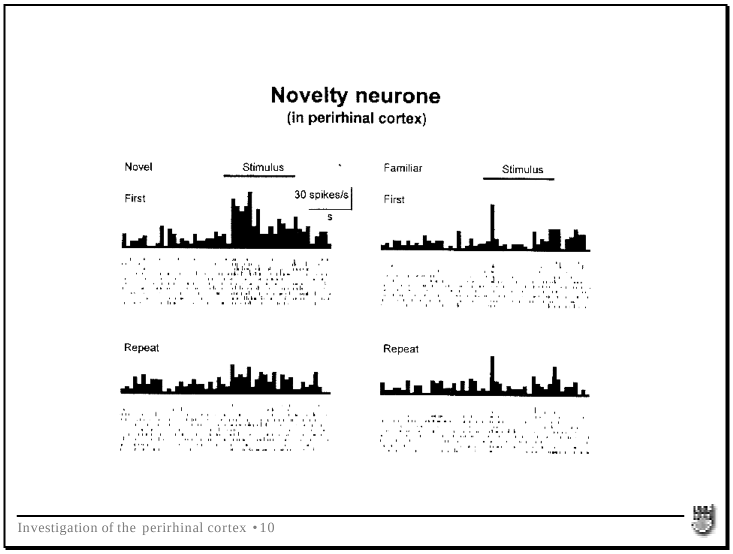
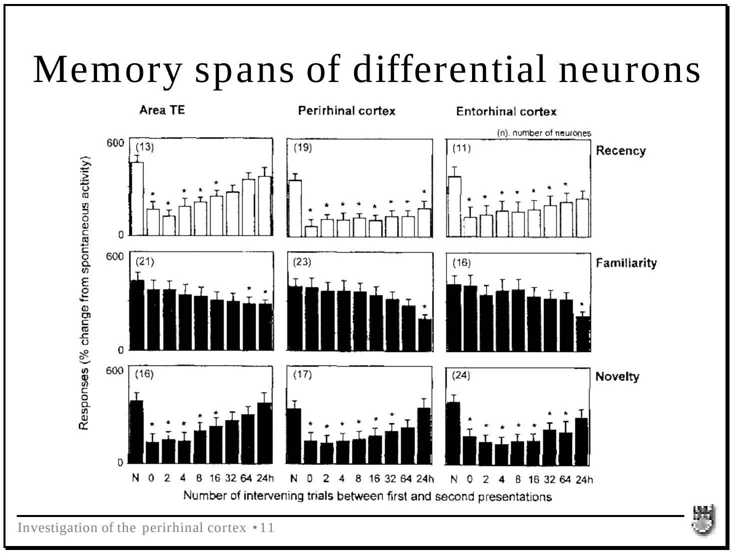
Slide 10


Novelty neurone
(in perirhinal cortex)
Novel
Stimulus
First
30 spikes/s
s
Repeat
Familiar
Stimulus
First
Repeat
Investigation of the perirhinal cortex • 10

Slide 11



- Summarized observations:
- Selectivity, rapidity and long-lasting nature of the response changes make them the foremost candidates for the neural substrates of a primary component to recognition memory.

Slide 12

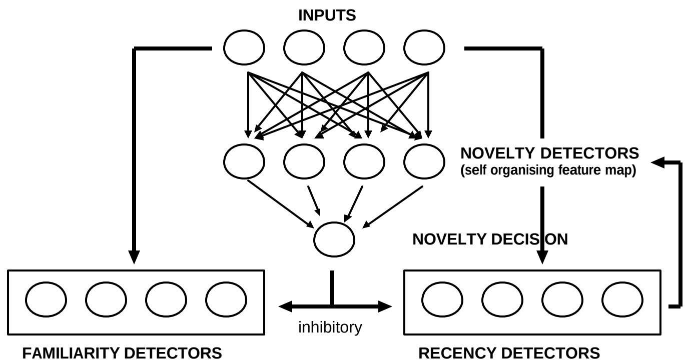
Preliminary investigations

Hypotheses of model:

- Memory is based on SOFM.
- Recency and familiarity are independent.
- Degradation an internal process (only dependent on time).

Slide 13

Preliminary investigations



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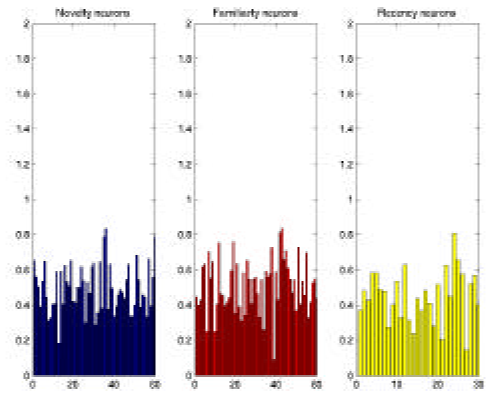
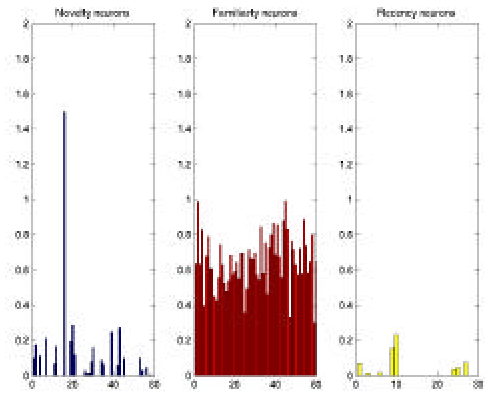
Preliminary investigations



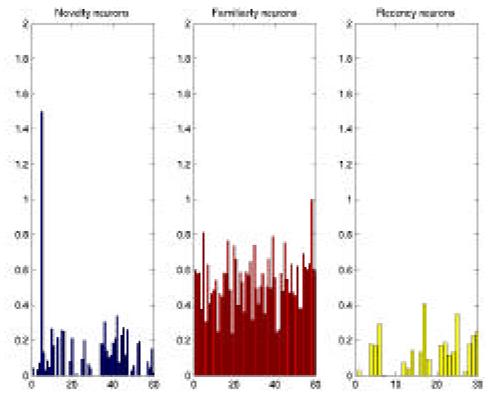
Slide 15

Preliminary investigations



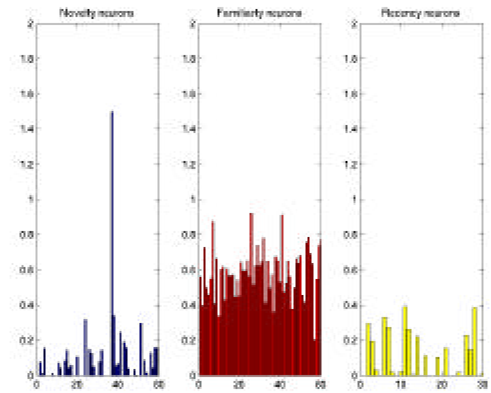
Slide 16

Preliminary investigations



Slide 17

Preliminary investigations



Slide 18

Considerations for building a model

- Different types of recency nodes.
- Multiple stimuli.
- Proximate physical distribution of network.
- Externally-independent progression of decision making.
- It seems probable that the *frequency* of stimulus is encoded.

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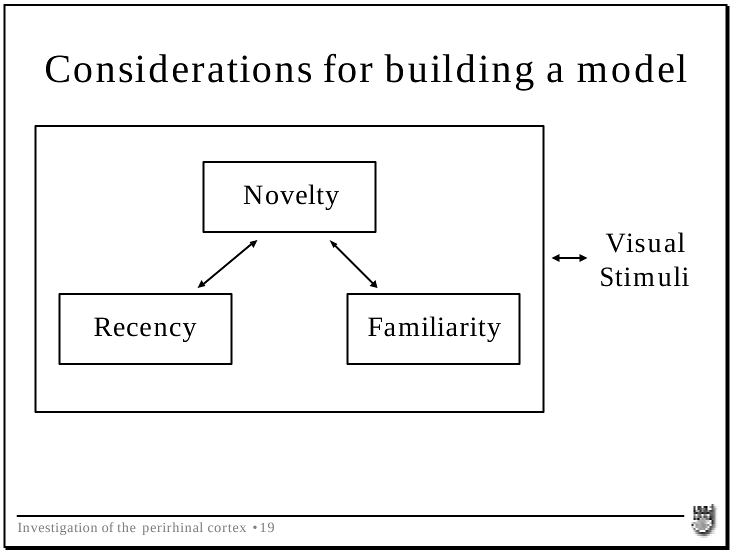
- To say the least, my model is not very robust and not very satisfying. We only consider a single varying stimulus.
- Therefore, locality of neuronal information is possibly very important to the success of this process (as observed in experiments – implicit?). This phenomenon has been observed elsewhere in the brain. We need to answer the question: how is it important?
- Different types of recency nodes (i.e. different durations) have been observed anecdotally in experiments. This seems plausible.
- A better understanding (perhaps through experiment!) of how we can include multiple stimuli in the modeling of serial recognition processes. This is probably strongly related to how the neurons are physically distributed in the perirhinal cortex.
- This last one is probably the most difficult, partly since we cannot observe the results directly. However, this is also the most crucial to a proper model.

Slide 19



- To say the least, my model is not very robust and not very satisfying. We only consider a single varying stimulus.
- Therefore, locality of neuronal information is possibly very important to the success of this process (as observed in experiments – given the high degree of correlation between neurons of the same time). This phenomenon has been observed elsewhere in the brain. We need to answer the question: how is it important?
- Different types of recency nodes (i.e. different durations) have been observed anecdotally in experiments. This seems plausible.
- A better understanding (perhaps through experiment!) of how we can include multiple stimuli in the modeling of serial recognition processes. This is probably strongly related to how the neurons are physically distributed in the perirhinal cortex.
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Slide 20

Bibliography

R. Bogacz, M.W. Brown and C. Giraud-Carrier (2001). Model of familiarity discrimination in the perirhinal cortex. *Journal of Computational Neuroscience* 10, pp. 5-23.

R. Bogacz, M.W. Brown and C. Giraud-Carrier (1999). High capacity neural networks for familiarity discrimination. *Proceedings of International Conference on Artificial Neural Networks, Edinburgh*, pp. 773-776.

M. W. Brown and J.-Z. Xiang (1998). Recognition memory: neuronal substrates of the judgement of prior occurrence. *Progress in Neurobiology* 55, pp. 149-189.

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Slide 21

"...and, as you go out into the world, I predict that you will, gradually and inperceptibly, forget all you ever learned at this university."

Slide 22

- Summarized observations:
- Selectivity, rapidity and long-lasting nature of the response changes make them the foremost candidates for the neural substrates of a primary component to recognition memory.