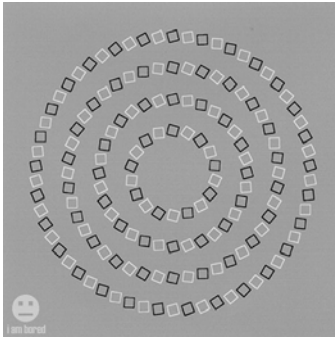


## Announcements

- This Thursday's reading is posted on Blackboard (Kim & Blake, 2005)
- First exam is on September 22nd (Thursday)
- Lecture files are on Blackboard



1

## Strategies for Studying Perception

- What do things look, sound, smell... like? (**phenomenology**)
- What are the limits of perception? (**Psychophysics**: thresholds, JND, PSEs)
- When does perception produce mistakes (study of illusions)
- Where and how perception occurs in the brain? (fMRI, EEG, TMS, neurophysiology)
- How brain damage affects perception? (neurology)
- How does perception vary among individuals and among species?

2

## Phenomenology



3

## Phenomenology

Moon looks larger when on the horizon

Viewing real motion subsequently produces experience of illusory motion

High frequency sounds are more difficult to localize

Food tastes bland when your nose is stopped up

Object size influences perceived weight

DEMO: reverse perspective



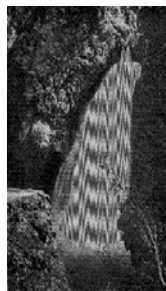
## Phenomenology Perception's Roots



Aristotle (384-322 BC)

The five senses:

- Sight
- Hearing
- Touch
- Taste
- Smell



First recorded account of a visual illusion (motion aftereffect)

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## Strategies for Studying Perception

- What do things look like? (**phenomenology**)
- **What are the limits of perception? (Psychophysics: thresholds, JND, PSEs)**
- When does perception produce mistakes (study of illusions)
- Where and how perception occurs in the brain? (fMRI, EEG, TMS)
- How brain damage affects perception? (neurology)
- How does perception vary among individuals and among species?

6

# Psychophysics



Psychophysics is

the **quantitative** branch of the study of perception, examining the **relations between** observed **stimuli** and **responses** and the **reasons** for those **relations**

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# Psycho-physics



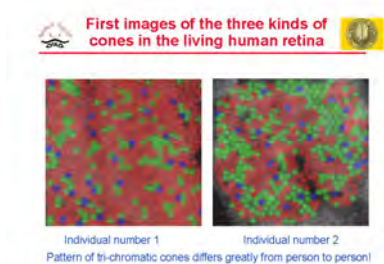
Psychophysics is

the **quantitative** branch of the study of perception, examining the **relations between** observed **stimuli** and **responses** and the **reasons** for those **relations**

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# ~~Psycho-physics~~

- Optical analysis of image forming system of the eye
- Use of adaptive optics to measure cone distribution
- Anatomical mapping of visual areas in the brain



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# Psycho-physics



Examples from vision

- ... quantify the influence of the **physical** intensity of a spot of light on its **detectability**,
- ... quantify the influence of **light's wavelength**, in nanometers, on the **perceived hue** evoked by the light.
- ... quantify the influence of **visual field location** on the **detectability of motion**

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## In psychophysical experiments...

- Human or non-human subjects are tested in an experimental environment that maximizes control of **stimulus** variations over variations in the **subject's** responses.
- Stimuli are carefully controlled, often varying along only a single physical dimension (e.g., intensity).
- Subject's responses are highly constrained (e.g., "Yes, I see the stimulus," or "No, I don't see it").
- Small numbers of subjects are tested with extensive within-subject designs. Individual differences are small in the normal population. (though there are exceptions to this)

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## Relationships to theory

- Interpretation of psychophysical data are often strongly influenced by **known anatomy and physiology of sensory systems**.
- Advances in psychophysics and in anatomy/physiology go hand in hand.
- Example: color vision's **psychophysical** trichromacy gave earliest evidence for idea that normal human color vision depended upon three and only three channels.

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A description of **psychophysics** (Baird and Noma, 1978):

**Psychophysics** is commonly defined as the **quantitative branch** of the study of perception, examining the **relations between observed stimuli and responses and the reasons for those relations**.

This is, however, a very narrow view of the influence it has had on much of psychology. Since its inception, psychophysics has been based on the assumption that the human perceptual system is a measuring instrument yielding results (experiences, judgments, responses) that may be systematically analyzed.

Because of its long history, its experimental methods, data analyses, and models of underlying perceptual and cognitive processes have reached a **high level of refinement**.

For this reason, many techniques originally developed in psychophysics have been used to unravel problems in **learning, memory, attitude measurement, and social psychology**.

On October 22:  
**Birth of psychophysics**



**Gustav Fechner** (1801-1887) conceived of "calibrating the mind" relative to physical stimuli:

The solution came suddenly on **October 22, 1850**. In bed, 'before getting up,' Fechner hit upon his "law of connection": changes in the bodily stimulus cause predictable changes in the mind.

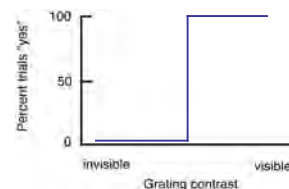
--R.I. Watson (1963, paraphrased)

On October 22: Happy Fechner Day!!!

**Psychophysical methods  
OUTLINE**

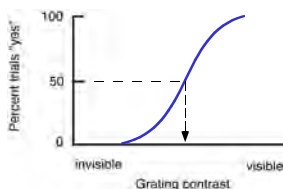
- **Psychometric and psychophysical function**
- Types of measurements
  - Absolute threshold
  - Difference threshold (JND) - (example)
  - Point of subjective equality (PSE)
    - Weber's law
- Methods for measuring thresholds and PSEs
  - Adjustment
  - Limits
  - Constant stimuli (example)
  - Staircase method (example)
- Signal detection theory

**Psychometric Function**

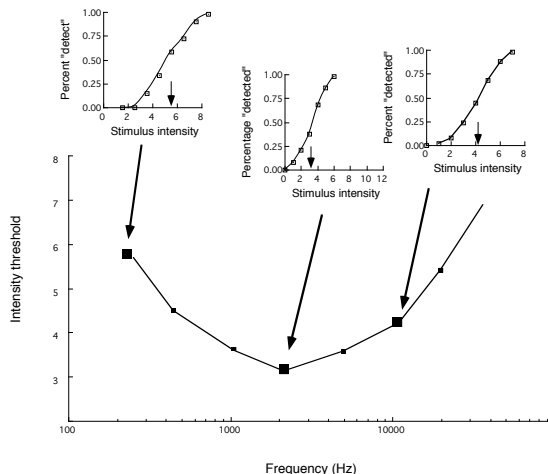


**Psychometric Function**

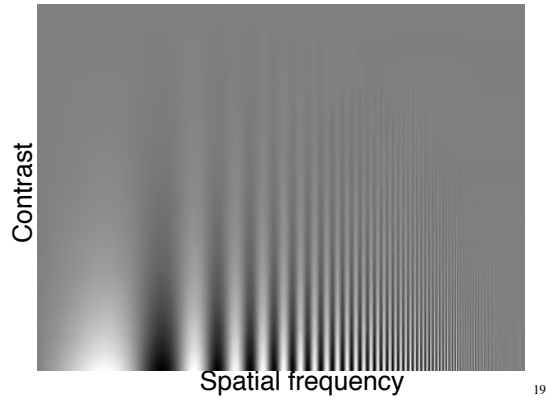
(almost always looks like a sigmoid)



**A psychophysical function from a set of psychometric functions**

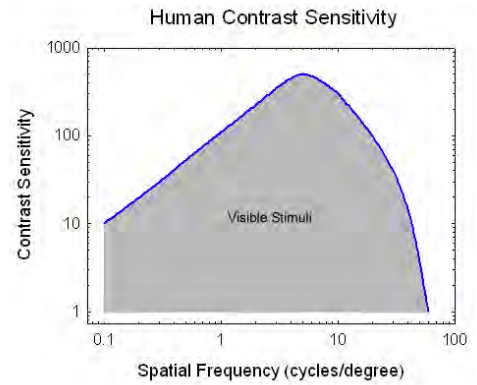


A **psychophysical** function from a set of **psychometric** functions



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A **psychophysical** function from a set of **psychometric** functions



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## Psychophysical methods OUTLINE

- Psychometric and psychophysical function
- **Types of measurements**
  - Absolute threshold
  - Difference threshold (JND) - (example)
  - Point of subjective equality (PSE)
    - Weber's law
- Methods for measuring thresholds and PSEs
  - Adjustment
  - Limits
  - Constant stimuli (example)
  - Staircase method (example)
- Signal detection theory

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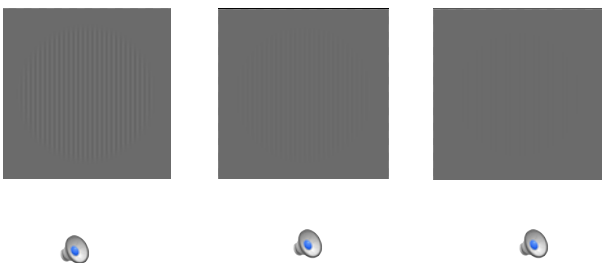
## Types of measurements

- **absolute threshold** - the lower limit of perception; weakest stimulus that can just barely be detected
- **difference threshold** - smallest reliably discriminable difference between two stimuli. Also called JND (*just noticeable difference*)
- **point of subjective equality (PSE)** - magnitude of one stimulus at which it is perceived as equivalent in magnitude to another

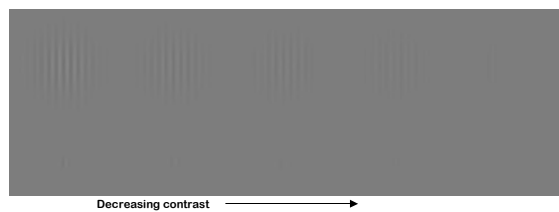
22

**absolute threshold** - the lower limit of perception; weakest stimulus that can just barely be detected

**absolute threshold** - the lower limit of perception; weakest stimulus that can just barely be detected



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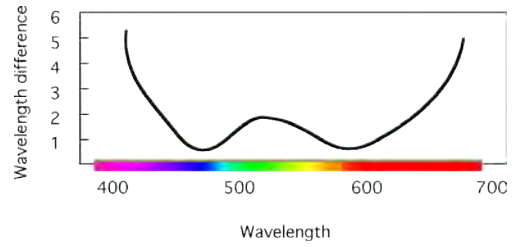
24

**difference threshold** (JND) - smallest, reliably discriminable difference between two stimuli



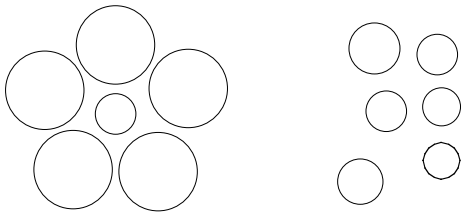
25

**difference threshold** (JND) - smallest, reliably discriminable difference between two stimuli



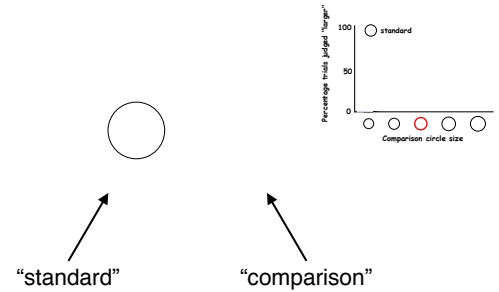
26

**point of subjective equality** - magnitude of one stimulus at which it is perceived to be equivalent in magnitude value to another stimulus



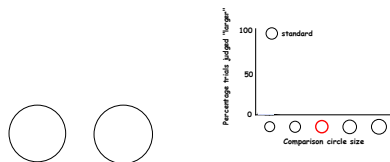
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**Psychometric Function:**  
Difference Threshold (JND)  
**EXAMPLE**



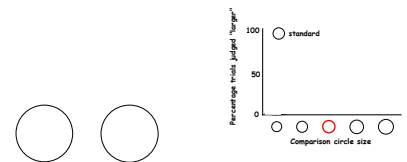
28

**Psychometric Function:**  
Difference Threshold (JND)  
**EXAMPLE**



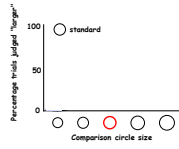
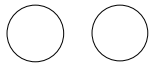
29

**Psychometric Function:**  
Difference Threshold (JND)  
**EXAMPLE**



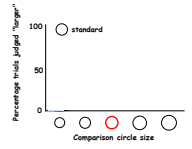
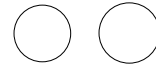
30

**Psychometric Function:  
Difference Threshold (JND)  
EXAMPLE**



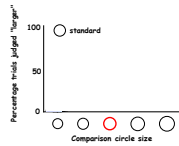
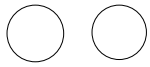
31

**Psychometric Function:  
Difference Threshold (JND)  
EXAMPLE**



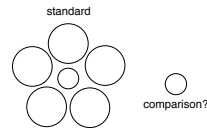
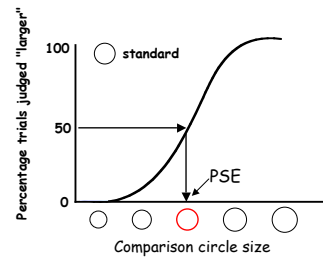
32

**Psychometric Function:  
Difference Threshold (JND)  
EXAMPLE**



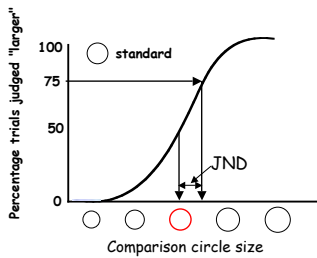
33

**Psychometric Function:  
Difference Threshold (JND)  
EXAMPLE**



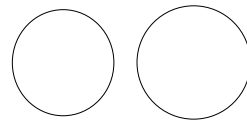
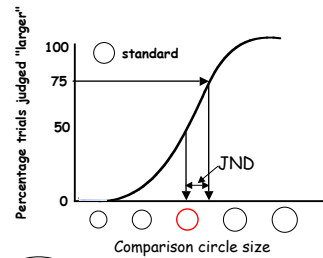
34

**Psychometric Function:  
Difference Threshold (JND)  
EXAMPLE**



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What happens to JND if we increase the size of the circle?

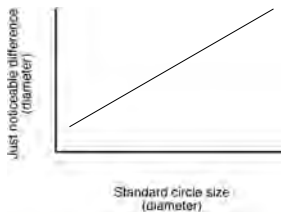


**The Weber Fraction:**  
JND divided by the magnitude of the standard

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## The Weber Fraction

(the JND divided by the magnitude of the standard)



**Weber's law:** Increases in intensity that are just noticeably different to an observer are constant fraction of stimulus intensity

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

The Weber fraction

**Weber's law:** Weber fraction is constant

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## The Weber Fraction

(the JND divided by the magnitude of the standard)

### Question:

- With a standard stimulus 1 kg, John's JND was 0.25kg. With a standard stimulus 10kg, what would be John's difference threshold?

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

The Weber fraction

**Weber's law:** Weber fraction is constant

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## Psychophysical methods OUTLINE

- Psychometric and psychophysical function
- Types of measurements
  - Absolute threshold
  - Difference threshold (JND) - (example)
  - Point of subjective equality (PSE)
  - Weber's law
- Methods for measuring thresholds and PSEs**
  - Tasks: Yes-No, 2AFC, 3AFC...
  - Procedures
    - Adjustment
    - Limits
    - Constant stimuli (example)
    - Staircase method (example)
- Signal detection theory

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## Techniques for Measuring Thresholds and PSEs: TASKS

### Tasks

- Yes/No task
- Forced choice tasks
  - X-AFC: 2AFC, 4AFC, etc.
    - "2-alternative forced choice", "4-alternative forced choice"



Preferential looking technique  
What is the task?

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## Techniques for Measuring Thresholds and PSEs: TASKS

Yes-No tasks	X AFC tasks
(NO option is absence of something; typically used in <b>detection</b> tasks)	(a choice between multiple, corresponding alternatives; used in <b>discrimination</b> tasks)
Subject to bias (corrected by SDT)	Bias free
When unsure, responses guided by personal biases	When unsure, subjects are <b>forced</b> to guess
-----	"pure" guessing performance determined by X in X AFC. E.g., for 2AFC = 50%, 4AFC = 25%
-----	the lower performance limit set by the guessing rate
Threshold usually set to 50%	Threshold usually set to ~halfway between the guessing rate and 100%. E.g., 75% for 2AFC

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## Techniques for Measuring Thresholds and PSEs: PROCEDURES

**method of adjustment** - **person adjusts** stimulus to value where it is barely detectable (absolute threshold) or adjusts one stimulus until it matches another (PSE) or differs from another (difference threshold)

**method of limits** - **experimenter changes** stimulus by small amounts to find point where person's judgment of stimulus first changes

**method of constant stimuli** - present stimuli at various "levels"; person responds (e.g., "yes" or "no") following each presentation, generating a **psychometric function**

**staircase method** : adaptive search for the threshold

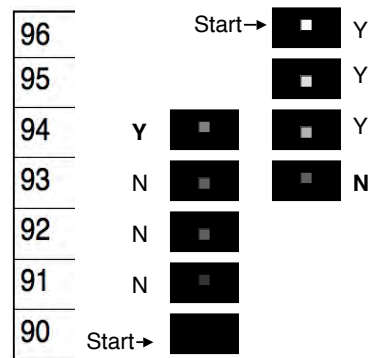
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## Methods of Adjustment and Limits

- Either subject or the experimenter manipulates the value of stimulus parameter of interest (e.g., brightness).
- Method of **adjustment**: the stimulus is adjusted by the subject
- Method of **limits**: the stimulus is manipulated by the experimenter (or a computer program)
- Lower/Raise until just barely detectable
  - Repeat # of times, average values to estimate threshold

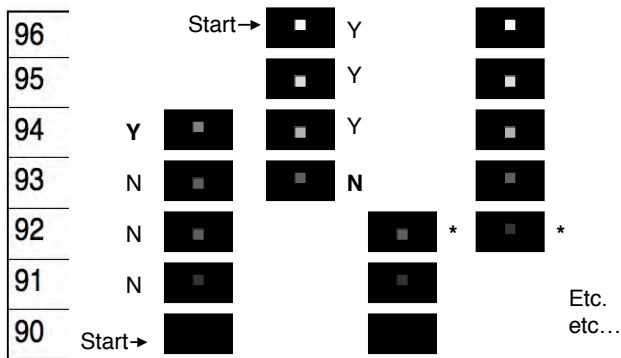
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## Method of Limits



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## Method of Limits



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## Method of Limits

Threshold = average of 'crossover' values

96		Y		Y
95		Y		Y
94	Y	Y		Y
93	N	N		Y
92	N		Y	N
91	N		N	
90	N		N	

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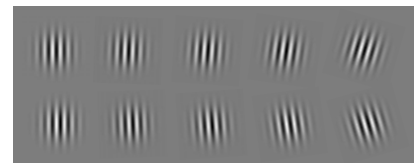
## Problems?

- “path dependence” (also called hysteresis)
  - Threshold value will differ dependent upon whether experimenter started with dim or bright light

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## Method of Constant Stimuli

- Create stimulus set
- Selecting a good range is important



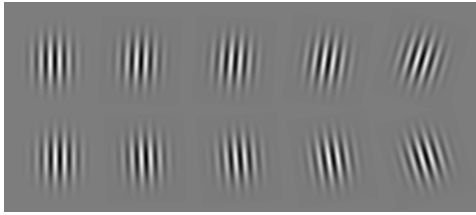
- Display stimuli in random order
- Repeat many times (minimum 40 per stimulus level)
- For each trial subject indicates his/her perception (here - left tilt or right tilt)
- Plot subjects' answers as response probability versus stimulus value
- Estimate **threshold** and/or **slope** (e.g., 75% correct)

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## Method of Constant Stimuli

Orientation discrimination demo

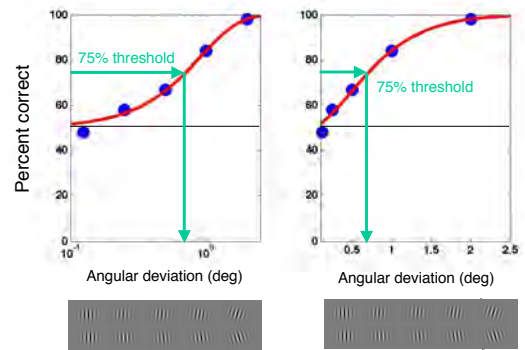
What kind of TASK this is?



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## Method of Constant Stimuli

Orientation discrimination demo



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## Staircase Method

• Subject's response (correct vs. incorrect) determines the subsequent stimulus value

- Correct response -> following trial = harder
- Incorrect response -> following trial = easier

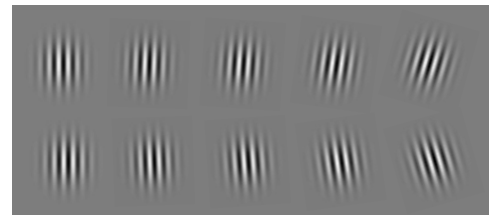
• Two types

- Fixed step size
- Adaptive step size

- Designed to **converge** to a certain threshold value
  - e.g., 75%

## Staircase Method

Orientation discrimination demo

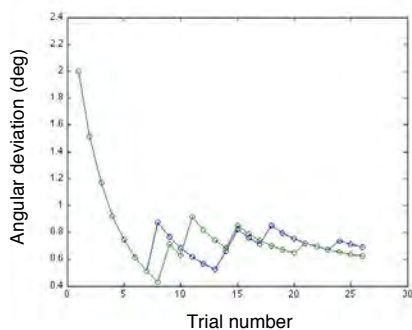


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## Staircase Method

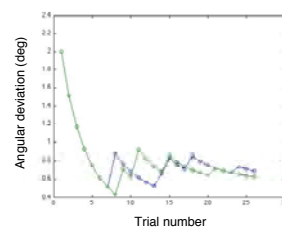
Orientation discrimination demo



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## Staircase Method

Orientation discrimination demo



Advanced Questions:

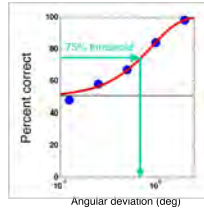
- which type of a staircase?
- compare step size for correct and incorrect trials - why the difference?
- what is the benefit of 2 interleaved staircases?

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## Staircase vs. Constant Stimuli?

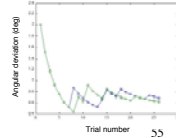
### • Constant stimuli

- PROS
  - "Gold standard" of psychophysics
  - Yields a complete psychometric function
- CONS
  - Takes many trials
  - Requires pre-selecting stimulus levels



### • Staircase methods

- PROS
  - The fastest method for estimating threshold
  - Does not require pre-selecting stimulus levels, just the starting point
  - Great for non-expert subjects, e.g., patients
- CONS
  - Does not yield a complete psychometric function
  - Focuses on estimating the threshold



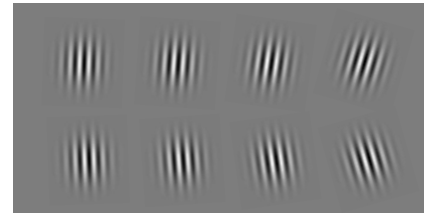
## Method of Constant Stimuli

Orientation discrimination demo

**YES - NO task**

**YES = presence of angular deviation**

**NO = absence of angular deviation**



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## Method of Constant Stimuli

Orientation discrimination demo

**YES - NO task**

**YES = presence of angular deviation**

**NO = absence of angular deviation**

### • Why even use YES-NO tasks?

- sometimes we are interested in subjects' decision biases
- Signal Detection Theory
  - allows us to separate one **bias** from actual **sensitivity**

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