Selectivity and temporal resolution of neural coding in rostral auditory cortex of macaques during a working memory task

Brian H. Scott[1], Alexander Kloth[1], Pingbo Yin[2] and Mortimer Mishkin[1]

[1]Laboratory of Neuropsychology, NIMH, NIH, Bethesda, MD [2]Institute for Systems Research, Univ. of Maryland, College Park, MD

174.10

HH14

Question

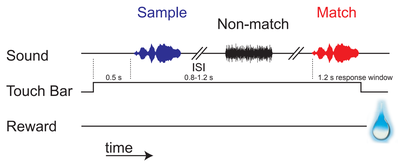
How do neurons of higher-level auditory cortex encode the identity of a sound?

- Rate codes (total number of spikes fired)
- Temporal codes (timing of spike occurrence)

Is this representation affected by the behavioral context in which the sound appears?

How might these neurons be involved in auditory working memory?

Auditory Delayed-Match-to-Sample



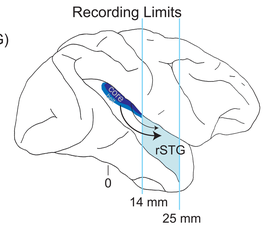
Monkey must release a touch bar upon hearing the match (repetition of the sample stimulus) to earn a liquid reward.

Recording Sites

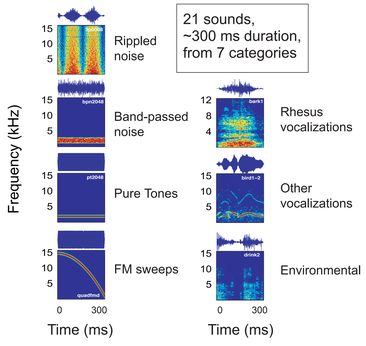
Rostral superior temporal gyrus (rSTG)
Anterior core and belt fields

Left and right hemispheres of 2 rhesus

Single units analyzed: 47

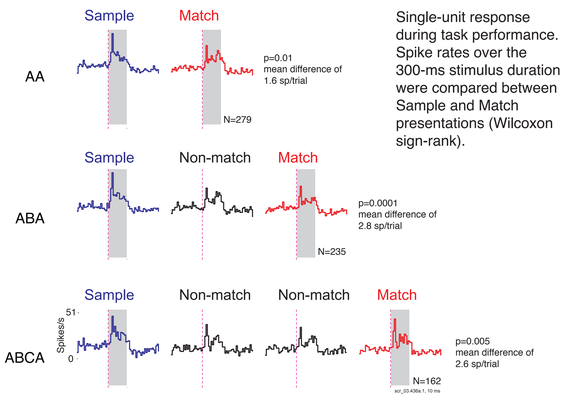


Stimuli

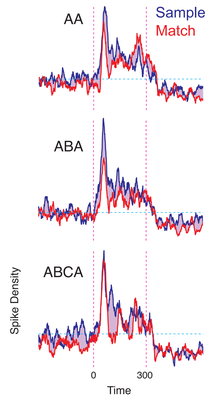


21 sounds,
~300 ms duration,
from 7 categories

Neural Responses



Single-unit response during task performance. Spike rates over the 300-ms stimulus duration were compared between Sample and Match presentations (Wilcoxon sign-rank).



In this neuron (shown at left), discharge rate during match presentations is suppressed relative to sample (with or without intervening non-match stimuli).

Across the population:

In about half of the neurons examined here, discharge rate differed between sample and match (p<.01).

AA trials:
- 13 (31%) cases of match suppression
- 6 (14%) of match enhancement

ABA trials:
- 18 (43%) cases of match suppression
- 1 (2%) of match enhancement

ABCA trials:
- 18 (43%) cases of match suppression
- no match enhancement

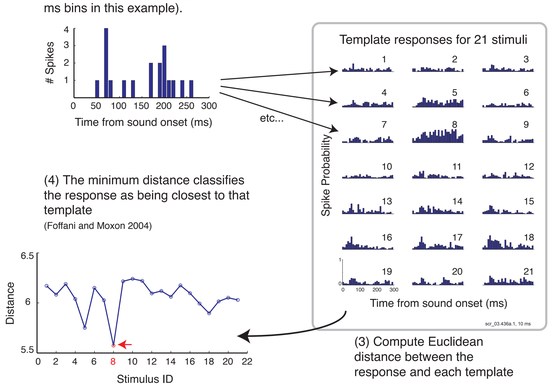
Question revisited:
- Is the neural code consistent across trial conditions?
- How might sound identity be encoded in a way that is robust to changes in discharge rate?

Analysis

Template-based classification of single-neuron responses:
- How well can one neuron encode the identity of the sample sound?
- How useful is temporal structure in the spike responses?
- How will neural responses to sample and match presentations differ?

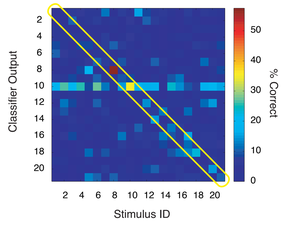
(1) For each response (one stimulus, one trial), bin the spike times to form a peri-stimulus time histogram (10 ms bins in this example).

(2) Compare that response against a template histogram constructed for each stimulus from all the remaining trials

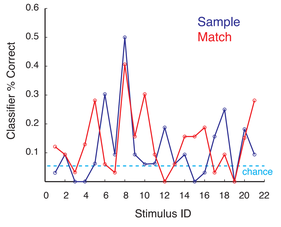


(4) The minimum distance classifies the response as being closest to that template
(Foffani and Moxon 2004)

(3) Compute Euclidean distance between the response and each template



Matrix relates actual stimulus identity (columns) to classifier output (rows).
Correct classifications fall on the diagonal. Values along the diagonal are plotted below.



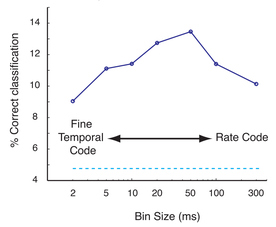
Overall performance in this neuron is ~12% correct, but is much higher for some stimuli, and at chance for others.

Performance differs between responses to sample and match presentations; in this neuron, the best stimulus is consistent across conditions.

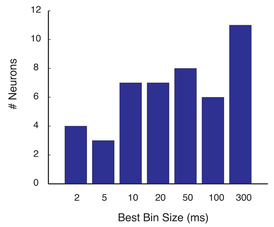
Results and Conclusions

I. Optimal temporal resolution varies between cells, but is consistent throughout the trial.

Varying temporal resolution between fine rate code (150 2-ms bins) and coarse temporal code (1 300-ms bin) reveals best performance at intermediate values (50 ms in this neuron).

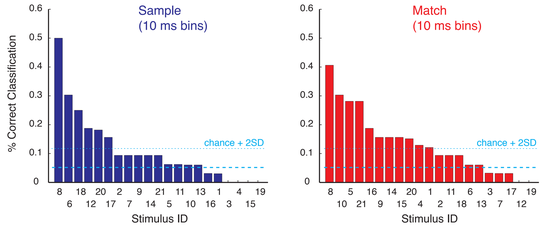


Best bin size varied across the population of recorded neurons, but did not differ between sample and match presentations within cells.



II. Neural selectivity can be affected by task context

For the example neuron, tuning was more selective to sample presentations, indicated by the more peaked distribution of classification performance in the left graph.



III. Temporal codes appear to be more informative, and are robust throughout the memory task

Mean number of stimuli classified at >2 s.d. above chance:

	Sample	Match	Wilcoxon sign-rank
Temporal code (best bin width)	4.7	4.5	not sig.
Rate code (300 ms window)	3.6	2.9	p=.01

References:

Foffani G, and Moxon KA (2004). *J. Neurosci Methods* **135**: 107.

Contact: *brianscott@mail.nih.gov*

Supported by IRP/NIMH/NIH