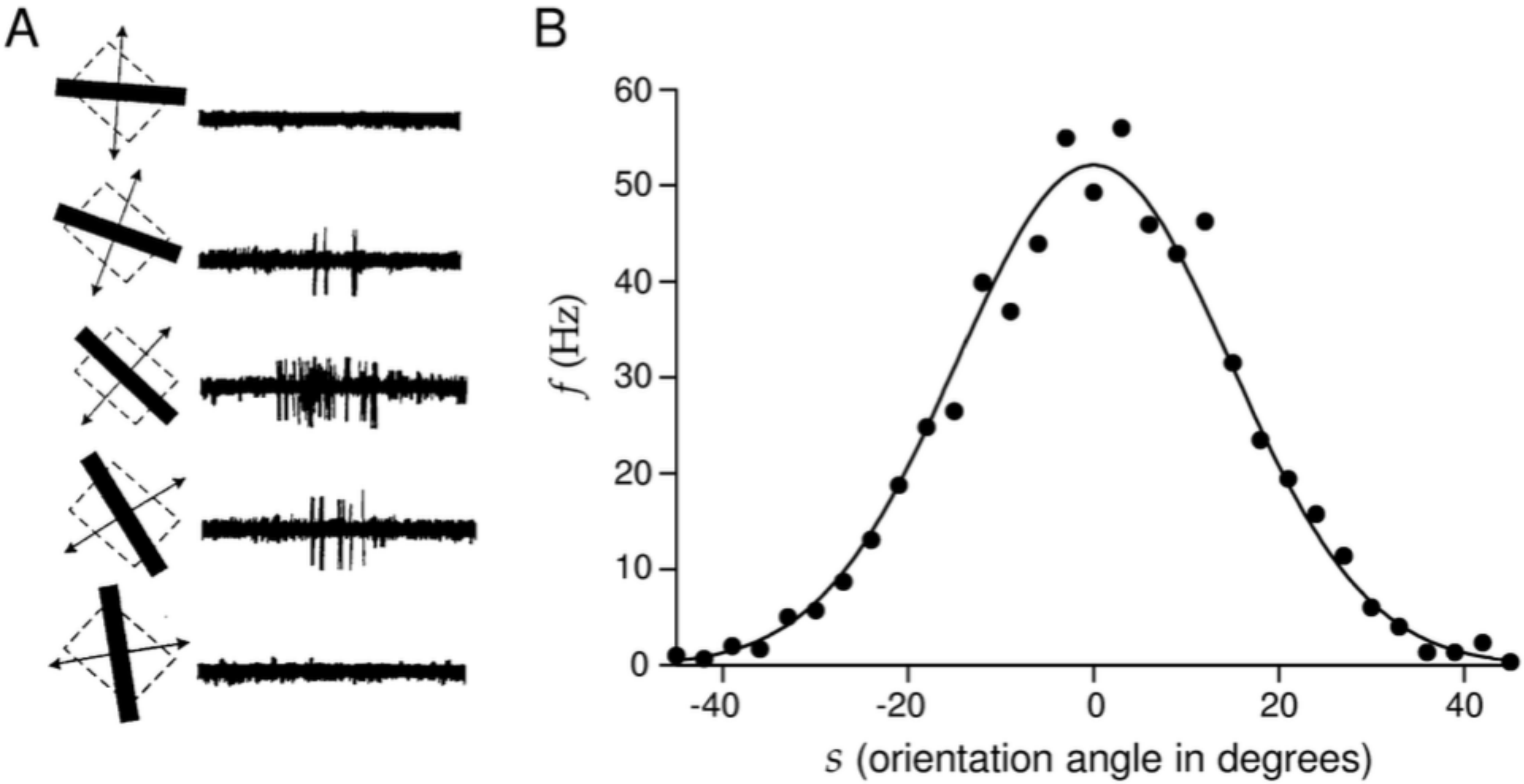
Thanks to Profs Brent Doiron and Adrienne Fairhall
For many of these slides and images!!

Receptive fields and tuning curves

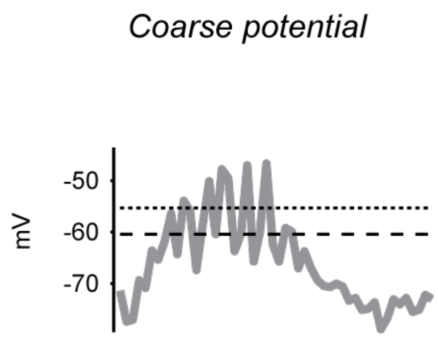
Tuning curve: r = f(s)



Gaussian tuning curve of a cortical (V1) neuron

How repeatable is response across trials?

Trial 1



Carandinni PLoS Bio. 2004

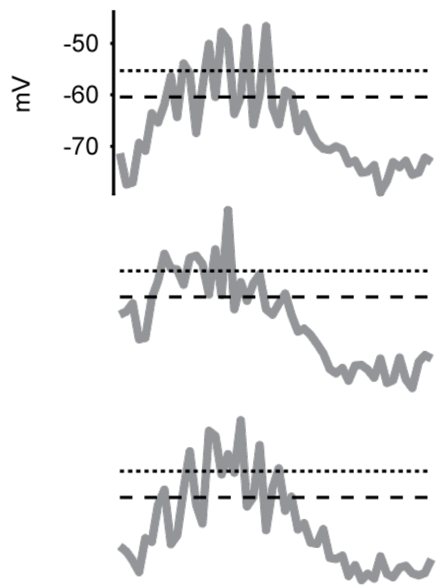
How repeatable is response across trials?

Coarse potential

Trial 1

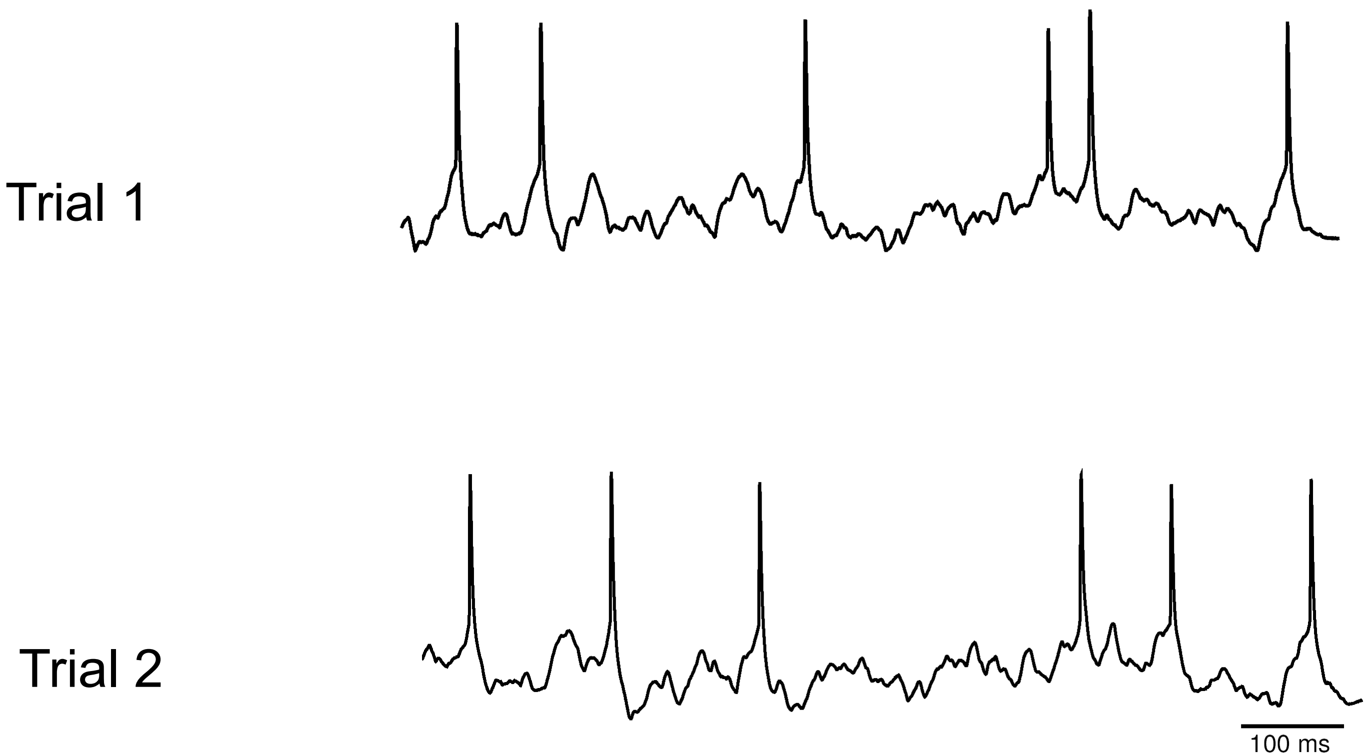
Trial 2

Trial 3



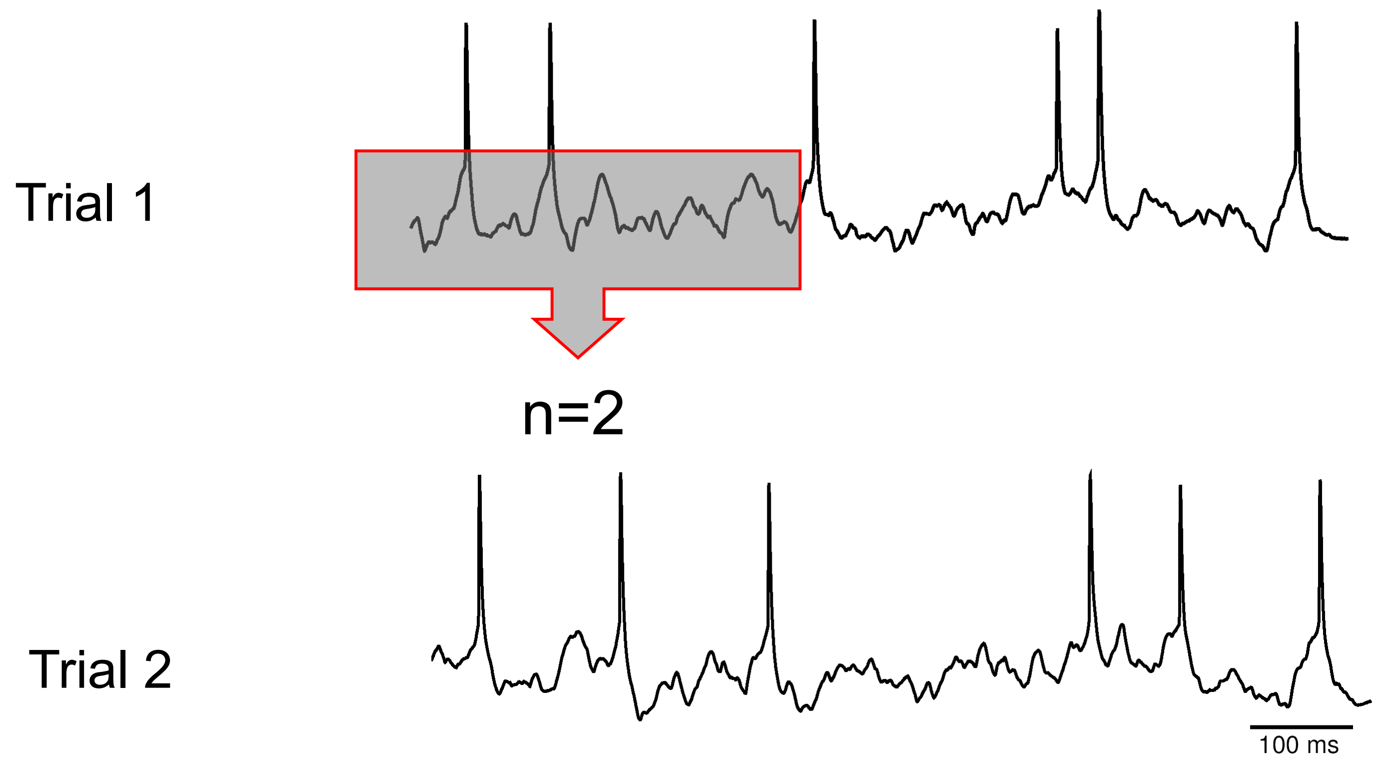
Carandinni PLoS Bio. 2004

Quantifying spike count variability across trials



Quantifying spike count variability across trials

define window of length T



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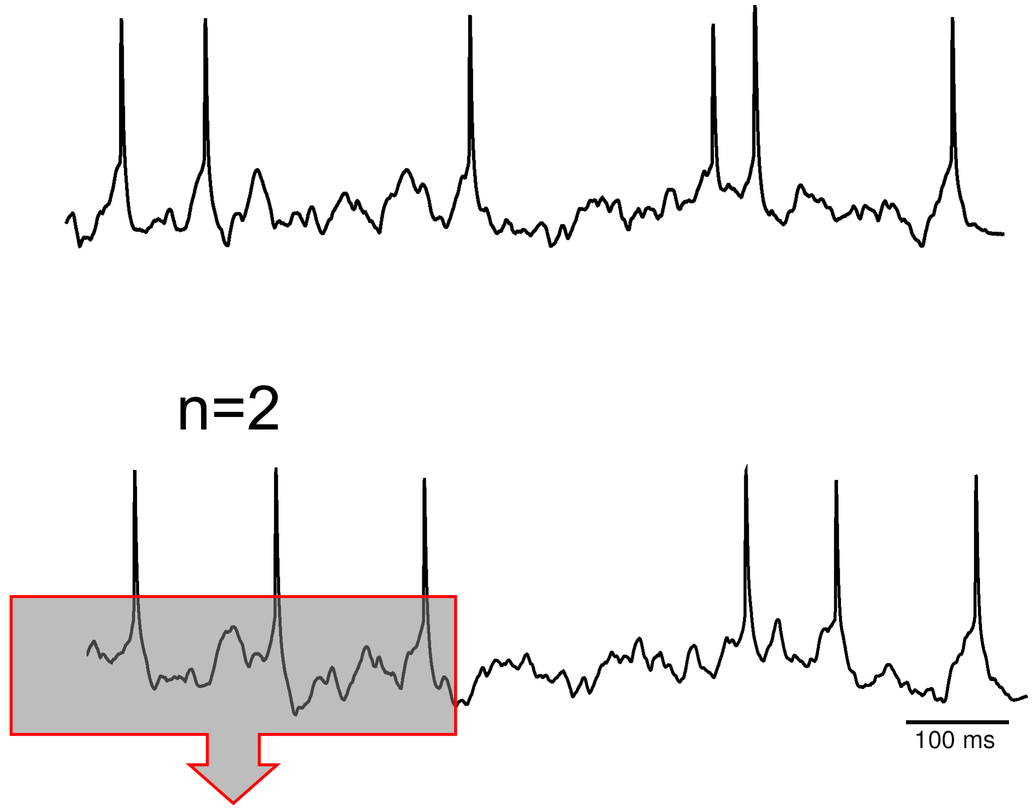
Quantifying spike count variability across trials

define window of length T

Trial 1

n=2

Trial 2



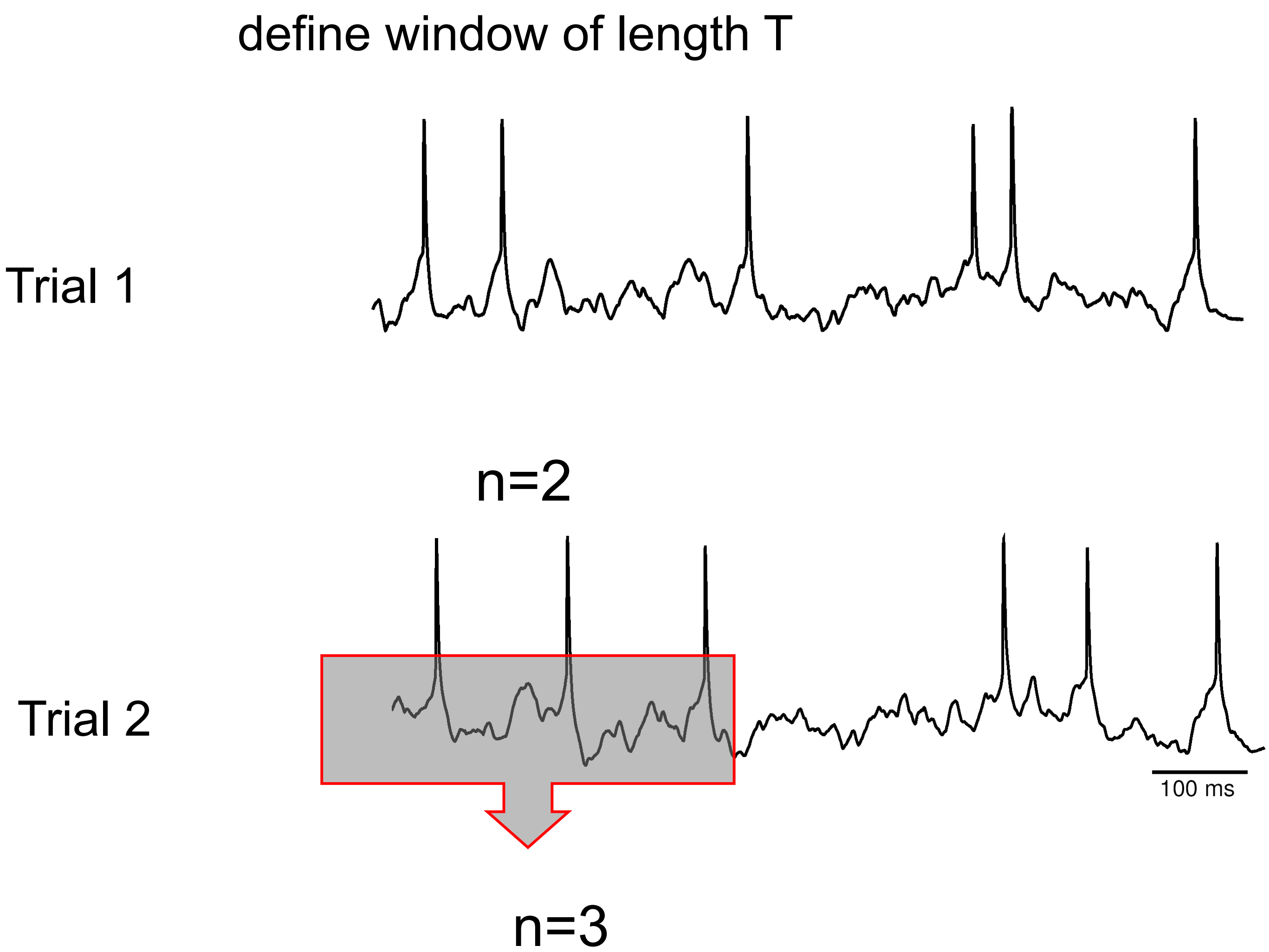
n=3

.

.

.

Quantifying spike count variability across trials

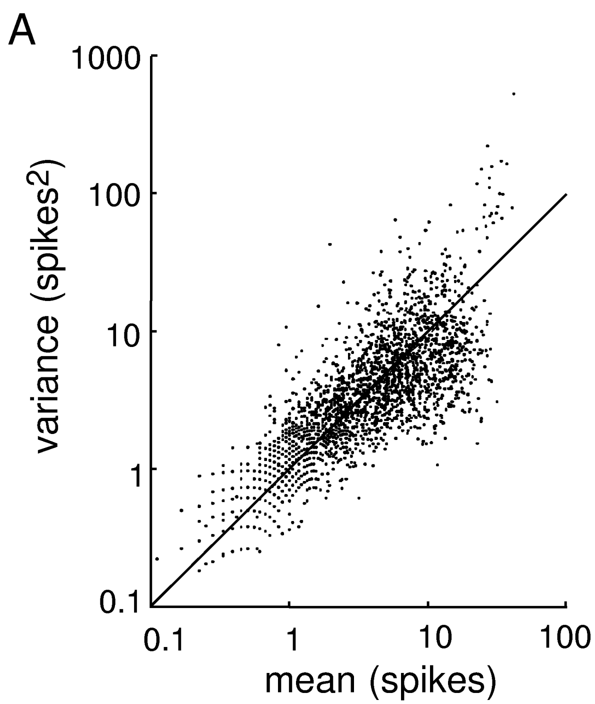


$$\text{mean across trials } (n) = mean_T$$
$$\text{variance across trials } (n) = var_T$$

FANO FACTOR

$$F_T = \frac{var_T}{mean_T}$$

In vivo responses are very unreliable



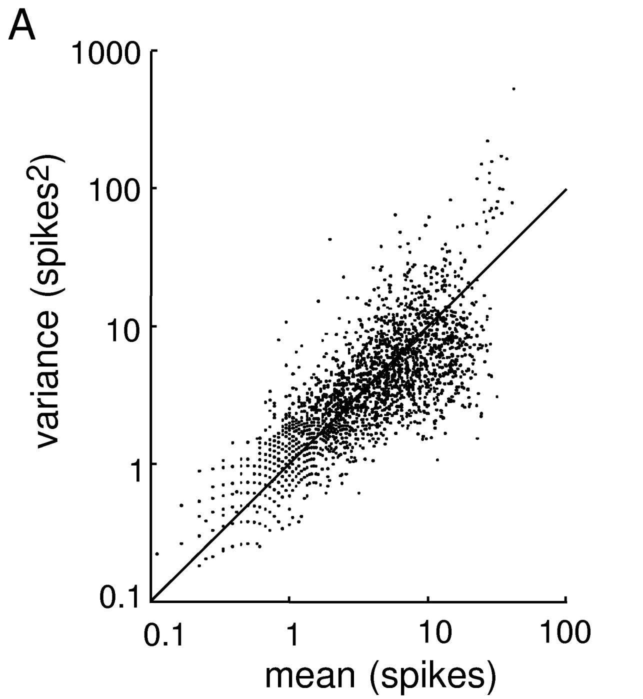
Timespan varies and the stimulus varies

$$F_T \approx 1$$

across very different timespans and stimulus varies

Fig. 1.14, Abbott and Dayan: Responses from MT visual neurons (O'Keefe et al '97)

In vivo responses are very unreliable



Where each spike is likely to occur evenly in each time been.
Prob of spike = firing rate * time bin size

FACT (Ch. 1):
FANO FACTOR FOR
POISSON PROCESS = 1

So responses appear as noisy
as for this “maximally random”

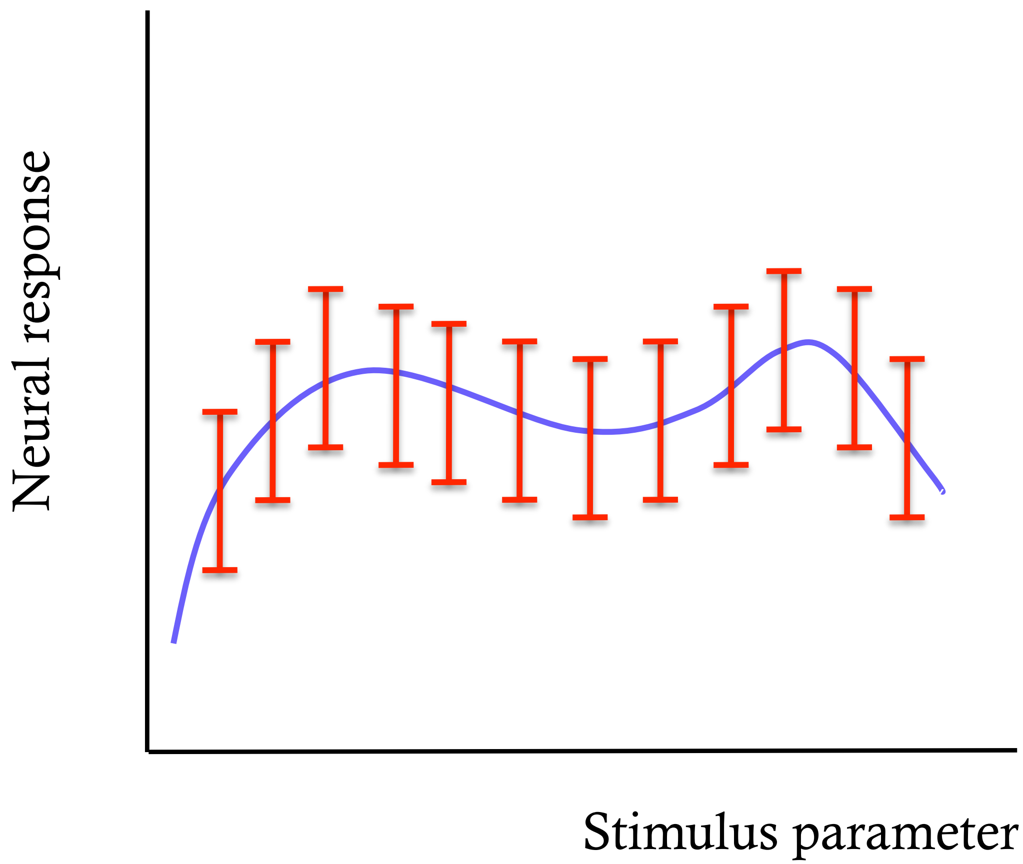
$$F_T \approx 1$$

Fig. 1.14, Abbott and Dayan: Responses from MT visual neurons (O’Keefe et al ’97)

Working with noisy responses

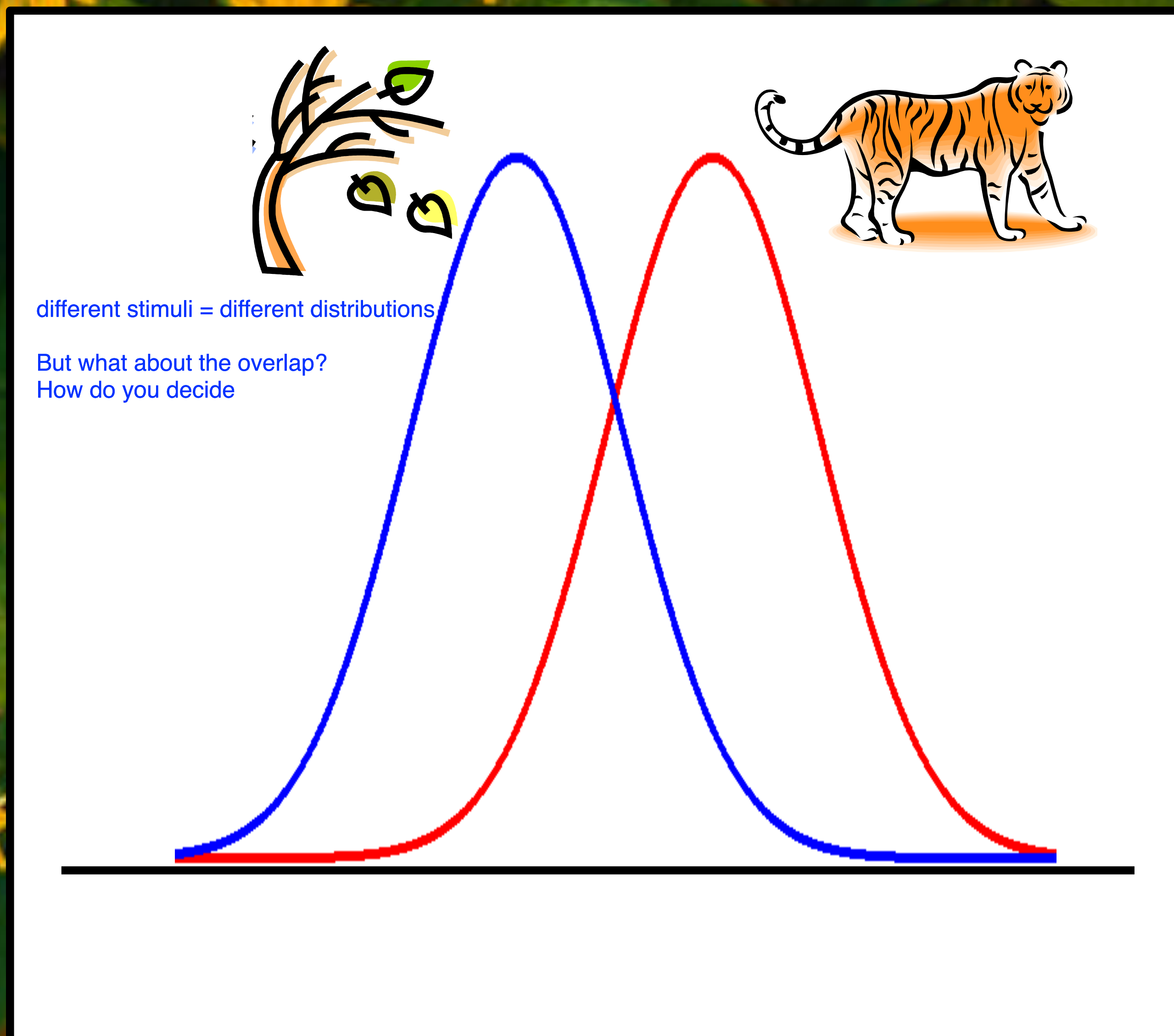
• Neural responses are noisy! How do we deal with that?

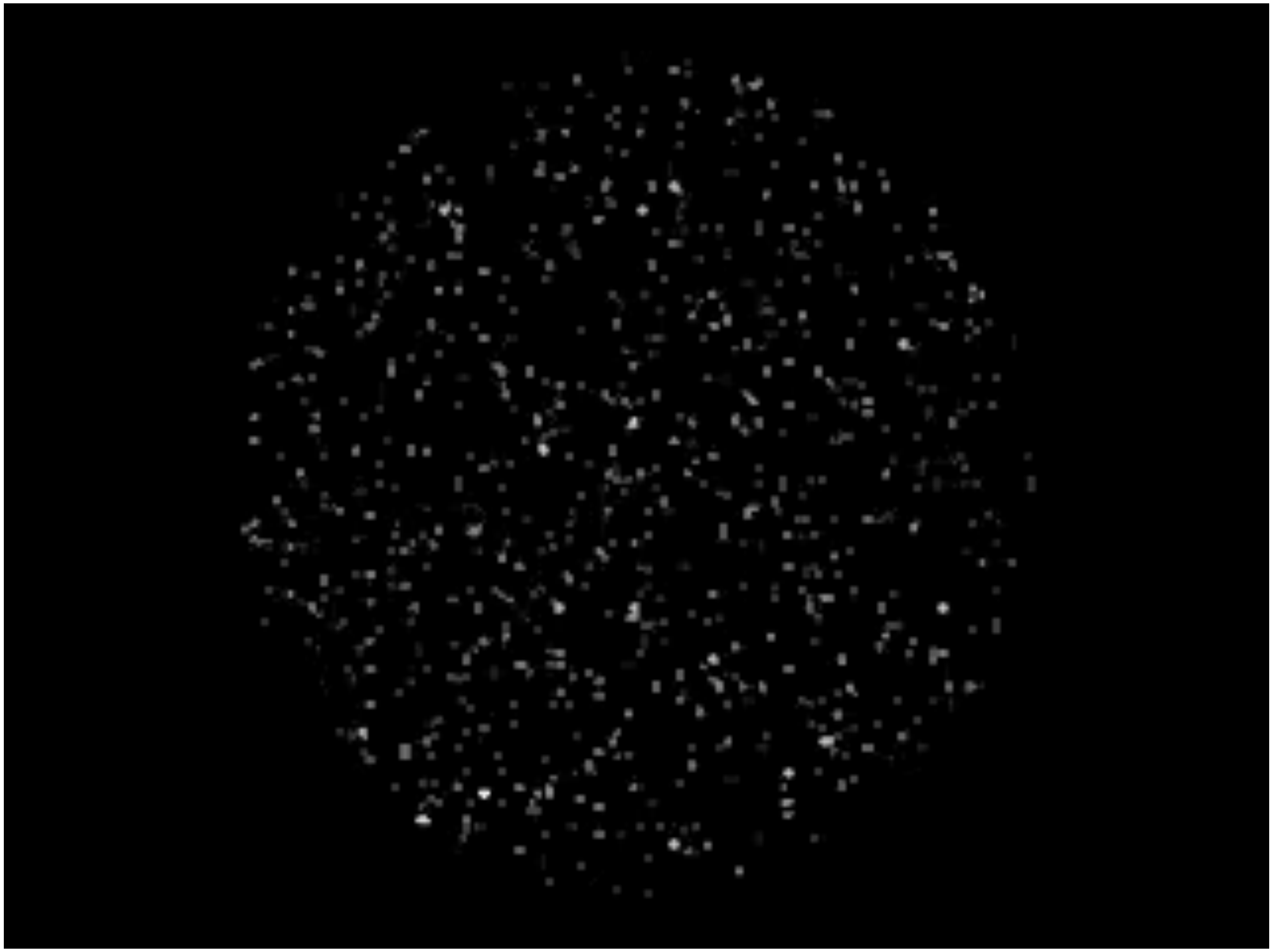
• In previous, our model assumed that every spike is independently produced, and the probability of a spike depends only on the rate, r(t): Poisson noise



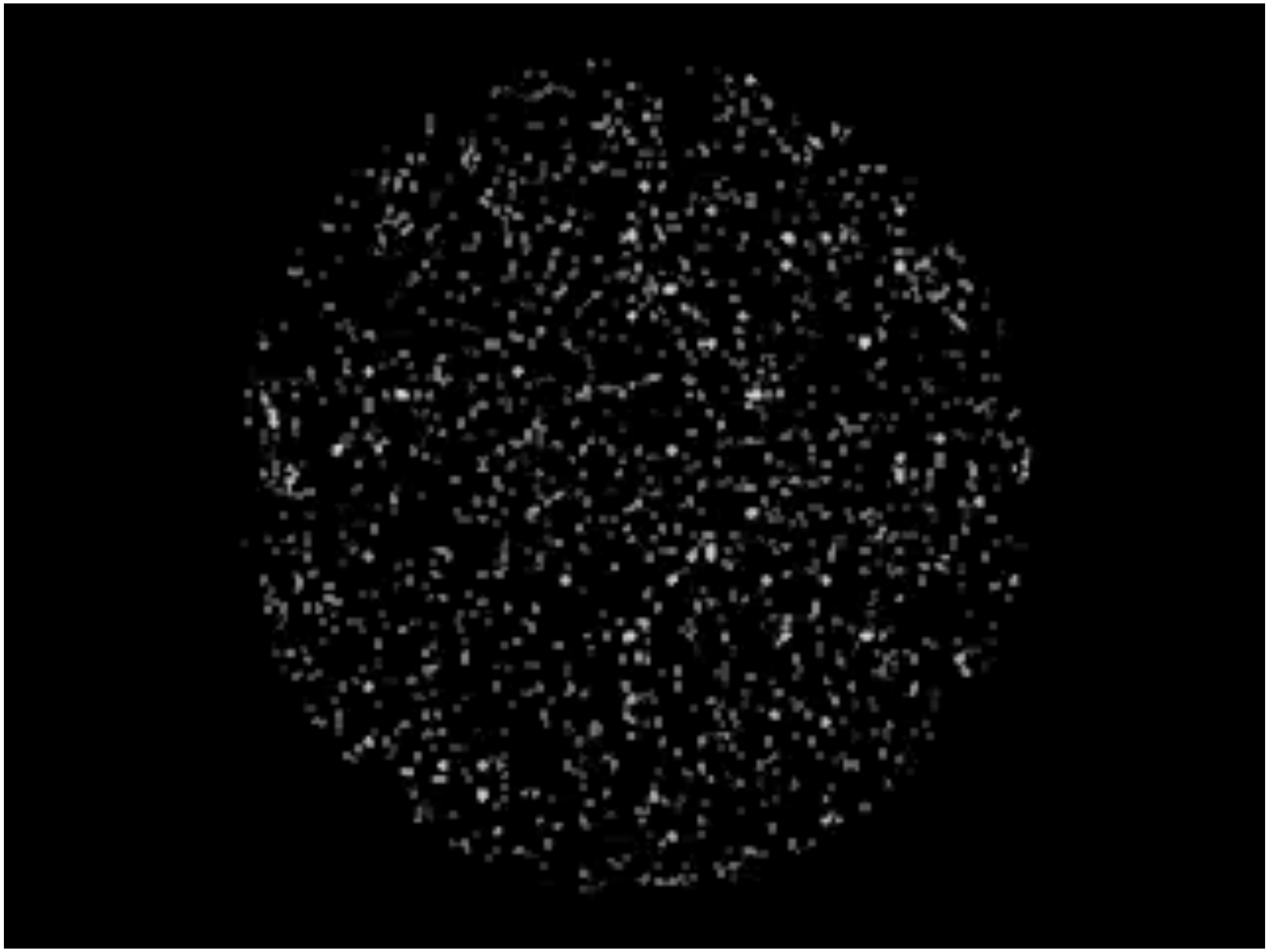
- look at + run code … hist_demo.m:
- making histograms

Do I stay or do I go?



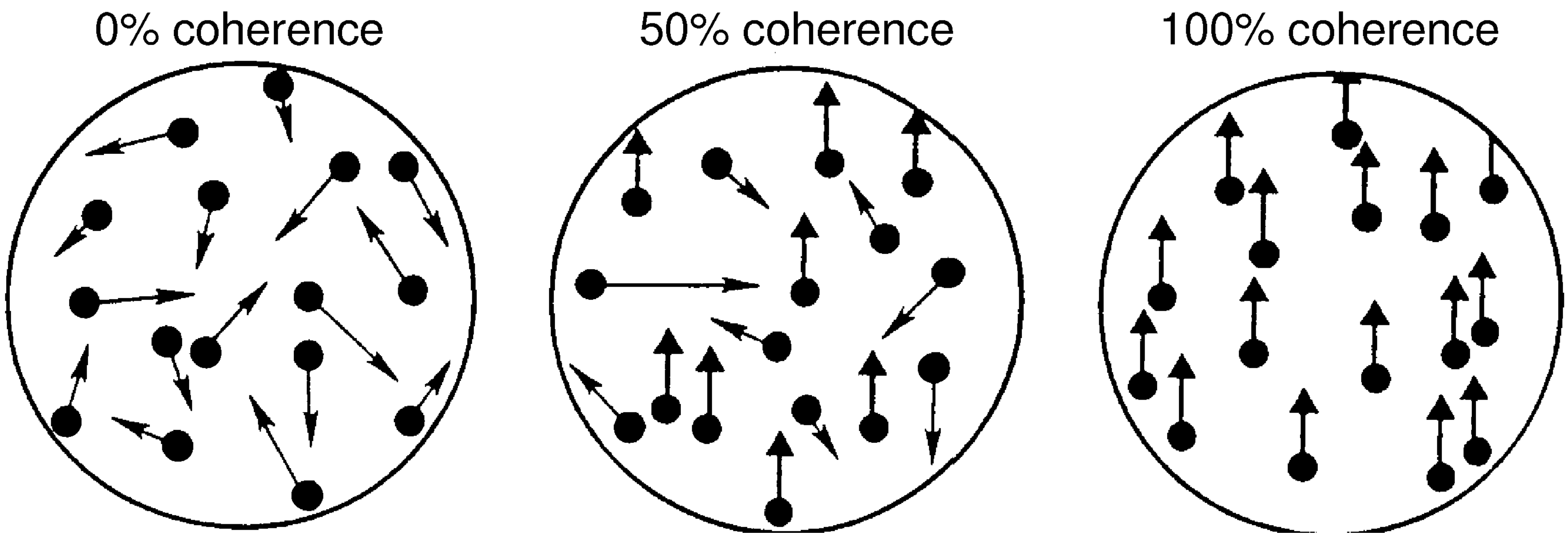


Bill Newsome



Bill Newsome

Making a decision

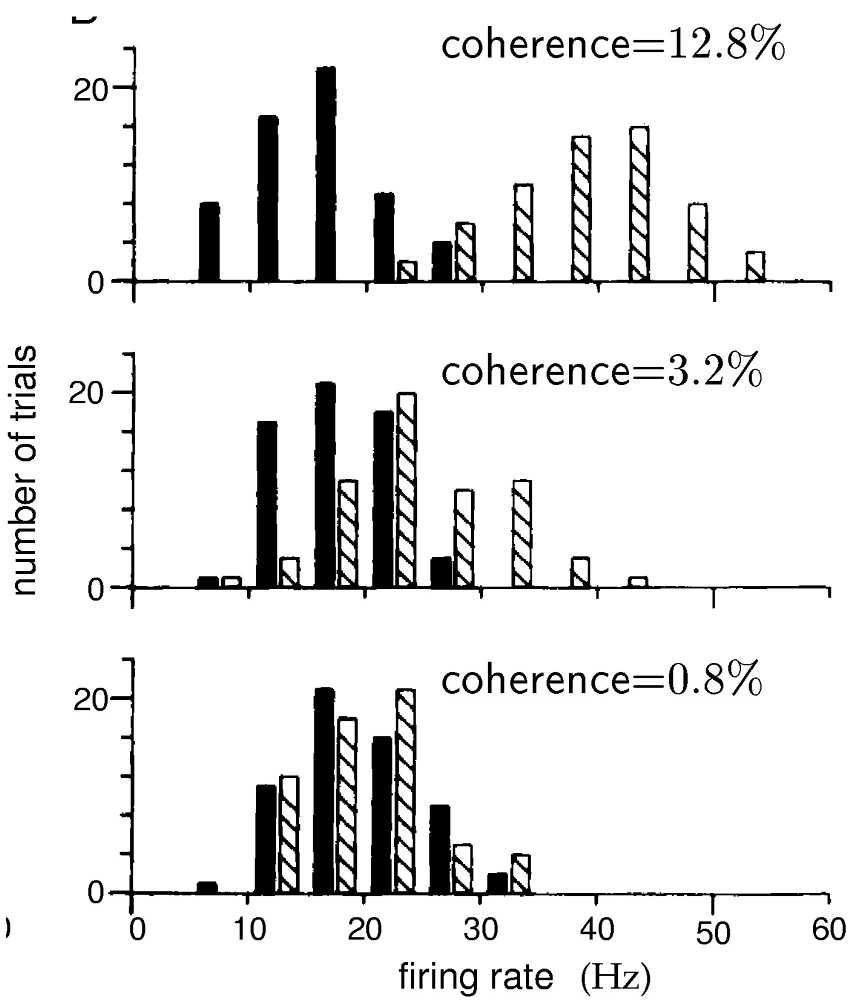


Abbott and Dayan, Fig. 3.1

Britten et al. '92

Predicting from neural activity

response from a given MT
normalize firing rate base
on given time window.



Maximum Likelihood decoding

Make mathematically most probable decision…

2 Coins.

The green coin is biased heavily to land heads up, and will do so about 90% of the time.

The purple coin is slightly weighted to land tails up, about 60% of flips. Both coins are otherwise identical.

If you hear heads, predict green
If you hear tails, predict purple

But why?

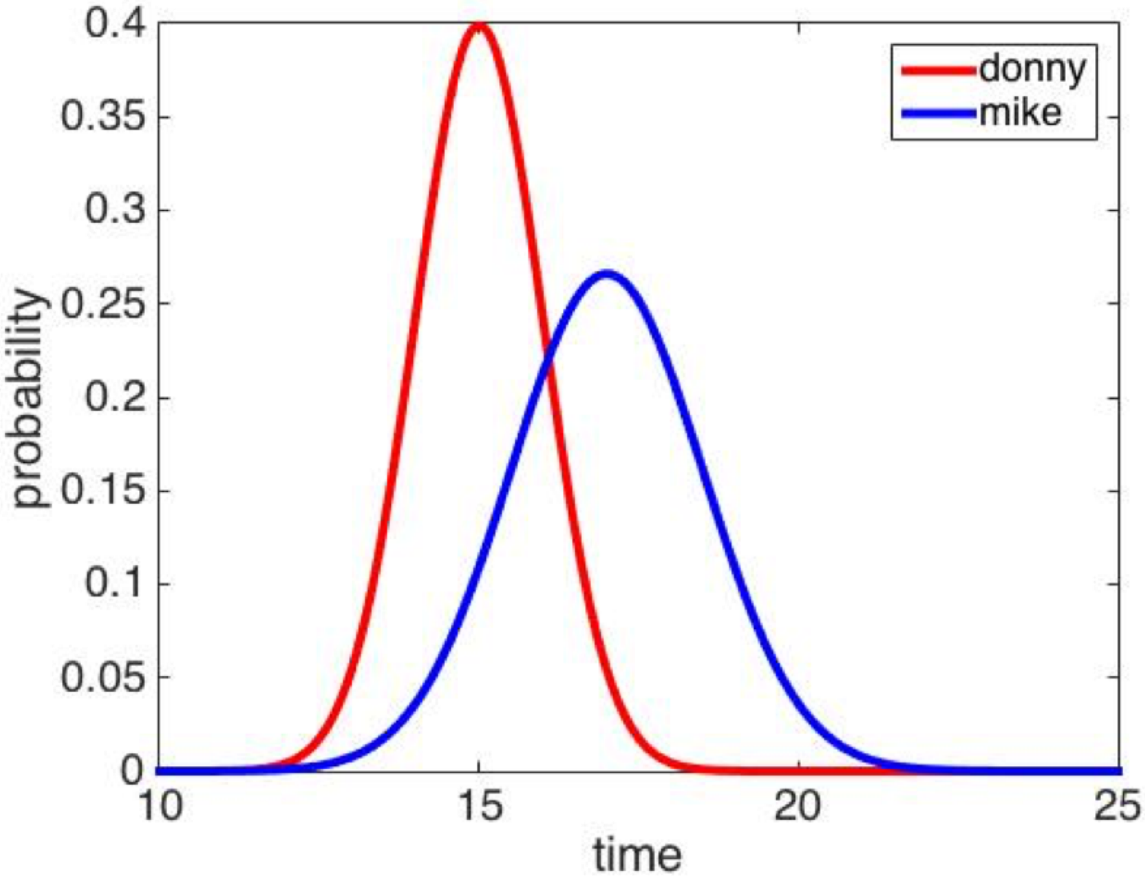
I'll pull a coin out of the bag without looking, flip it in secret, and tell you what landed up, either heads or tails. To win this game, you have to guess which color of coin I picked out of the bag.

Boardwork: decision via max likelihood

Maximum Likelihood decoding

Two world class sprinters running the 150m dash: Donovan Bailey, and Michael Johnson.

Each runner has a normal (Gaussian) distribution for their finishing times: Donovan has a mean of 15 seconds with a standard deviation of 1second, Michael has a mean of 17 seconds with a standard deviation of 1.5 seconds. In this game, I'll tell you the finishing time of one of the runners, and you win if you guess who ran that time correctly.



MAXIMUM LIKELIHOOD DECODING OF RESPONSE r FOR STIMULUS "+" VS STIMULUS "-"

After you have your histograms defined,
given a response, choose the stimulus
that maximizes P(stim I response) but we dont know this
but we know by bayles law that this
is proportional to

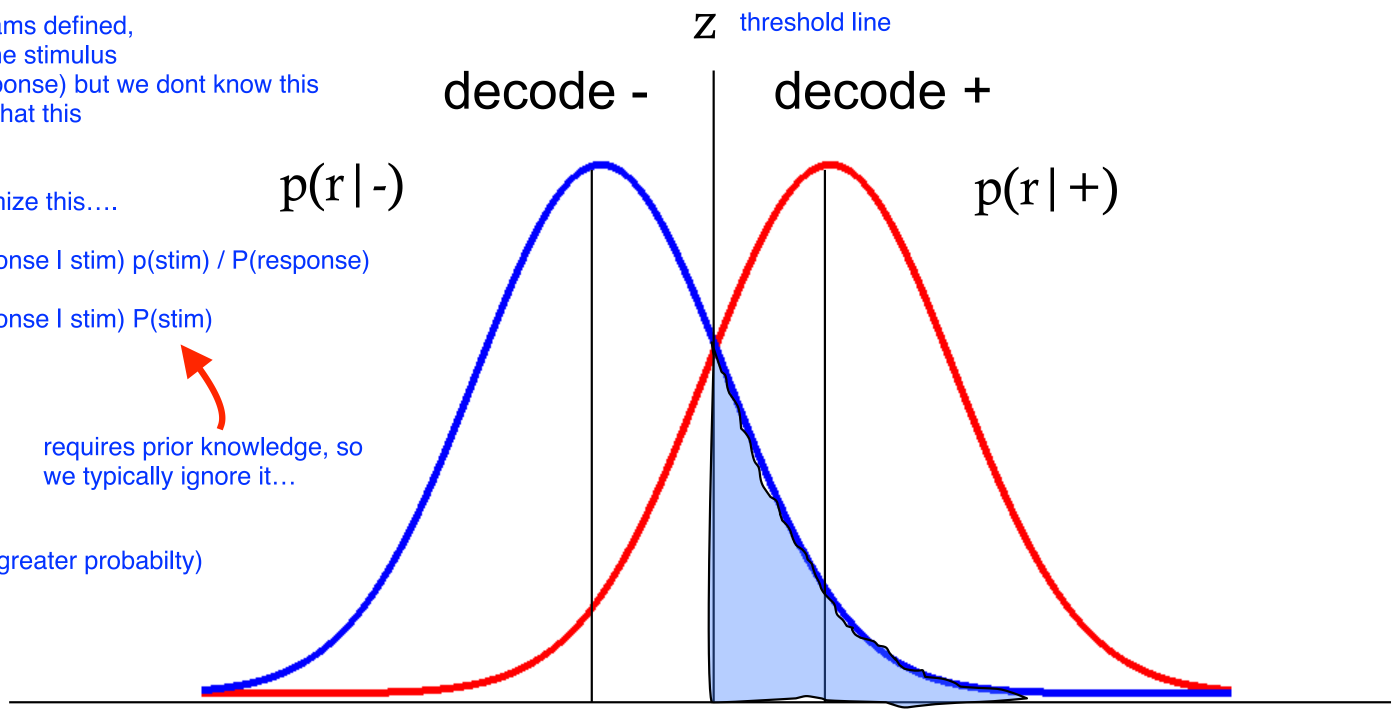
P(response I stim) so maximize this….

P(stim I response) = P(response I stim) p(stim) / P(response)

P(stim I response) = P(response I stim) P(stim)

requires prior knowledge, so
we typically ignore it…

Which graph is higher? (greater probabilty)



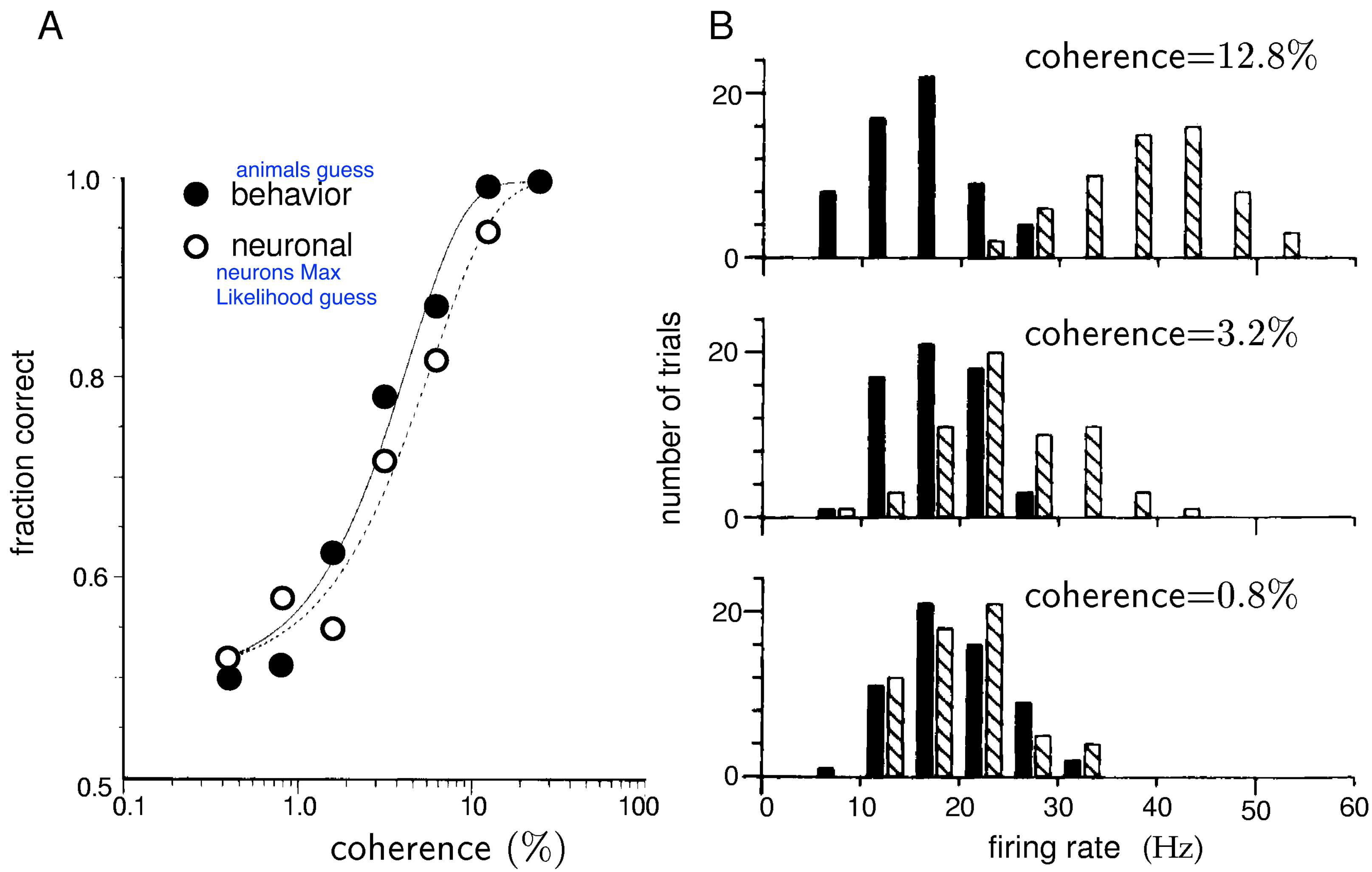
Decoding corresponds to comparing test, r, to threshold, z.

Shaded area: given that stim - is presented, probability of guessing +
=PROBA (ERROR | -)

ERROR RATE = PROBA (ERROR | -) P(-) + PROBA (ERROR | +) P(+)
where P(-) and P(+) are probabilities of presenting stim - and +

FRACTION CORRECT = (1 - ERROR RATE)

Neurons vs organisms



Close correspondence between neuron decoding and behavior..

So why so many neurons?

Hypothesis: redundant codes (Zohary et al Nature '96): Still actively debated today!