

PSYCHOPHYSICS

Dr. Frederike H. Petzschner

Brown University

Twitter: @rikepetzschner

@peaclub



Where models can take us.

Qualitative → Quantitative

A trip back in time to 1860



Fechner

**Qualitative
Psychology**

*What I experience.
Mind.*

PsychoPhysics

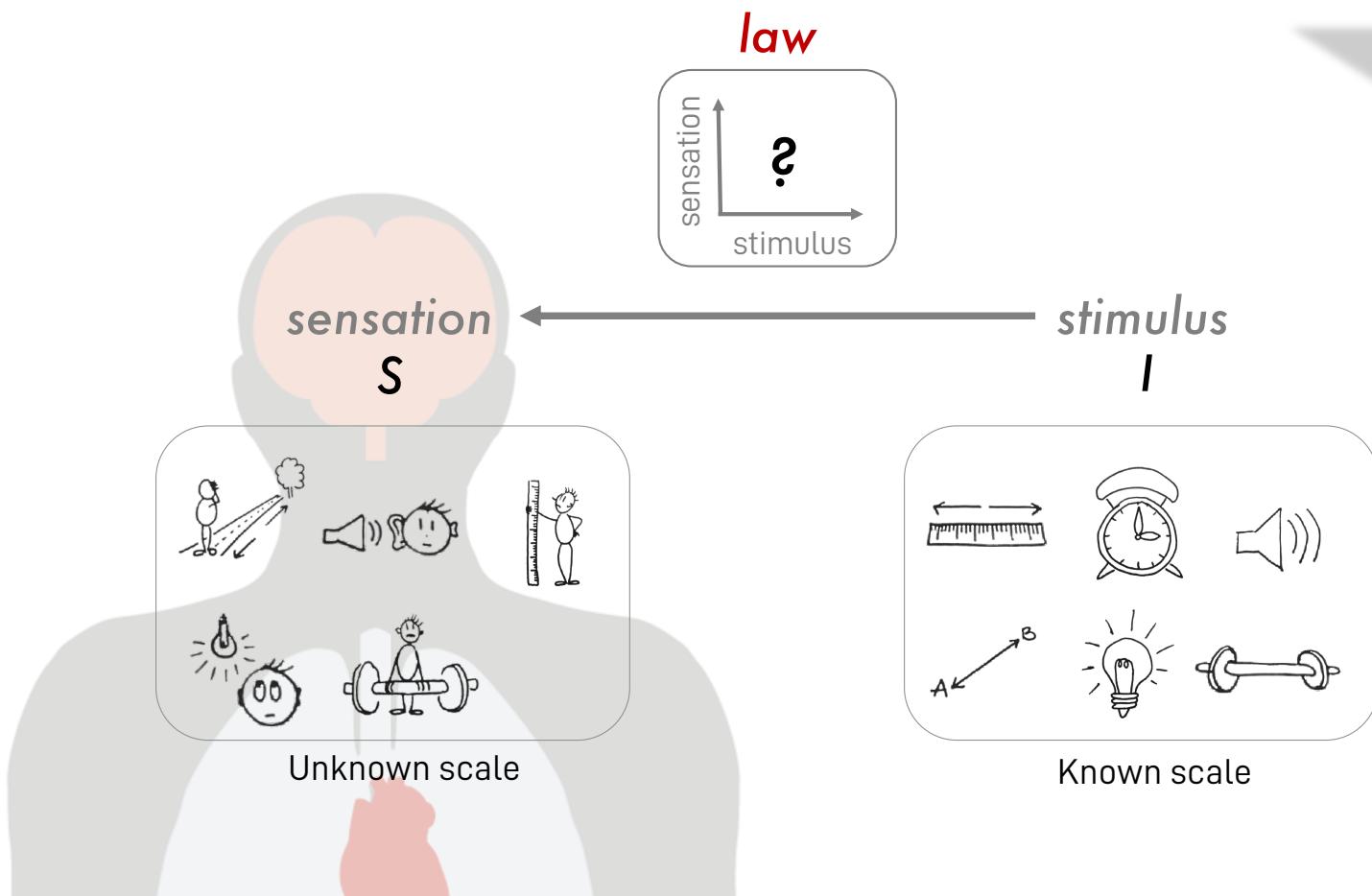
**Quantitative
Physics**

*What is 'real'.
Matter.*

How do you measure sensation?



Fechner

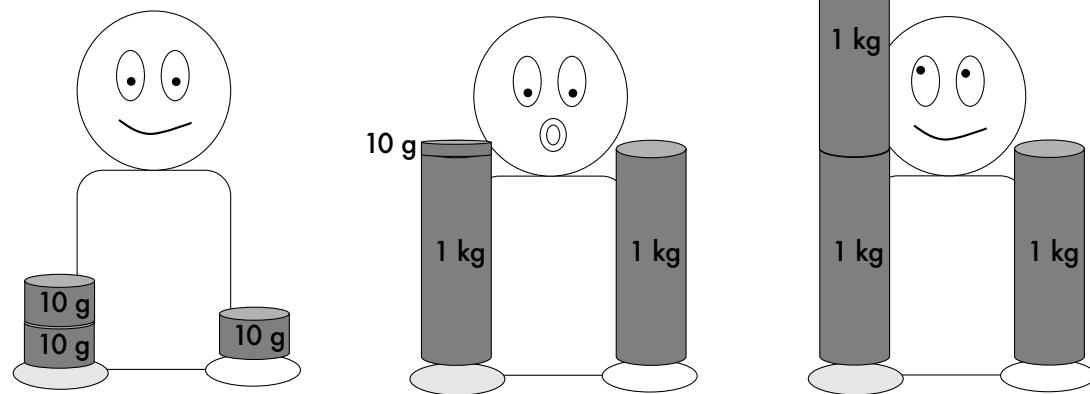


Just-noticeable difference

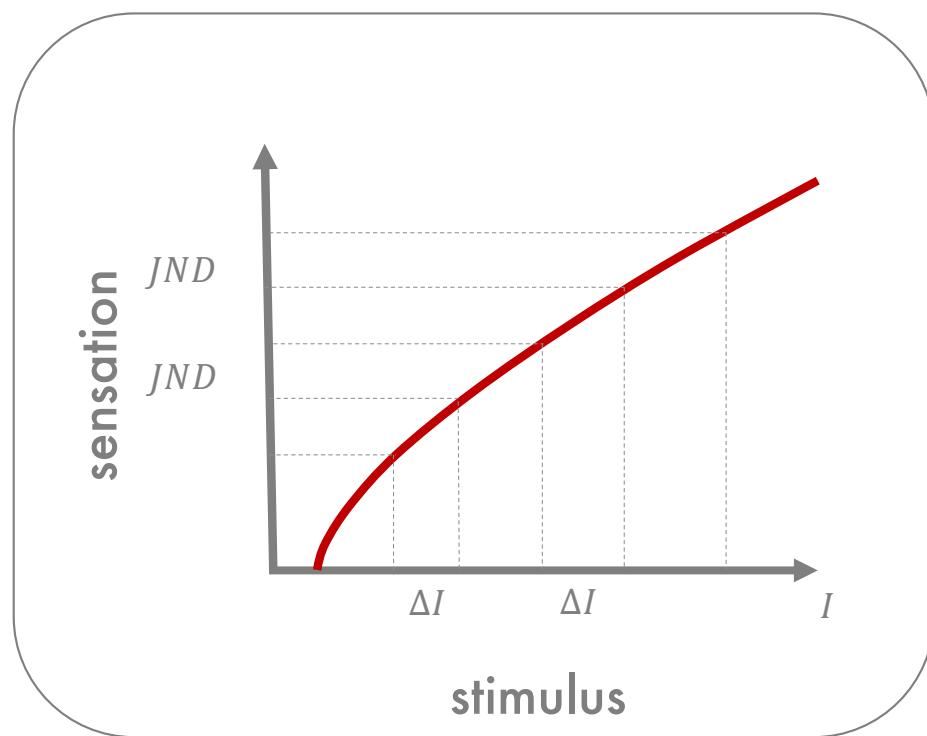


1834

$$\frac{\Delta I}{I} = k$$



Just-noticeable difference



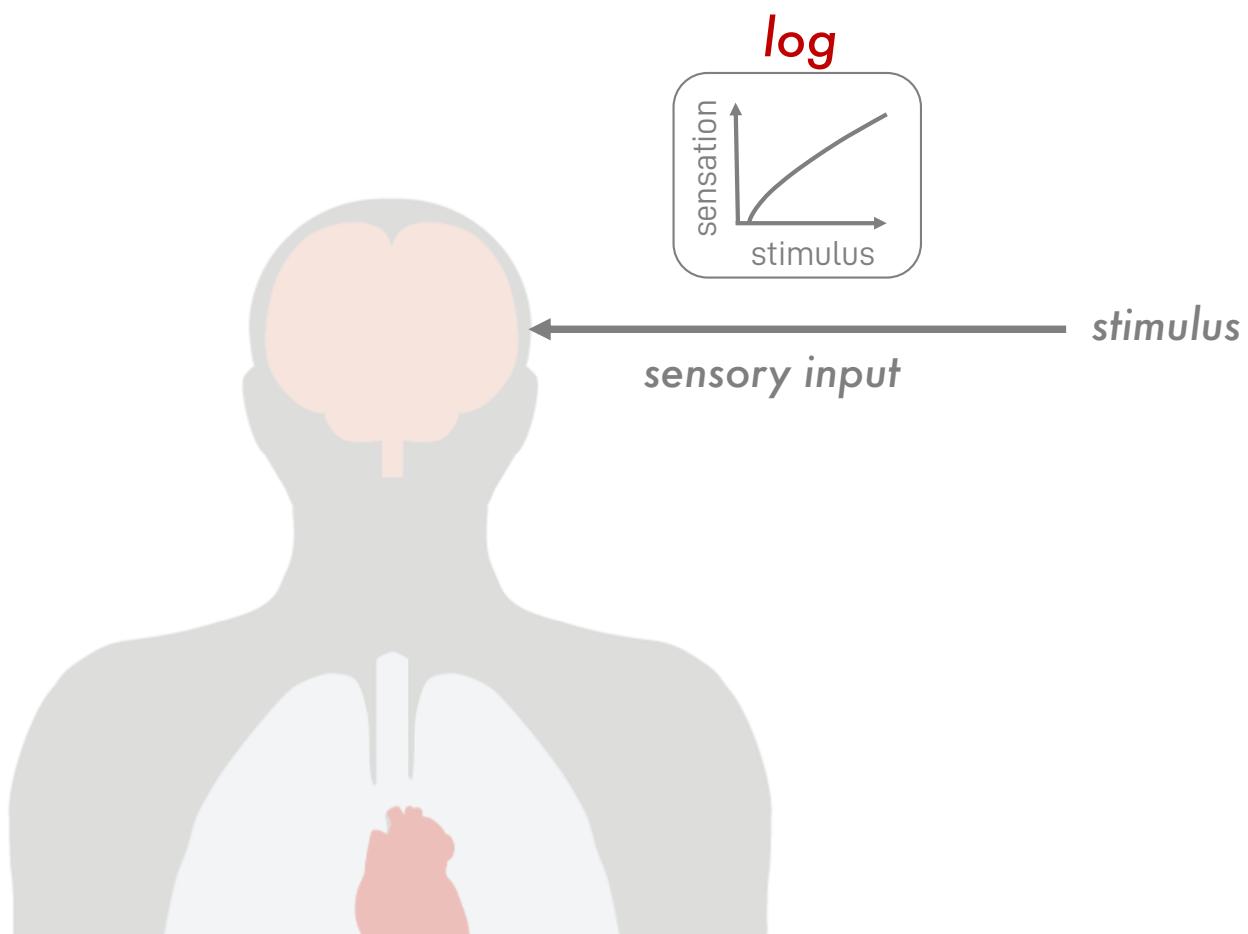
$$JND = \frac{\Delta I}{I} = k$$

$$S \propto \log I$$

Weber-Fechner Law



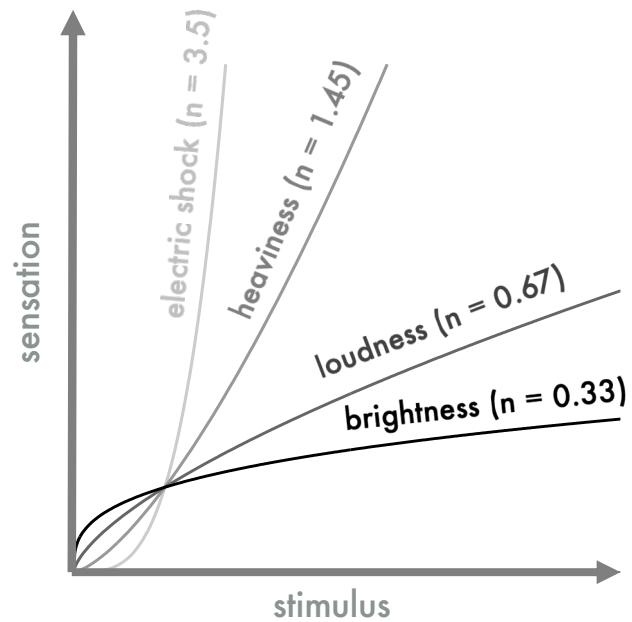
Psychophysical “LAW”



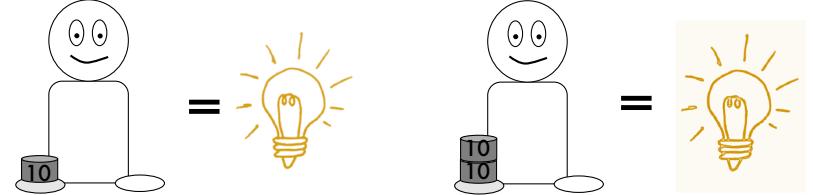
Steven's Power LAW



1961

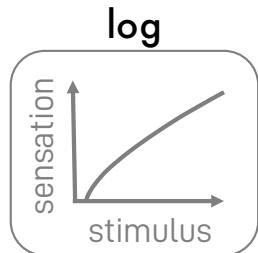
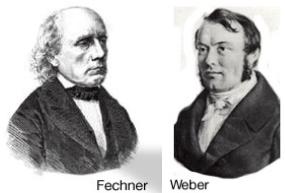


$$S \propto I^n$$



The importance of measurements...

Weber-Fechner Law



*Theoretically derived
Just noticeable difference ($I \rightarrow S$)*

Steven's Power Law



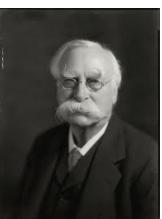
To Honor Fechner and
Repeal His Law

A power function, not a log function, describes the
operating characteristic of a sensory system.

S. S. Stevens

MacKay 1963, Science

*Empirical
cross/modality matching ($I_1 \rightarrow S_1 \rightarrow S_2 \rightarrow I_2$)*



E. Poulton

Psychophysics
The new ~~Ps~~eudophysics
E. Poulton
1968

TICS-1416; No. of Pages 9 ARTICLE IN PRESS

Review CellPress

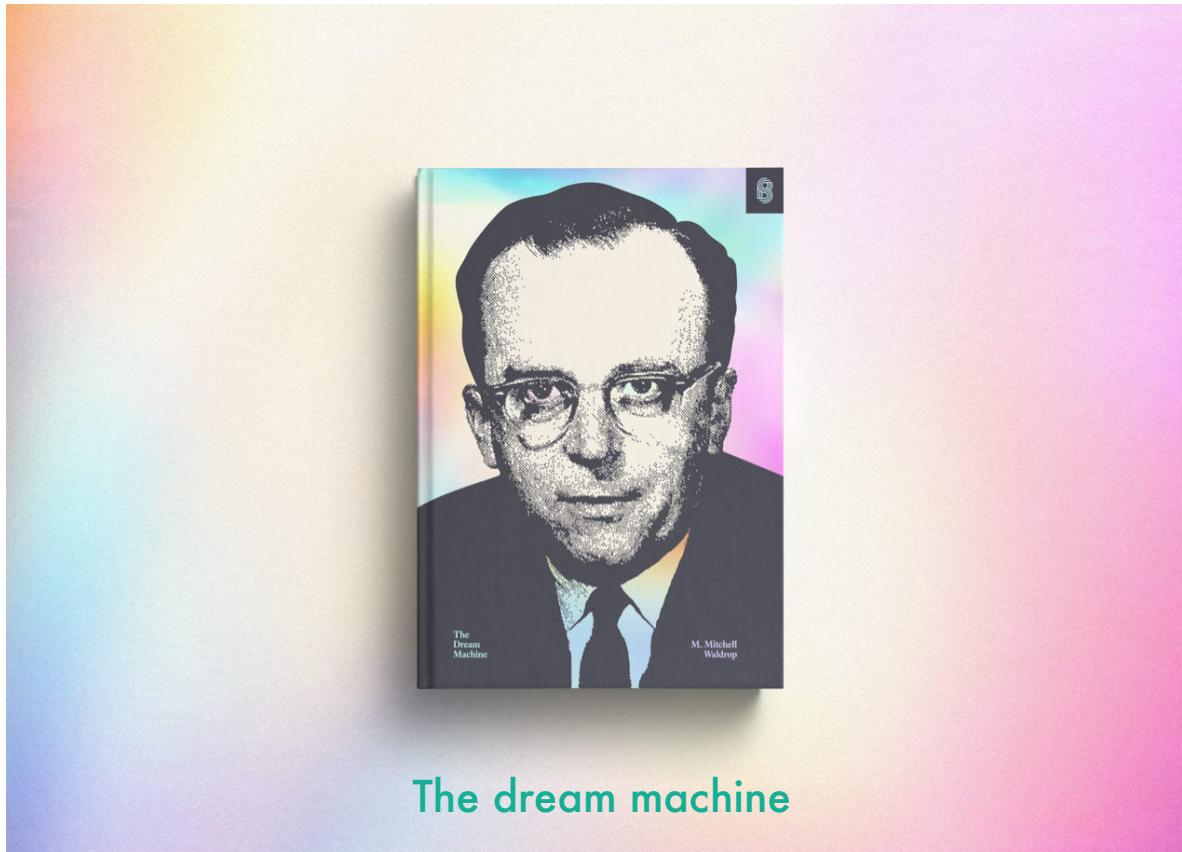
A Bayesian perspective on magnitude estimation

Frederike H. Petzschner¹, Stefan Glasauer^{2,3,4}, and Klaas E. Stephan^{1,5}

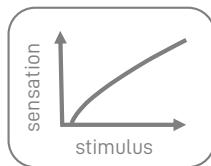
**Next talk on
Bayesian
perception**

Side note

If you like science history

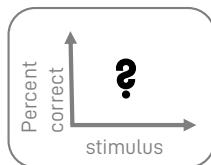


The importance of measurements...



Methods of adjustment/ estimation

- cross/unimodality matching
 - production – reproduction
- no right or wrong response!



Methods of performance

- discrimination (e.g., bigger than)
- detection (yes/no)

Detection Threshold

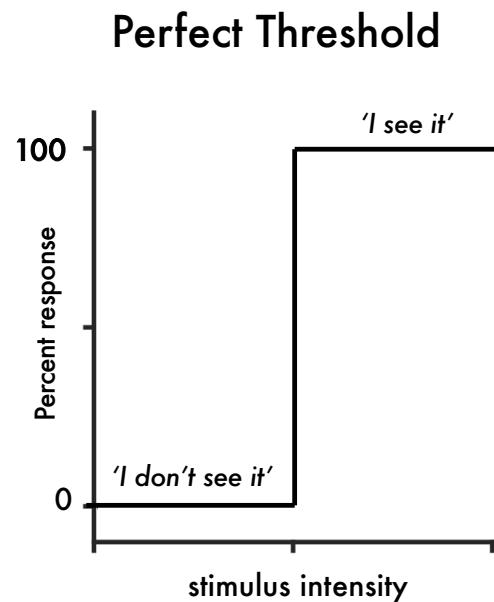
How far can you still see a candle flame on a dark clear night?



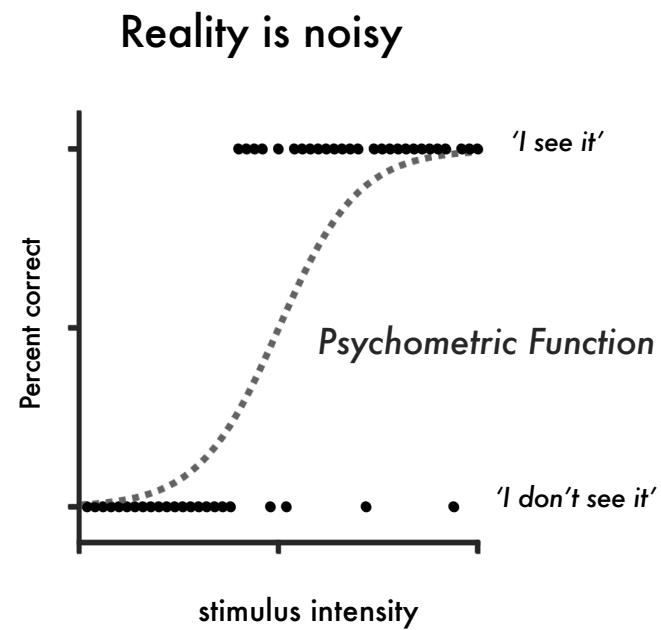
- A. 1 mile
- B. 3 miles
- C. 10 miles
- D. 30 miles

Estimating thresholds

Was there a light? Yes or No.

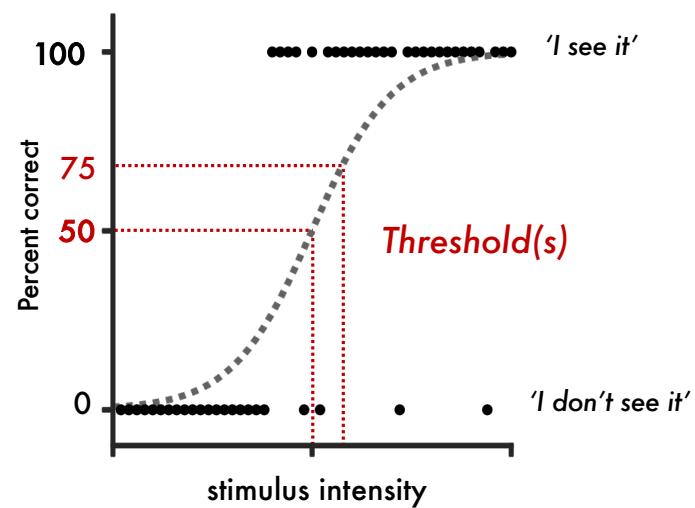


Estimating thresholds



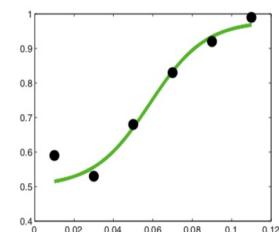
Estimating thresholds

Where is the threshold?



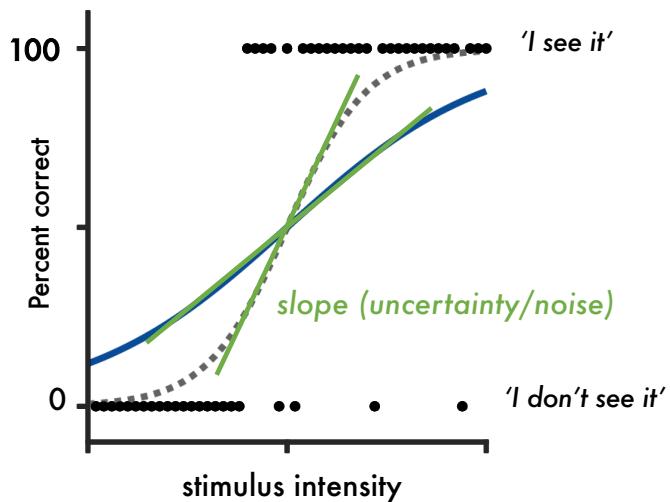
Fitting the psychometric function

Fitting the Psychometric function



- Cumulative Normal Distribution
- Logistic Function
- Weibull Function
- Cummulative Normal
- Gumble (Log-Weibull)
- Quick
- Hyperbolic Secant
-

Kingdom & Prins, Psychophysics, 2016



You can use Lionel's code to fit this function using ALL of the inference methods presented in this course: MLE, MAP, MCMC, VB
<http://github.com/lionel-rigoux/tutorial-bayesian-inference>

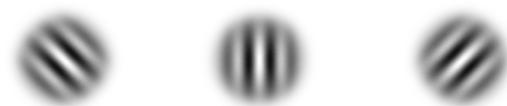
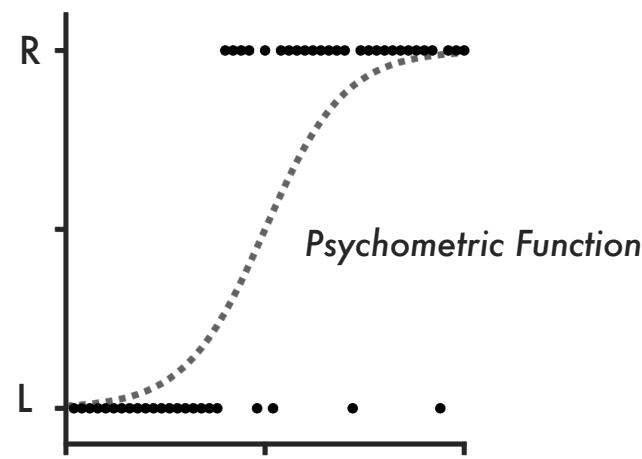
Psychometric function are universal

AFC: Alternative forced choice

1 AFC: Left-oblique or right-oblique?



2 AFC: Which one left-oblique?

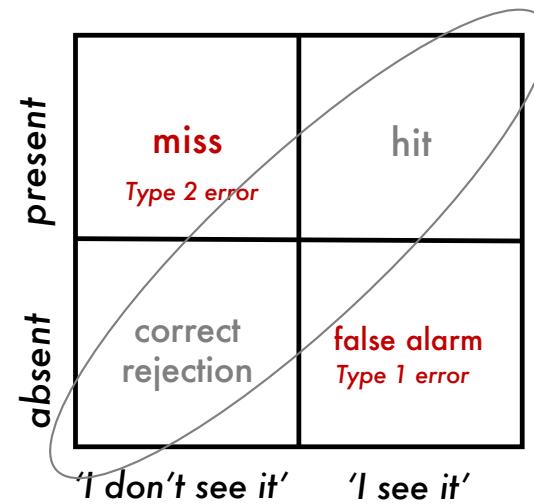
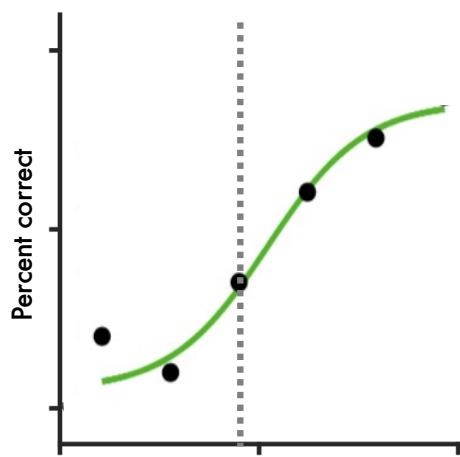


Relationship between physical quantity and detection/discrimination probability.

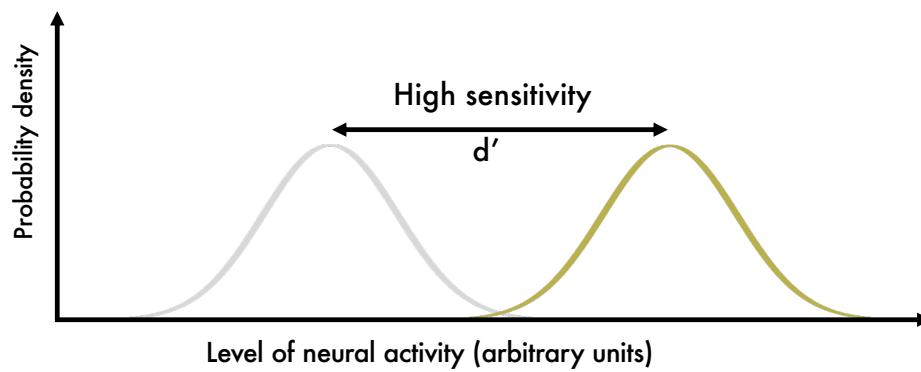
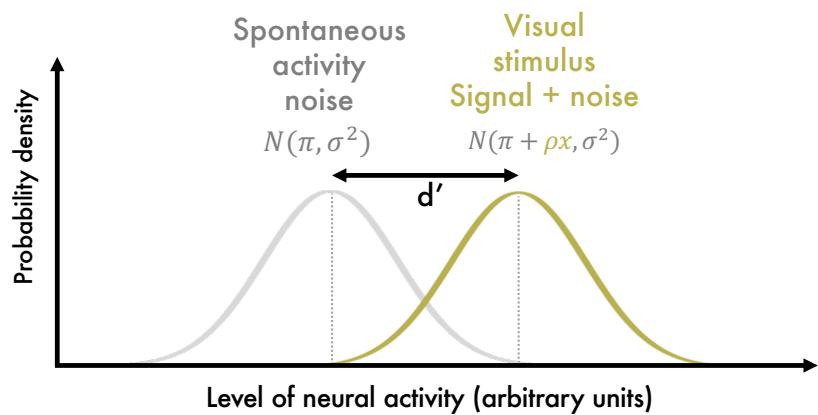
What is behind and beyond the Psychometric Function?

Signal detection theory

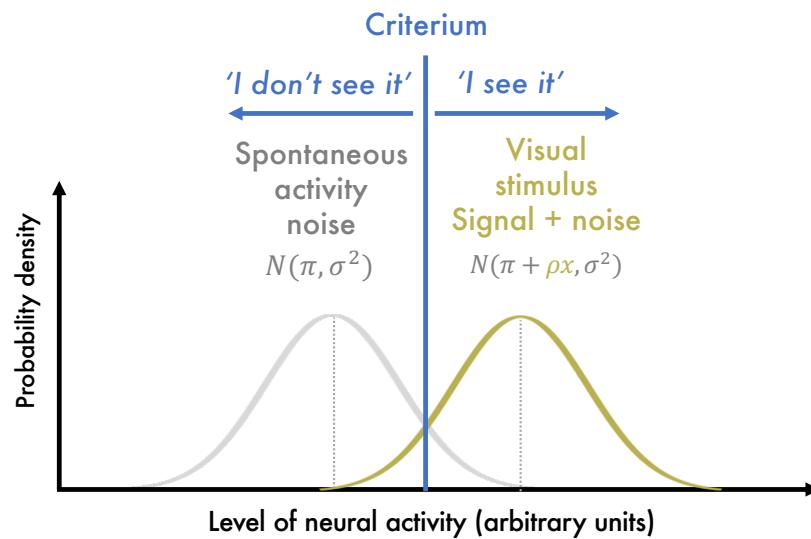
The details of probability correct



Signal detection theory

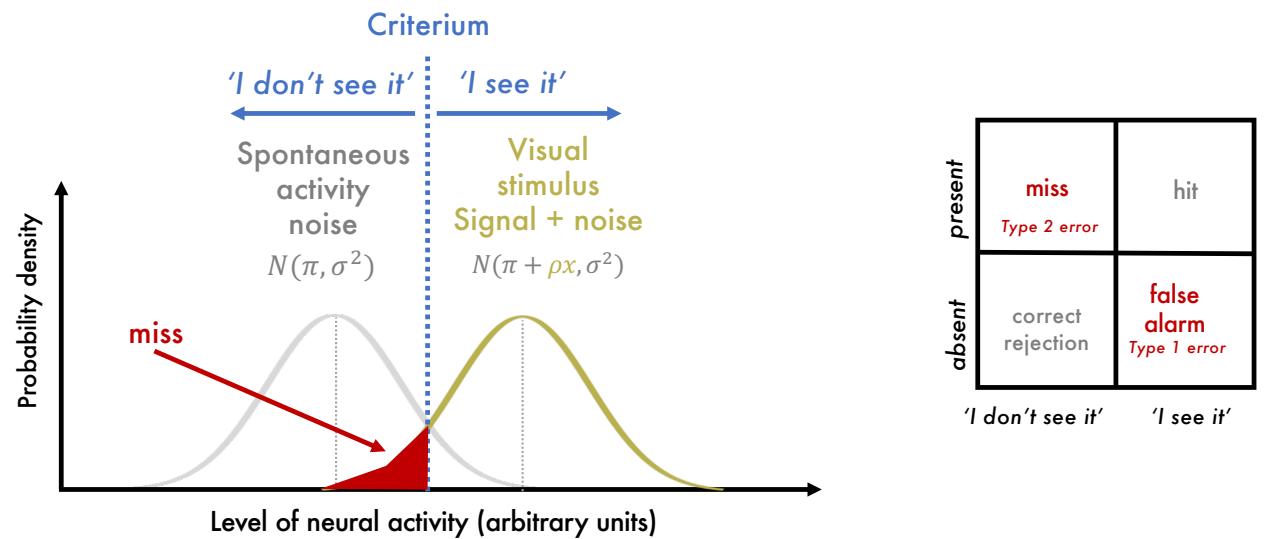


Signal detection theory

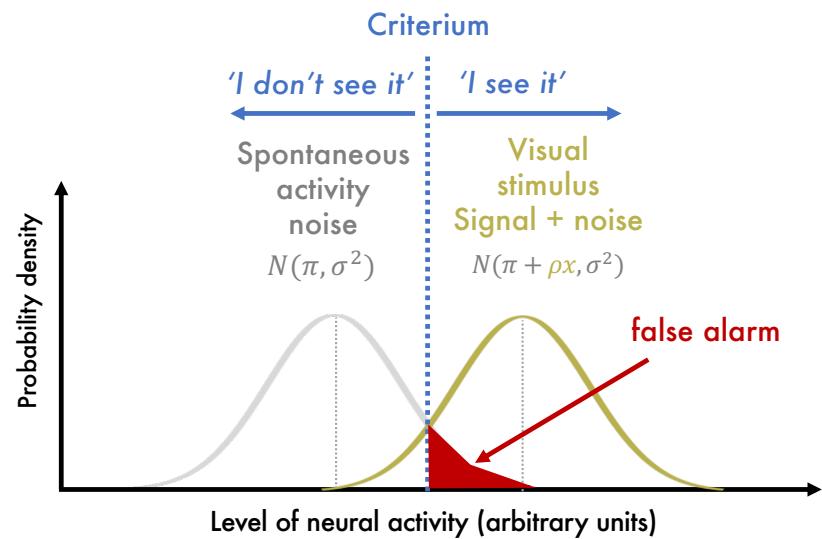


Criterium: Converting neural activity into an overt response

Signal detection theory



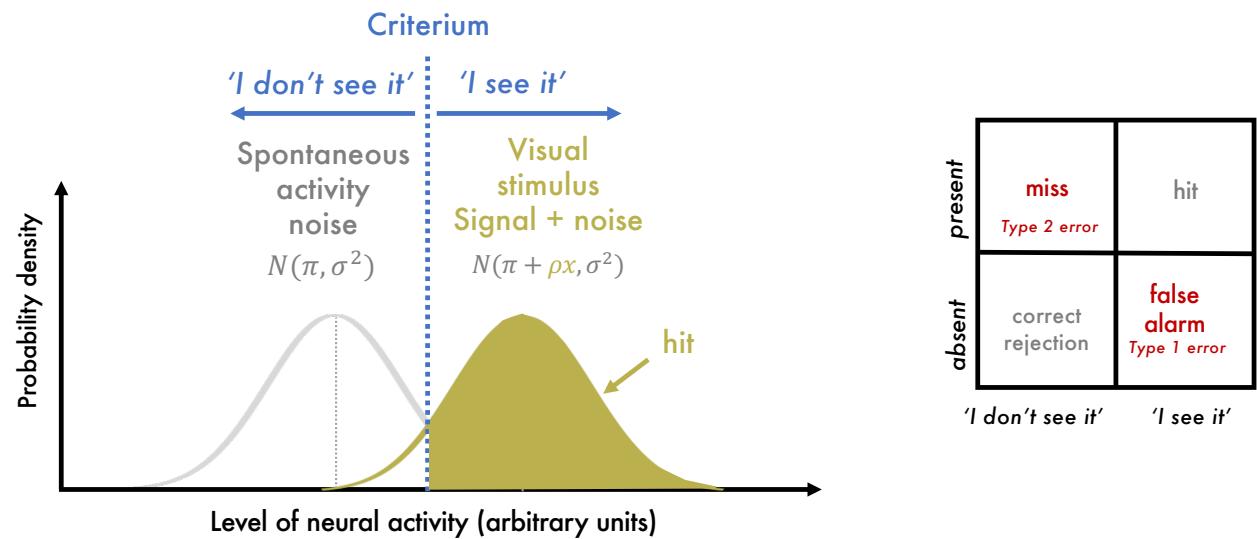
Signal detection theory



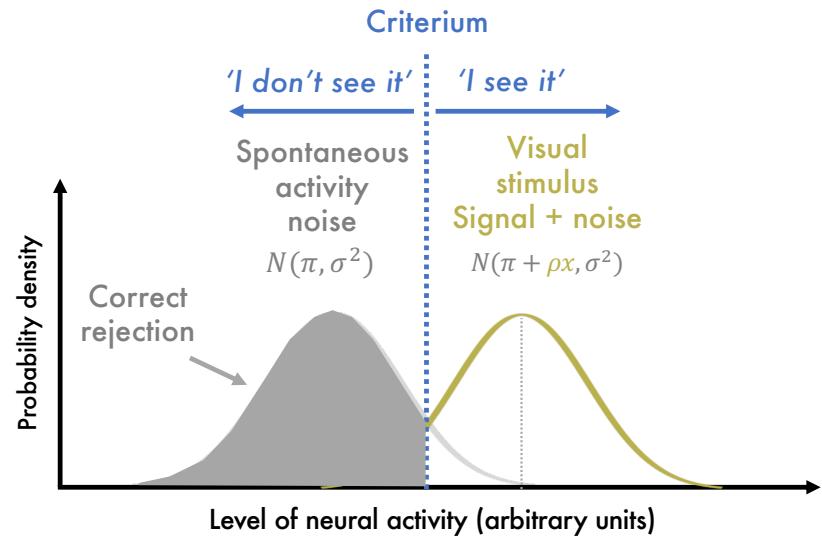
present	miss Type 2 error	hit
absent	correct rejection	false alarm Type 1 error

'I don't see it' 'I see it'

Signal detection theory



Signal detection theory



present	miss Type 2 error	hit
absent	correct rejection	false alarm Type 1 error

'I don't see it' 'I see it'

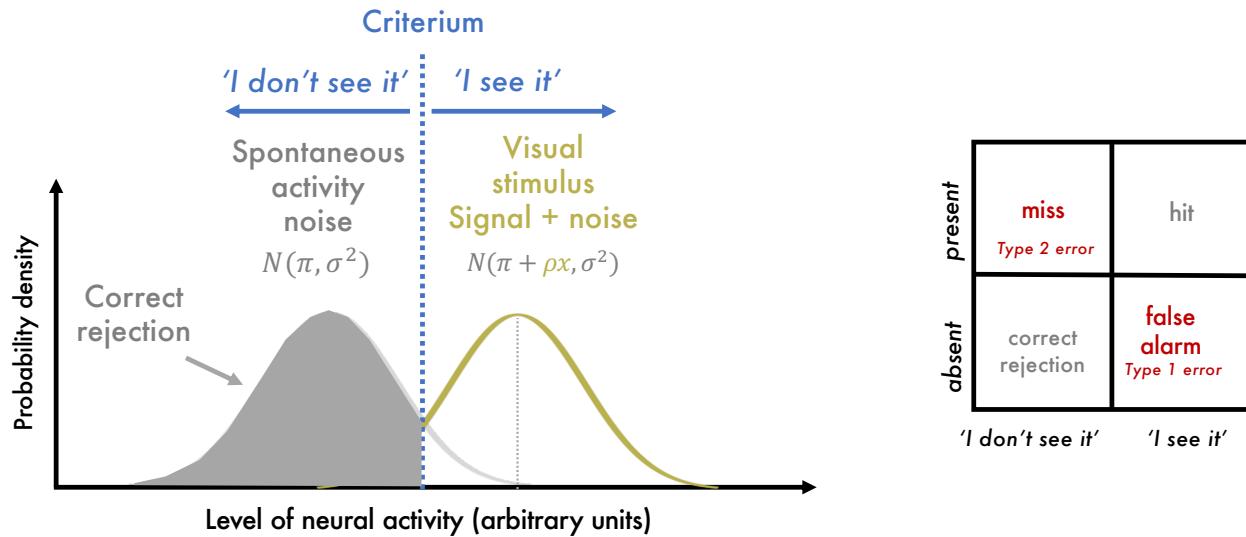
Signal detection theory

Calculating d' and bias

- Depends on the exact experiment 2AFC, 1AFC
- Conversion maps from PC to d'

Code & Formula
Kingdom & Prins, Psychophysics, 2016

McNicol (2004),
Chapters 5-8 Gescheider (1997)
Nonexpert: Macmillan and Creelman (2005)
More mathematical: Wickens (2002)
More mathematical: Green and Swets (1974)



	present	
'I don't see it'	miss <i>Type 2 error</i>	hit
'I see it'	correct rejection	false alarm <i>Type 1 error</i>

$$2 \text{ AFC with bias: } d' = \frac{[z(pH) - z(pF)]}{\sqrt{2}}$$

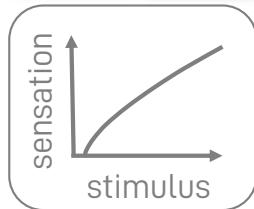
pH = Hit rate

pF = False alarm rate

z-score: transform into SD units

Summary

Weber-Fechner Law



Steven's Power Law



To Honor Fechner and
Repeal His Law

A power function, not a log function, describes the
operating characteristic of a sensory system.

S. S. Stevens

Methods of adjustment



Psychophysics

The new ~~Pseudophysics~~

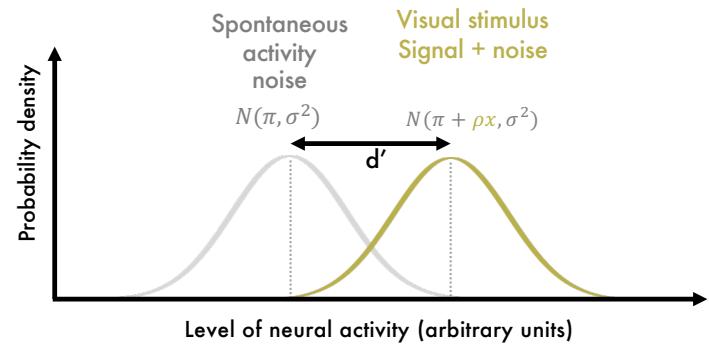
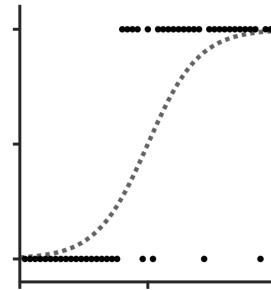
E. Poulton
1968

Performance measures

1 AFC: Left-oblique or
right-oblique?



2 AFC: Which one
left-oblique?



Thank you

@rikepetzschn
@peaclub

Interested in working with us?

<https://fpetzschn.com/lab/>

Read Me:

Kingdom & Prins, Psychophysics, 2016
Petzschn et al., TiCS, 2015

APPENDIX