Cognitive (Neuro) Psychology

IV. Psychophysics

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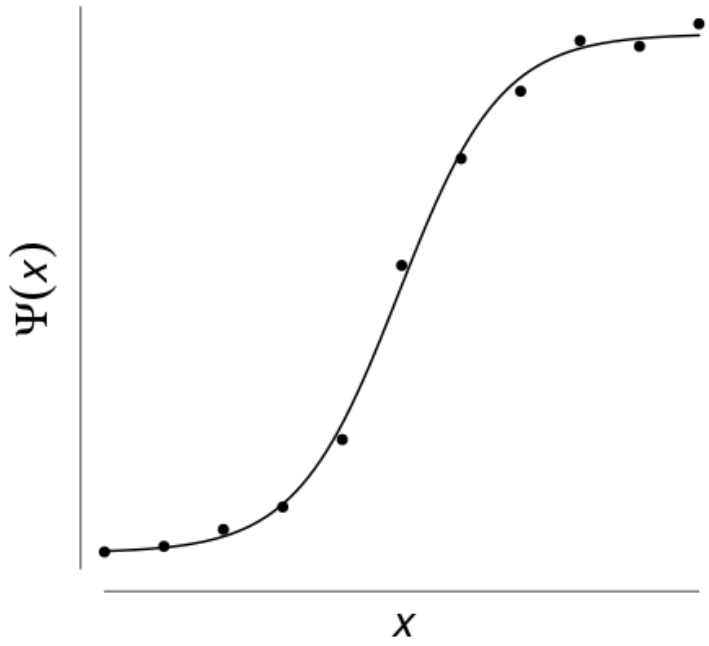
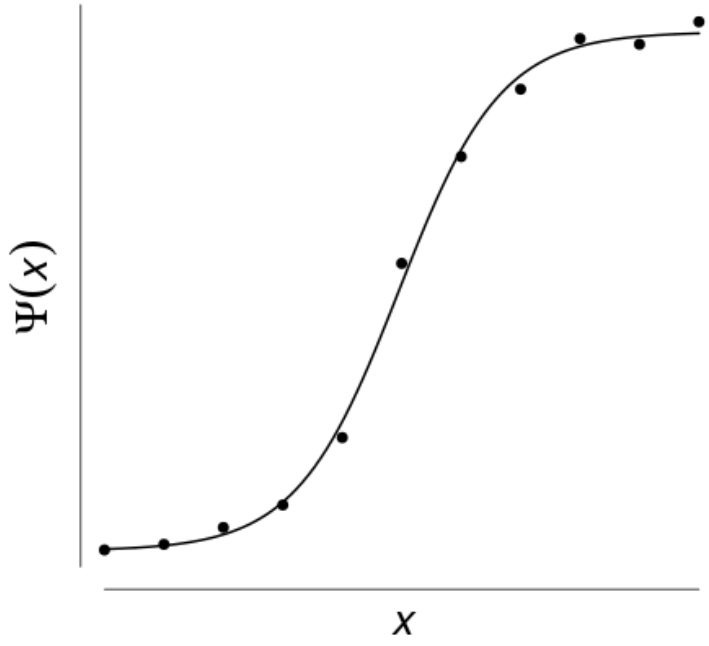
What is real?

"What is real? How do you define real? If you're talking about what you can feel, what you can smell, what you can taste and see, then real is simply electrical signals interpreted by your brain. This is the world that you know." - Morpheus' answer to Neo in *The Matrix*, 1999

Psychophysics

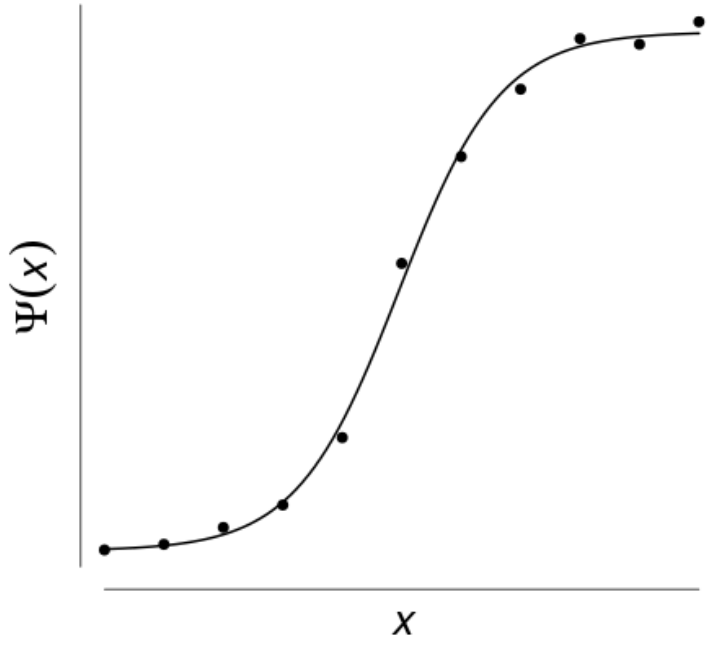


Psychophysics



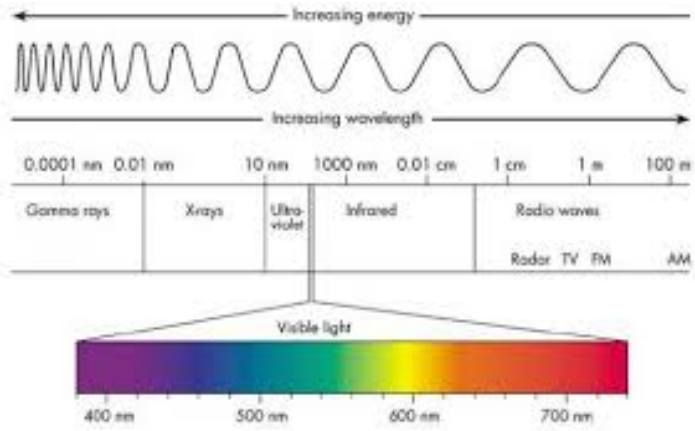
- subdiscipline of psychology

Psychophysics



- subdiscipline of psychology
- addresses the relationship between physical stimuli, x, and their subjective correlates (percepts), $\Psi(x)$

Psychophysics



Outline

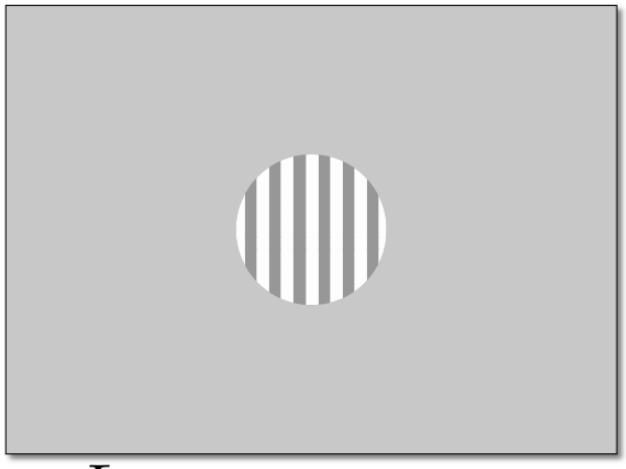
- Components of a psychophysical experiment
- Classification of psychophysical experiments
- Measuring performance: The psychometric function

Components of a psychophysics experiment

- stimuli
- task
- method
- analysis
- measure

Example: contrast sensitivity

Stimulus

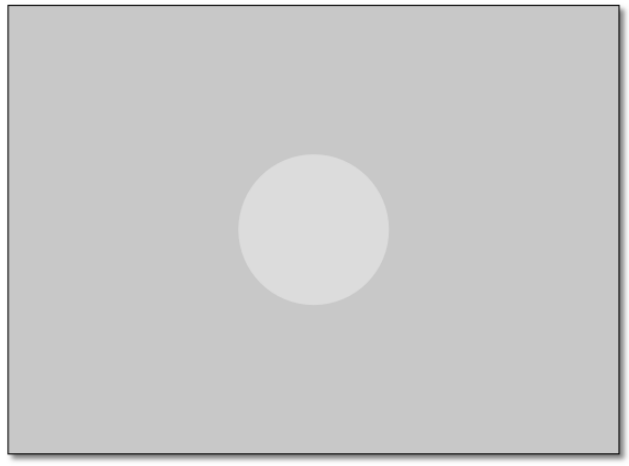


L_{max}

L_b

L_{min}

$$C = \frac{L_{max} - L_{min}}{L_b}$$



ΔL

L_b

$$C = \frac{\Delta L}{L_b}$$

Measure

Absolute threshold

- The minimum amount of stimulation necessary for a person to detect a stimulus **50%** of the time.

Measure

Absolute threshold

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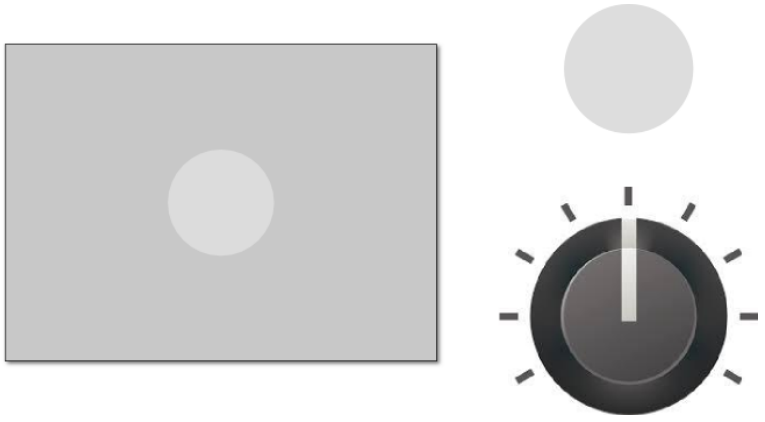
Just noticeable difference - JND

- The smallest detectable difference between two stimuli.

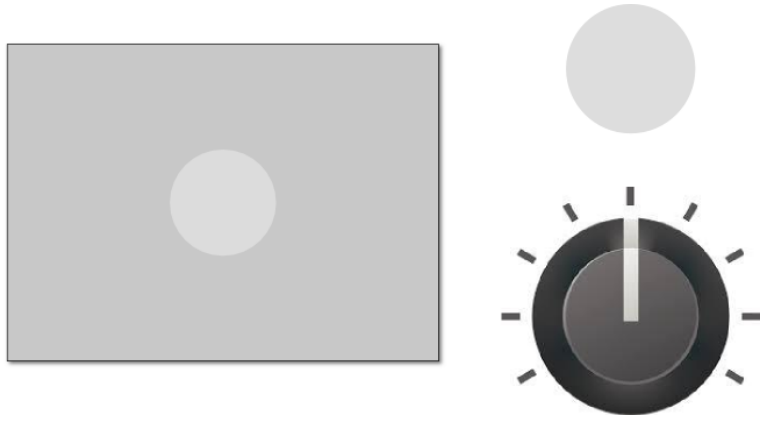
Task

- Method of adjustment

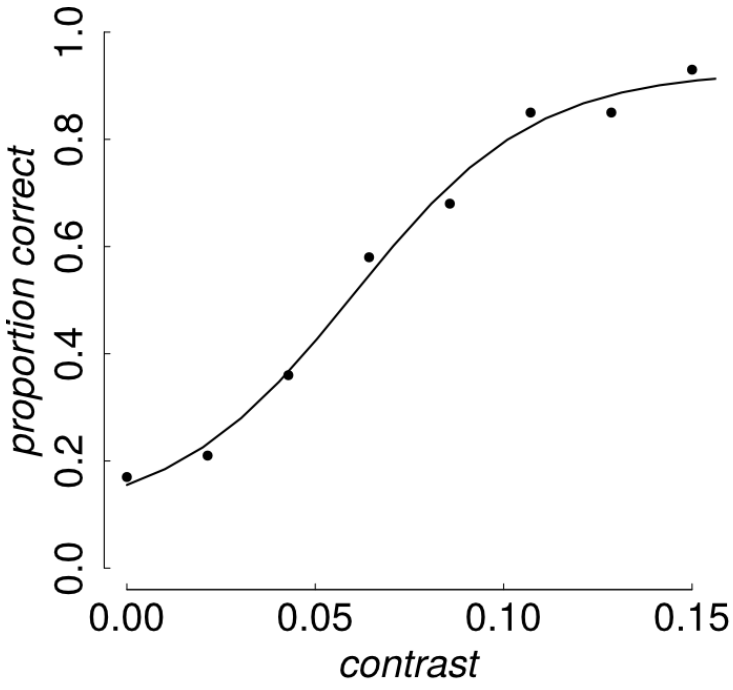


Task

- Method of adjustment

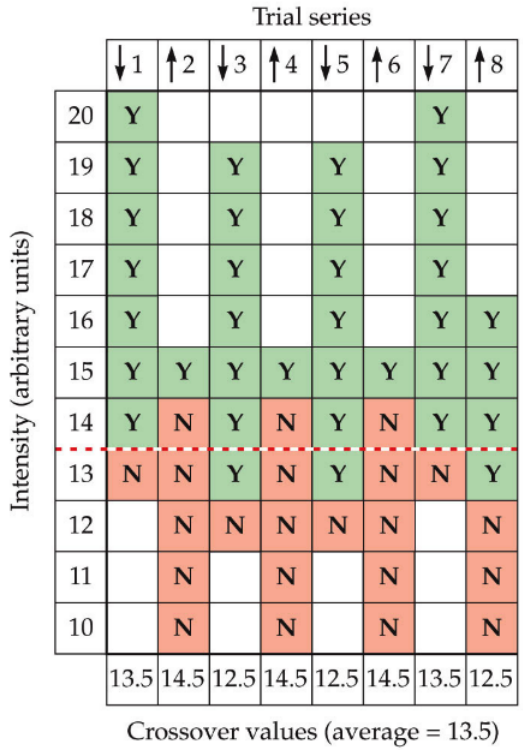


- Method of constant stimuli



Method & Analysis

- Method of limits



Method & Analysis

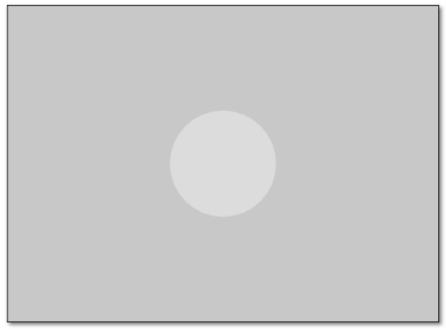
- Method of limits

Trial series

Intensity (arbitrary units)	↓1	↑2	↓3	↑4	↓5	↑6	↓7	↑8
20	Y						Y	
19	Y		Y		Y		Y	
18	Y		Y		Y		Y	
17	Y		Y		Y		Y	
16	Y		Y		Y		Y	Y
15	Y	Y	Y	Y	Y	Y	Y	Y
14	Y	N	Y	N	Y	N	Y	Y
13	N	N	Y	N	Y	N	N	Y
12		N	N	N	N	N		N
11		N		N		N		N
10		N		N		N		N
	13.5	14.5	12.5	14.5	12.5	14.5	13.5	12.5

Crossover values (average = 13.5)

- Cross modality matching



Classifications

- all understanding begins with making comparisons and those comparisons, in turn, lead to the construction of categories

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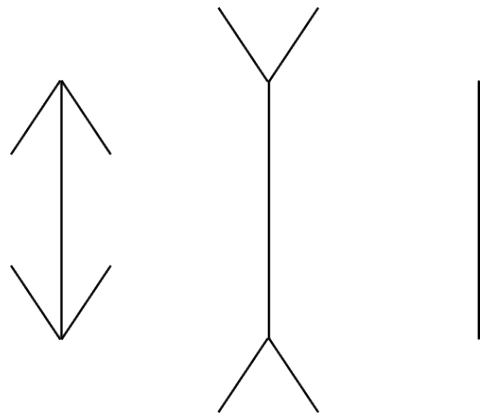
- simplify and make explicit design choices
- which method is appropriate for studying which aspect of visual functioning

Objective vs. Subjective

- nature of measurement e.g. Muller-Lyer illusion



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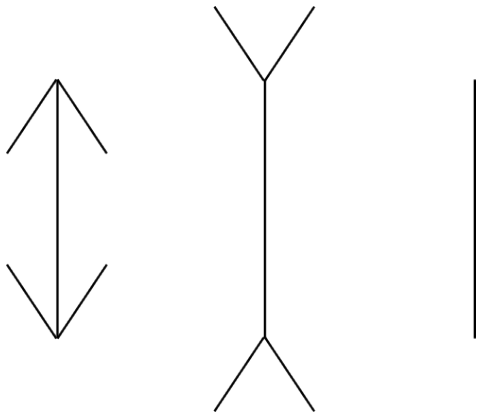

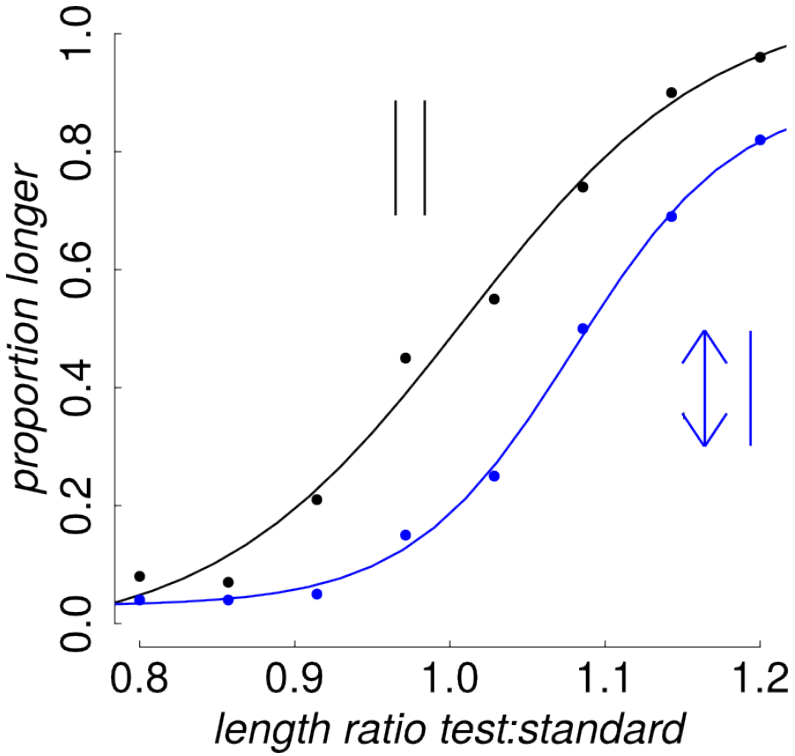

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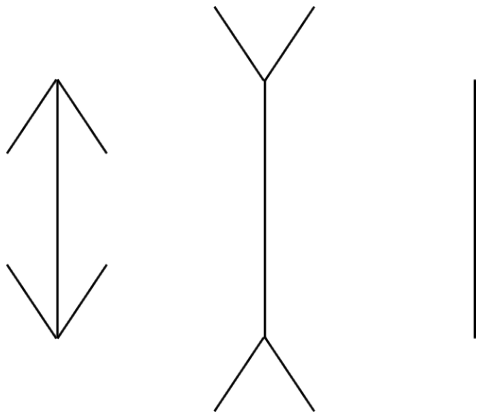

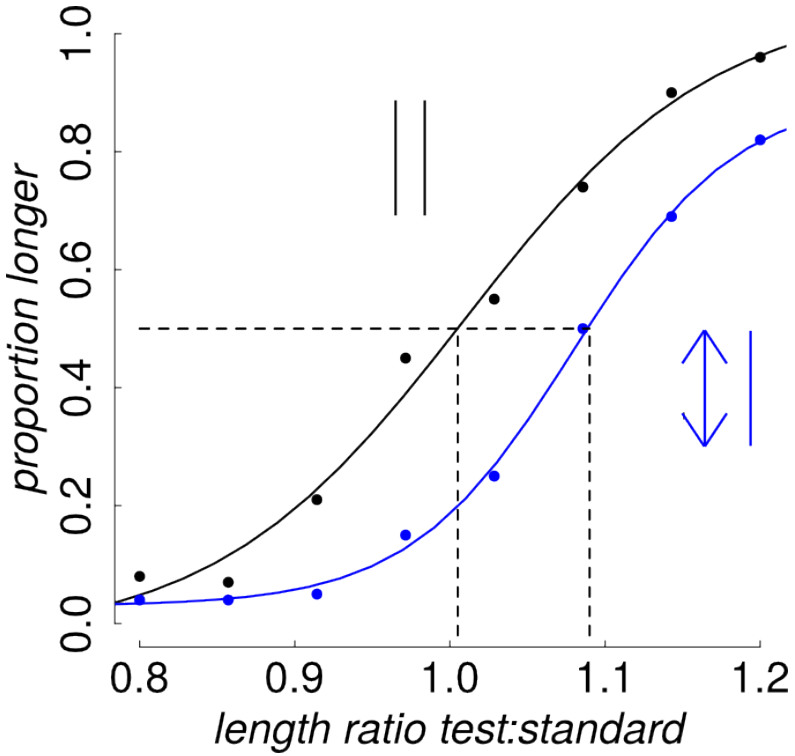

- PSE: point of subjective equality
- objective: correct vs. incorrect

Objective vs. Subjective

- method of data collection

  method of adjustment = subjective

  method of constant stimuli = objective

Performance vs. appearance

- How good is an observer in a particular task? e.g. orientation discrimination in the fovea vs. the periphery
- Performance can not be meaningfully considered as 'better' e.g. apparent lightness of targets

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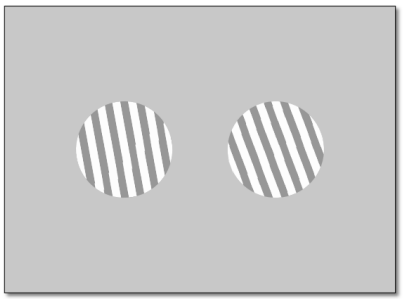

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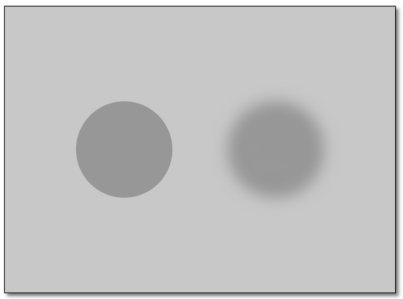

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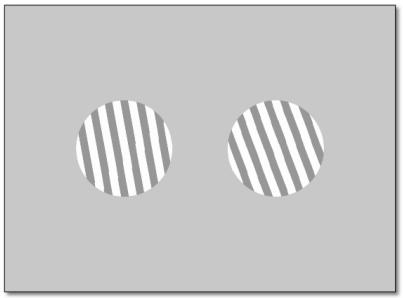
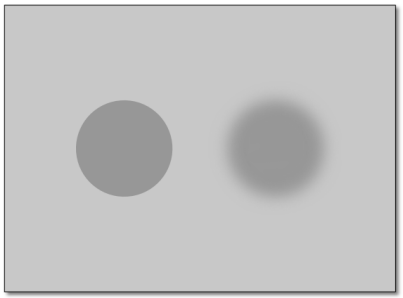


- accuracy
- threshold

- Performance can not be meaningfully considered as 'better' e.g. apparent lightness of targets



- PSE
- scales

Forced-choice vs. non-forced

- criterion-free vs. criterion-dependent

Detection vs. Discrimination

- is there a / where is the single stimulus?
- which of two stimuli is more 'x'?

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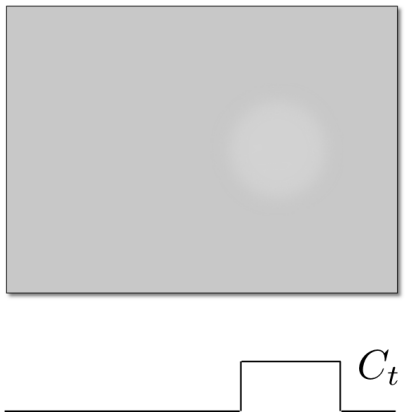

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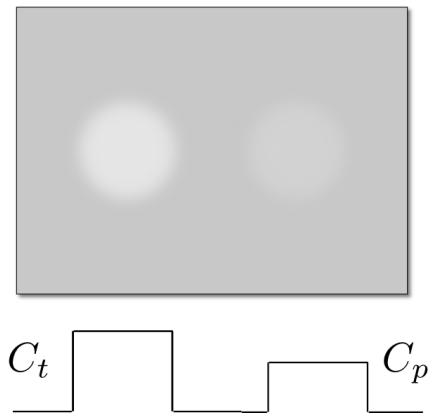

→ absolute threshold: minimum signal for 50% correct detection

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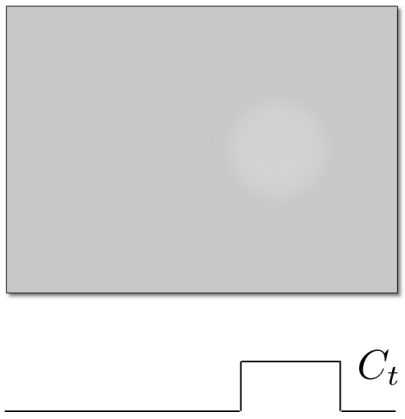

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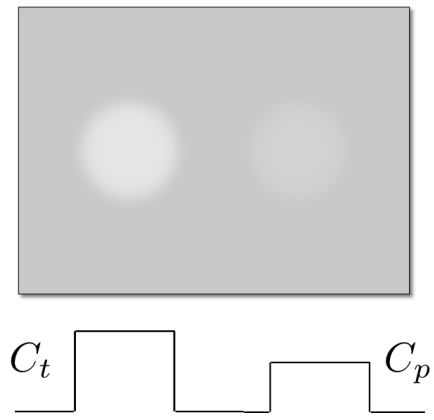

→ difference threshold

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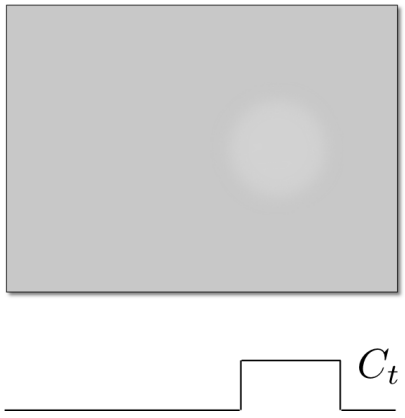

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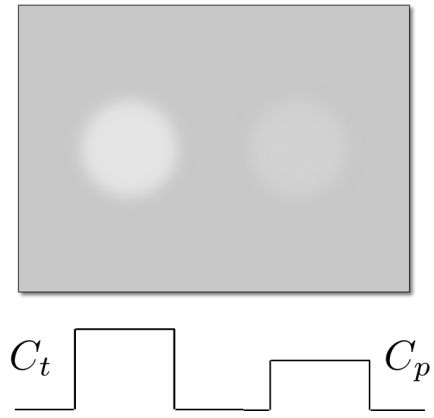
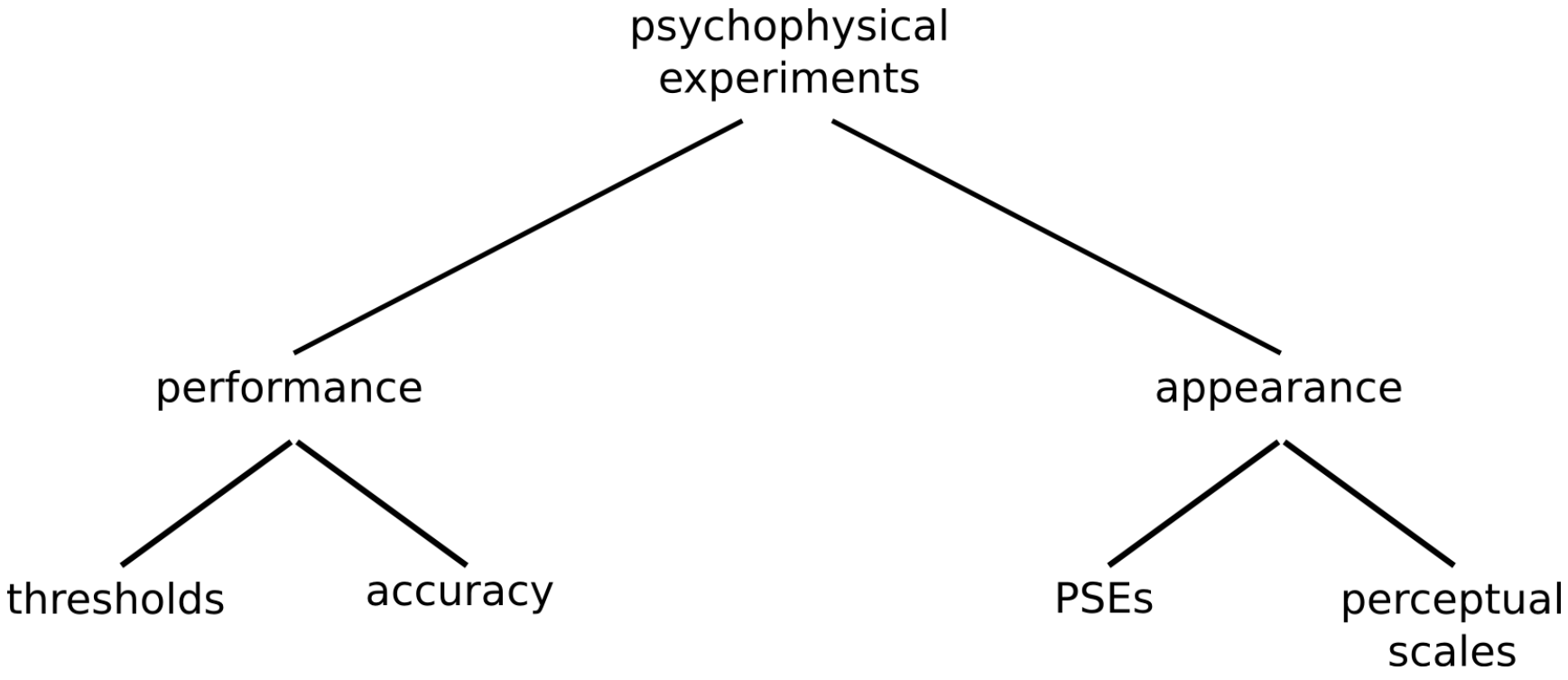
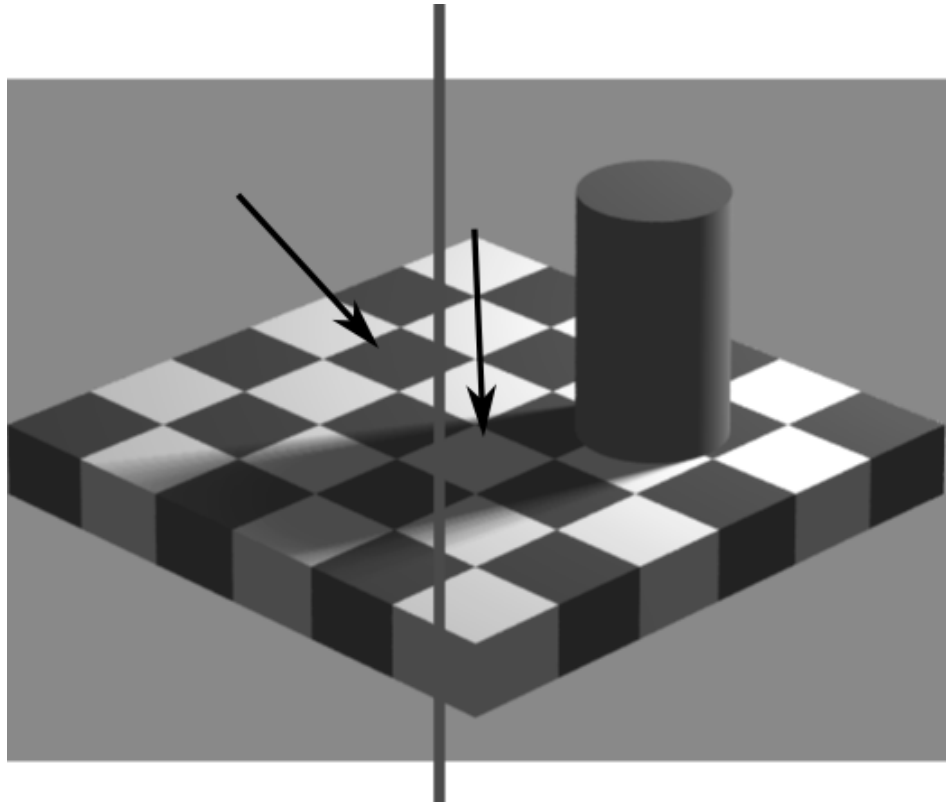


→ difference threshold

- contrast discrimination - detection of an increment on a pedestal

Psychophysics Summary

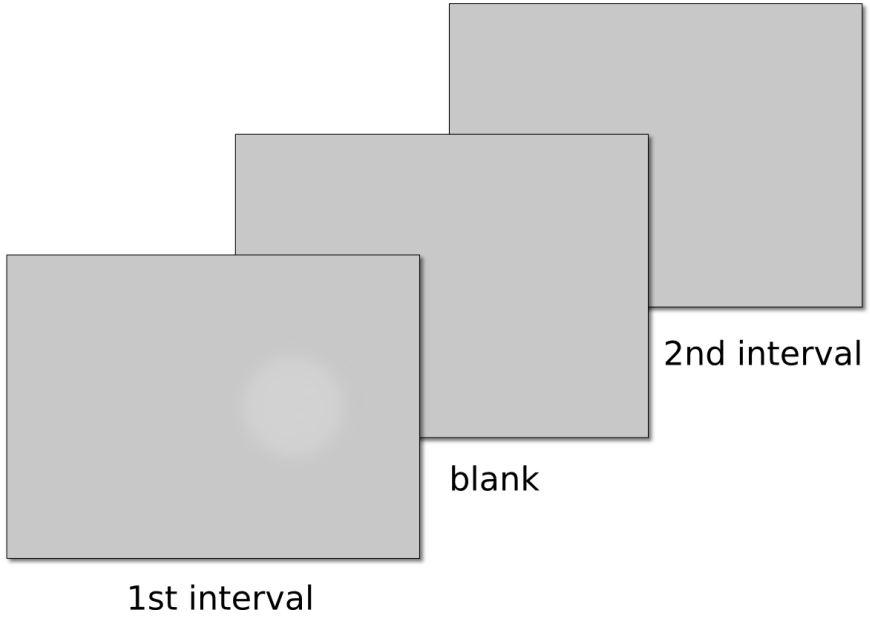




Thinking

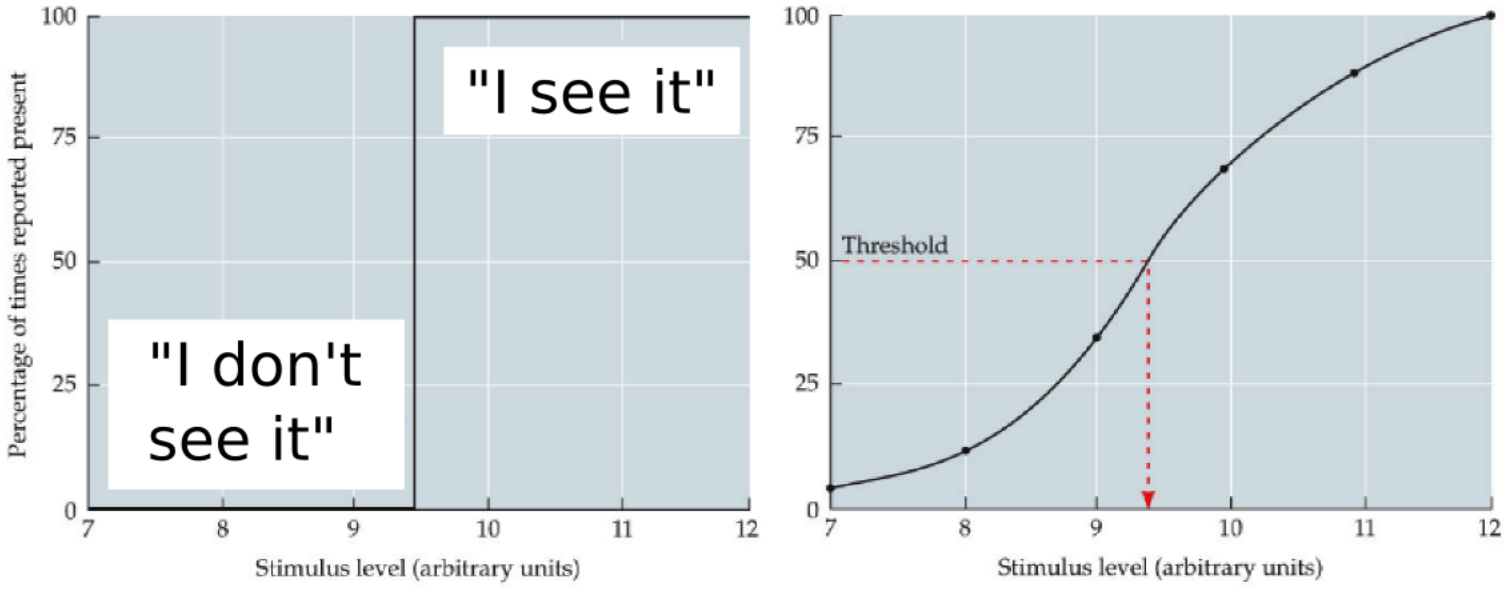
The two checks indicated by arrows have the same retinal luminance but differ in apparent lightness. Design an experiment to quantify the perceived difference between the two checks!

Psychometric function theories

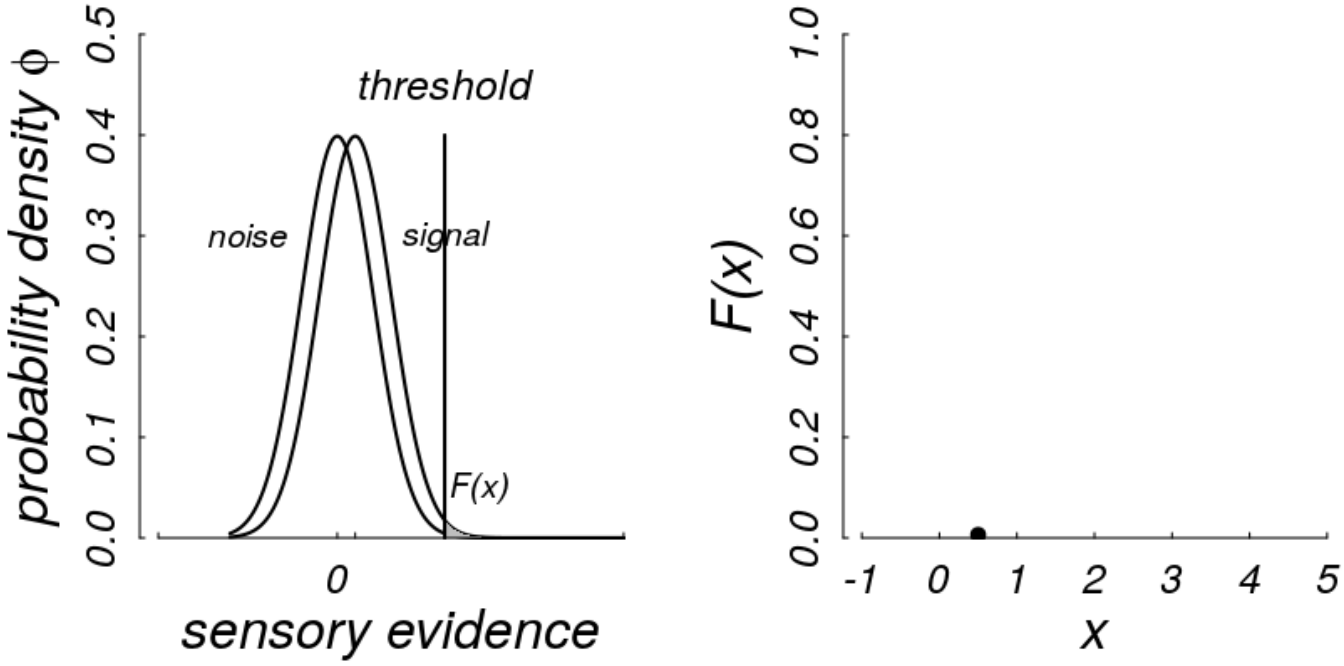


- 2-IFC: S signal and N noise
- Which of the two intervals contained the stimulus?
- sensory evidence fluctuates from trial to trial $n \sim N(0, 1)$

Psychometric function theories



Psychometric function theories: high threshold theory



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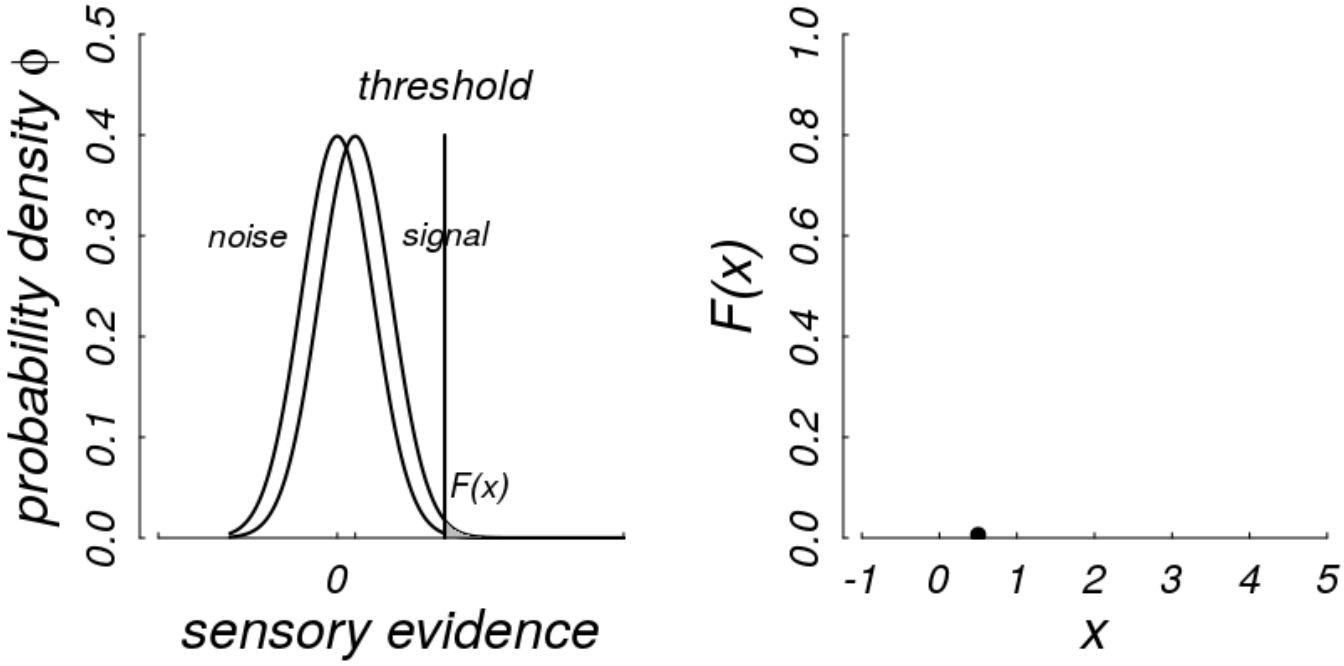

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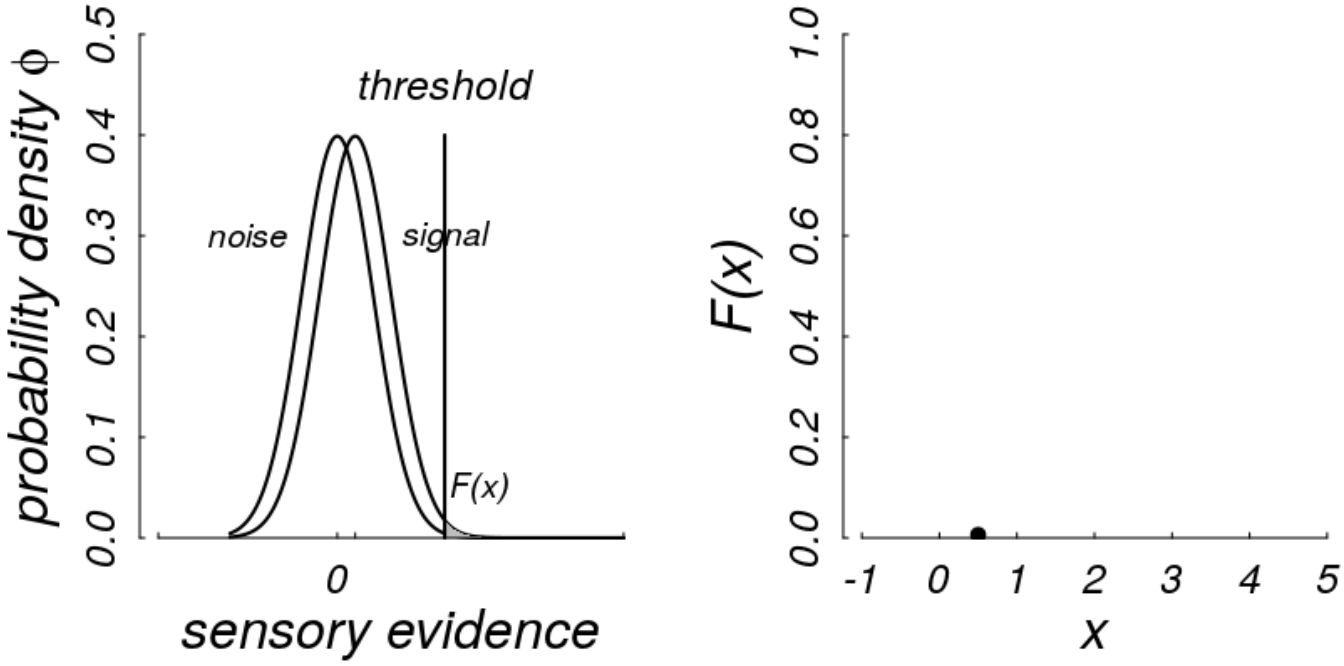

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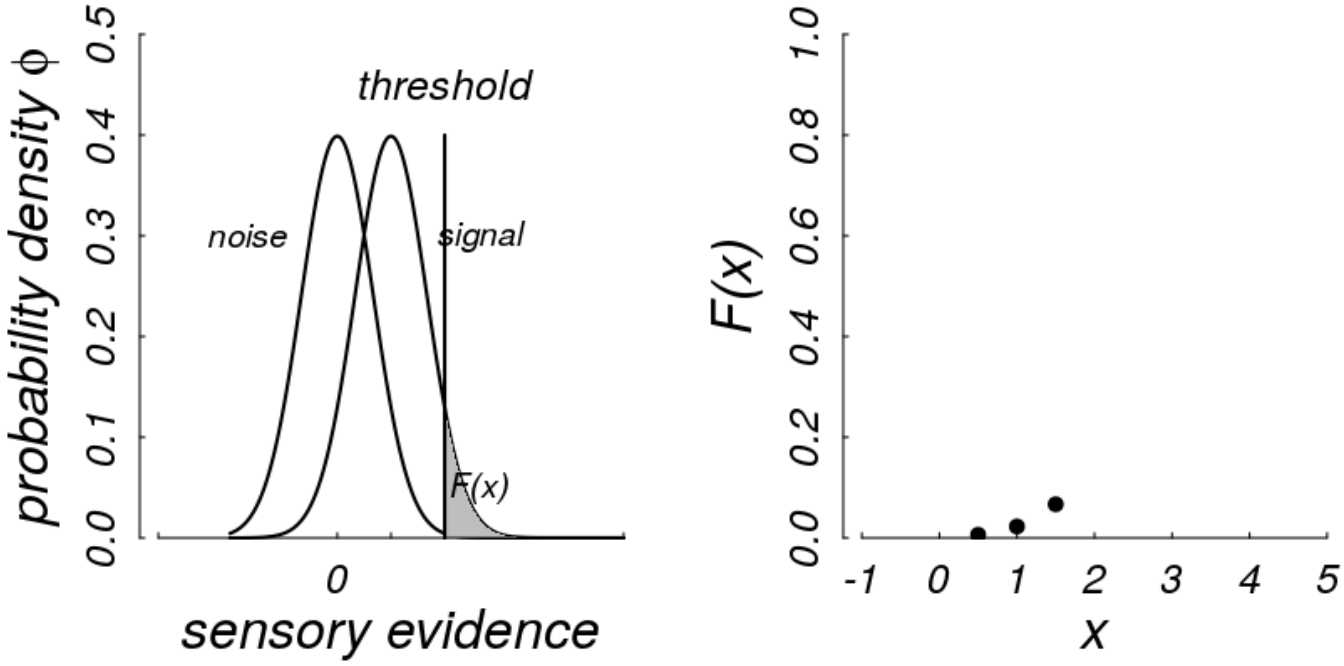

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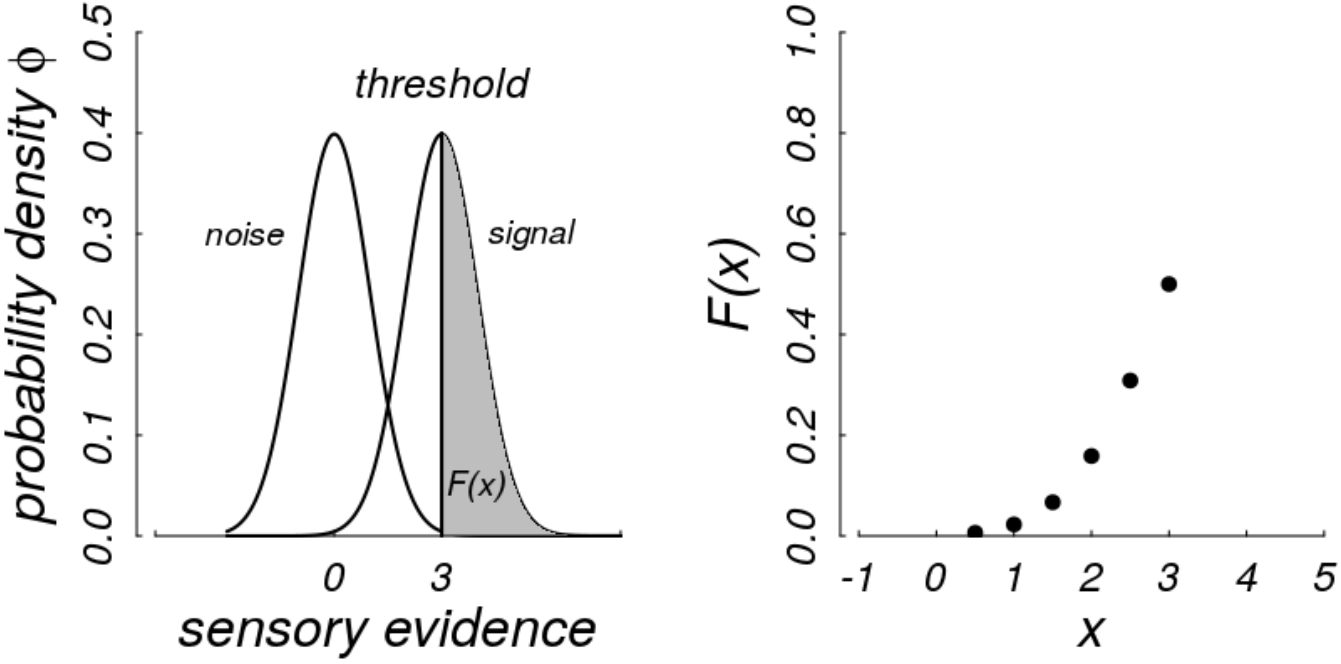

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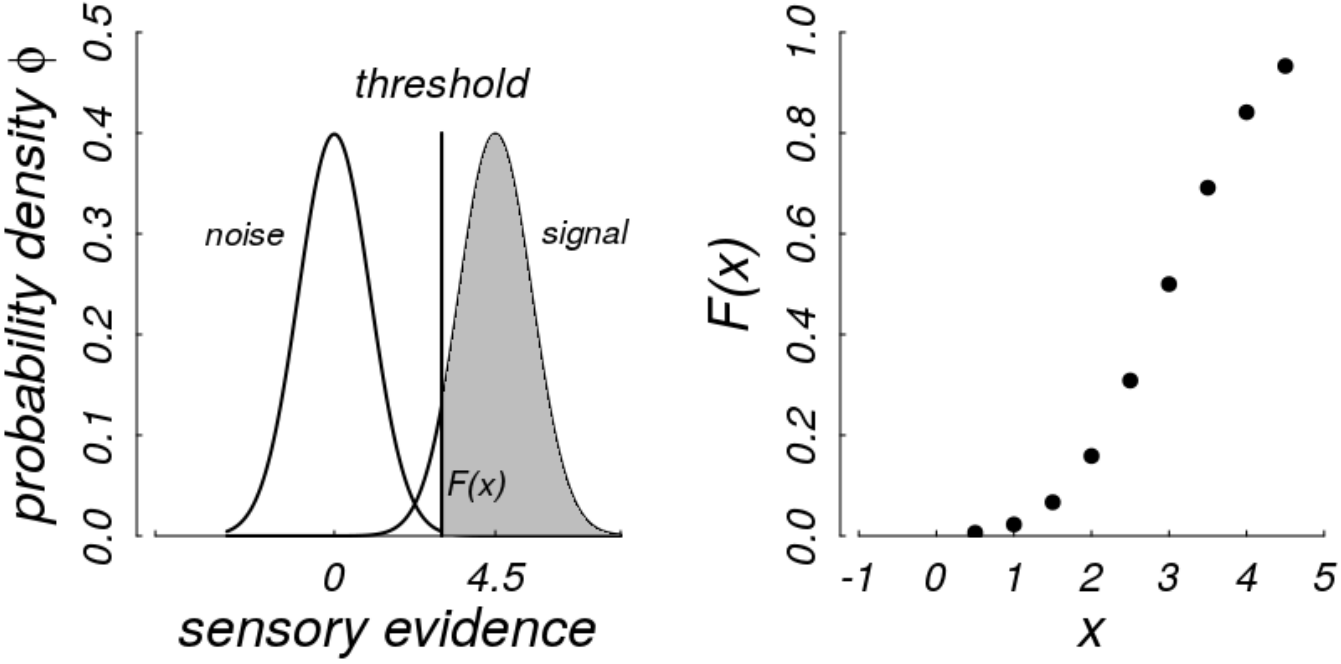

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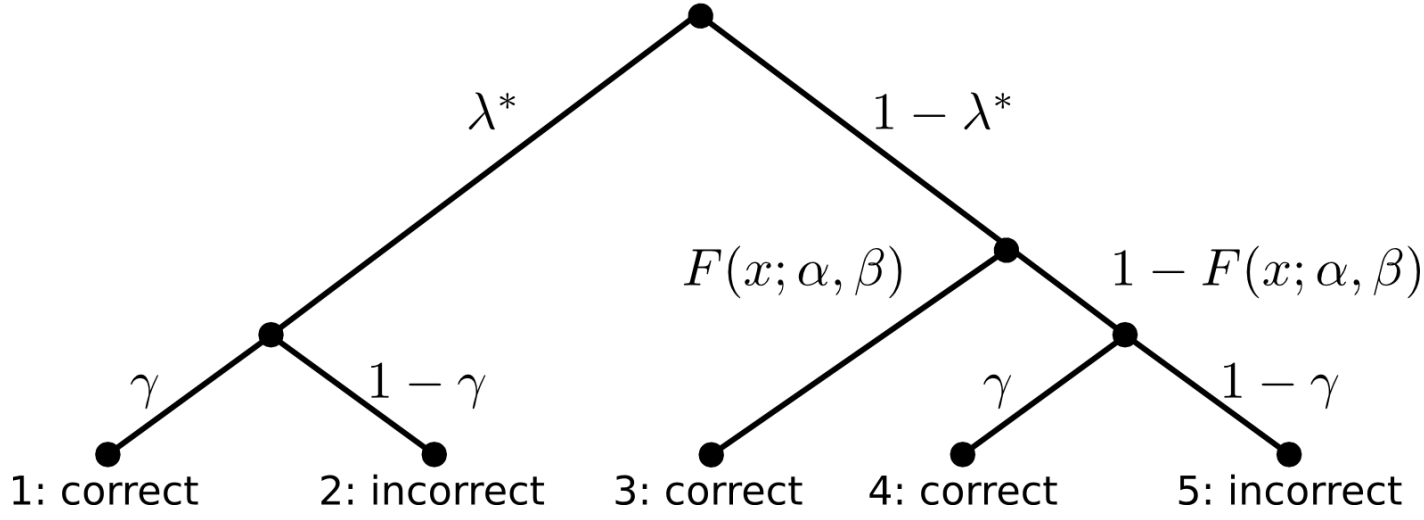
High threshold theory - decision process

$$\Psi(x;\alpha,\beta,\gamma,\lambda) = \gamma + (1-\gamma-\lambda^* + \gamma\cdot\lambda^*)\cdot F(x;\alpha,\beta)$$



- relation between observable behavior $\Psi(x)$ and unobservable decision mechanism $F(x)$
- λ : lapse rate, lapse = stimulus not witnessed, response error
- γ : guess rate

High threshold theory - relevance

- amount of sensory evidence accumulated is unavailable to the decision process
- probability that the threshold is exceeded when x=0, i.e. by noise is effectively zero, no false alarms

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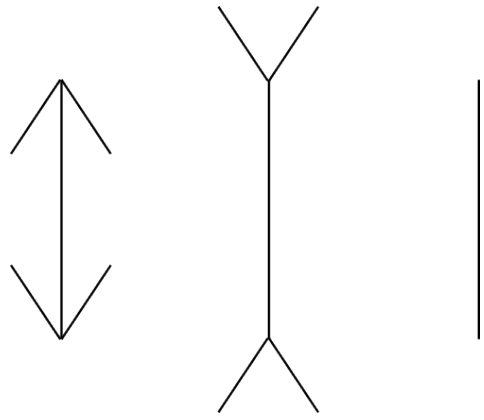
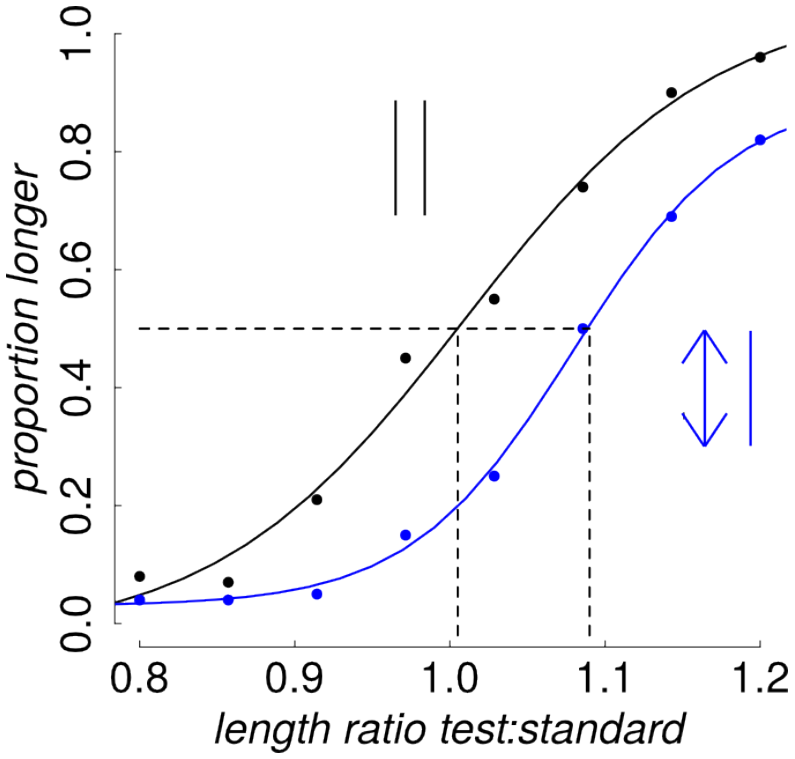
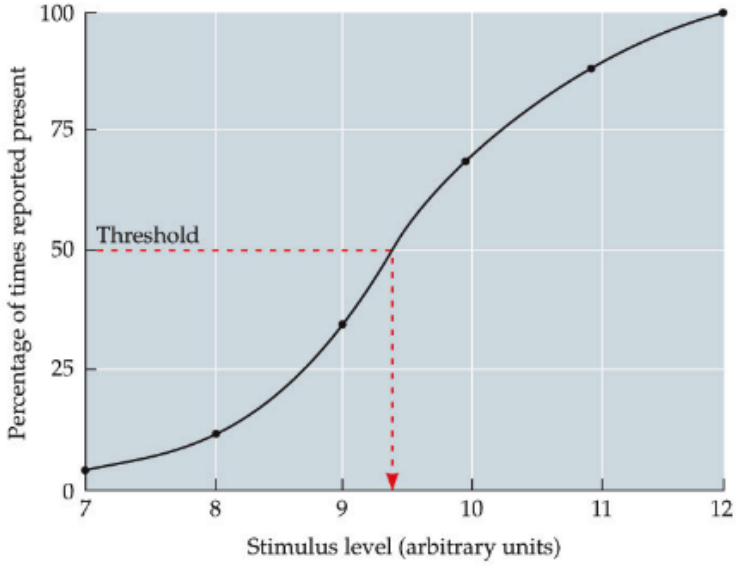
- above assumptions largely discredited
- psychometric function of the type $F(x; \alpha, \beta, \gamma, \lambda) = \gamma + (1 - \gamma - \lambda) * F(x; \alpha, \beta)$ in practical use
- **threshold** as the location parameter of the psychometric function characterizes performance

Measuring the magnitude of the Muller Lyer effect





Measuring a psychometric function



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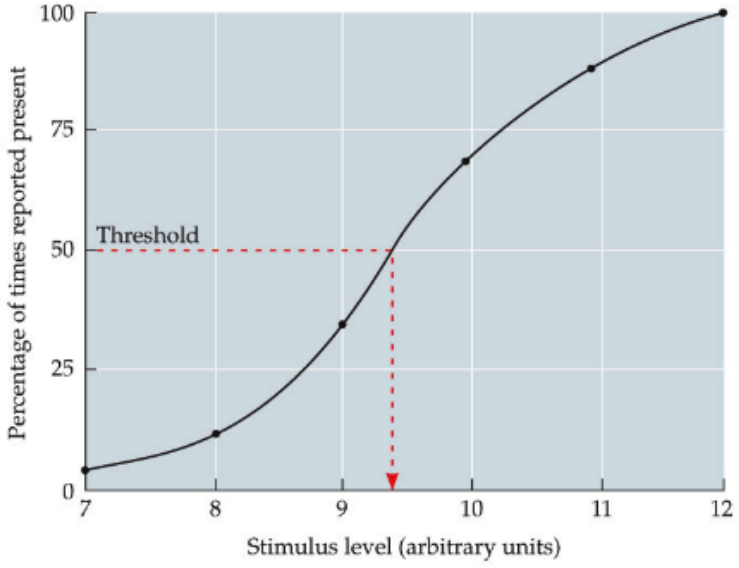

- at each stimulus level x, observer responds 'yes' with certain probability
- probability increases with increasing x
- $F(\alpha, \beta) = \frac{1}{1+exp(-\frac{x-\alpha}{\beta})}$
- $F^{-1} \rightarrow$ threshold

Summary

- psychophysics
- absolute vs difference threshold
- methods of threshold estimation
- classification of psychophysical tasks
- theory and praxis of psychometric function fitting

References

- Kingdom, F.A.A. & Prins, N. (2010). Psychophysics. A practical introduction. London, UK: Elsevier Academic Press.