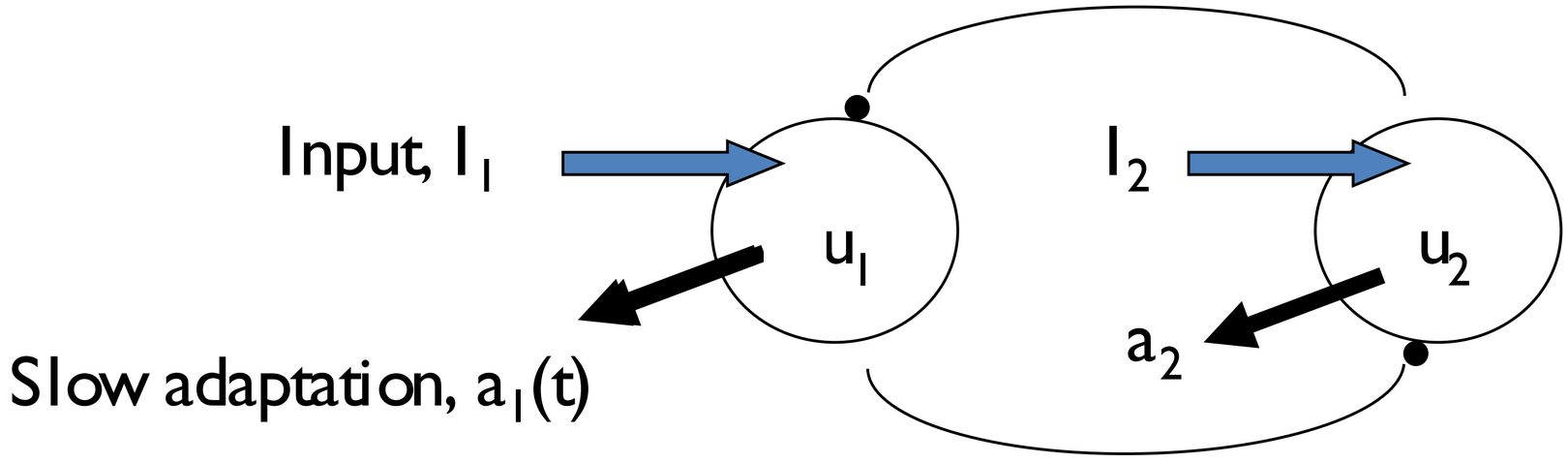
Applying competition models for perceptual bistability to perceptual grouping problems

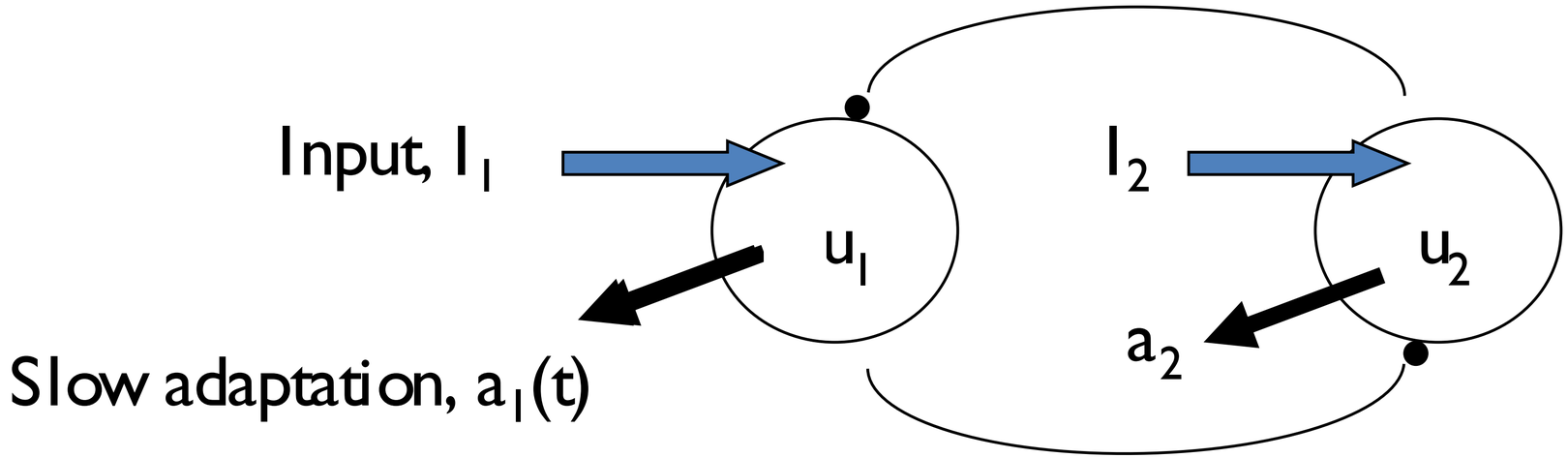
Sara Steele, on Shpiro et. al. (2009) "Balance between noise and adaptation in competition models of perceptual bistability."

Competition firing rate models



Shpiro et. al. (2009)

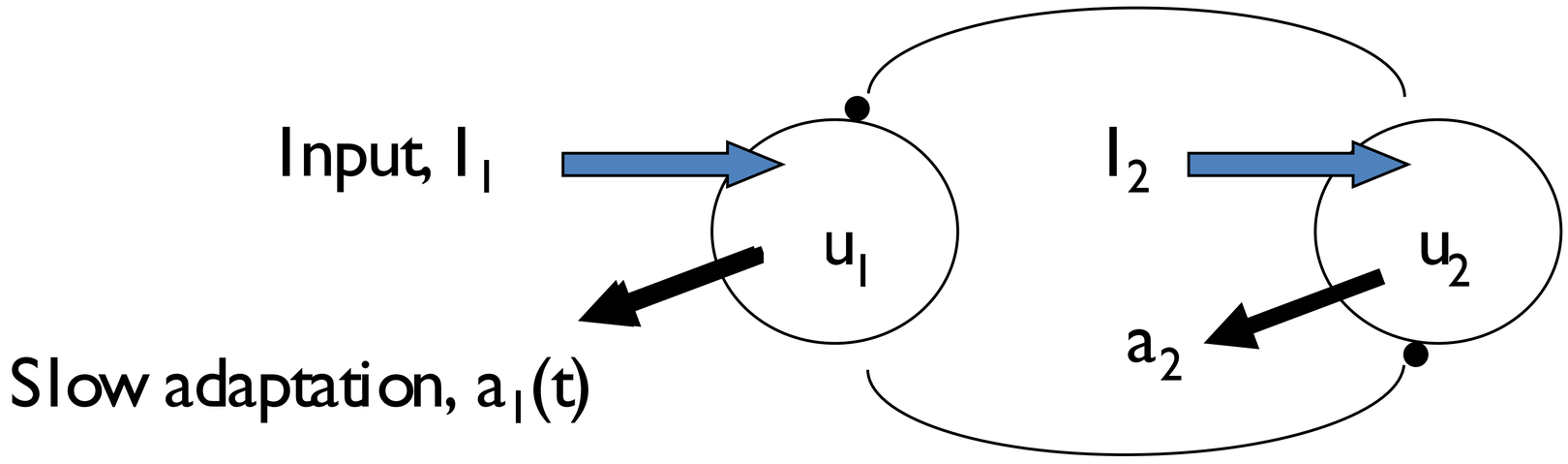
Competition firing rate models



$$
\begin{cases}
\dot{u}_1 & = -u_1 + f(-\beta u_2 - \gamma a_1 + I_1 + n_1) \\
\tau_a \dot{a}_1 & = -a_1 + u_1 \\
\dot{n}_1 & = \dfrac{-n_1}{\tau_n} + \sigma\sqrt{\dfrac{2}{\tau_n}}\eta(t) \\
\dot{u}_2 & = -u_2 + f(-\beta u_1 - \gamma a_2 + I_2 + n_2) \\
\tau_a \dot{a}_2 & = -a_2 + u_2 \\
\dot{n}_2 & = \dfrac{-n_2}{\tau_n} + \sigma\sqrt{\dfrac{2}{\tau_n}}\eta(t)
\end{cases}
$$

Shpiro et. al. (2009)

Competition firing rate models



$$\begin{cases} \dot{u}_1 & = -u_1 + f(-\beta u_2 - \gamma a_1 + I_1 + n_1) \\ \tau_a \dot{a}_1 & = -a_1 + u_1 \\ \dot{n}_1 & = \dfrac{-n_1}{\tau_n} + \sigma\sqrt{\dfrac{2}{\tau_n}}\eta(t) \\ \dot{u}_2 & = -u_2 + f(-\beta u_1 - \gamma a_2 + I_2 + n_2) \\ \tau_a \dot{a}_2 & = -a_2 + u_2 \\ \dot{n}_2 & = \dfrac{-n_2}{\tau_n} + \sigma\sqrt{\dfrac{2}{\tau_n}}\eta(t) \end{cases}$$

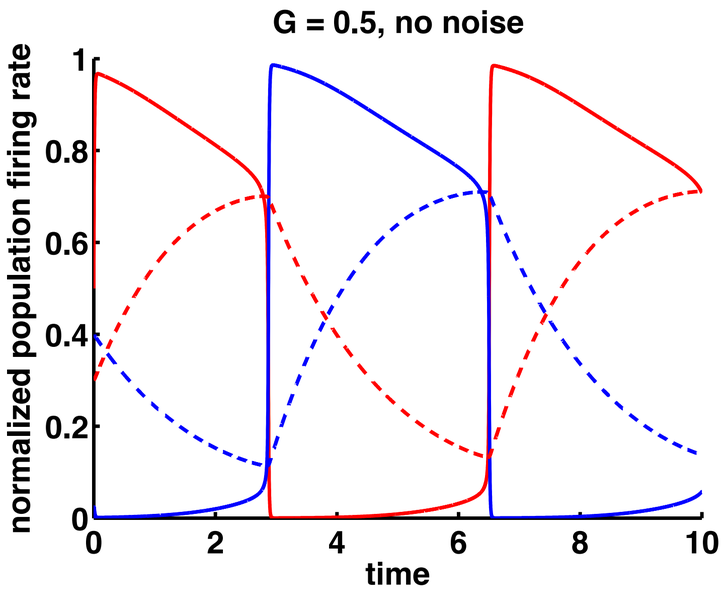
$$f(x) = 1/(1 + exp((x - \theta)/k))$$

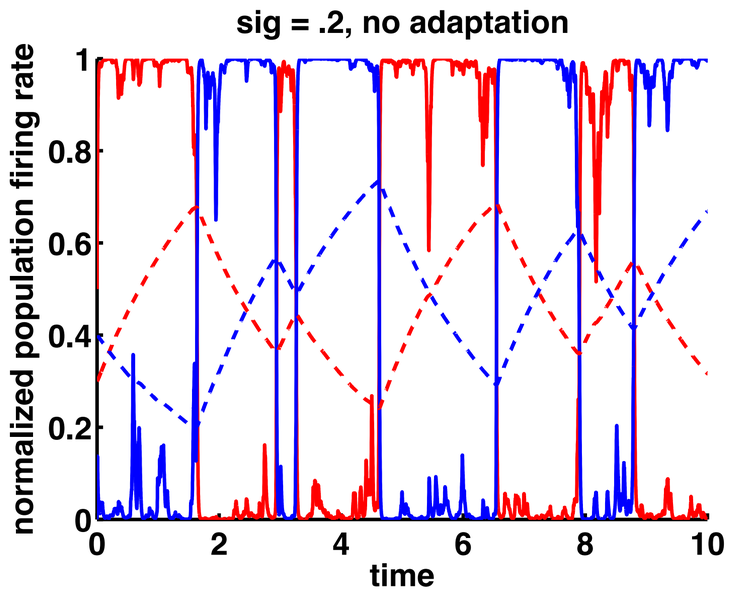
$$k = 0.1, \theta = 0, \beta = 1$$

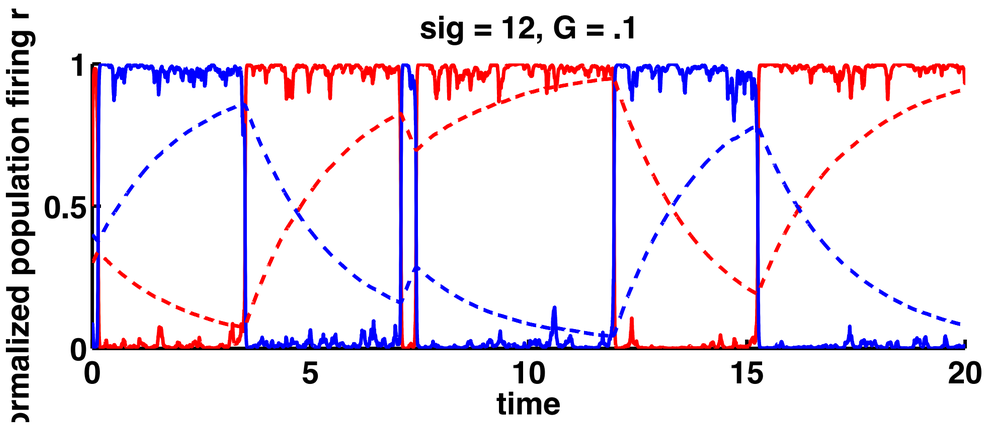
$$\tau_a = 2000, \tau_n = 100$$

Shpiro et. al. (2009)

Typical output

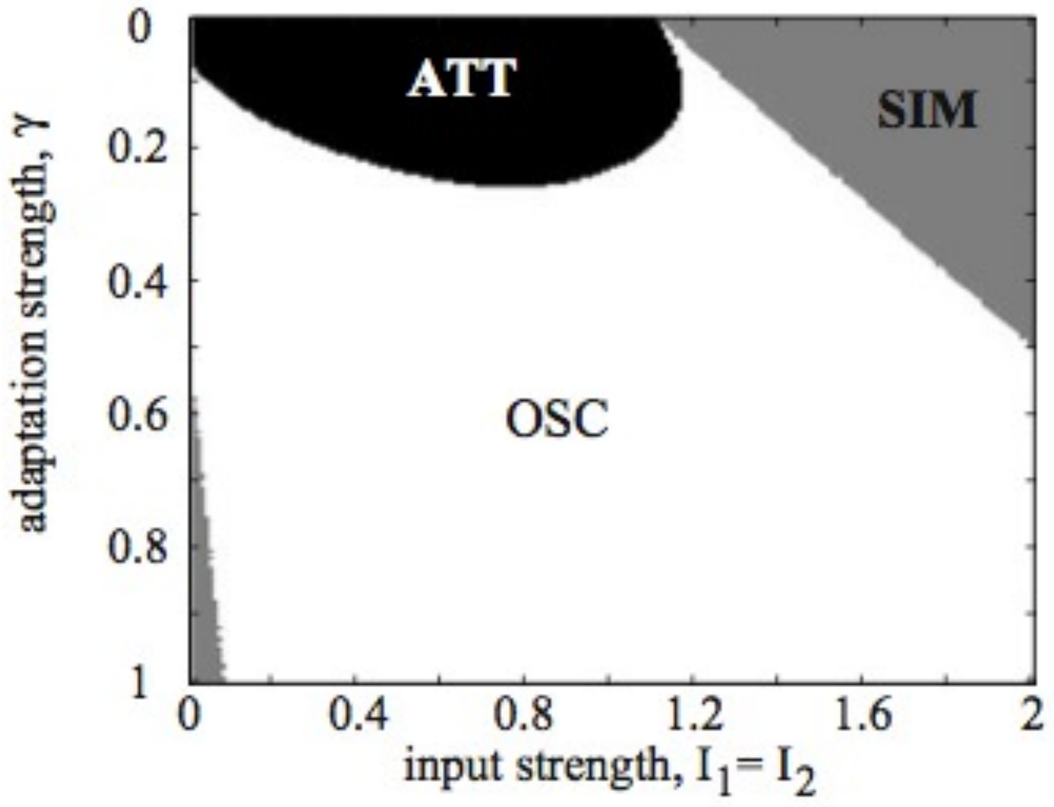


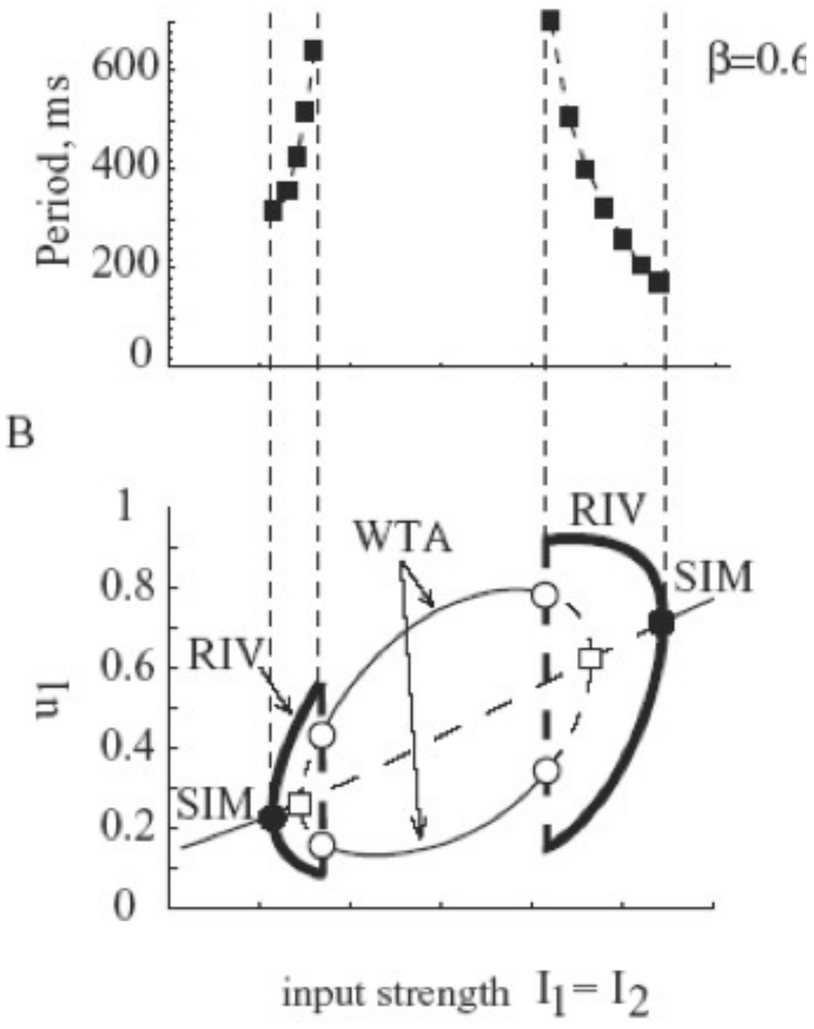




Iboth = 0.6

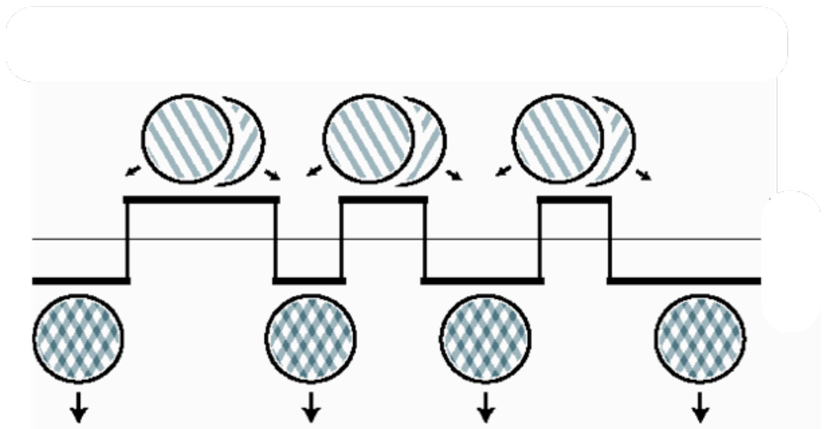
Bifurcations



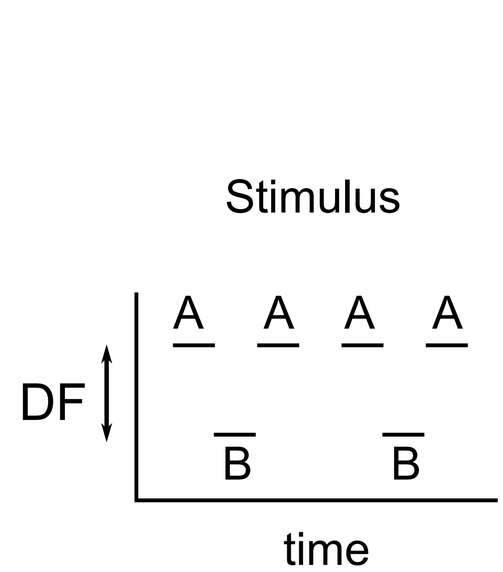


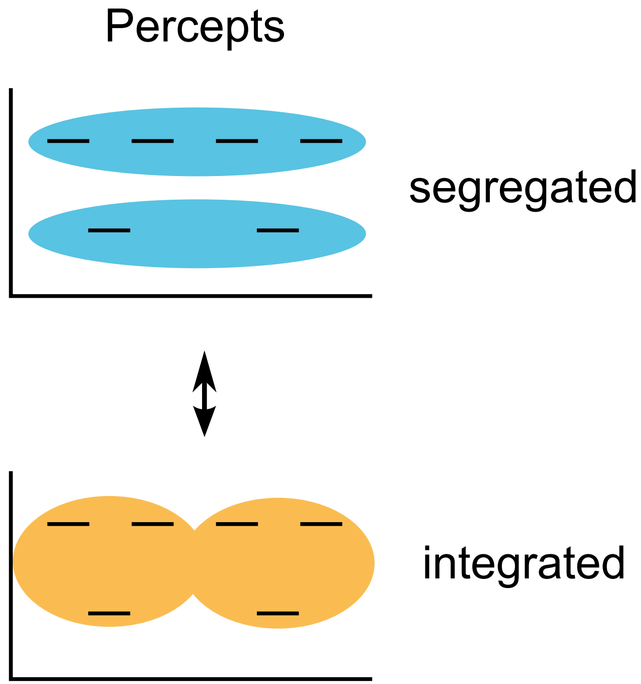
Stimuli with bistable grouping

From Pressnitzer & Hupe 2006

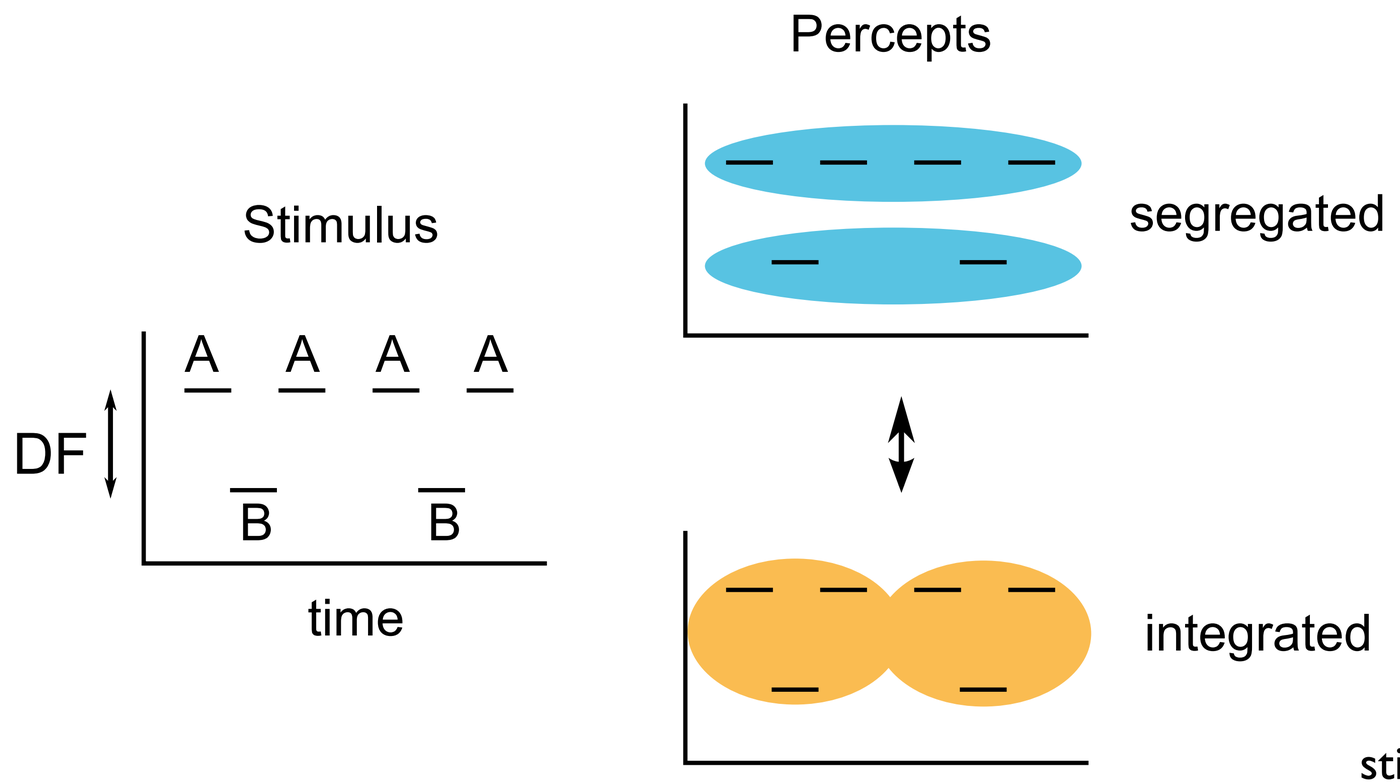


From Rubin & Hupe 2004



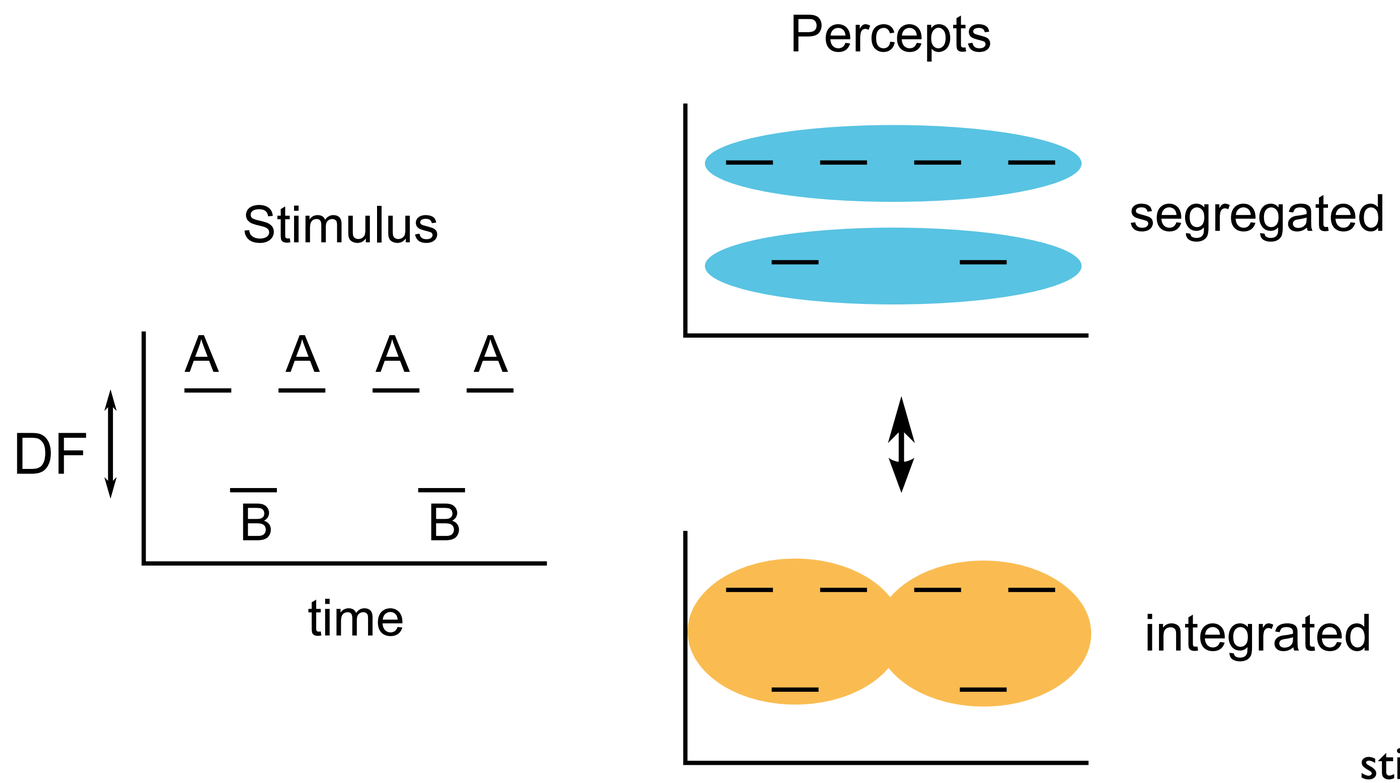


DF = 2 st DF = 11 st DF = 5 st



stimuli: van Noorden, 1975

DF = 2 st DF = 11 st DF = 5 st



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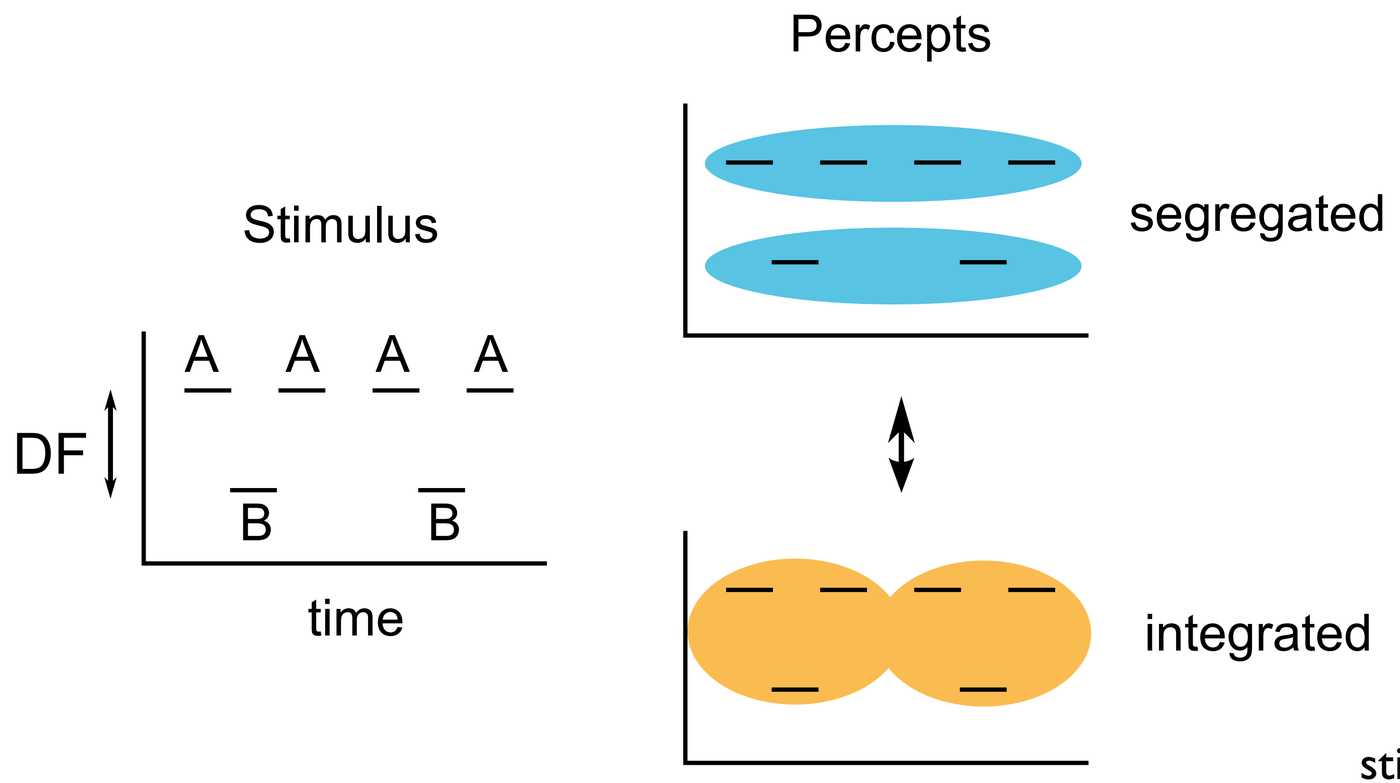

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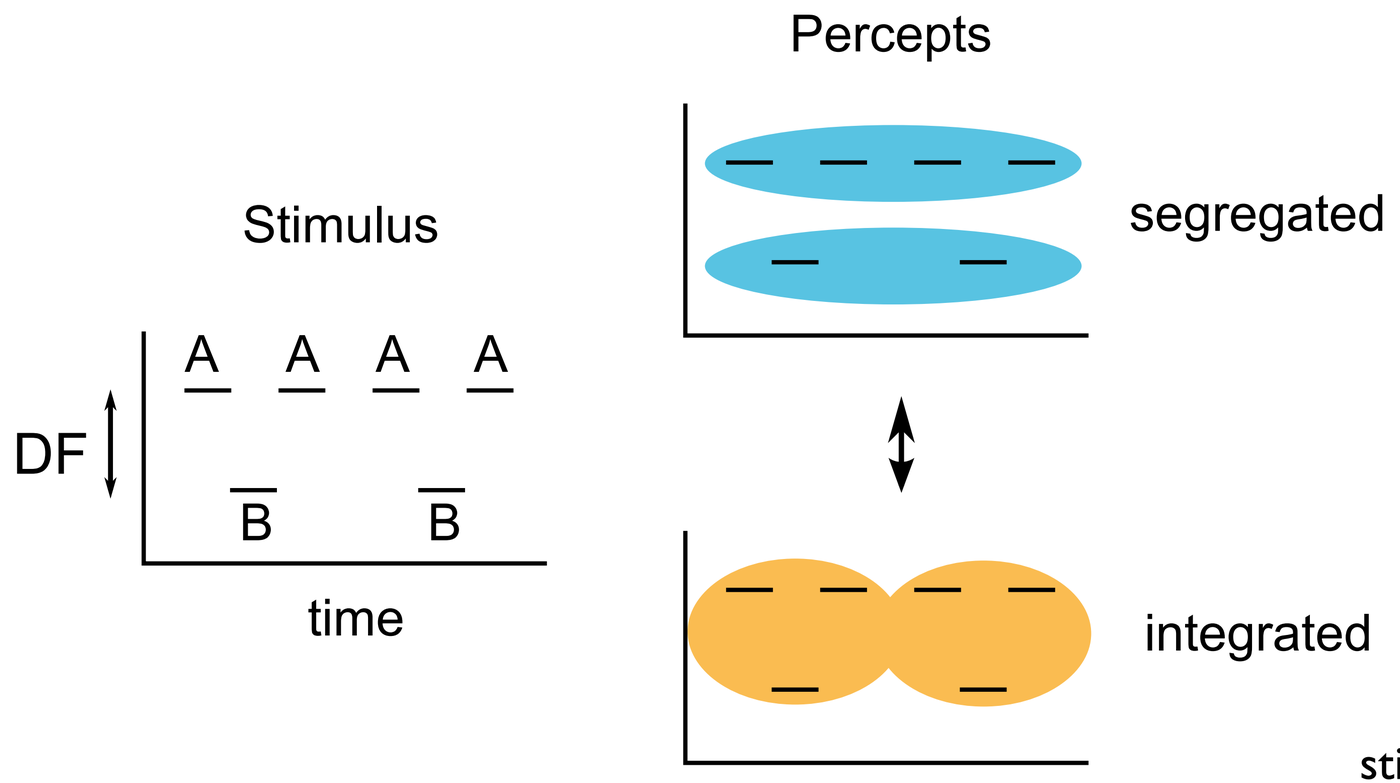

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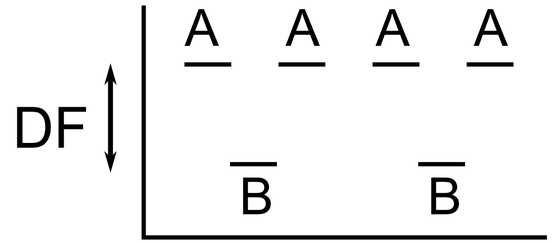
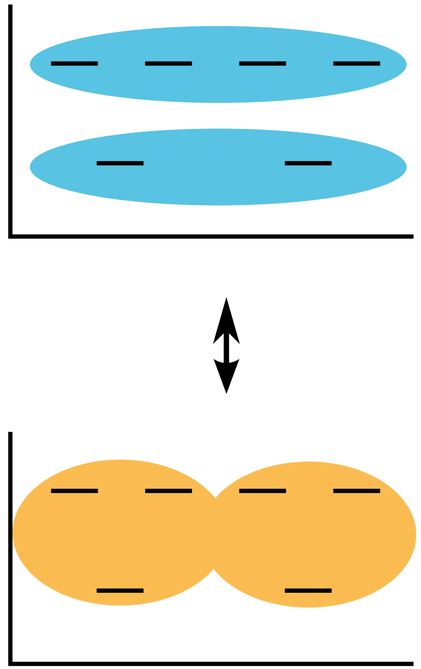
Percepts

Stimulus





segregated

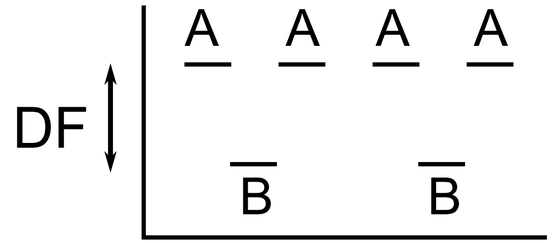
integrated

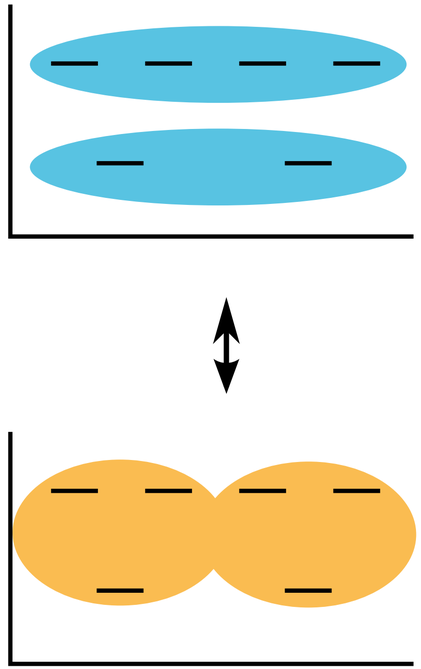
stimuli: van Noorden, 1975

DF = 2 st DF = 11 st DF = 5 st

Percepts

Stimulus





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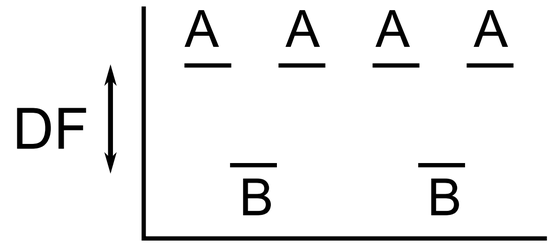

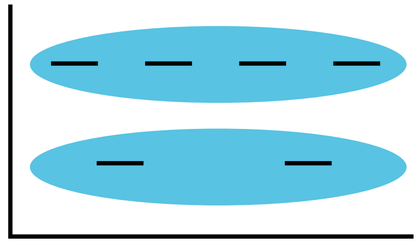

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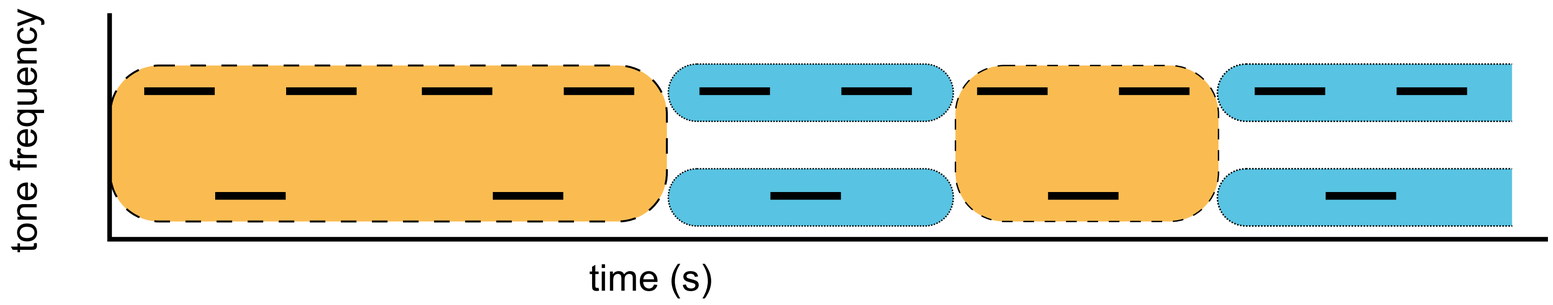
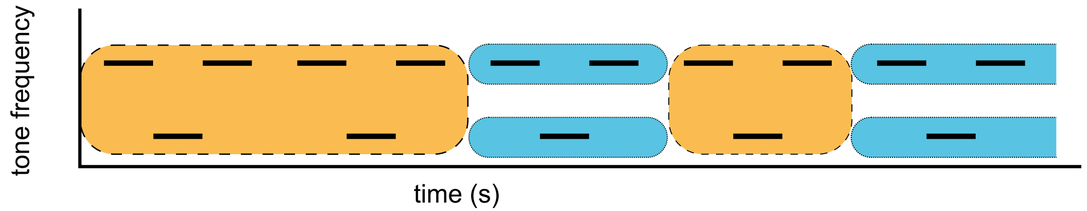
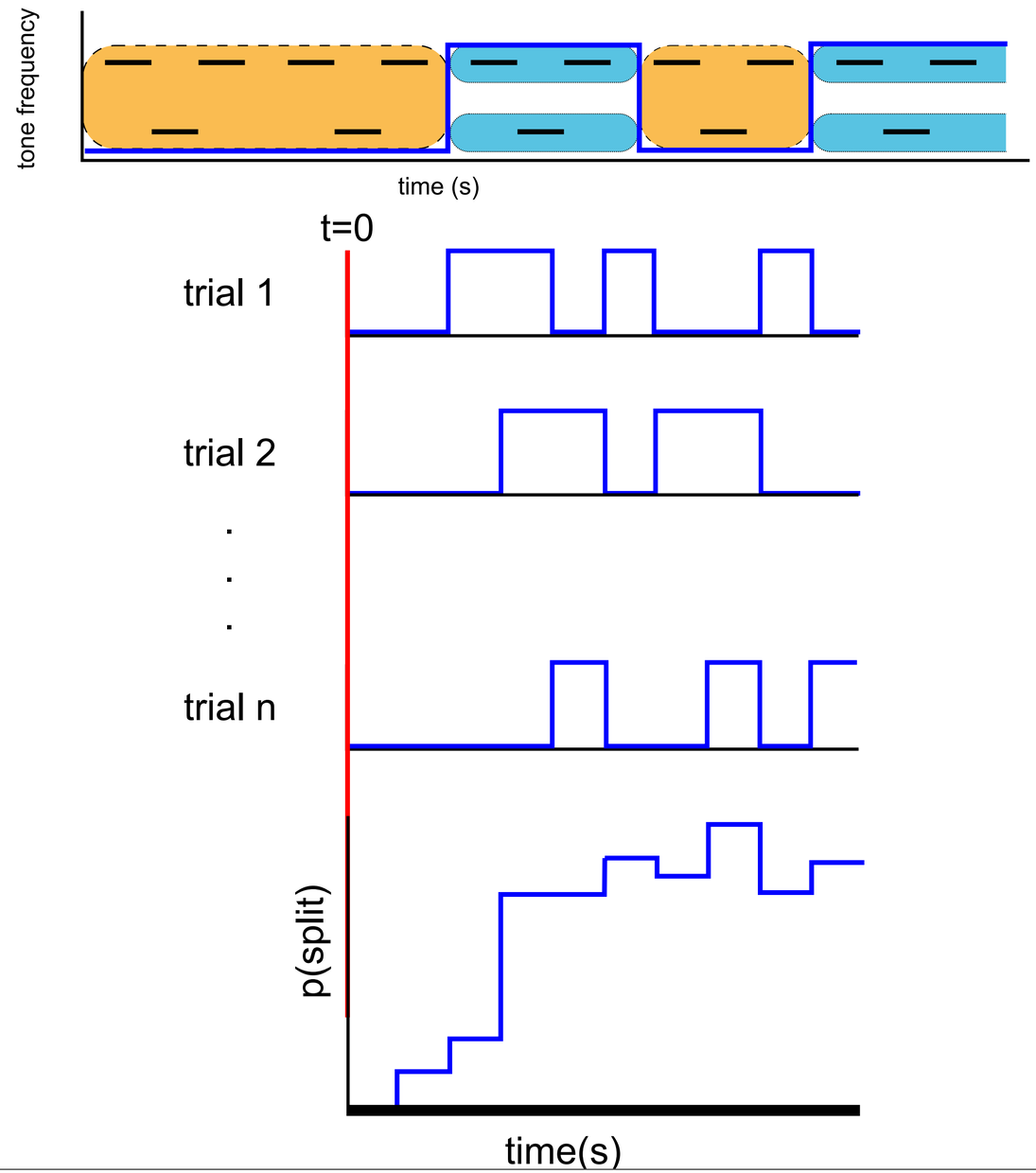


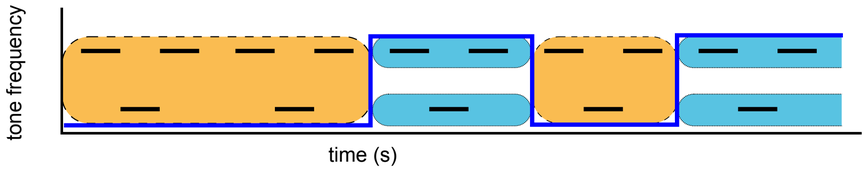
Averaging over trials gives buildup

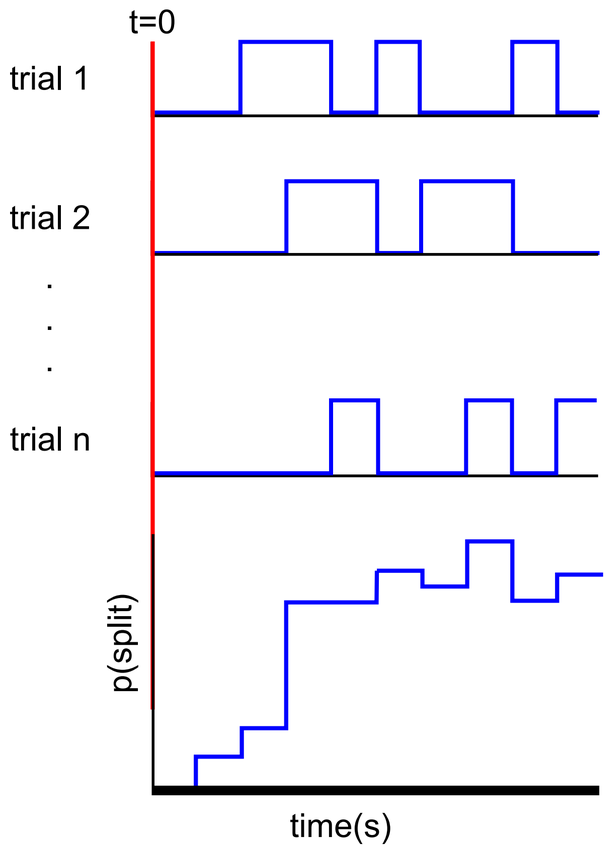


Averaging over trials gives buildup

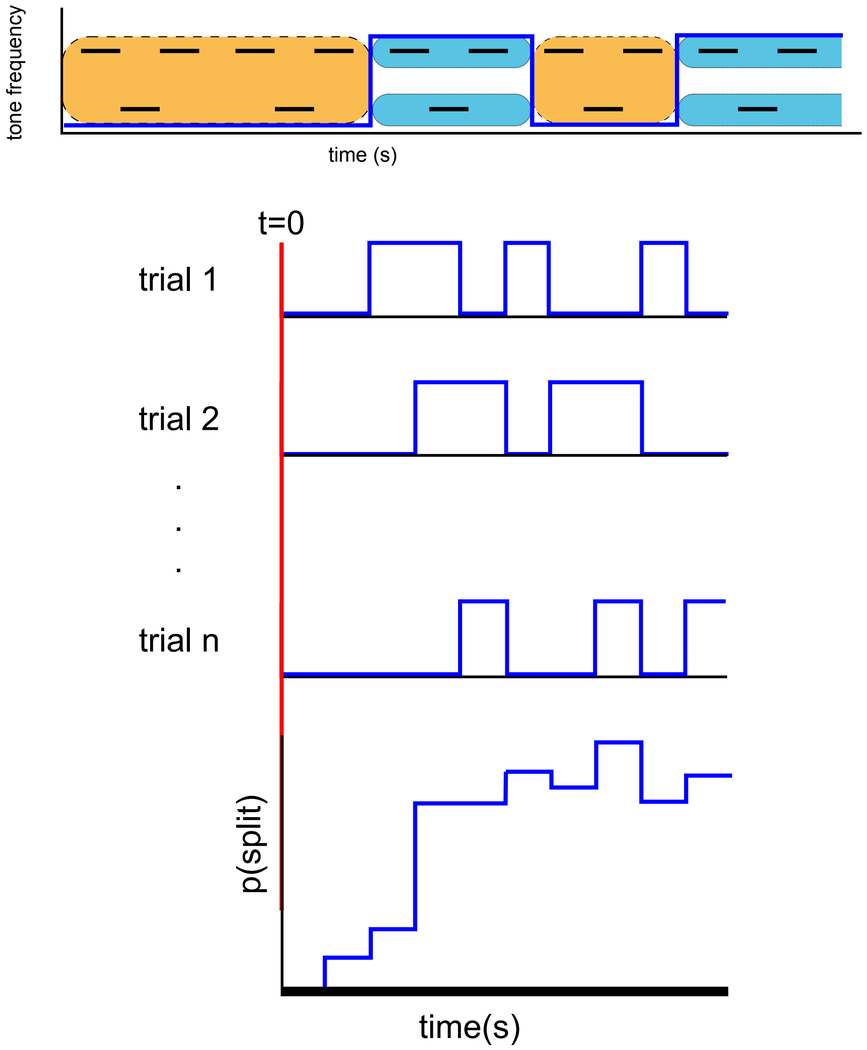


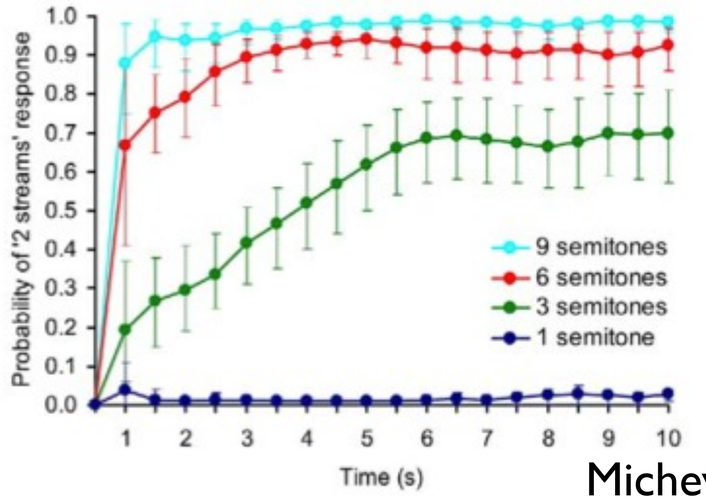
Averaging over trials gives buildup



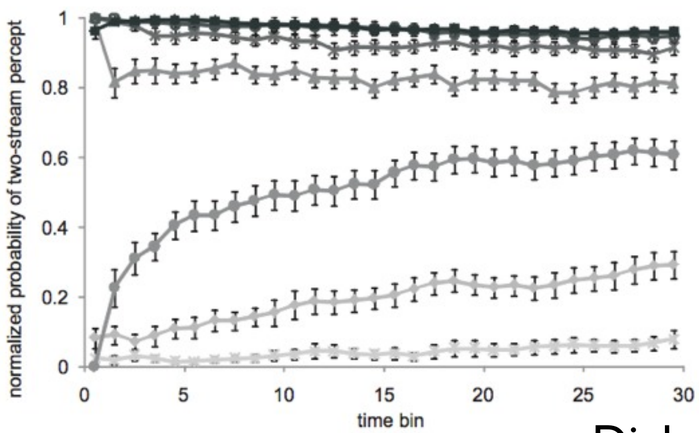


Averaging over trials gives buildup



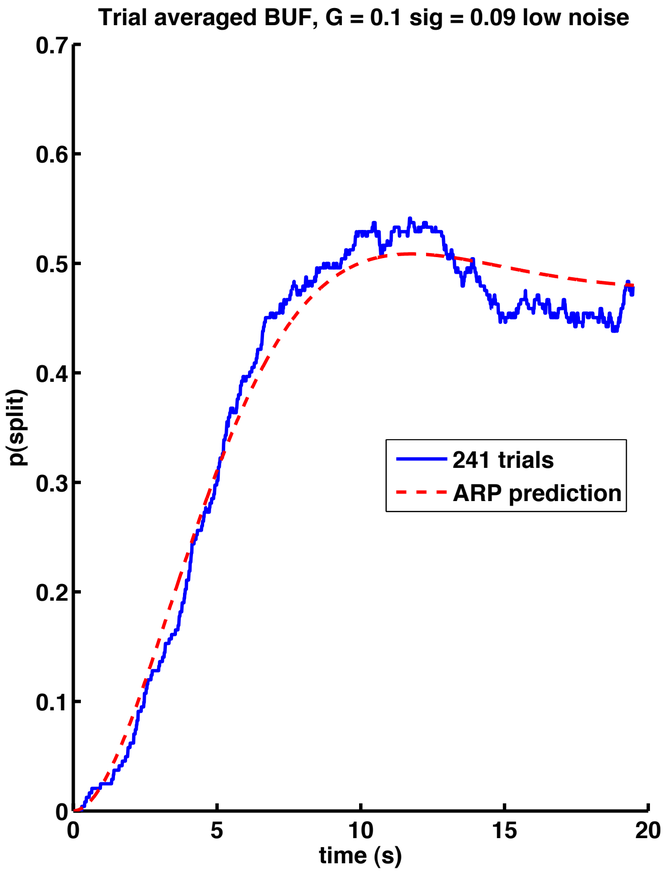


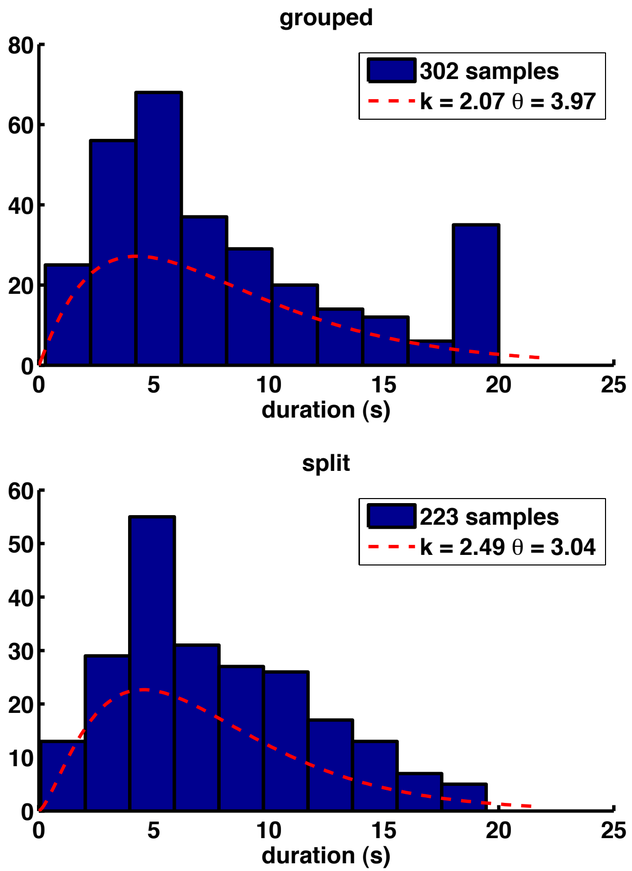
Micheyl, et. al.



Dieke, et. al.

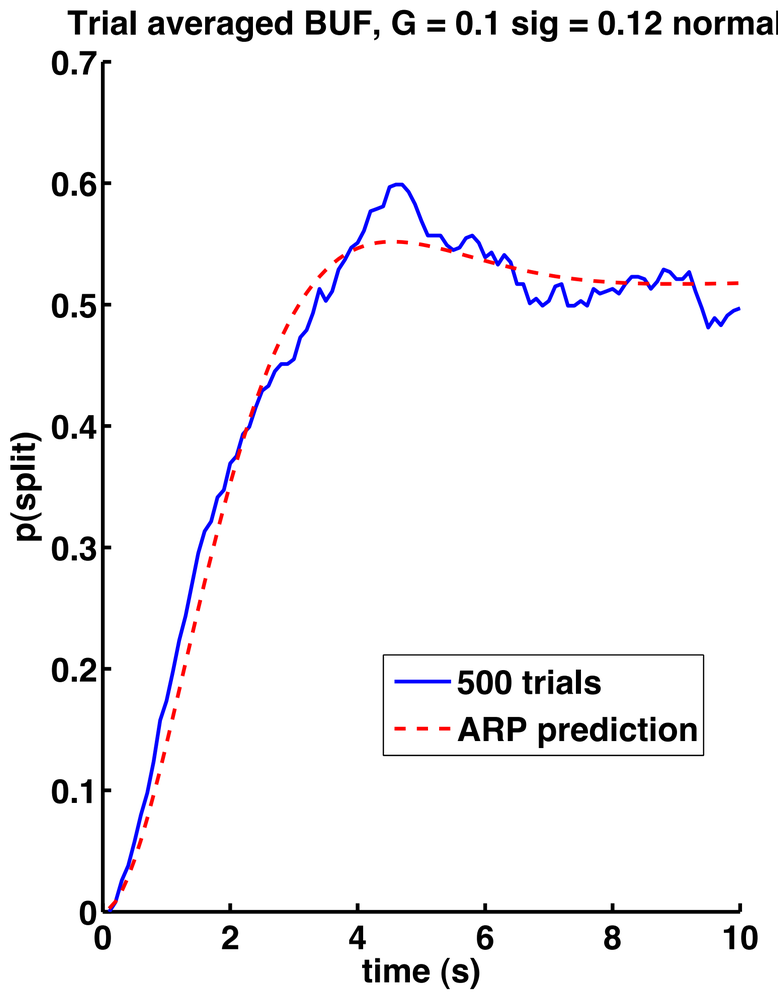
low noise + weak adaptation

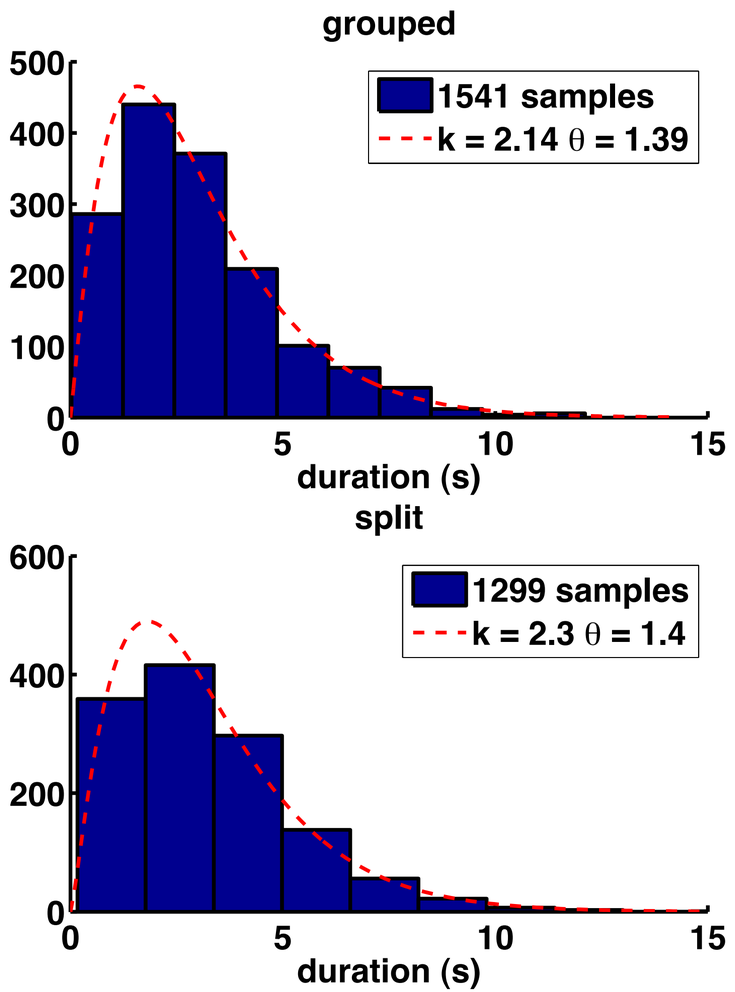




mean = 8.21

mean = 7.56

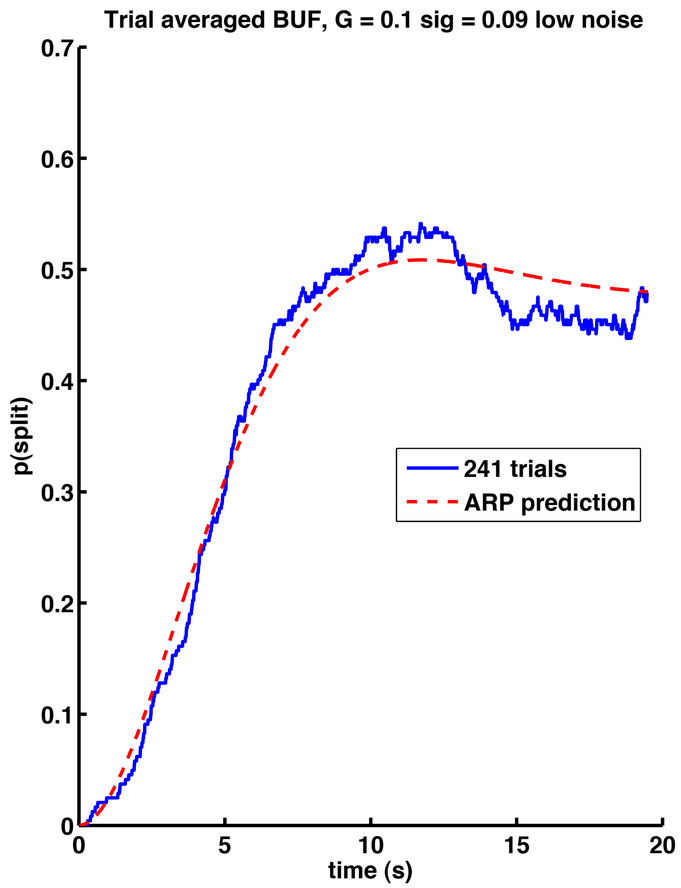


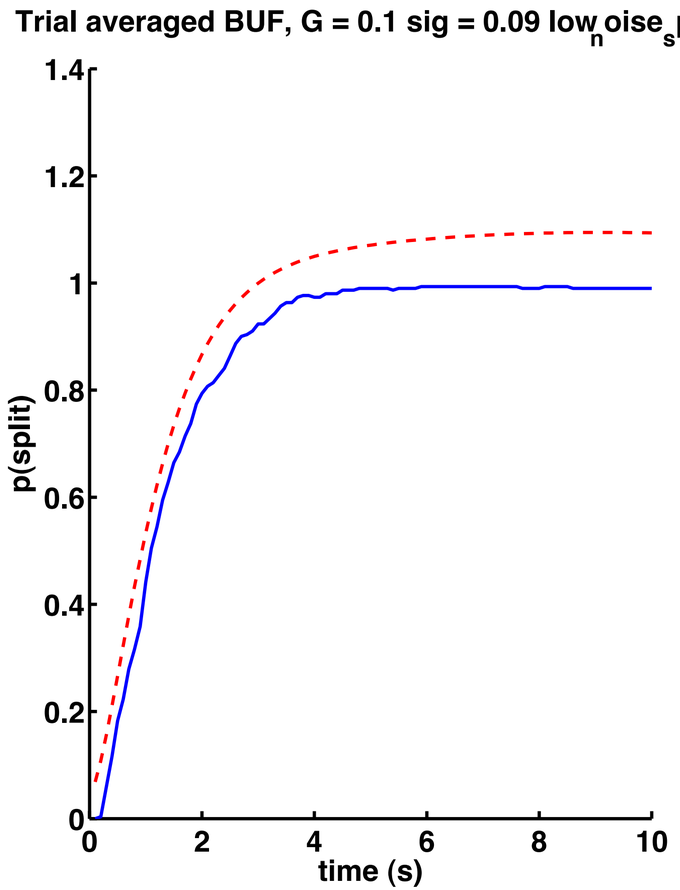


mean = 3.0

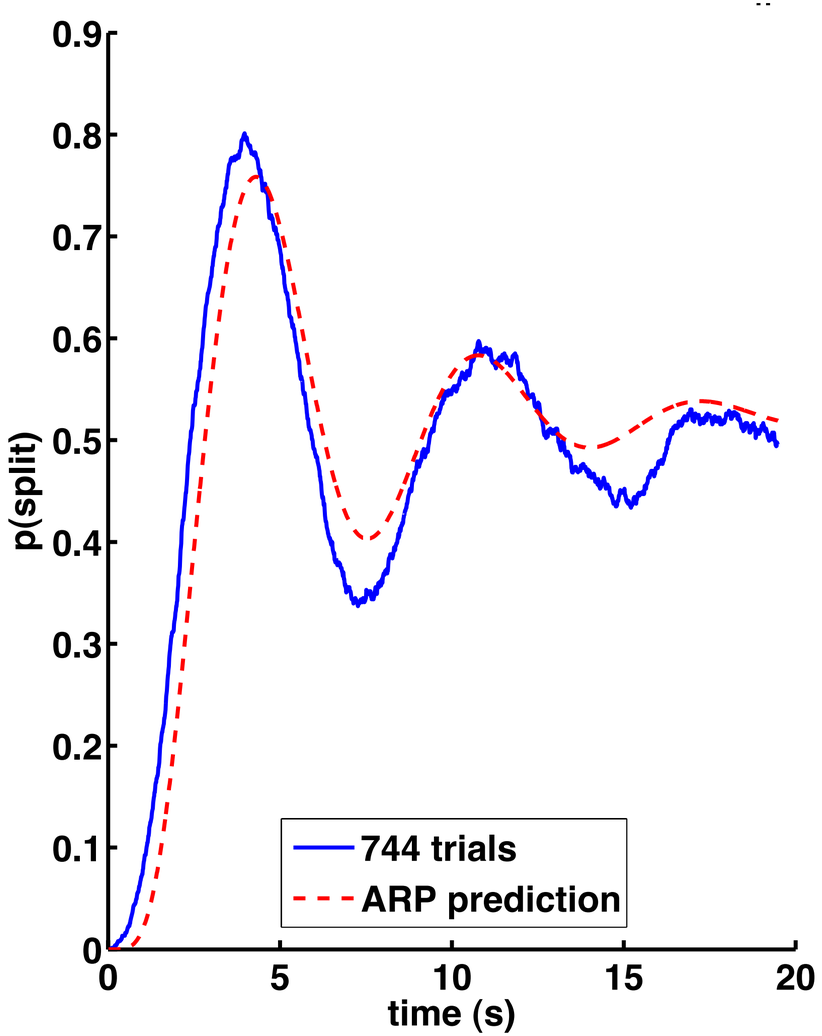
mean = 3.2

less ambiguous = faster buildup

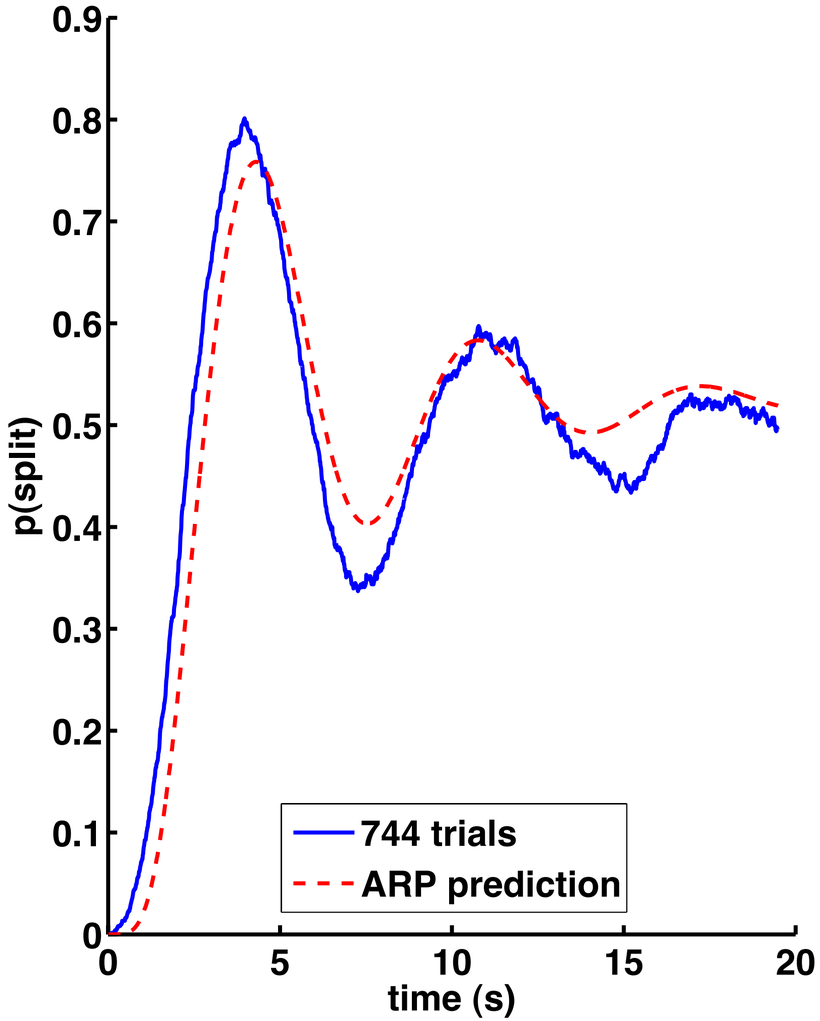


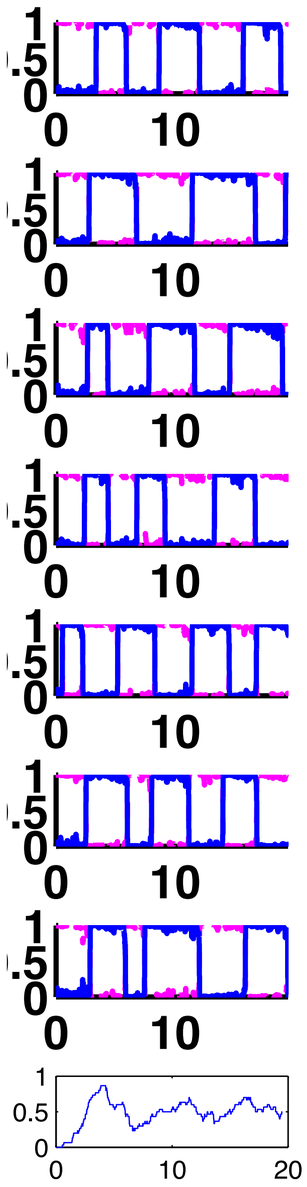


high adaptation, low noise

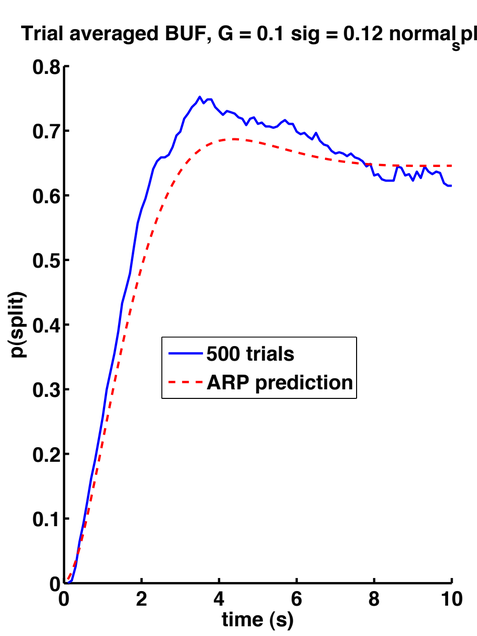


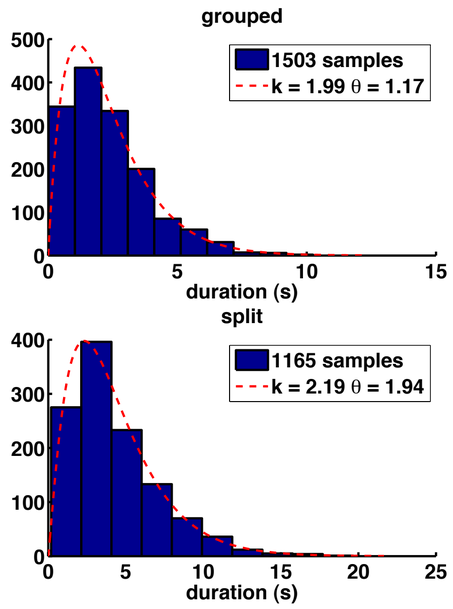
high adaptation, low noise

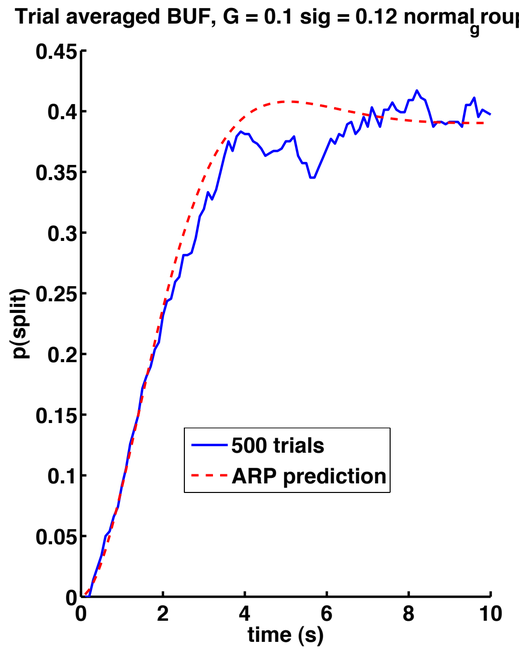


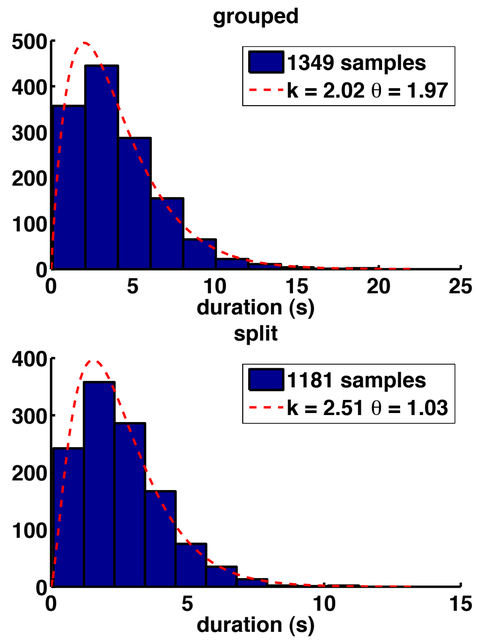


Unequal currents

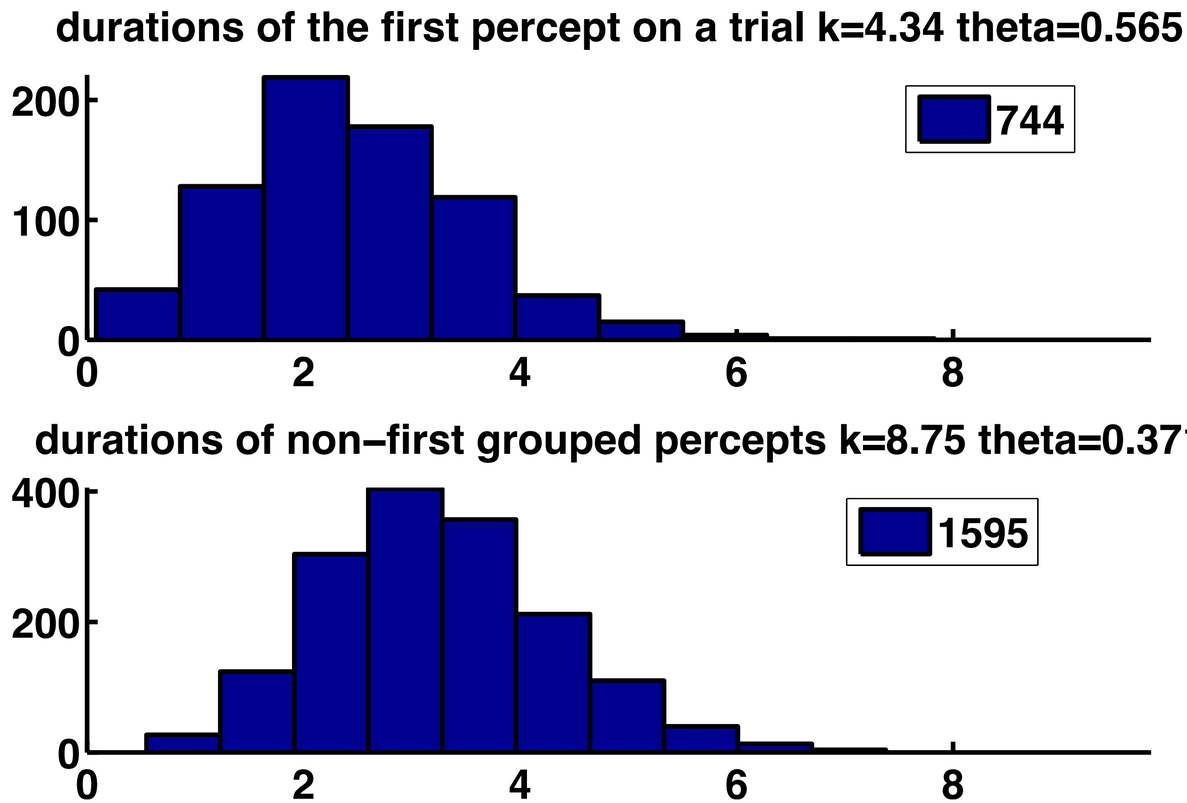








first percepts (high A, low N)



violates Hupe & Pressnitzer, 2012

Conclusions

- Competition model can give realistic-looking buildup curves, but only if noise is high and adaptation is low, supporting the attractor-model for these kinds of stimuli
- The weaker the mechanism for alternation (noise + adaptation), the longer buildup takes to get to steady state
- Oscillation-based regimes give rise to buildup curves with damped oscillations

Future directions

- How should I set the value of the initial conditions? Buildup only occurs for ambiguous stimuli. Perhaps a2(0) is better than u1(0)

- Can we explain the source of the noise? Is this noise fixed or can its strength be modulated internally?

- What role does adaptation in peripheral neural channels play in causing the first percept to be more likely to be grouped and longer than later percept epochs?

other talks in Nphys

- newton raphson parameter estimation using maximum likelihood