Introduction

PSY 200

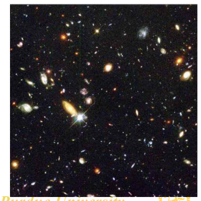
Greg Francis

Lecture 01

Four great mysteries.

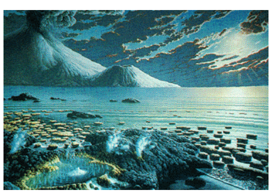
Four great mysteries

- Humans face four great mysteries about the universe
- 1) Why is there something instead of nothing?
  - This is the domain of physics
  - Most of us are not going to understand the ideas
  - Leptogenesis



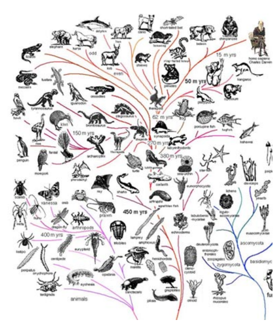
Four great mysteries

- Humans face four great mysteries about the universe
- 2) How did life form?
  - This question is addressed at the boundary between chemistry and biology



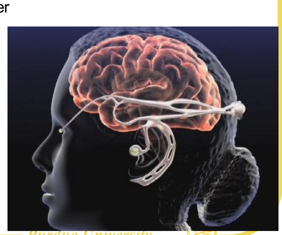
Four great mysteries

- Humans face four great mysteries about the universe
- 3) Why is there so much diversity of life?
  - This is the domain of biology
  - Evolution and natural selection answer this question



Four great mysteries

- Humans face four great mysteries about the universe
- 4) What is the basis of human intelligence and consciousness?
  - Cognitive psychology and neuroscience
  - Far from a complete answer
  - Lots of issues to discuss



Topics

- Discuss a sample of issues in cognitive psychology / cognitive neuroscience
- Try to relate cognitive psychology to stories you may have heard in the popular press
- Identify how the topics can help you to be a better person

Topics

- For example
  - *What's the deal with left and right brains?*
  - *Why does everyone love Prozac?*
  - *Why telephone operators seem rude.*
  - *Why there is a gate at the first floor stairway in the Psychology building.*
  - *What to do if you are drunk while studying for an exam.*
  - *What is the plural of* walkman*?*

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Textbook

- There is no textbook
- Lecture notes are used instead
- If you want a book, borrow from a past class
- There are optional readings in the syllabus
  - Not for every subject

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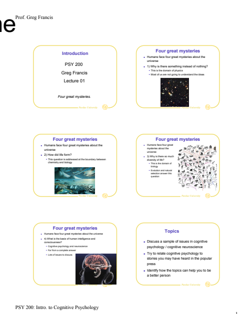
Lecture notes

- Downloadable from the class web page
  - Adobe Acrobat (pdf) format
  - Reduced form (6 to a page)


Prof. Greg Francis
Introduction
PSY 200
Greg Francis
Lecture 01
Four great mysteries
Four great mysteries
Four great mysteries
Four great mysteries
Topics
PSY 200: Intro. to Cognitive Psychology

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Lectures

- I will record the lecture and post the recording on the class website (details to be determined)
- Should a lecture be canceled, I will post a recording from a previous semester
- I encourage questions during lectures

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Attendence

- Class attendance is **mandatory**
- At the start of class pick up a bubble sheet and enter your information
  - Provide an answer (any option) for item 1
  - The bubble sheets are only available for the first 10 minutes of the class period
- At the end of class drop off the bubble sheet at the front or back of the room
- Attendance counts as 10% of your class grade
- Everyone gets 6 misses before it impacts your grade

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Course web page

- Syllabus on the web
- http://www.psych.purdue.edu/~gfrancis/Classes/PSY200/indexF23.html
  - updates to the syllabus
  - Links to lecture recordings
  - Links to labs
  - Links to writing assignments
  - Study guides for the exams
  - Links to optional readings
  - Grades will be posted after the first exam
- The course does not use BrightSpace

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Course outline

- Neuroscience -- EXAM 1 (15%)
- Perception, Attention & Memory – EXAM 2 (15%)
- Memory & Mental representation -- Exam 3 (15%)
- Language -- Exam 4 (15%)
- Reasoning
- *Cumulative* Final (15%)

Exams

- In class
- 25 multiple choice questions, 5 short-answer questions
- Detailed study guides are already on the class web site

Practice Exams

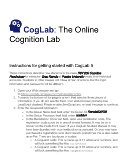
- From Spring 2016
- Available on the class website

CogLab

- Homework
- You participate in classic experiments
- Total lab grade contributes to 15% of your class grade.
- Grade is based solely on *completing* the experiment on time, not on the quality of the data

CogLab

- Labs are listed on the syllabus
- They must be completed by **1:00 pm** at the date indicated in the syllabus
  - else you get no credit
  - Better to do it the night before
- Since I wrote CogLab, you get access to the experiments for free
  - (a $50 value!)
- See handout for instructions on getting started (sent by email)
- Registration code is near the bottom of page 2
- *First lab is due at 1:00 pm on Wednesday!* (*all times Eastern US*)



Grading

- Straight scale
  - 98% -100% A+
  - 93% - 97% A
  - 90% - 92% A-
  - 88% - 89% B+
  - 83% - 87% B
  - 80% - 82% B-
  - 78% - 79% C+
  - 73% - 77% C
  - 70% - 72% C-
  - 68% - 69% D+
  - 63% - 67% D
  - 60% - 62% D-
  - 0% - 59% F
- No rounding up: 82.99 is a B-

No extra credit

Grading

- Previous semester's grades (Spring 2020)

	E1	E2	E3	E4	Final	CogLab	Writing	Attendance	Total
Average	77	71	72	83	72	83	64	92	75
Max	100	100	100	100	98				

- Last semester's grades (Fall 2020)

	E1	E2	E3	E4	Final	CogLab	Writing	Total
Average	78	76	75	86	81	85	85	80
Max	96	100	96	100	99			

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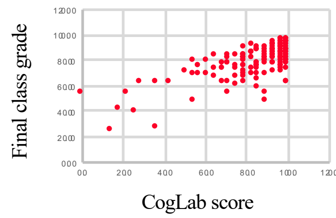
Grading

- Last semester's grades (Fall 2020)



	Frequency
A	32
B	65
C	40
D	18
F	11

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Instructor office hours

- During scheduled class lecture time
- Monday, Wednesday, Friday, 2:00 – 3:00 pm
  - Or by appointment
  - PSYCH 3186
  - Email: gfrancis@purdue.edu

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Teaching assistants

- Corey Nack
- Grade exams
- Keep track of grades
- Have office hours (PSYCH 3192)
  - Tuesday, Thursday 10:00 am – 12:15 pm

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Attitude/Advice

- Print out the lectures and bring them to class. Take notes during class. Not everything is on the slides.
- Everything we talk about in class is important
- Get the "free" attendance points by attending every lecture
- Stay on top of the CogLab assignments, sometimes more than one lab is due for a given day
- Don't wait till the last minute to do an assignment
- Work on the study guide every week, so the ideas/answers from lecture are fresh in your mind.
- This class is an introductory class, but that does not mean it is easy
  - It's like *Introduction to Physics* or *Introduction to Chemistry*
  - Almost every other subtopic in psychology depends on the ideas in cognitive psychology
  - Everything is at least 10,000 times more complicated than what we discuss
- If you don't find a topic interesting, just wait a week

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Next time

- Cognitive neuroscience
- The brain
- The modularity hypothesis
- CogLab on Brain asymmetry due!
- *What's the deal with left and right brains?*

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Brain parts

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Lecture 02

What's the deal with left and right brains?

1

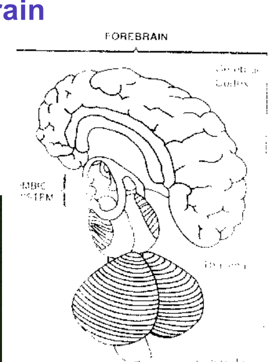
The brain

- *The* source of cognition (consider transplant!)
- Weighs about 3 pounds
- Damage to some parts result in immediate death or disability
- Damage to other parts seems to have no effect!
- What brain parts are important to cognition?
- How do we discover the role of each brain part?

2

The brain

- Fore-brain
  - cortex
- Hind-brain
  - brain stem)



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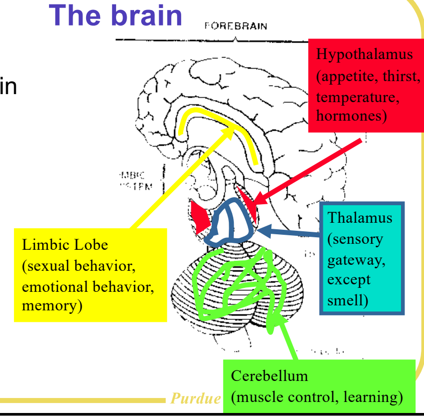
The brain

- Hind-brain
  - (brain stem)



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Fore-brain

- Cortex
- Similar to a thick, crumpled newspaper page
- Grooves (fissures or sulci) separate regions

5

Fore-brain

- Cortex
- Similar to a thick, crumpled newspaper page
- Grooves (fissures or sulci) separate regions

6

Fore-brain

- Cortex
- Similar to a thick, crumpled newspaper page
- Grooves (fissures or sulci) separate regions

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7

Fore-brain

- Cortex
- Similar to a thick, crumpled newspaper page
- Grooves (fissures or sulci) separate regions

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8

Contralateral processing

- Processing in the brain is done on the opposite side of your organs
- Control of your *right* arm is from the *left* side of your brain
- Information from your *left* field of view goes to the *right* side of your brain

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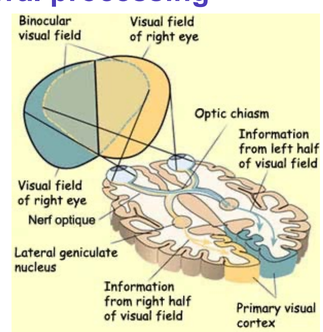
Contralateral processing

- Neural fibers from the eye cross on way to cortex



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Contralateral processing

- Brain hemispheres are connected by a mass of neural fibers called the *corpus callosum*

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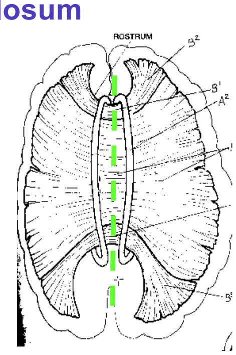
Cut corpus callosum

- Behavior changes very little
- Subtle effects



http://www.youtube.com/watch?v=ZMLzP1VCANo

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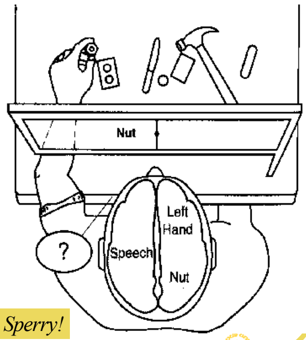
Brain sides

- If "nut" flashes on left screen
  - subject cannot name it
  - subject can pick up nut with left hand
- If "nut" flashes on right side
  - subject can name it
  - subject cannot pick up nut with left hand until he says "nut" out loud



1981 Nobel Prize for Roger Sperry!

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Brain sides

- Results led to further study and common belief that
  - Left side: language, analytical, classification, Western rationalization
  - Right side: art, music, recognition of faces and shapes, Eastern mysticism
- *Vast* oversimplification
  - in a normal brain, both sides are involved in many tasks
- Results *do* support the idea that different parts of the brain are involved in different cognitive tasks (*modularity hypothesis*)

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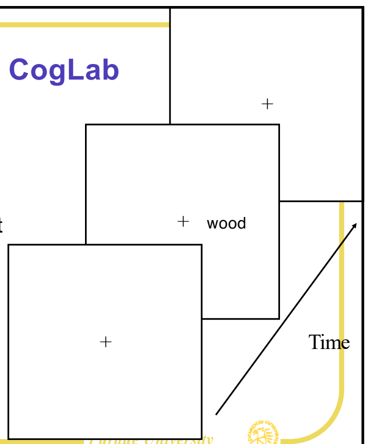
CogLab

- In the CogLab experiment *Brain asymmetry*
- You stared at a central fixation point
- A word was presented to either the left or right side of fixation



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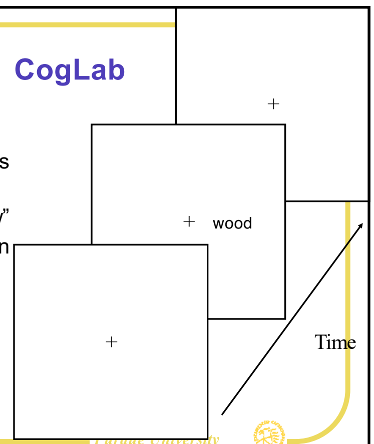
CogLab

- Your task was to judge whether the presented word was "old" (seen on an earlier trial) or "new" (not previously seen in this experiment)



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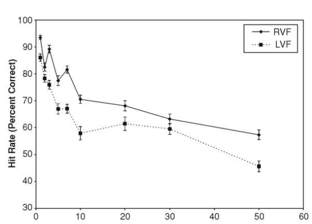
CogLab

- Federmeier & Benjamin (2005) found better memory performance for words presented in the right visual field
- Words in the right visual field go to the left hemisphere
  - Which is known to be specialized for language



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CogLab

- Other explanations than hemispheric specialization
  - Reading goes from left to right, from fixation to right visual field
  - Perceptual advantage to right visual field?
  - Attentional advantage to right visual field?
- It is difficult to come up with an experiment that isolates hemispheric specialization

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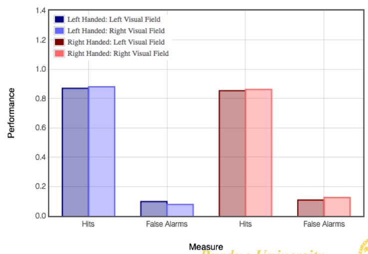
CogLab Data

- Class (108 right-handed participants; 16 left-handed participants)
  - Very tiny effect for right handers (probably just noise)
  - Tiny effect for left handers (not expected)



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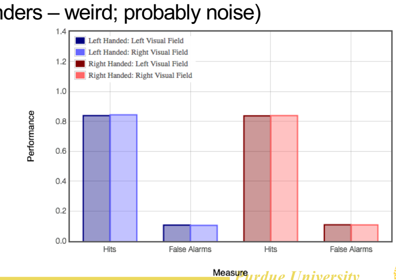
CogLab Data

- Global (52,158 right-handed participants; 5635 left-handed participants)
- Very tiny effect (but bigger for left-handers than right handers – weird; probably noise)



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Anatomy

- The cortex contains large fissures that separate five major areas
  - Limbic (already discussed)
  - Occipital
  - Parietal
  - Temporal
  - Frontal
- Each has distinct properties

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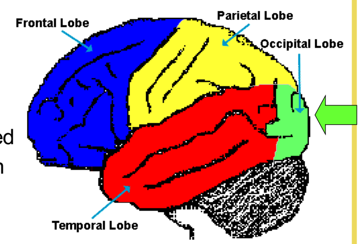
Occipital lobe

- Receives information from the eye
  - Most investigated area of the brain



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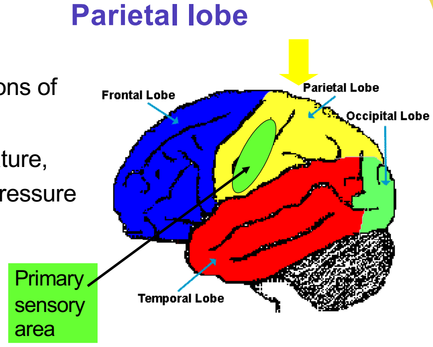
Parietal lobe

- Sensations of pain, temperature, touch, pressure



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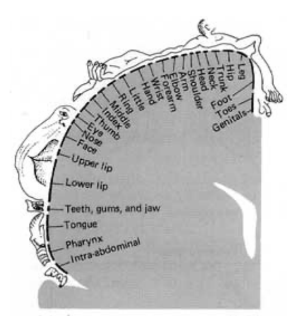
Parietal lobe

- Primary sensory area
  - sensitivity involves disproportionate areas of the brain, relative to size of body part



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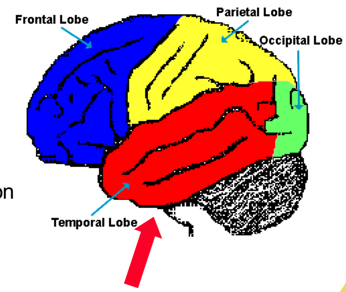
Temporal lobe

- Hearing
  - speech (left)
  - music (right)
- Memory and attention
  - visual recognition



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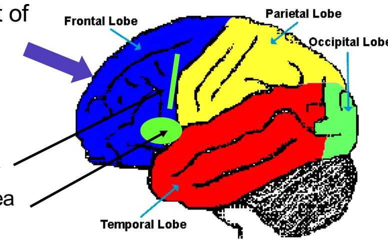
Frontal lobe

- Largest part of cortex
  - planning
  - prediction
  - motor area
  - speech area



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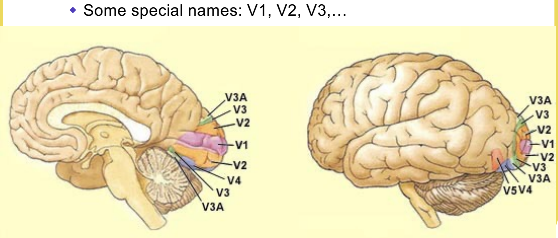
Broadman areas

- Divide lobes into areas
- e.g. Broadman
  - Area 1, Area 12, … Area 200
  - Some special names: V1, V2, V3,…



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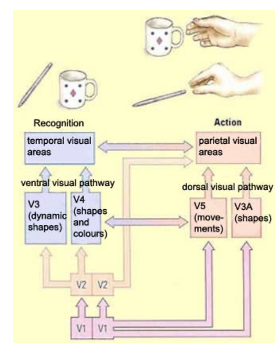
Area function

- Can partly identify function by looking at nerves coming in and out of area
- Pathways through areas seem to be involved in different kinds of cognitive tasks



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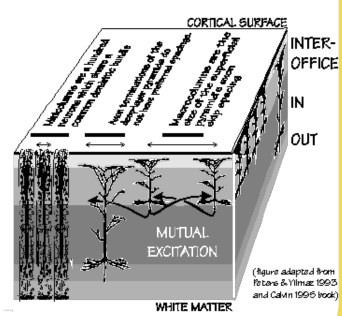
Brain layers

- There is order and function even within an area
- The cortex is a *sheet* of neurons
- In its thickness are 6 layers of neurons
  - numbered 1-6
  - sometimes include subdivisions (4a, 4b, 4cα, 4cβ, …)



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Conclusions

- Lots of research in this area
- New brain regions are being mapped out daily with ever increasing resolution
- Cognitive neuroscience relies strongly on the "modularity hypothesis"
- Putting everything together is very difficult

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Next time

- Brain scans
- EEG recordings
- MRI scans
- Functional MRI

- *How to study the brain without killing someone.*

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Brain scans

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Lecture 03

How to study the brain without killing someone.

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1

Scanning

- Technology provides insight into brain processes
  - EEG recordings
  - MRI
  - Functional MRI
- Non-invasive
- Maps of brain activity
- The goal is to *relate* brain events to cognitive events

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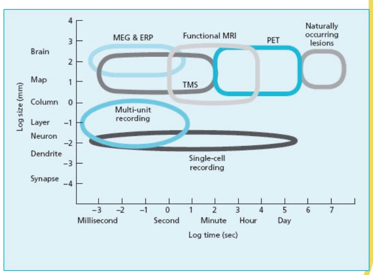
2

Resolution

- For almost every technique we have to worry about its ability to discriminate differences in
  - Space: which **place** is active?
  - Time: **when** does something happen?
- Finer resolution is usually better
  - But can be difficult to deal with so much data



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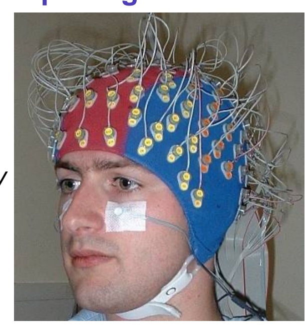
Electroencephalogram

- EEG
- The brain produces *electrical activity*
- Put electrodes on the head



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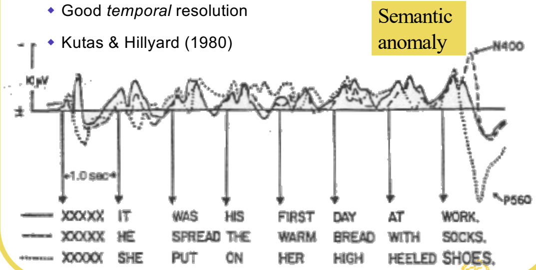
EEG

- Watch the electrical current change through time while reading sentences (averaged across many trials)
  - Good *temporal* resolution
  - Kutas & Hillyard (1980)

Semantic anomaly



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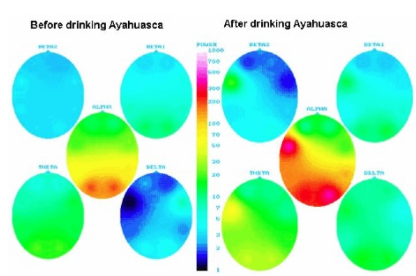
Brain maps

- You can analyze the EEG signals in many different ways
- Compare the signal strength for different situations
- Ayahuasca is a Brazilian psychoactive tea



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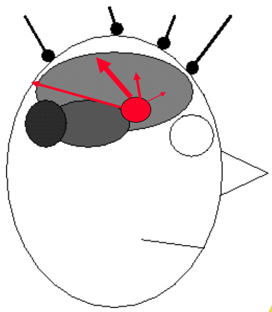
Spatial resolution

- Poor spatial resolution
- You never really know which part of the brain is making the current
  - Lots of work to improve



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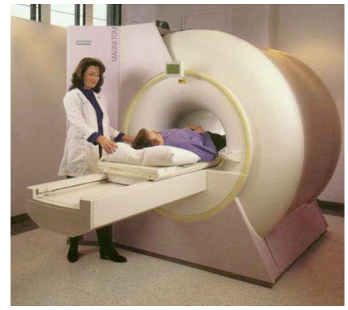
Magnetic Resonance Imaging

- Magnetic field forces protons in your body to line up
  - pulses of radio into field bounces protons around
  - as they return to normal position, they emit a signal that can be decoded into a map



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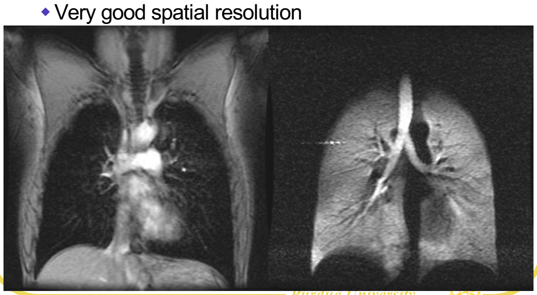
Magnetic Resonance Imaging

- MRI Scans: Like an x-ray machine, but can look at soft tissue (like lungs, heart,..)
  - Very good spatial resolution



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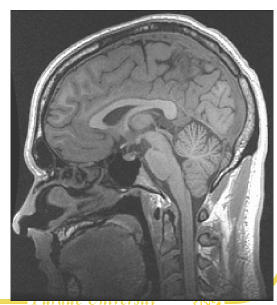
Magnetic Resonance Imaging

- MRI Scans: Like an x-ray machine, but can look at soft tissue (like ankles, my brain,..)
  - Very good spatial resolution
  - millimeters



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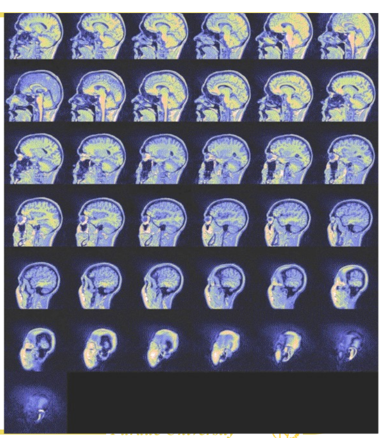
MRI Scans

- MRI provides a “slice” at a time
- Take multiple slices to build up full image

Nobel prize winning work!



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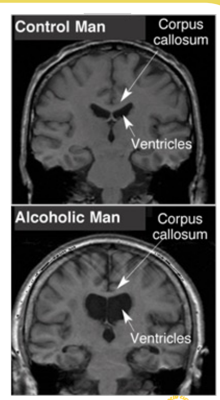
MRI Scans

- Can identify **anatomical** differences between brains
- Alcoholic has larger ventricles and thinner corpus callosum
- Note, comparing across brains is a bit tricky!
  - Everyone’s brain is a bit different



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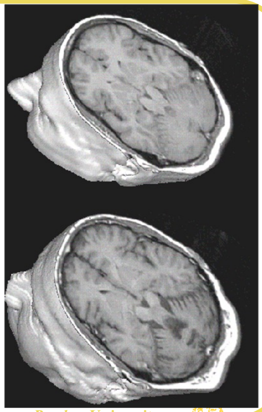
MRI Scans

- 3-D maps
- Normal
- Ataxia:
  - loss of motor control



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MRI Scans

- Non-invasive, no side effects
- Allows early detection of brain disease, tumors,…
- Fantastic spatial resolution
- But…
  - it only shows *structure*
  - no way to know what a brain area *does*

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Functional MRI

- Just like MRI, but with a new analysis
  - MRI differentiates between different *types* of tissue (cell types)
  - Functional MRI differentiates between *active* and *inactive* neurons: concentration of oxygen
  - The measurement is called the "blood oxygen level dependent" (BOLD)
    - » It roughly tracks the flow of blood in the brain
    - » More active neurons recruit more blood

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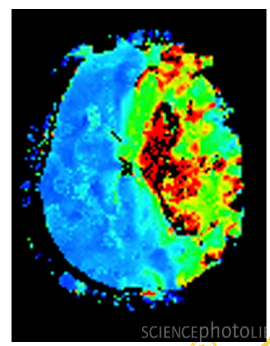
Functional MRI

- Color maps show strongest "responses"
- E.g., fMRI scan of a woman after a stroke
  - Blue/green: normal blood flow
  - Red/black: abnormal blood flow



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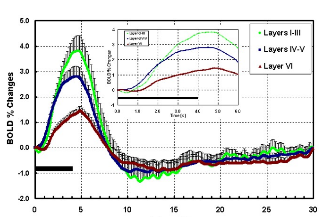
Functional MRI

- Very good *spatial* resolution
  - millimeters
- Pretty good *temporal* resolution
  - Seconds
  - (Silva, 2002)



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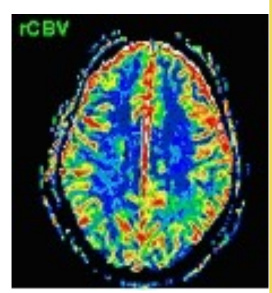
Scanning

- Consider this fMRI scan
- It shows regional cerebral blood volume (rCBV)
- You cannot tell how/if different regions are involved in different activities
  - Breathing
  - Digestion
  - Thinking about exams
  - …..



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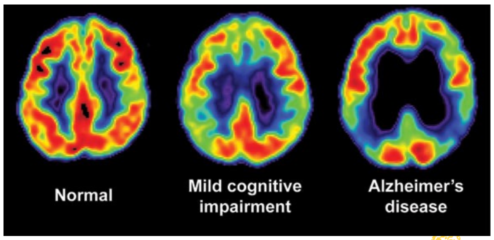
Differences

- We have to look for *differences* in activity
- Alzheimer's patients have reduced brain activity



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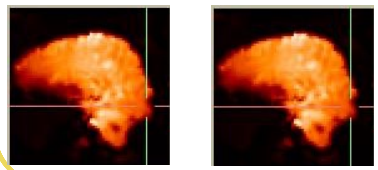
A simple experiment

- Suppose you run an fMRI experiment where a person alternates between seeing a blank screen and a face
- You take multiple fMRI scans with half recording brain activity during the blank and half recording brain activity during the face
- Add them up pixel by pixel for each condition

Viewing blank Viewing face



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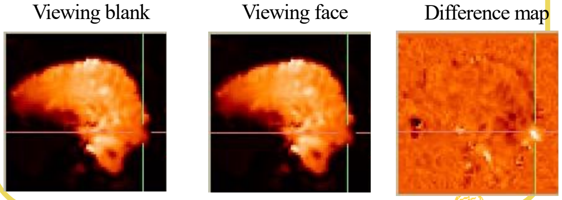
Subtraction method

- Subtract the fMRI signals produced by one condition from the fMRI signals produced by another condition
- The *difference map* indicates those brain regions that are involved in the different cognitive tasks
- It requires a sophisticated statistical analysis to avoid false positives!

Viewing blank Viewing face Difference map



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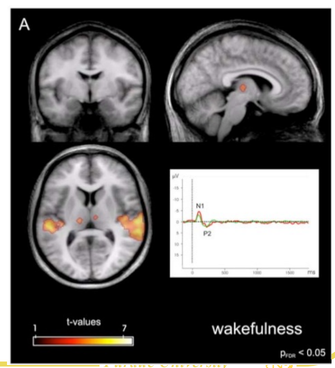
Reporting

- What is usually reported is just the *difference map*
- Colors mark places in the brain that are *statistically different* between conditions
- Czisch et al. (2009) for rare tones vs. frequent tones
- The map would be different if it compared rare tones versus speech



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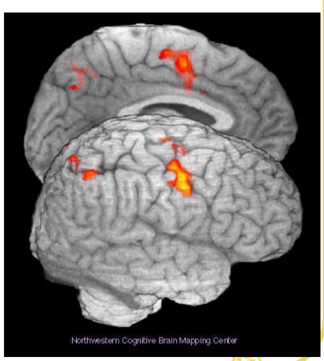
Functional MRI

- Color maps show strongest "responses"
- e.g., during a task that requires covert spatial attention compared to one that does not require attention



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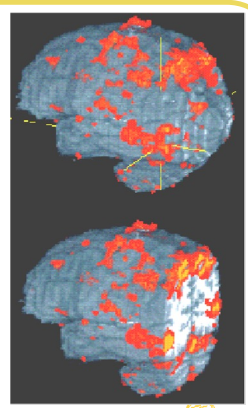
Functional MRI

- When moving a pointer to a target box compared to no movement
  - "activity" in areas involved in vision, planning, and motor control



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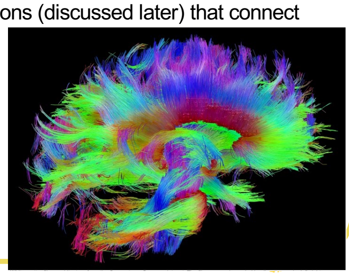
Connectome

- You can use similar technology (diffusion spectral imaging) to focus on particular types of cellular material
  - E.g., identify axons (discussed later) that connect brain cells
- Gives an anatomical map of how information can travel



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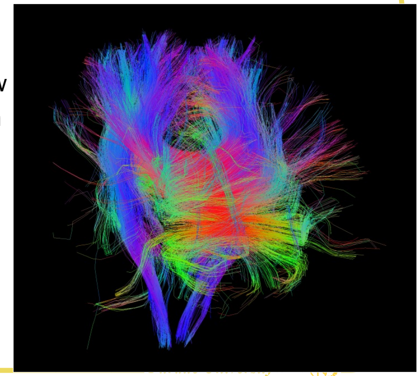
Connectome

- Gives an anatomical map of how information can travel



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Limitations

- Brain scans do not really tell us how the brain works
  - the scans just tell us approximately *where* in the brain something occurs
  - sometimes it can tell approximately *when*
- Even trying to find *the* place may be problematic
  - Lots of cognitive abilities involve many different areas of the brain
- Most *theories* of cognition are derived from experimental psychology
  - Brain studies explore how to implement the theories

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Common misconception

- Brain scans *demonstrate* a physiological basis to things that were thought to be emotionally or cognitively based
  - e.g., MRI scans of stutters
  - in fact, *all* behavioral traits are physiologically based

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Conclusions

- Lots of research in this area
- Technology is improving in many ways
- There are many other types of scanning technologies
  - Computerized Axial Tomography (CAT)
  - Diffusion tensor imaging (DTI)
  - Single Photon Emission Computed Tomography (SPECT)
  - Near Infrared Spectroscopic Imaging (NIRSI)
  - Magnetoencephalography (MEG)
  - Positron Emission Tomography (PET)

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Next time

- How do we use brain scans to study cognition?
- How good are the scans?
- What is really being measured?
- *How to read someone's mind.*

30

Brain scans

PSY 200

Greg Francis

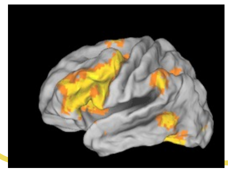
Lecture 04

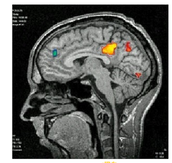
How to read someone's mind.

1

Scanning

- Brain scanning techniques like fMRI provide spatial and temporal patterns of activity across the brain
- We want to analyze those patterns to discover how the brain works





2

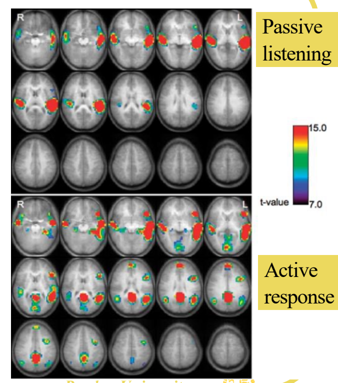
fMRI

- Passive listening vs. active listening
  - Vannest et al. (2009)
- Twenty children (ages 11-13) complete three tasks
  - Passive listening: hear a female speaker tell a 30-second story
  - Active response: hear the same speaker tell a story in 5 second segments of two sentences. Scanning occurred after the sentences (silence). Answer questions
  - Random tones: no task, just listen

3

fMRI

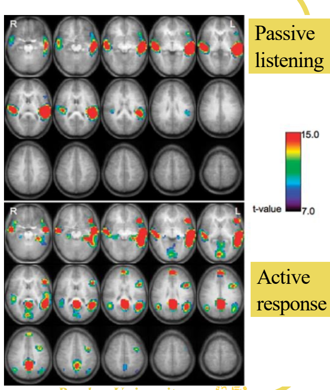
- The colors show the *difference maps* relative to listening to the tones
- Common activity (breathing, digestion, hearing machine noise,…) is subtracted out
- The colors are **not** brain activity!



4

fMRI

- More signals and different patterns for active listening compared to passive listening
- (Could it be otherwise?)



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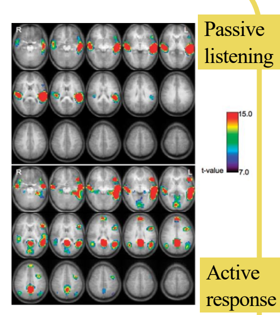
fMRI

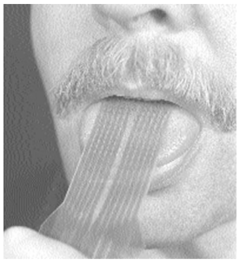
- Does more signal for the active response mean active response listening is "better" than passive listening?
- Tested children on comprehension of stories
  - PL: 75.1% correct, SD=12.7
  - AR: 79.1% correct, SD=9.1
- No real difference in comprehension



6

Sensory substitution

- Some scientists look for replacements to lost perception
- For example, there is a tongue display unit that attempts to present spatial information for blind people



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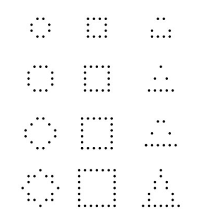
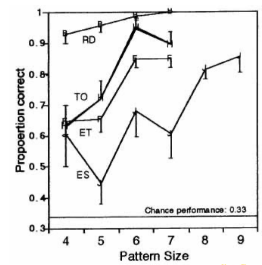
Sensory substitution

- People can use a TDU to discriminate shapes
  - Kaczmarek, Bach-y-Rita & Tyler (1998)
  - Link to video on class web page

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Sensory substitution

- So what happens in the brain?
- Are there responses from areas typically involved in shape perception? Or in areas related to touch on the tongue? (or both or neither?)

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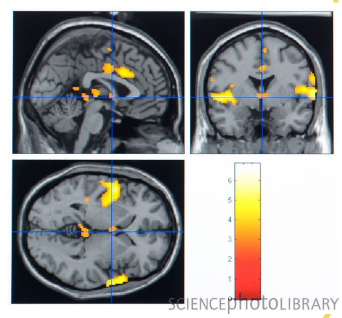
Sensory substitution

- fMRI differences suggest that using the TDU involves areas of motor cortex
- Not areas that are traditionally for visual perception
- This is the kind of question that can best be answered with brain scan technology



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Walking

- There is no portable MRI machine
- But scientists are creative about how to use it to study a wide variety of activities
- Volta et al. (2015) studied walking by having participants "walk" on a cylinder outside the MRI machine

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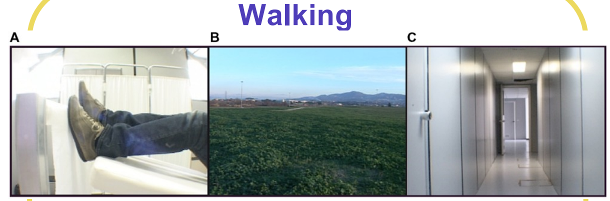
Walking



- Can compare walking "indoors" versus "outdoors"
- Execution (actually "walk") versus observation (not "walk")
- Complicated controls
  - Press feet against cylinder
  - Still (non-moving) image
  - Gray image (no picture)

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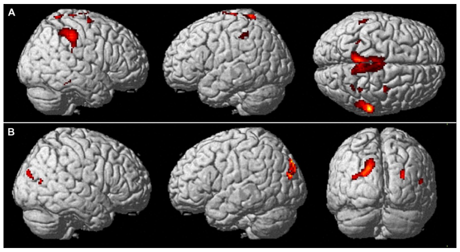
Walking



- Top: Executing or observing walking versus gray image
  - Interesting that they involve some similar brain regions
- Bottom: Hallway walking versus open field walking

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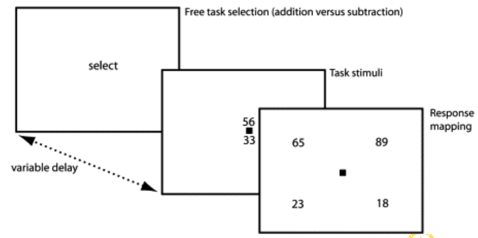
Reading minds

- Long-term, the goal of fMRI research is to be able to analyze a brain scan and identify what a person is thinking
- There are several attempts to do this (Haynes et al., 2006)
  - Adding or subtracting numbers



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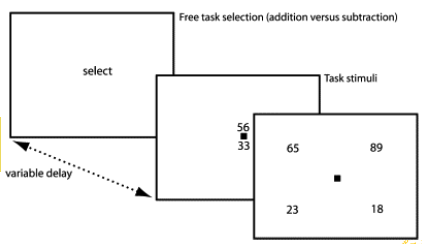
Reading minds

- Based on the choice at the end, we can deduce whether the subject chose addition or subtraction for that trial
- Make an fMRI scan during the selection process
  - Whether to add or subtract numbers

Scan now



Or scan now

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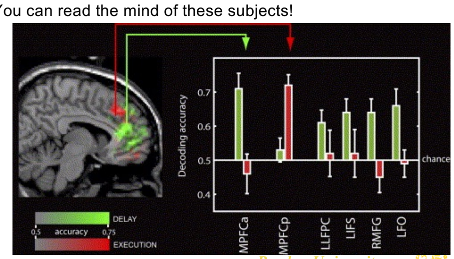
Mind reading

- It is possible to build a recognition system that distinguishes (with 71% accuracy) the brain patterns for addition and subtraction
  - Depends on the place in the brain
  - Different places for intention and execution
- You can read the mind of these subjects!



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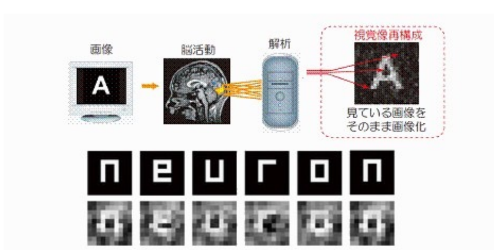
Thought reconstruction

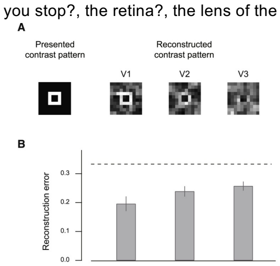
- Another research group analyzed fMRI responses to *reproduce* a shown image



17

Thought reconstruction

- Performance depends on where the signals come from
- Fewer errors for "lower" brain areas
  - Where do you stop?, the retina?, the lens of the eye?



18

Thought reconstruction

- These kinds of studies are mostly a demonstration of technology
  - we already know the brain represents visual information!
- Before the study was run, we knew that there were differences in the brain when we see different images
  - The percept is the brain's behavior, so there must be differences!
- These kinds of studies tell us that the neurophysiological differences between cognitive events *can be measured* by these brain scanning technologies
  - Failure would only indicate limits of the technology

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Mind reading limits

- fMRI: If subjects decide to multiply numbers, a system trained to distinguish between subtraction and addition is clueless
- Thought reconstruction: As the number of possible images to be shown increases, it becomes harder to reconstruct the shown image
- In general, brain scans provide a *very* limited form of mind reading
  - People do better than this every day by watching people behave (posture, eyes, skin tone)

20

Problems / limitations with scanning

- So much data that it is difficult to know what to do with everything
  - Statistical analysis is complicated
  - In a small brain scan, you may have 64 x 64 voxels x 10 slices
    - =40,960 voxels overall
  - Some of those voxels will give different responses just by chance
- Difficult to compare across subjects
  - Slightly different anatomy
- Blurring of images is difficult to deal with (subjects move in the scanner)
  - Sometimes blur together brain areas, across a fissure, that are actually far apart on surface of cortex
- Some cognitive events are faster than the technology can track
- Can only measure the brain, cannot manipulate it

21

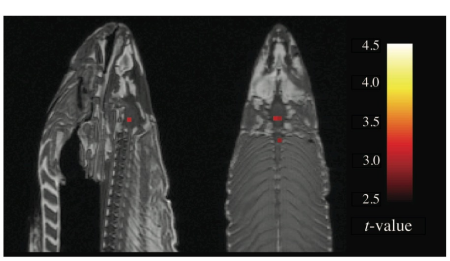
Statistics

- It is easy to do the statistics incorrectly (it has taken a while for the field to sort this out)
- Bennett et al. (2010) ran a study where the subject was shown a series of photographs depicting people in social situations with a specified emotional valence, either socially *inclusive* or socially *exclusive*. The subject was asked to determine which emotion the individual in the photo must have been experiencing.
- fMRI contrasts were computed between the scans for the two types of emotional valence

22

Statistics

- There is a significant difference in fMRI activity for some regions of the brain
  - Medial brain cavity and upper spinal column



23

Statistics

- The "subject" in this study was a mature Atlantic salmon (sex unknown)
- The "active" regions identified by the fMRI are due to chance
- Even with purely random noise, there will be some statistically significant findings
  - The brain has lots of random noise
- These problems can be reduced but never entirely eliminated
  - They are common to many areas of psychology, not just brain scans

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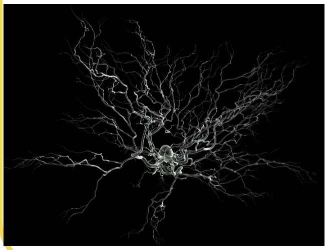
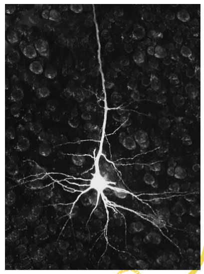
Neurons

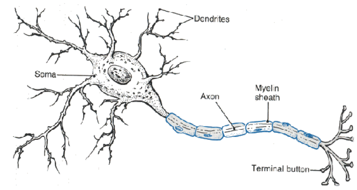
- The brain cells that are responsible for cognition are neurons

25

A neuron

- Dendrite
  - input
- Soma
  - integrate
- Axon
  - output
- Myelin sheath
  - insulate



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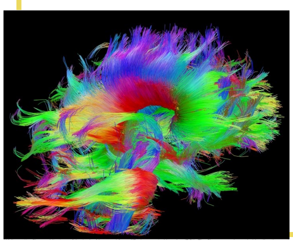
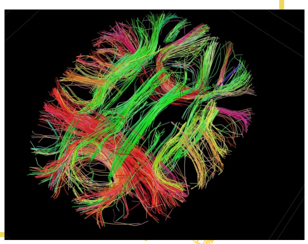
Myelin

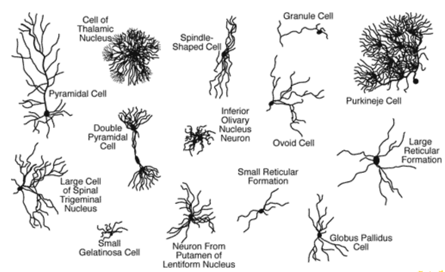
- Diffusion Spectral Imaging detects properties of the myelin sheath ("white matter")
- Allows imaging of human brain connectome

27

A neuron

- There are many different types of neurons
- We will describe only the most common characteristics



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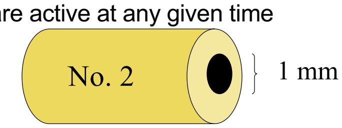
How many neurons?

- Estimates of 10^11 neurons in the human brain
  - 100,000,000,000; one hundred billion
  - estimates of 100,000 per cubic millimeter
  - (about the resolution of functional MRI)
- Millions are active at any given time



https://www.youtube.com/watch?v=2qTuZlMvFgY
(time 2:55)

29

Conclusions

- Brain scans usually look at *differences* in brain "activity"
- Lots of technical (and ethical) issues
- The goal is to be able to look at a map (or movie) and be able to *read someone's mind*
- That is many years off
  - questionable if it can even be done with these methods alone

30

Next time

- What is the neural activity that produces brain scans?
- How do neurons transmit information to other neurons?

- *Why does (nearly) everyone like Prozac?*

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31

Neurons and neurotransmitters

PSY 200

Greg Francis

Lecture 05

Why does (nearly) everyone love Prozac?

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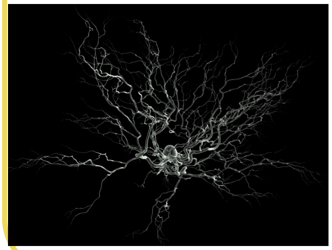
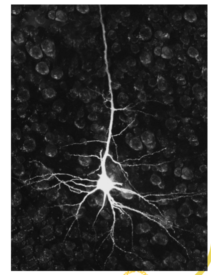
1

Neurons

- The brain cells that are responsible for cognition are neurons

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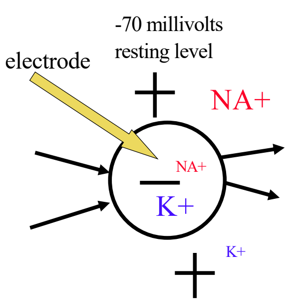
2

Input / output

- Electrical signal
  - Established by the relative amount of charged ions inside versus outside the cell membrane
- Inputs change the resting potential of the cell
- Output identifies when the cell potential has increased a *lot*



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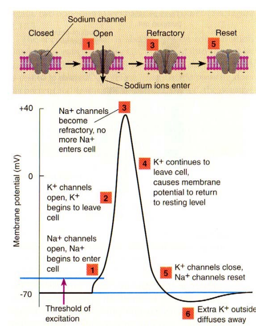
Input at dendrites

- Changes the cell membrane potential
  - which causes further changes in the cell's chemistry
  - which causes further changes in the membrane potential
- Strong enough input crosses a *threshold* and the cell *fires*
  - action potential



https://mind.ilstu.edu/curriculum/neurons_intro/flash_action_potential.html

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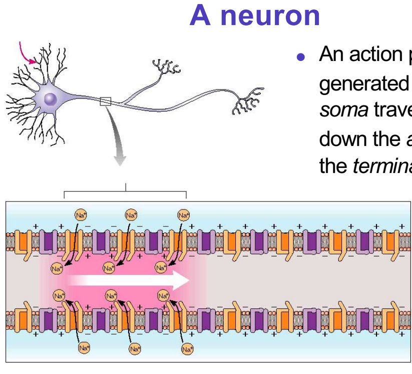
4

A neuron

- An action potential generated at the *soma* travels down the *axon* to the *terminals*



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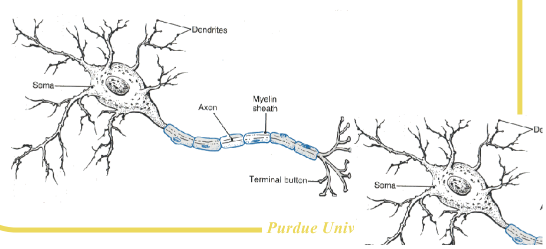
5

A neuron

- The action potential then affects the membranes of other cells' dendrites



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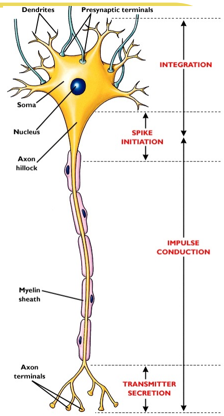
Output

- Myelin is like insulation for the cell's axon
  - it insures that the signal generated by the action potential is strong
  - Jumps electrically rather than the normal chemical exchanges
- In multiple sclerosis the body's immune system attacks myelin
  - physical problems (paralysis)
  - cognitive problems (memory, reasoning, judgement)
  - cause unknown (300,000 people)



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Output

- The output of a neuron is either *excitatory* or *inhibitory* on the other neuron it reaches
- **Excitatory:** when our neuron sends an output, the receiving neuron is *more* likely to produce an action potential
- **Inhibitory:** when our neuron sends an output, the receiving neuron is *less* likely to produce an action potential

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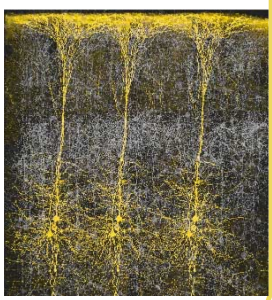
8

Networks

- Cognitive behavior is related to groups of neurons working together
- Include excitation and inhibition
  - more later



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9

Epilepsy

- Disease of central nervous system
  - causes mostly unknown
- Seizures
  - bursts of electrical activity travelling through networks in the brain
  - brain activity is out of control
  - epileptic fits
- *Isolated* seizures also occur due to high fever, lack of oxygen, or head injury

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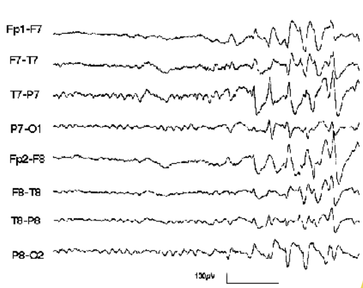
10

Epilepsy

- EEG recordings are often used to diagnose epilepsy
- Many different types of epilepsy, with different EEG patterns



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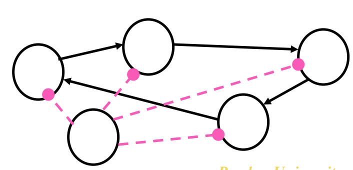
Epilepsy

- One theory (but not yet proven) is that epilepsy patients' *inhibitory cells* are not working properly
- Excitatory cells activate everything until they "exhaust" themselves



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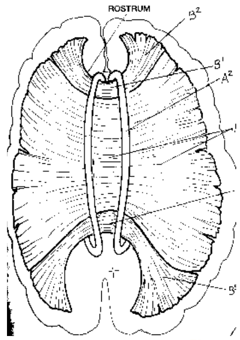
Epilepsy

- Treatment generally involves
  - drugs, diet, avoiding stress, keeping regular schedule
- In extreme cases surgery prevents seizures from spreading throughout the brain



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A balanced brain

- The brain is a dynamic system
  - at multiple levels
- Neurons
  - balance between “forces” inside and outside of cell membrane allows for action potentials
- Networks
  - balance between excitation and inhibition
- Without these balances you do not think
- Contrast with ideas about using “more” of your brain

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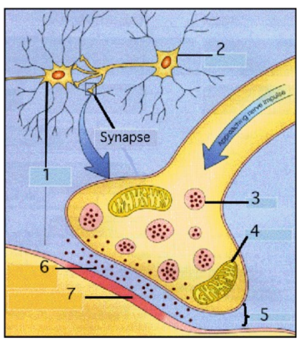
Neural connections

- Axon --> dendrites



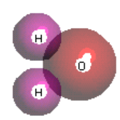
https://mind.ilstu.edu/curriculum/neurons_intro/flash_chemical.html

15

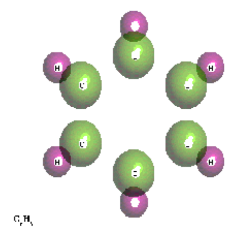
Molecular structure

- Molecules have a particular three-dimensional **shape**

water



benzene



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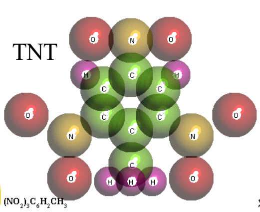
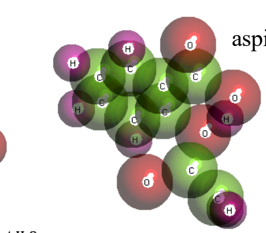
Molecular structure

- Different molecules have different shapes

TNT



aspirin



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Molecular structure

- Neurotransmitters are just *molecules*
- At least 50 different neurotransmitters
  - dopamine, norepinephrine, serotonin, acetylcholine, glutamate, gamma-aminobutyric acid (GABA)
- All with different *shapes!*

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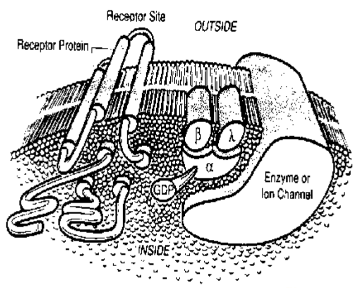
Receptor

- **Very** large molecules called *proteins*
- Similar to a filter
  - accepts some neuro-transmitters
  - rejects others



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Receptor

- When it accepts a neurotransmitter, it starts a chain reaction of events
  - physical, chemical, electrical
  - locally changes the cell membrane
    - » depolarization (excitation)
    - » hyperpolarization (inhibition)

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Neurotransmitters

- Different neurotransmitters are associated with different properties
  - actually neurotransmitter and receptor pairs
- neural
- cognitive
- behavioral

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Tourette's syndrome

- Inherited (~200,000 in US)
- Behavior
  - Swearing
  - Tics
    - » Simple: eye blinking, facial grimacing, sniffing
    - » Complex: coordinated patterns, sniffing objects, jumping, twisting
- Too much dopamine
- Treated with Haldol (among others)
  - blocks dopamine

https://www.youtube.com/watch?v=NlFpkruxrCI (6:15 in)

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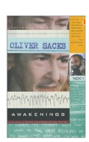
Parkinson's

- Lack of dopamine
  - Many different causes
  - In extreme cases, patients are "frozen"
- Give patients large doses of L-DOPA
  - a precursor of dopamine
  - sometimes solves the problem
  - lots of side effects
- *Awakenings*, by Oliver Sacks



https://www.youtube.com/watch?v=koL0PWCJ4lo

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Drugs

- Interact with neurotransmitters in lots of ways, for example
  - Replace: accepted by receptor and with similar effect
  - Production: increase or decrease
  - Reuptake: knock out enzymes that remove neurotransmitter from receptor, neurotransmitter has a bigger effect
  - Blocking: enter receptor but does not trigger reaction, partly closes receptor protein so neurotransmitter cannot enter

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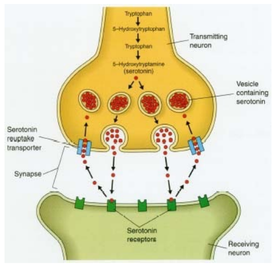
Prozac

- Some forms of depression seem to be related to limits in the use of the neurotransmitter *serotonin*
- Prozac is a selective serotonin reuptake inhibitor (SSRI)
  - it keeps serotonin bound to a receptor for longer than usual, thereby increasing its effect
- Prozac is one of the most widely prescribed drugs in the world!



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Other drugs

- Amphetamines: release of norepinephrin or dopamine
- LSD: resembles serotonin
- Phenothiazine drugs: block dopamine
- Curare: blocks acetylcholine
- Cocaine: prolongs effects of dopamine
- Morphine: resembles a small set of neurotransmitters called endorphin peptides (modulate pain perception)
- Tetrahydrocannabinol (active ingredient in marijuana): binds to some neuroreceptors, but it's not clear what it does

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Conclusions

- Neural action potentials
- Shape of proteins
- Specific use of neurotransmitters for certain behaviors
- Current work on identification of role of neurotransmitters
- *Lots* of money to be made
- *Lots* more complicated than what we've seen here

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Next time

- Neural sensitivity
- Neural codes
- Receptive fields
- CogLab on Blind spot due!
- *How do you recognize your grandmother?*

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Receptive fields

PSY 200

Greg Francis

Lecture 06

How do you recognize your grandmother?

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1

Action potential

- With enough excitatory input, a cell produces an action potential that sends a signal down its axon to other cells
  - But a single action potential has little effect
- If the input stays present, the cell produces another, and another,…
  - A rapid series of action potentials can influence other cells
- The *number* of action potentials in a certain length of time determines the *firing rate* of the cell

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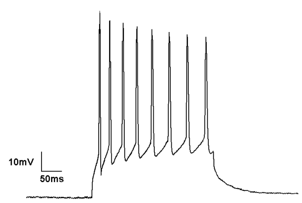
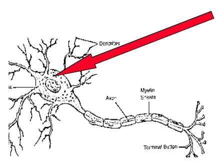
Firing rate

- 8 spikes (action potentials) during 300 ms
  - Firing rate of 27 Hz (27 spikes per second)





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Specificity

- Two key questions in cognitive neuroscience are
  - What stimulus (or stimuli) makes a given cell fire at a strong rate?
    - » something red?
    - » a pen?
    - » your grandmother?
  - What does it mean when a given cell fires strongly?
    - » You are thinking of something?
    - » Seeing something?
    - » Remembering something?

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Receptive field

- The set of stimuli that reliably *changes* a cell's firing rate.
- A stimulus could *excite* the cell
  - above normal firing rate
- Or *inhibit* the cell
  - below normal firing rate

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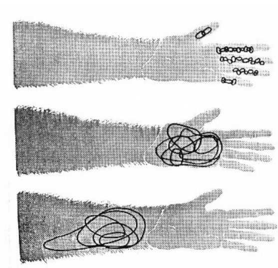
Receptive field

- Receptive fields are very useful for studies of spatial perception
- Touch involves sensitivity to pressure on skin
- The loops indicate the regions where a single neuron responds to pressure



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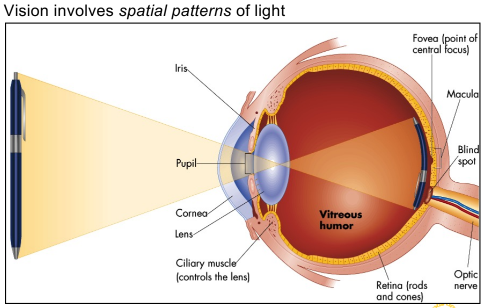
Receptive field

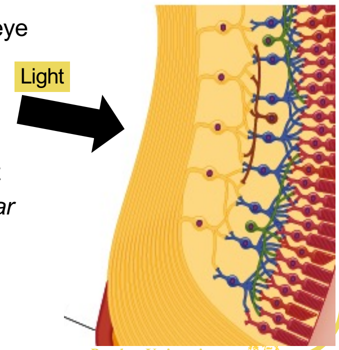
- Receptive fields are very useful for studies of visual perception
- Vision involves *spatial patterns* of light



7

Receptors

- The back of the eye contains tightly packed sensors called rods and cones that detect light *at a particular location*



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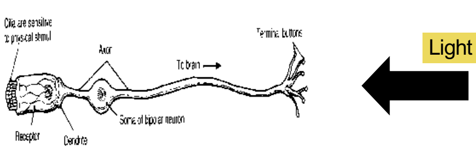
Receptors

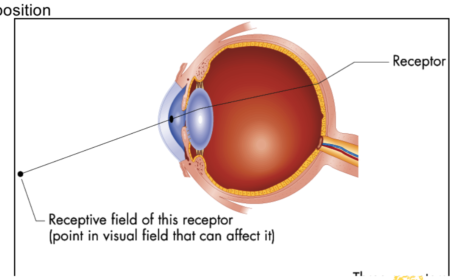
- Light sensors (rods and cones) respond to light at a *particular location* in the back of the eye
  - produces a neural response



9

Receptors

- A receptor has a simple receptive field
  - it responds to light of the right wavelength (color) and the right position



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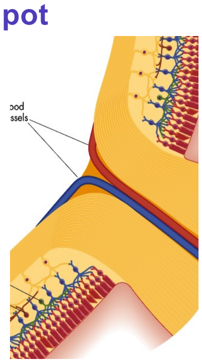
Blind spot

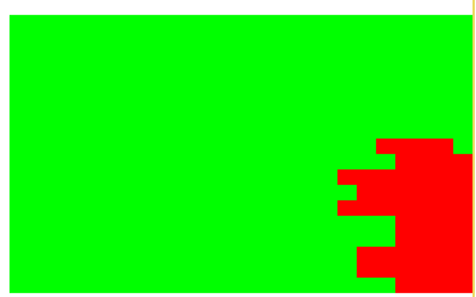
- Where nerves leave the back of the eye, there are no light receptors
  - light that hits this spot is not visible



11

Blind spot

- In CogLab you mapped your blind spot
- my data looks like this



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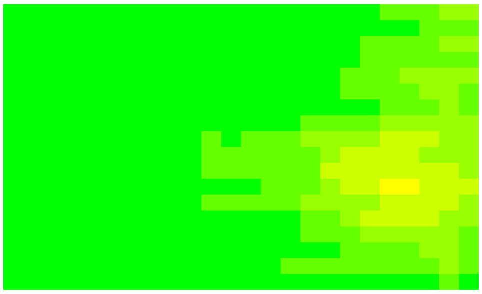
Blind spot

- Here's the average data for the whole class
  - 111 participants



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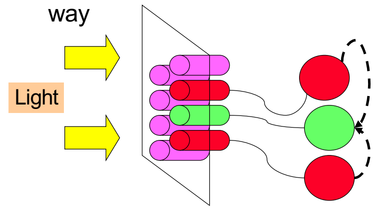
Network

- Light receptors do not just pass information to the brain
- Neurons are hooked together in an inhibitory way



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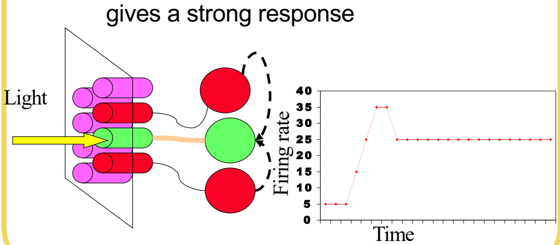
Evidence of inhibition

- Stimulation of a center region alone gives a strong response



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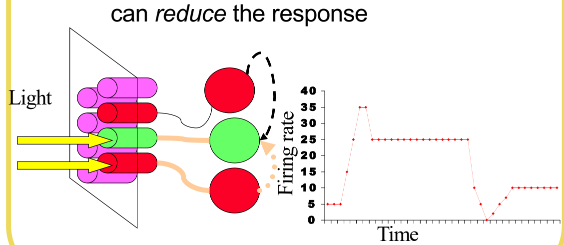
Evidence of inhibition

- *Adding* light to a surrounding region can *reduce* the response



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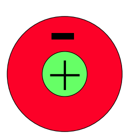
Receptive field

- The receptive field of this cell includes any place on the retina where light excites the cell *and* any place where light inhibits the cell
- On-center, off-surround



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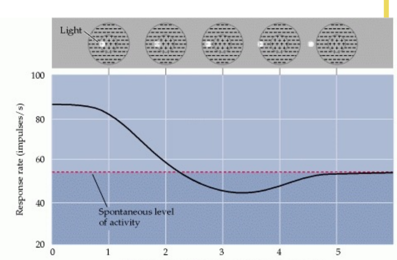
Spatial responses

- The spatial pattern of excitation (center) and inhibition (surround) means the cell is sensitive to the location of a small spot of light



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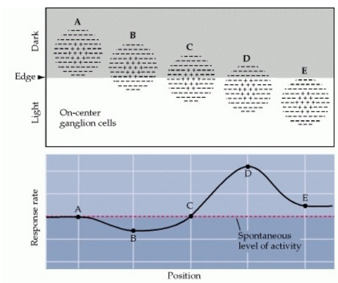
Spatial responses

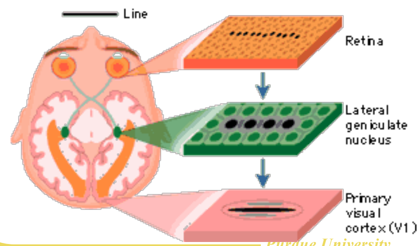
- You have many different such cells with receptive fields that are centered at different locations
- They respond differently to an edge



19

Simple cells

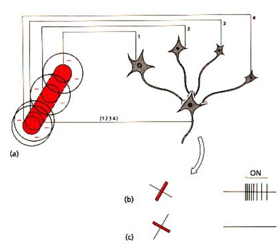
- On-center, off-surround cells send action potentials to simple cells in parts of visual cortex, which have *oriented* receptive fields



20

Simple cells

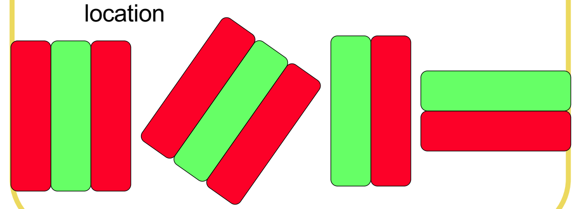
- On-center, off-surround cells send action potentials to simple cells in parts of visual cortex, which have *oriented* receptive fields



21

Simple cells

- Simple cells come in a variety of types, but all are sensitive to *bars* or *edges* of a preferred orientation at a particular location



22

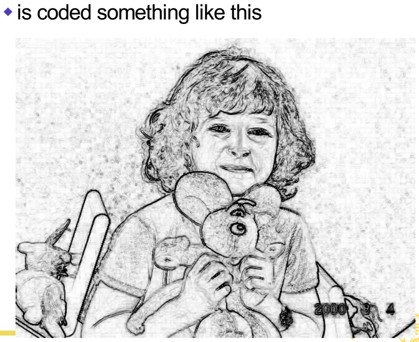
Information processing

- For simple cells, an image like this

23

Information processing

- For simple cells, an image like this
  - is coded something like this

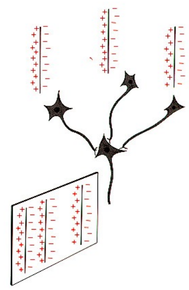


Strong responses at edges!

24

Complex cells

- Many simple cells feed into a *complex* cell, which is insensitive to direction of *contrast* and responds to an oriented bar in many different places



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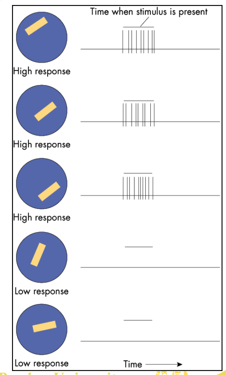
Complex cells

- Many simple cells feed into a *complex* cell, which is insensitive to direction of *contrast* and responds to an oriented bar in many different places
  - Often these cells are also sensitive to directions of *motion*



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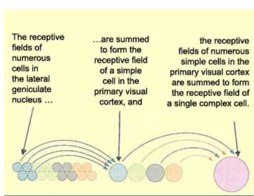
Receptive field hierarchy

- Receptive fields inherit some properties from "lower-level" cells
- But they also gain new selectivity by interacting with each other (and across levels)



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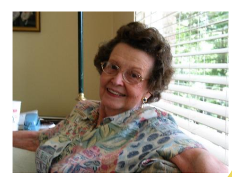
Higher order cells

- Complex cells feed into hypercomplex cells, which are sensitive to some types of *curves* and visual *forms*
- Receptive fields seem to get ever more complex
- What does this mean?
- Is there a grandmother cell?



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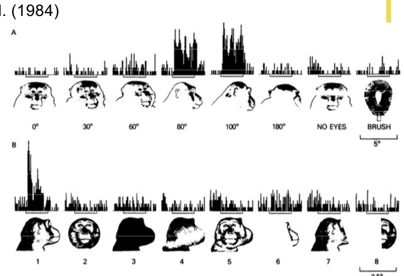
Receptive field

- In the inferior temporal cortex of monkeys
  - Desmione et al. (1984)
- some cells appear to have receptive fields that respond to monkey faces, in profile



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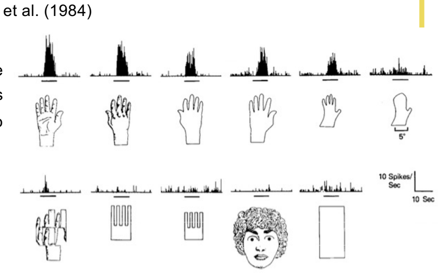
Receptive field

- In the inferior temporal cortex of monkeys
  - Desmione et al. (1984)
- Other cells appear to have receptive fields that respond to hands



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Grandmother cells?

- It *could* be that a single cell has a receptive field selectively tuned to respond to the image of your grandmother
  - but it is unlikely
  - not enough cells
  - cell death
- Receptive fields become less useful as we search for neural representations of non-sensory concepts
  - What is the receptive field of a neuron that codes "love" or "trust"?

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Conclusions

- Receptive fields
  - any stimulus that affects a cell's firing rate
  - excitatory
  - inhibitory
- Very useful for studies of the visual nervous system
- Lots of issues left unresolved

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Next time

- Networks of neurons
- Connections between cells
- Feedback – resonance
- *Seeing things that are not there.*

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Neural networks

PSY 200

Greg Francis

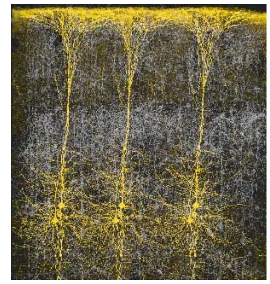
Lecture 07

Seeing something that is not there.

1

Receptive field

- As we saw last time, a cell's receptive field depends to a large extent on the receptive fields of other cells
  - (e.g., complex cells depend on simple cells)
- Today we look at some issues involved in *networks* of neurons

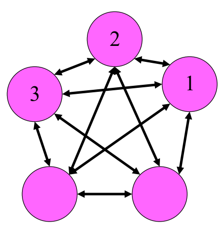


https://www.youtube.com/watch?v=2qTuZlMvFgY

2

Feedback

- Cell 1 can affect cell 2, which can affect cell 3, which can affect cell 1 again, which…
- What happens to cell firing rates?
  - high firing rate==> active
  - low firing rate ==> inactive



3

Resonance hypothesis

- Initially cell firing rates may vary a lot
- In some networks cell firing rates stop changing much (unless outside input changes)
- The remaining active cells are those that support each others' activities through *excitation:* **resonance**
- Inactive cells are *inhibited* by the active cells
- Mental awareness ==> resonance

4

A "simple" model

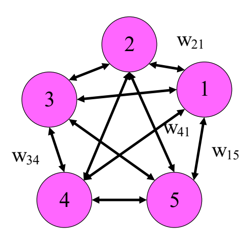
- A cell's activation is *on* or *off* (one or zero)
- Cell connections (synapses or weights) are reciprocal
- Cells update activations one at a time
- Cell activations are calculated with the rule

$$a_i = \begin{cases} 1 \text{ if } \sum w_{ij} a_j > 0 \\ 0 \text{ if } \sum w_{ij} a_j \leq 0 \end{cases}$$

5

A simple model

- Neural connections (synapses) are described as *weights* on the links between cells
- Input to a cell is the summed multiplication of sending activation and weight
- Reciprocal weights have $w_{ij} = w_{ij}$



6

Demonstration

- Cell activities *do* settle down eventually
- Final pattern of activities satisfies constraints of the network connections
- Error correction capabilities
- Can tolerate the loss of some cells
- *Emergent properties* of the network
  - no single cell has these properties

7

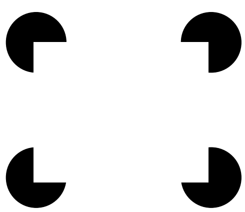
Feedback

- Feedback in networks can act to “clean up” noisy sensory information to make it *consistent* with what our systems expect
- In a very real way, what we see, hear, taste, smell, touch, and think, is biased by our network’s expectation
- A network’s expectation is established by its connection weights
  - excitation -- inhibition

8

Seeing things that are not there

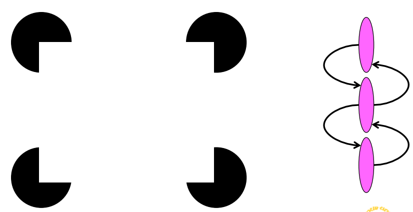
- Do you see a square in front of the pac men?



9

Seeing things that are not there

- Neurons in area V2 of your brain “create” the illusory contours



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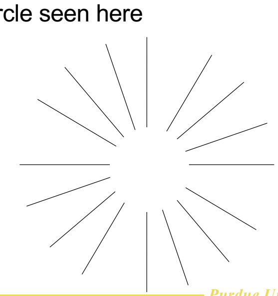
Feedback

- Similar situation with the illusory circle seen here



11

Conclusions

- Networks of neurons have properties different from single cells
  - emergent properties
  - stable activities
  - multiple constraints
  - tolerance to errors and cell loss
- Structure of connections (synapses) determines the final pattern of responses

12

Next time

- How networks learn
- Changing connections
- Learning rules
- Self-organization
- CogLab due for Implicit Learning

- *A problem with virtual reality.*

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13

Neural learning

PSY 200

Greg Francis

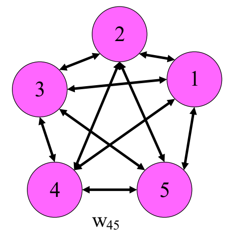
Lecture 08

A problem with virtual reality.

1

Networks

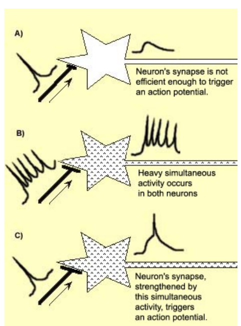
- As we saw last time, a network of neurons can have very complicated behavior
- The behavior depends on the *connections* between cells
- How do those connections get established?



2

Hebb's rule

- If two neurons are active simultaneously, then they strengthen the connection between them
- Signals from the *environment* change the properties of the network



3

A "simple" model

- A cell's activation is *on* or *off* (one or zero)
- Cell connections (weights) are reciprocal
- Cells update activations one at a time
- Cell activations are calculated with the rule

$$a_i = \begin{cases} 1 \text{ if } \sum w_{ij} a_j > 0 \\ 0 \text{ if } \sum w_{ij} a_j \leq 0 \end{cases}$$

4

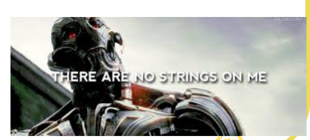
Simplified learning

- Initially, all connections are zero
  - $w_{ij} = 0$
- Hebb's rule
  - cells that are simultaneously active develop *positive* weights (excitation)
  - an active cell develops *negative* weights with inactive cells (inhibition)
- Demonstration

5

Self-organization

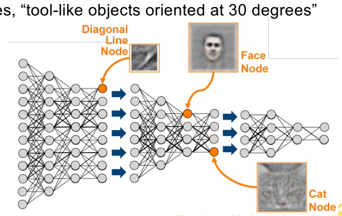
- A network of this type does not need an intelligence to set the connection weights
- The network self-organizes in response to stimulation
- It can *remember* things it has previously experienced
- It can interpret new information on the basis of things it has previously learned



6

Deep learning

- Google used one version of a neural network to analyze 10 million YouTube stills
  - 1000 computers (16,000 cpu's) over 3 days
- The network self-organized to identify common patterns
  - Cats, faces, "tool-like objects oriented at 30 degrees"



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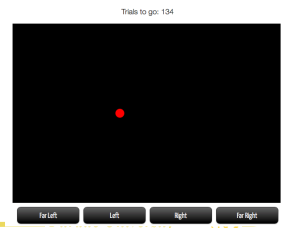
Learning

- This may *not* be the same type of learning you do when you study for school
  - but it is important just the same
- Consider implicit learning
  - A long sequence of trials, where you press a key to indicate the appearance of a dot at a corresponding location



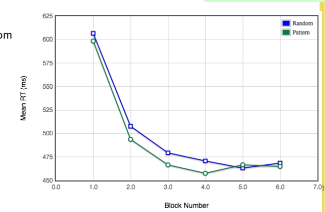
8

Implicit Learning

Class data (~80 in each group)

Global data (~13,000 in each group)

- We are interested in how fast you respond to the dot
- Two groups of subjects:
  - Random: each sequence is random
  - Pattern: each sequence is the same (but so long that people typically do not notice)
- Subjects in the pattern condition are faster (they have partly learned the sequence, and generate faster responses to expected locations)



- More generally, networks in your brain can learn information about your environment without you being aware that something is being learned

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Learning

- Lots of learning happens that you do not notice
- Consider the length of your arm
  - to catch and throw objects your brain must know exactly your arm's length
  - but the length of your arm changes as you age!
    - » And depends on unknown environmental factors

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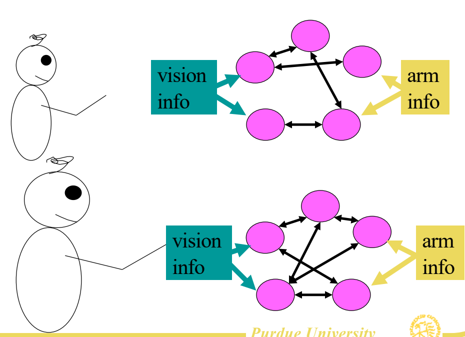
Hand-eye coordination



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Coordination and learning

- We do not know the exact nature of the network involved in this coordination
  - but we know it continually modifies part of itself to match up with the current situation
- This is actually a good design feature, because the brain cannot know in advance every detail of the eye-hand system

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Virtual reality

- Using computer graphics to convince the body it is someplace other than it really is
- Useful for
  - architects, designers
  - surgeons, pilots
  - entertainment

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Cameras

- Enhance visual perception
- Night vision for helicopter pilots

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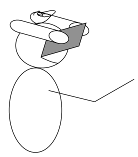
Cameras

- Enhance visual perception
  - MRI overlaid on actual image of brain for surgeon
    - » highlight tumor
  - Avoid other brain regions
    - » faster



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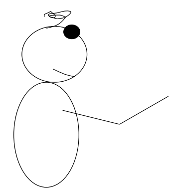
Problem

- The network coordinating eye-hand systems, adjusts itself
- Extended use of the computer cameras makes the user adapt so his eyes are where the cameras are!



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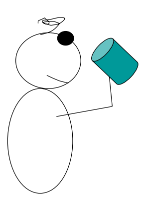
Problem

- After taking the cameras off, it takes some time to adapt back
- Eye-hand coordination is off
- Could be a problem for surgeons and pilots!



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Other adaptations

- Inverted prisms
- Fortunately, the adaptations return to normal pretty quickly
- Kind of like the feeling you get after roller-skating

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Conclusions

- Learning in neural networks
  - changing connections
  - relatively simple rules
- Much of our perceptual and motor behavior is based upon this type of continuous learning
- It's not clear if more cognitive learning is similar

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Next time

- Review for Exam 1
- Then
- Neural networks for visual perception
  - brightness
  - color
  - form
- *Why we see color afterimages.*

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Visual perception

PSY 200

Greg Francis

Lecture 09

Why you see color afterimages.

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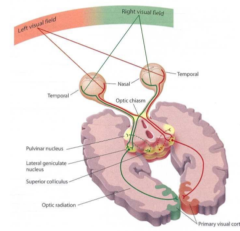
1

Visual perception

- Light enters eye
- Signals sent to area V1 in cortex
- Neural networks tuned to
  - brightness
  - color
  - form
  - motion
  - texture
  - depth...



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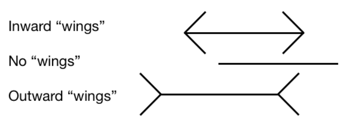
Seeing

- It's kind of like a camera, but what we see is not just an image
- In particular, we do not see the world the way it "really" is
- When we notice these discrepancies, we call them illusions
- Muller-Lyer illusion is one example
- How big is the illusion? How can you measure a subjective experience?



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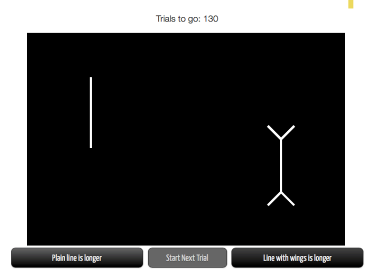
Measuring perception

- CogLab uses the method of constant stimuli
- Judge which of a pair of lines is longer
- Vary the length of the line without wings
- Repeat many times



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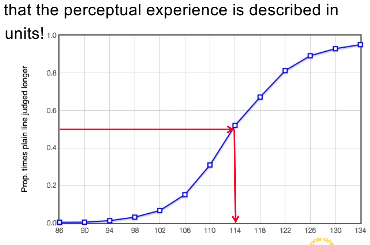
Psychometric function

- Plot proportion of times line without wings is judged "longer" than the line with wings
- 50% is point of subjective equality (around 114 pixels)
- A key property is that the perceptual experience is described in terms of physical units!

Class data
(147 observers)



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Neurophysiology

- How we see things is largely determined by the properties of receptive fields
  - on-center, off-surround
  - simple cells
  - complex cells
- And by network interactions among cells

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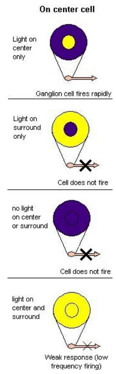
On-center, off-surround

- Characteristics of cell receptive fields force additional properties of the visual system
  - center-surround cells tend to not respond well to homogeneous light that covers both excitatory and inhibitory parts
  - => percepts of the middle of an object is derived from the edges



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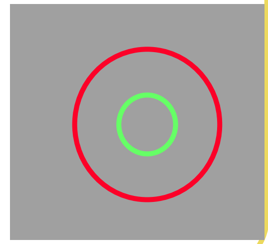
On-center, off-surround

- Characteristics of cell receptive fields force additional properties of the visual system
  - center-surround cells tend to not respond well to homogeneous light that covers both excitatory and inhibitory parts
  - => percepts of the middle of an object is derived from the edges



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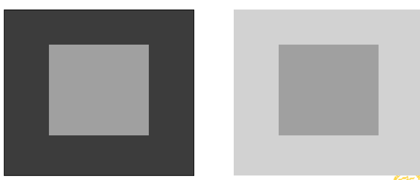
Brightness contrast

- Edge responses are influenced by the surrounding light
  - both center squares have the same light intensity



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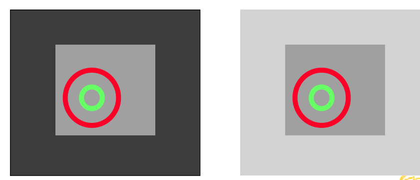
Brightness contrast

- Two receptive fields inside the middle square receive the same excitatory and inhibitory signals
  - Little response



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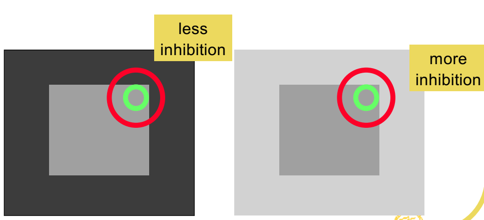
Brightness contrast

- Receptive fields on the corner
  - Receive the same excitation at the center
  - differ in the amount of inhibition in the surround



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Brightness contrast

- Thus, the visual system computes brightness as something like *local* contrast
  - It' s a property of the center-surround cells
  - Our percept of brightness is determined by the responses of cells at contrast edges
  - As a result, things that have equal physical intensities can look dramatically different (next slide)

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Brightness contrast

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.

13

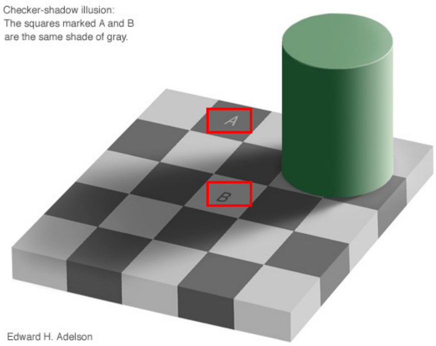
Brightness contrast

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.

14

Brightness contrast

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.

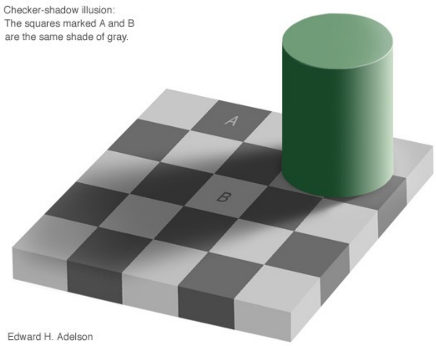


Edward H. Adelson

15

Brightness contrast

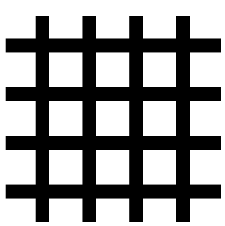
Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.

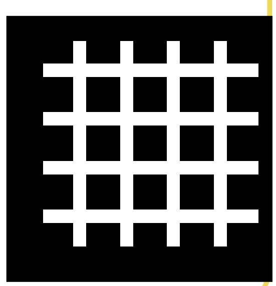


Edward H. Adelson

16

Hermann grid

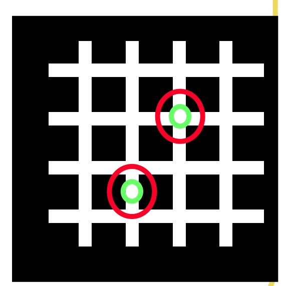




17

Hermann grid

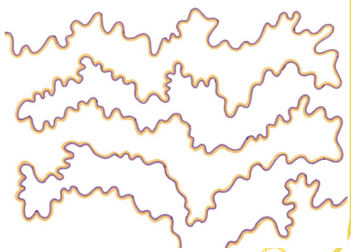
- Seems related to on-center, off-surround cells
- Cells at intersections receive more inhibition than cells at single roads
- How do we explain the other version?



18

Filling-in

- We *see* color and brightness inside objects
  - so edge information must fill-in to the interior
- It sometimes gets things messed up
- Water color effect



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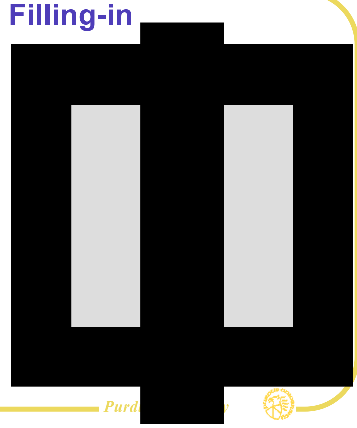
Filling-in

- Brightness information spreads across surfaces
  - Craik-O' Brien-Cornsweet effect



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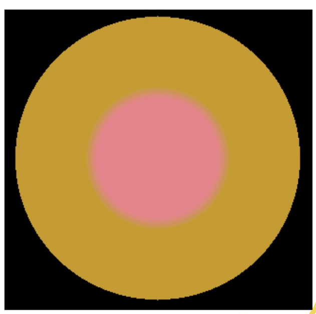
20

Filling-in

- Carefully fixate the pink center
- If you keep your eyes *very* still, it will disappear
- The yellow fills-in!



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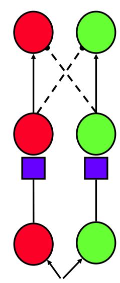
21

Color system

- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- habituating gate
- offset of one color leads to rebound in other
- Gated dipole circuit



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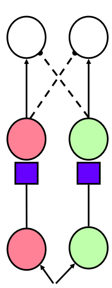
Color system

- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- Initial balance
  - Neither color wins competition



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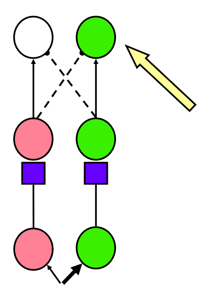
23

Color system

- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- Extra input to green
  - Green wins competition



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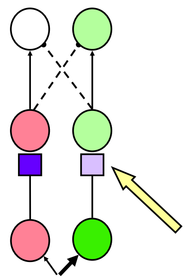
Color system

- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- Extra input to green
  - Fading of green signal



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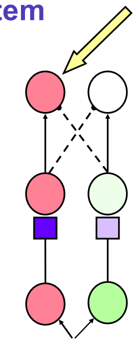
Color system

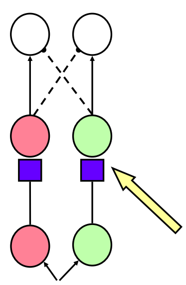
- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- Offset of green
  - Rebound of red signal



26

Color system

- competition between opposite colors
  - red-green
  - blue-yellow
  - black-white
- Recovery of green pathway
  - Disappearance of rebound
  - Return to initial state



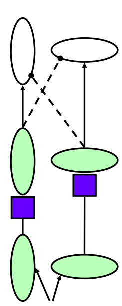
27

Color afterimage

28

Orientation competition

- competition between orthogonally tuned cells
- habituating gate
- offset of horizontal leads to rebound in vertical
- Same kind of gated dipole circuit
  - Principles of neural computation!
- Baseline response
  - Due to tonic input



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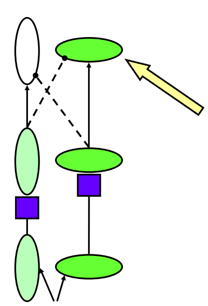
Orientation competition

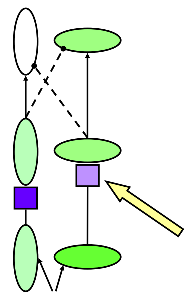
- With additional input to horizontal pathway, horizontal channel wins competition



30

Orientation competition

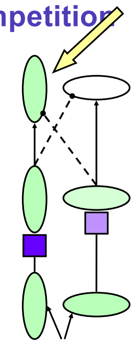
- With additional input to horizontal pathway, horizontal channel wins competition
- But as horizontal gate habituates, horizontal signal weakens
- It still wins the competition, though



31

Orientation competition

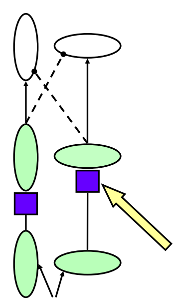
- At offset of horizontal input, the gated horizontal signal is weaker than the vertical signal
- A vertical rebound appears



32

Orientation competition

- As the horizontal gate recovers, the system returns to baseline and the vertical after response disappears



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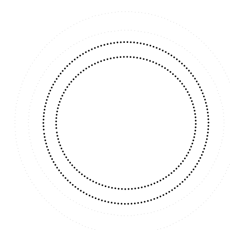
Oriented afterimages

- Oriented reset signals are also implicated in an unusual type of afterimage



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Conclusions

- Visual perception
  - brightness
  - color
  - form
- Largely determined by the receptive fields and network structure of visual circuits
- Neurophysiology strongly determines what we see!

35

Next time

- Visual dynamics
  - Flicker
  - Persistence
  - Motion perception
- CogLab on Apparent motion due!
- *Why computer monitors work.*

36

Visual dynamics

PSY 200

Greg Francis

Lecture 10

Why computer monitors work.

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1

Flicker

- A flashing light looks constant if it is presented rapidly enough
- The frequency of flashing at which subjects do not detect flicker is called the *Critical Flicker Frequency (CFF)*
  - about 50 Hertz (50 on-off cycles in a second)
  - 20 millisecond durations

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CFF

- Establishes minimum characteristics of electronic devices
- Lights flicker at 120 Hz
  - we spend a lot of time in darkness
- Computer (Cathode Ray Tube, CRT) monitors and TV's flicker at around 60 Hz
  - better monitors go faster
  - Liquid Crystal Display (LCD) monitors work differently
    - » Although some still flicker

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3

Phosphor

- The phosphor on a computer screen typically glows less than 10 milliseconds
  - ten thousandths of a second
- The gun reactivates the phosphor every 17 milliseconds
- Thus, at any given time 1/3 of the screen is dark
  - the percept persists in your head!

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4

Persistence

- What is the source of the persisting percept?
  - Receptors in the eye?
  - Receptive fields?
  - Network interactions?
  - Cognitive (memory)?
- Studies support network interactions

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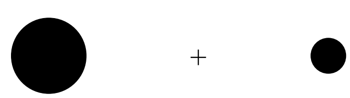
Experiment

- Bowen, Pola & Matin (1973)
  - subjects adjust duration of a blank stimulus so onset of probe matched *perceived* offset of the target



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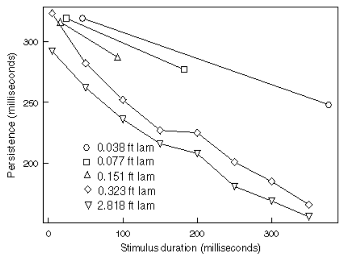
Strange property

- As the target's duration or luminance *increases*
  - its persistence *decreases*



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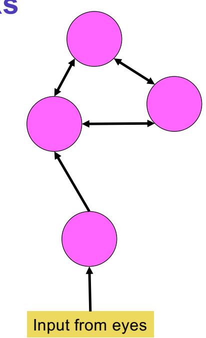
Networks

- Feedback is important
- Produces a persisting response
- Demonstration



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Explanation

- Francis, Grossberg & Mingolla (1994)
- Something has to *reset* the network
  - else it would keep "persisting" forever
- Two mechanisms
  - (1) new inputs inhibit old responses
  - (2) afterimages act as new inputs
- Note: afterimages get stronger as duration and luminance increase!

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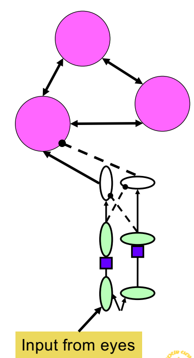
Explanation

- Offset of input from the eyes produces an after response
  - e.g., due to competition from orthogonally tuned cells
- Offset response inhibits persisting response



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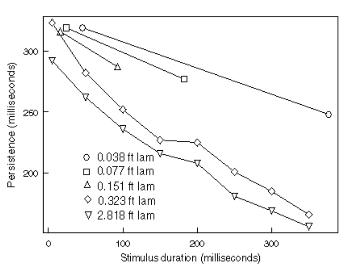
Explanation

- As the target's duration or luminance *increases*
  - the afterimage produced at target offset increases in strength
  - so there is stronger inhibition to break the feedback
  - so the persistence of the original percept *decreases*



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Wait a minute

- If visual percepts persist for over 100 milliseconds, why doesn't the world seem blurry?
  - There should be smears of objects as they move or as we move
- There must be something else preventing such blurring
  - masking

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12

No mask

- Write down all the letters you see

13

No mask

- Write down all the letters you see

R F
L P
M Q

14

No mask

- Write down all the letters you see

15

Masking demonstration

- Write down all the letters you see

16

Masking demonstration

- Write down all the letters you see

Y S
D H
W F

17

Masking demonstration

- Write down all the letters you see

X X X X
X X X X
X X X X

18

Significance

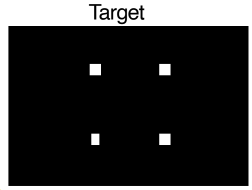
- The mask appeared *after* the target turned off
- The target was presented all by itself for a *brief* period of time
- However, our visual system is unable to develop a complete percept of a scene in a such a period of time
  - Thus, the XXX mask interferes with processing of the letters by shortening their persisting responses
  - And prevents perceived blurring of changing scenes

19

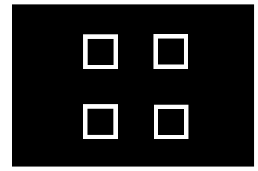
Metacontrast

- Masks do not have to “write over” the target to have an effect
- In metacontrast masking the mask and target do not overlap in space and (often) in time (CogLab)

Target



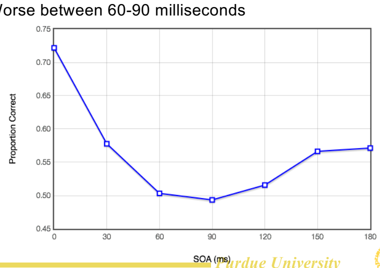
Mask



20

Metacontrast

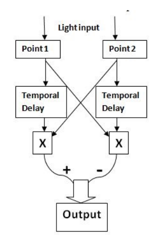
- Correct identification of the narrow target is affected by the Stimulus Onset Asynchrony (SOA) of the target and mask (111 participants)
  - Worse between 60-90 milliseconds

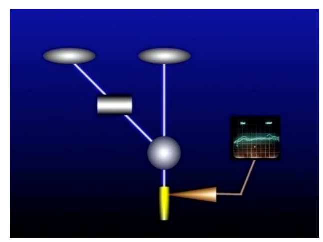


21

Motion

- In simple animals (like flies and frogs), we know how motion is detected
  - Demo on web page
- Reichardt detector





22

Detecting Motion

- Humans have something like Reichardt motion detectors
  - at lots of different positions in the visual field
  - sensitive to lots of different motion directions
  - sensitive to lots of different motion speeds
- Think of them as receptive fields that vary in both space and time
- Many aspects of how we perceive motion follow from the properties of Reichardt motion detectors

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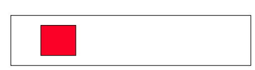
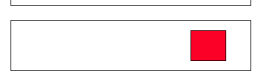
Apparent Motion

- When objects move, there is a continuous path of motion
- Reichardt motion detectors do not require continuous motion
  - and, continuous paths are not necessary for motion to be seen

Time1



Time2



24

Apparent Motion

- For just two stimuli, it does not depend on
  - color
  - shape
  - attention
  - cognitive priming

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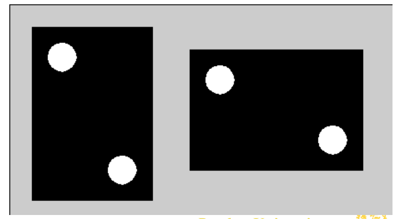
Apparent Motion

- The percept of motion does depends on
  - stimulus duration
  - interstimulus interval (50-200 msec)
  - distance



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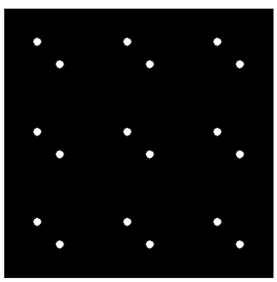
Apparent Motion

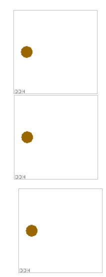
- Weird grouping effects (not fully understood)



27

Timing

- For a Reichardt detector to indicate motion, the signal from the second area must follow the signal from the first by just the right length of time
- Vary the Interstimulus Interval (ISI) between the stimuli
  - The time between offset of the first stimulus and onset of the second stimulus



ISI too short

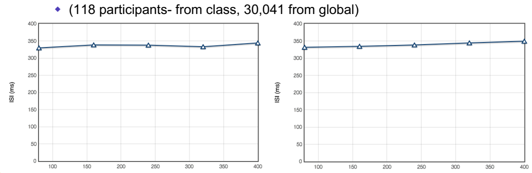
ISI about right

ISI too long

28

Korte's laws

- Apparent motion was highly studied at the beginning of the 20th century
  - Korte (1915) noted that to get good motion, you needed to increase the ISI between the stimuli as the distance between them increased
- CogLab data
  - (118 participants- from class, 30,041 from global)



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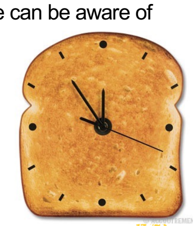
Motion representation

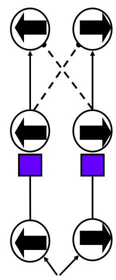
- One conclusion of studies of apparent motion is that motion is a fundamental percept
  - It has an explicit representation in the visual system
- You could imagine otherwise, we can be aware of something moving without actually seeing the movement
- Apparent motion is the source of motion for all movies and animation



30

Motion aftereffect

- Just like for color and orientation, we might expect an aftereffect of motion
- competition between opposite directions of motion
  - Left-right
  - Up-down
- habituating gate
- offset of one direction leads to rebound in other



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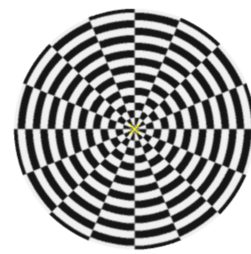
After effect

- Motion can be adopted by non-moving stimuli
  - http://www.michaelbach.de/ot/mot_adapt/index.html



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Conclusions

- Dynamic vision
  - flicker
  - persistence
  - network dynamics
  - Masking
  - Reichardt detectors
  - Apparent motion
  - Motion aftereffect
- Also used to investigate other areas of cognition and types of mental problems

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Next time

- Attention
- What is attention?
- What does it do?
- CogLab on Simon Effect due.

- *How could you* not *see it?*

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Attention

PSY 200

Greg Francis

Lecture 11

How could you not *see it?*

1

Attention

- The world contains more information than we can fully interpret or process all at once
- The ability to deal with some stimuli and not others is *attention*
  - not clear if there is an attentive *system*
  - or if attention *derives* from other systems

2

Information processing

- Modern theories see cognition as *information processing*
  - much like a computer
- Different systems have different capabilities, capacities, and speeds
- Necessarily, some information is ignored because it is not processed

3

Attention

- Part of attention seems to be due to mental effort on your part
  - attending a lecture
  - ignoring whispering around you
- Part of attention seems a natural side effect of mental effort
  - ignoring the "uhs" and "ums" from a speaker
  - ignoring the feel of clothes on your body
- Part of attention seems effortless
  - a loud noise

4

Magic trick

5

Magic trick

- Now the computer will shuffle the cards and present them again

6

Magic trick

7

Drawing attention

- Attention can be focused by meaningful stimuli
- Attention can be focused by environmental characteristics

8

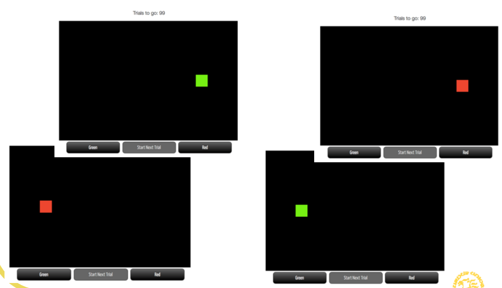
Automatic attention

- Simon effect (Simon & Wolf, 1963)
- An irrelevant cue can affect response time to a stimulus
- Task: respond as quickly as possible to identify the *color* of the square
- The square is sometimes on the left and sometimes on the right side of the screen (irrelevant)
- You respond with a keypress on the left (green) or on the right (red)

9

Automatic attention

- Location of the square is irrelevant, but it sometimes is congruent with the response location (left-green; right-red) while sometimes it is incongruent (left-red; right-green)

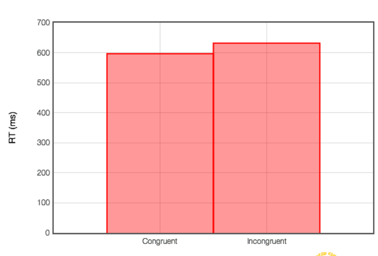


10

Automatic attention

- People are faster identifying color for congruent compared to incongruent conditions
  - 35 millisecond difference

CogLab class data (126 observers)



11

Automatic attention

- The Simon effect is, in some sense, a *failure* of attention
- You want to ignore the location of the target square and only attend the color
  - But you cannot ignore the target location
- CogLab has several labs that play on similar ideas
  - Stroop effect (more next time)
  - Spatial cueing
  - Several labs related to memory and decision making have similar properties

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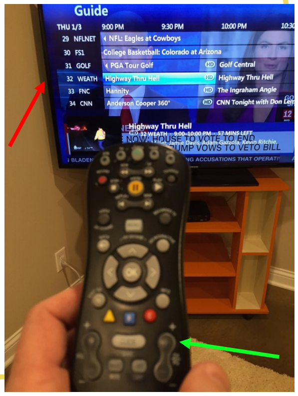
Automatic attention

- These kinds of effects are small (~50 ms), but they matter a lot
- Consider the remote control and on-screen channel guide provided by my cable provider
- To move the "cursor" up on the screen, I press the "+" button the right side
- The effect on the screen is to go "up" one line, but that is to a channel with a *lower* number!



13

Human Factors

- Applied cognitive psychology
- Among other things, design interfaces so that stimuli and responses are compatible
- Products "feel" better, are used as intended, and users make fewer errors
- Really important in high stress situations
  - Aircraft cockpits, nuclear power plant control stations
- Really important in everyday (low stress) situations that are used a lot
  - Your phone
  - Doors

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Drawing attention

- In some situations, attention can be focused by certain stimulus characteristics, especially changes
  - Flashes of light
  - Movement
  - Color
  - Think of advertising signs
- We depend on these characteristics a *lot*
  - Removing these cues can make simple tasks rather difficult

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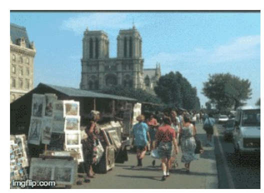
Drawing attention

- Raise your hand when you spot what changes in the two images



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Drawing attention

- Raise your hand when you spot what changes in the two images

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Drawing attention

- Raise your hand when you spot what changes in the two images

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Drawing attention

- Suppose these cues were masked by other changing stimuli
- You might not notice the change at all

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Drawing attention

- Raise your hand when you spot what changes in the two images

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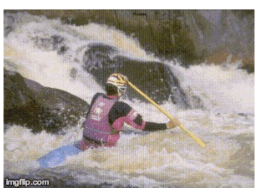
Drawing attention

- Raise your hand when you spot what changes in the two images



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Drawing attention

- Raise your hand when you spot what changes in the two images

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Drawing attention

- Raise your hand when you spot what changes in the two images

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Attention

- Masking the changes makes it difficult to identify the changed parts of the image
  - Suggests that you do not actually "see" the entire image with each presentation
- Attention seems to be *necessary* to detect stimulus changes
- Explains how people can "look" but not "see"
  - walking into doors
  - driving into trains
  - detecting changes on a radar screen
  - why magicians use flashes of light!

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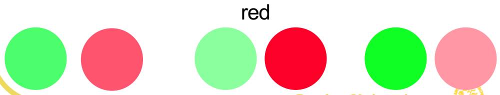
What does attention do?

- It is not clear, and it is probably different things for different situations
- To many people, attended information feels "stronger", so they think neural representations must be stronger in the brain.
- But if attention strengthens perceptual representations, we should lose perceptual veridicality
  - We might expect what is schematized below
  - But we normally do not experience this
- Attention generally seems to strengthen information about a stimulus that is not *perceptual*

Stimulus — Attend red — Attend green



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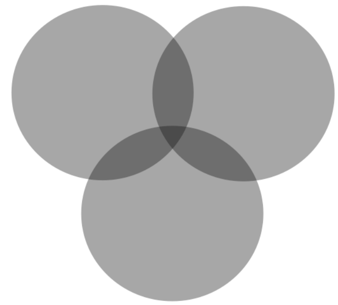
Attention illusion

- Sometimes attention *can* change perceptual properties
- But then we have an incorrect perception of the properties of the visual scene
- So it is difficult to understand how attention is helping here



Tse, 2005

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More demos

- If time permits, here's some more demos
  - http://viscog.beckman.uiuc.edu/djs_lab/demos.html
- Field
- Living room
- Phone call
- Lunch conversation (9 changes)
- Paris scene

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Conclusions

- Attention can have very powerful effects
  - help processing of focused on things
  - can cause unawareness of unattended things
- Not precisely defined
  - characteristic of processing?
  - An "extra" system?

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Next time

- Methods of studying attention
- What things influence attention
  - Timing, features
- CogLabs on Attentional blink and Visual search due!
- *Should you pay $59.95 for* Mega-speed reading*?*

29

Attention

PSY 200

Greg Francis

Lecture 12

Should you pay $59.95 for Mega-speed reading?

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1

Attention

- We saw last time that attention can have very powerful effects
  - when it is focused on one thing, you ignore other things
- Today we want to consider some more specific properties of attention
  - and look at experimental methods that are used to study attention

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2

Characteristics of attention

- By identifying the properties and characteristics of attention we can deduce properties of the underlying systems that are involved in cognition
  - whether attention is thought of as a “system”
  - or as a by-product of other systems
- Look at
  - temporal
  - featural

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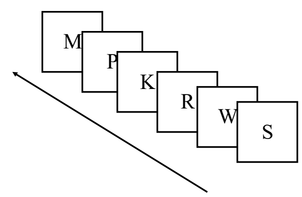
Attentional blink

- Suppose you have to identify rapidly presented (100 ms) letters
  - e.g., detect J and/or K in a stream of letters



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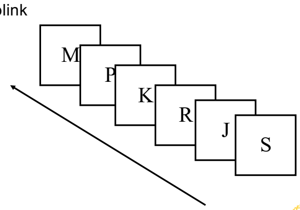
Attentional blink

- Turns out that detection of first letter tends to make detection of the second letter very difficult
  - if it immediately follows the first
  - Attentional blink



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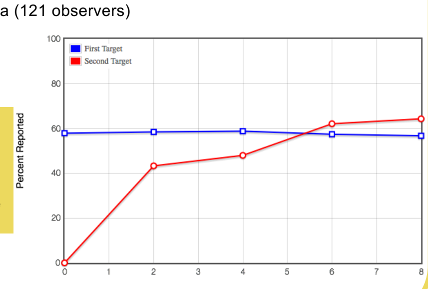
Attentional blink

- Measure frequency of detection
  - class data (121 observers)

Implies that detecting the first letter causes you to miss the second letter!



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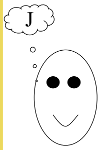
Attentional blink

- Suggests that processing the first target letter, "J"
  - uses up resources that would otherwise be used to process second target letter, "K"
  - attentional focus and refocus takes *time* and for this task takes approximately 400 ms



S
L
N
B
J
R
K
H
...

Once processing is done (a few hundred milliseconds), there is no difficulty detecting second letter.

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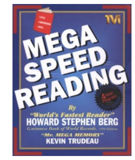
Speed reading

- Ever seen the ads for speed reading?
- One is for a program called *Mega Speed Reading*
  - claims to teach you to read 25,000 words per minute
  - ==> 2.4 milliseconds for each word
  - impossible, if only by attentional blink!
- The seller is skimming at best, and lying at worst



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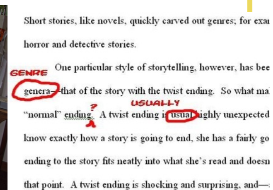
Visual search

- Proofreading
- Much of our time is spent looking for various things
  - Staplers, Road signs


Short stories, like novels, quickly carved out genres; for exa
horror and detective stories.
GENRE One particular style of storytelling, however, has bee
genera that of the story with the twist ending. So what ma
USUALLY
"normal" ending? A twist ending i usual highly unexpected
know exactly how a story is going to end, she has a fairly go
ending to the story fits neatly into what she's read and doesn
that point. A twist ending is shocking and surprising, and—

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Visual search

- Time and type of processing can also be measured by having observers respond as quickly as possible when they detect a target
  - hypothesize that tasks that involve attention will be slower than "perceptually" based tasks
  - expect attention to depend on the number of things that must be searched
- Typically, we distinguish between a target and distracters by one or more features
  - we vary the number of distracters
  - and measure reaction time

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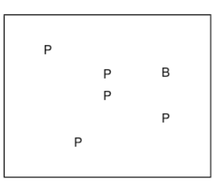
Set Size

- In some situations, more distracters make search take longer
  - fast



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Set Size

- In some situations, more distracters make search take longer
  - slow

P	P	P	P	P	P	P
P	P	P	P	P	P	P
P	P	P	P	P	P	P
P	P	P	P	P	P	P
P	P	P	P	P	P	P
P	B	P	P	P	P	P
P	P	P	P	P	P	P

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Feature Search

- But if the target differs from the distracters in the right way, search can be fast even with lots of distracters
  - "pop out"
- This often happens when the target has a unique *feature* relative to the distracters
  - shape

x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	o	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x

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Feature Search

- But if the target differs from the distracters in the right way, search can be fast even with lots of distracters
  - "pop out"
- This often happens when the target has a unique *feature* relative to the distracters
  - color

x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	o	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x

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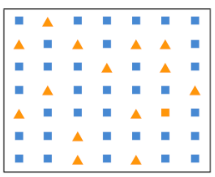
Conjunctive Search

- But if the target has shared features with different distracters, search is difficult
  - No "pop out"
- This often happens when the target is defined by a *conjunction* of features relative to the distracters
  - Orange rectangle: color and shape



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Visual search experiment

- Four types of responses
  - 1) Feature - present (can respond as soon as see target)
  - 2) Feature - absent (must examine all stimuli before sure target is not present)
  - 3) Conjunctive - present (can respond as soon as see target)
  - 4) Conjunctive - absent (must examine all stimuli before sure target is not present)

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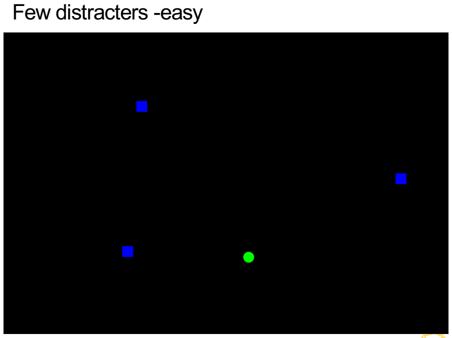
CogLab feature search

- Few distracters -easy



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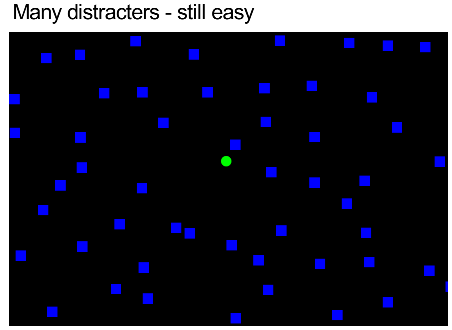
CogLab feature search

- Many distracters - still easy



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Conjunctive search

- Few distracters - fairly easy

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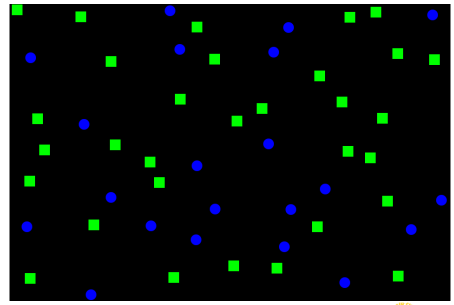
Conjunctive search

- Many distracters - difficult



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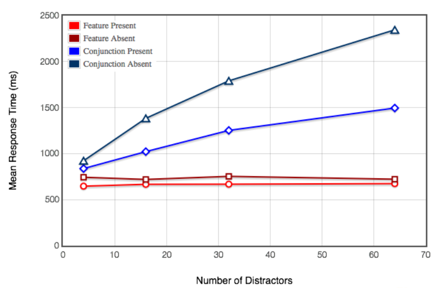
Visual search

- CogLab data (119 observers)



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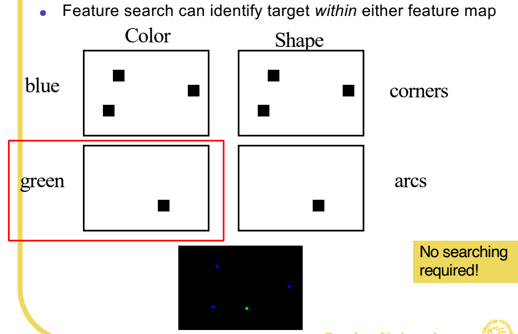
Interpretation

- Feature maps: color, shape
- Feature search can identify target *within* either feature map



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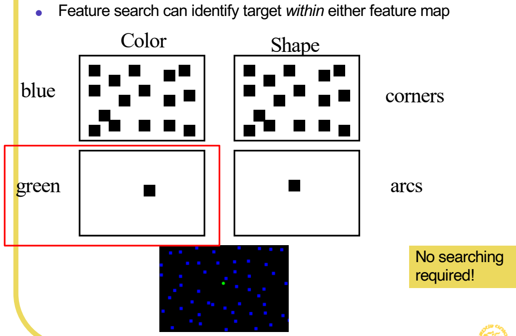
Interpretation

- Feature maps: color, shape
- Feature search can identify target *within* either feature map



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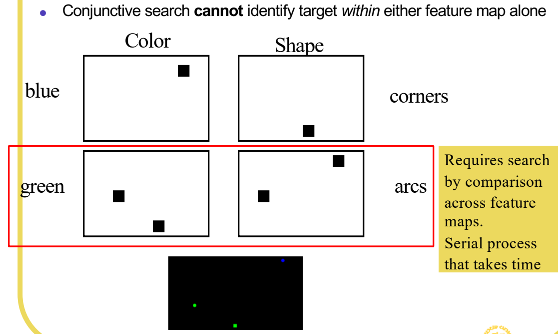
Interpretation

- Feature maps: color, shape
- Conjunctive search **cannot** identify target *within* either feature map alone



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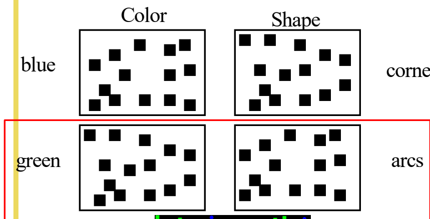
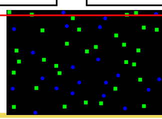
Interpretation

- Feature maps: color, shape
- Conjunctive search **cannot** identify target *within* either feature map



Requires search by comparison across feature maps.
Serial process that takes time



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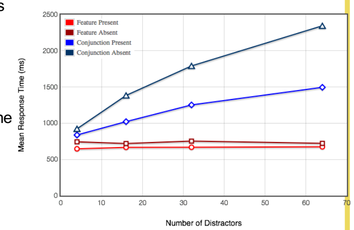
Visual search

- Conjunctive search for target absent has a slope twice as steep as for target present
  - Because when the target is present you find it, on average, after searching half the items and then can stop the search
  - For target absent searches, you must search all items to verify each is not the target



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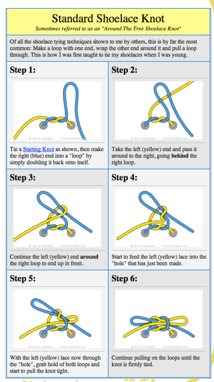
Automaticity

- When a task is unfamiliar it seems to require a lot of attention to perform
- Later it requires less attention
  - riding a bike
  - driving a car
  - typing
  - tying shoelaces
    - » http://www.fieggen.com/shoelace/knots.htm



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Automaticity

- The process whereby a task goes from requiring a lot of attention to requiring little is called *automatization*
- Many tasks are automatizable
  - color naming
  - word naming
- Can measure effects by pitting an automatized task against a non-automatized task

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Stroop task

- Stroop (1935)
- Identify the color of ink for words
- It takes longer when the words are color names
- Demonstration
  - measure reaction time

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Stroop effect

blue green red
yellow red blue
green yellow red
blue green red
yellow red blue
green yellow red
blue green red
yellow red blue
green yellow red

30

Stroop effect

blue green red
yellow red blue
green yellow red
blue green red
yellow red blue
green yellow red
blue green red
yellow red blue
green yellow red

31

Stroop effect

- Word name interferes with ink color naming
  - ink color does not generally interfere with word naming
  - lots of studies on Stroop effect
- Many effects that are similar to it
- You can try it on CogLab
  - Not required, no credit

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Explanation

- Word reading is well practiced
  - especially among college undergraduates
  - so it occurs quickly and is automatic
- Color naming is unpracticed, so it occurs slowly and requires attention
- With two tasks, both trying to report on a color
  - the automatic one tends to mess up the unpracticed one, it takes more mental effort (and time) to do the unpracticed task

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Conclusions

- Methods of studying attention
  - attentional blink
  - visual search
  - Stroop task
- Characteristics of attention
  - timing
  - role of perceptual features
- Automaticity

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Next time

- Intersection of attention, perception, and memory
  - Iconic memory
  - echoic memory
- Serial position curves
- CogLab on Partial report due!
- *Why telephone operators seem rude.*

35

Sensory memory

PSY 200

Greg Francis

Lecture 13

Why telephone operators seem rude.

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1

Memory

- Humans demonstrate memory when they behave in a way that could only be based upon previous experience
  - does not necessarily imply that there are memory *systems*
- Memory could be a by-product of other systems (vision, audition, language,…)

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Perception to memory

- Suppose you want to know how much information is available in a single visual glance
- How would you measure it?
- It turns out it's a complicated task because it involves perception, attention, and memory

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3

Whole Report

- Write down as many letters as you see

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4

Whole Report

- Write down as many letters as you see

B X P Q

M H E L

V N W A

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5

Whole Report

- Write down as many letters as you see

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6

Whole report results

- Subjects report 4.5 letters on average (Sperling, 1960)
- Subjects claim they *saw* more letters, but lost the percept while they reported
  - they cannot report fast enough
- How can we tell if percept is lost?

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7

Partial report

- Same type of letter matrix
- Indicate which row to report *after* the matrix disappears
  - choice of row is *random*
- Suppose the subject reports 3 of 4 letters from *any* row
  - =>3/4ths of *each* row was available
  - ==> entire field was available
- This is essentially how college tests are designed!

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8

Partial report

- Write down letters from the indicated row

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9

Partial report

- Write down letters from the indicated row

S T Y I

R F C Q

Z E V N

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10

Partial report

- Write down letters from the indicated row

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11

Sensory memory

- Temporal characteristics
  - delay

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12

Sensory memory

- Temporal characteristics
  - delay

R Q V L

S D G F

P N B A

13

Sensory memory

- Temporal characteristics
  - delay

14

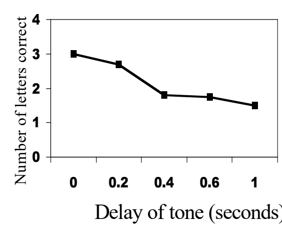
Sensory memory

- Temporal characteristics
  - delay

15

Results

- Vary delay to watch decay from memory
  - compare to CogLab data



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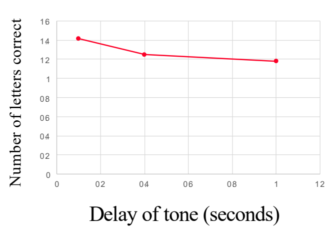
Results

- CogLab data (121 participants)
  - 3 letters in each row



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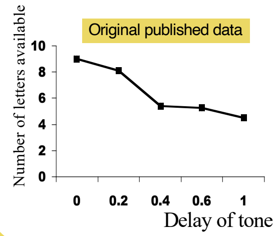
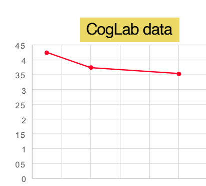
Results

- We can test on any row and get essentially the same result
  - so, the number of letters that actually persist and is available is found by *multiplying* by the number of rows (3)





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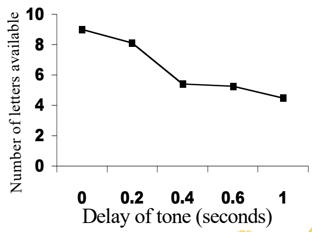
Iconic/sensory memory

- Performance is better than the whole-report procedure because you can focus *attention* on just one row before the percepts fade away
- Fading percepts are due to visual persistence, which we talked about earlier
- We call the use of this information *iconic memory*
  - Large capacity
  - Short duration



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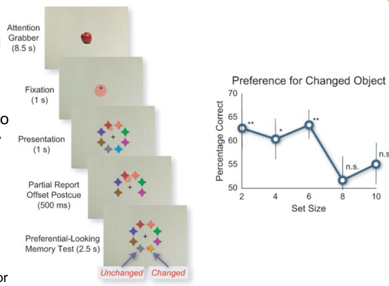
Infant iconic memory

- The partial-report experiment can be modified in several ways
- Blaser and Kaldy (2010) modified it to test iconic memory of infants
  - 60, 6 month old infants
- Infants show a preference to look at the changed object for small enough set sizes



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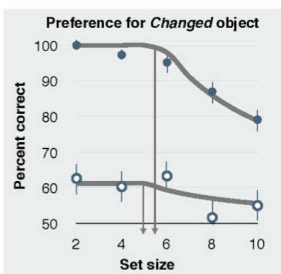
Infant iconic memory

- Infant iconic memory is actually quite similar to adults
- Ask adults to report the location of the changed color item
  - They do better than infants (who did not understand the 'task')
- Look for sharp drop in performance as set size increases
- Estimate items in memory
  - Adults = 5.75
  - Infants = 5.0



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Masking

- Masking effects can influence iconic memory
  - persistence-based memory is *very* brief, and is easily destroyed by a mask
- Iconic memory is
  - brief
  - easily disturbed

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Partial report with masking

- Write down letters from the indicated row

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23

Partial report with masking

- Write down letters from the indicated row

X V F R

W K D M

S N J Y

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24

Partial report with masking

- Write down letters from the indicated row

X X X X

X X X X

X X X X

25

Masking

- With the mask you do not have enough time to focus attention on the indicated row
- Iconic memory is so brief (less than a second) that it probably has little to do with "normal" memory
  - Too brief to be useful for many situations (except maybe knowing how to reach for something just after lights go out)
- Other similar systems are more notable

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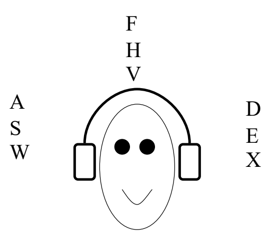
Echoic memory

- Other senses have a similar type of persistence or sensory memory



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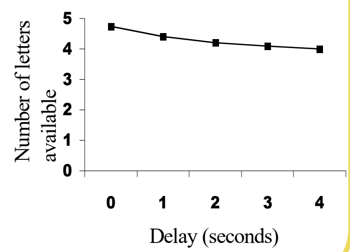
Echoic memory

- Properties
  - Longer duration (seconds)
  - Smaller capacity
- Significant for some memory tasks



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Immediate serial recall

- After given a list of items
  - e.g., digits, letters, words,…
  - subject must report them back
  - 1) no delay (immediate)
  - 2) in the correct order (serial)
  - 3) no cues (recall, not recognition)
- Plot percentage correctly recalled against position of item in list

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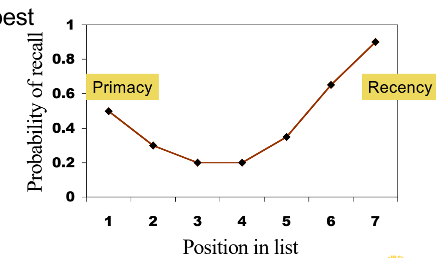
Serial position curve

- Often, subjects recall first and last items best



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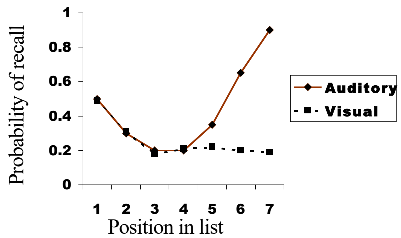
Modality effect

- Recency depends on the *modality* of presentation



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Modality effect

- Explanation:
  - In this task, recency depends on sensory memory
  - It takes time to report all the items in the list, in order
  - in the visual presentation, iconic memory of the last item is gone before subject tries to report it (poor recall)
  - in the auditory presentation, echoic memory of last item is still present when subject tries to report it (good recall)
- Thus, auditory presentation shows recency, but visual does not
- We will explain the primacy effect later

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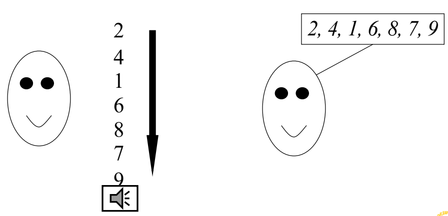
Suffix effect

- Auditory presentation only
- Cue to report is either a word or a tone



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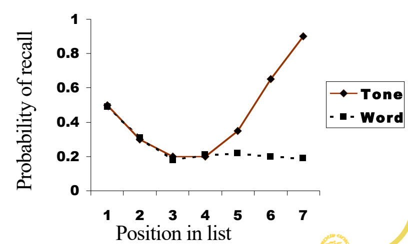
Suffix effect

- Recency when cue to report is a tone
- Loss of recency when cue to report is a word



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Suffix effect

- *Not* affected by
  - practice
  - meaning of cue word
  - common vs. rare word
- Words are *physically* different from tones
  - suffix word acts like a *mask* to wipe out last word in list from echoic memory
  - the situation is similar to being unable to report the letters in the partial report task with the X-masks

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Phone operators

- Call *information* for a number
- Operators are very short
  - give the number
  - do not say “goodbye” or “have a nice day”
- Avoiding the suffix effect!
  - you would forget the last part of the phone number if they finished with pleasantries

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Conclusions

- Partial report experiment
- Sensory memory
  - iconic memory (visual)
  - echoic memory (auditory)
- Relation to immediate serial recall (recency)
  - modality effect
  - suffix effect
  - significance for phone operators

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Next time

- Lecture is a vodcast available on the class web site!
- Memory
- Modal model
  - short term memory
  - long term memory
- Experiments
- CogLabs on Brown-Peterson and Serial position due!
- *Why it is difficult to win a pizza at Little Caesars.*

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Two store model

PSY 200

Greg Francis

Lecture 14

Why it is difficult to win a pizza at Little Caesar's.

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1

Memory

- Simple view
  - memory is a container of past impressions and knowledge
  - memories can leak-out, decay away
- Not very realistic
  - need to explain *why* memories disappear

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Simple view

- The container theory of memory does not explain, for example,
  - why some memories are very long lasting (my childhood car trips to Utah)
  - why some memories are very brief (my wife asks me to take out the trash)
- We are not going to get a full theory of memory, but we can start to get an outline
  - and identify some misconceptions about memory

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Ebbinghaus' experiments

- First memory experiment (1885)
- Measure how long it takes to learn a list of nonsense syllables *perfectly*
  - NOF, QAP, HOS, LEQ, FIK, MEC, KIJ, HOM, NEM, MOJ
- How long does the memory last?
- In what form does the memory last?
- How does it affect future behavior?
- Does it help relearn the list at a later time?

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Ebbinghaus

- Relearn the list at later points in time
  - a different list each time
- Measure how long it takes to *relearn* the list
- Calculate savings

$$\text{Savings} = \frac{Time_{original} - Time_{relearn}}{Time_{original}}$$

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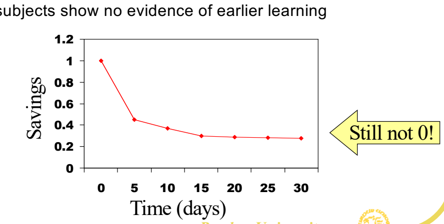
Forgetting curve

- Savings =1
  - subjects do not need to relearn, perfect memory
- Savings=0
  - subjects show no evidence of earlier learning



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Significance

- Ebbinghaus' results suggest that memories can last a very long time, in some form
  - Memories were believed to be "stored" in a memory system and did not just fade away (otherwise, the curve should not asymptote above zero)
  - Memory loss was believed to be due to interference of other memories
- Other experiments challenge this view

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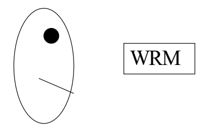
Memory task

- See (or hear) a trigram of consonants
- Report it back in order
- Ebbinghaus' results suggest good memory until other letters are also memorized



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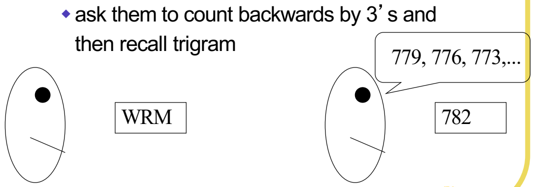
8

Retention

- Peterson & Peterson (1959)
  - Brown (1958)
- Give subjects trigram
  - ask them to count backwards by 3's and then recall trigram



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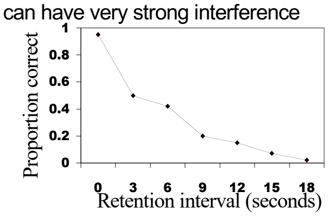
Retention

- Vary duration of counting backward
- Numbers are *different* from letters, you might not expect any interference
  - but they can have very strong interference

Suggests some memories last only a few seconds!



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Retention

- The results of the Brown-Peterson study suggest that some aspects of forgetting are *process driven*
  - keeping a memory "active" requires effort
  - if you are distracted by another task, you cannot apply the effort to keep the memory
  - similar to our observations about attention and processing

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Retention

- The results of the Brown-Peterson study also suggest that some aspects of forgetting are *passive*
  - even if you are distracted, you can recall the trigram if only a short time has passed
  - if many seconds have passed, while you are distracted, you cannot recall the trigram
  - memory has "decayed", or something like decay, while you were doing the distracting task

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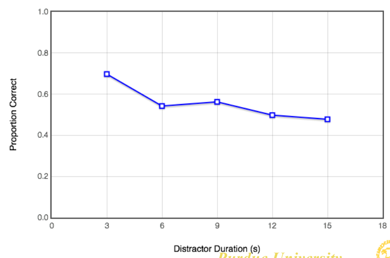
Retention

- CogLab data
  - 124 subjects
  - Not everyone shows interference on this task



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Another experiment

- Memory span
  - how many items can you correctly recall immediately after exposure?
- "The magic number 7+/-2:…"
  - Miller (1956)

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Interpretation

- There exist two types of memory systems
- Long Term Memory (LTM)
  - high capacity (no limit)
  - long duration (forever)
  - Ebbinghaus' experiment
- Short Term Memory (STM)
  - small capacity (~7 items)
  - short duration (seconds)
  - Memory span, Brown-Peterson

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Pizza

- The Little Caesar's in W. Lafayette used to have a game where you could win a pizza
  - must repeat a sequence of flashing lights (changes every time)
  - The sequence gets longer until you make a mistake
  - need a sequence length >7 to win much
    - » Counts number of correct button presses
    - » 56 (sequence of 11 buttons): win a soft drink
    - » 110 (sequence of 15 buttons): win crazy bread
    - » 210 (sequence of 20 buttons): win pizza
    - » nearly impossible with STM properties
  - http://www.freegames.ws/games/kidsgames/simon/simon.htm

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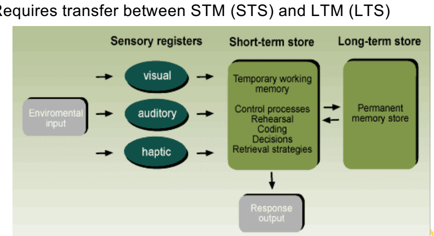
Modal Model of Memory

- Atkinson & Shiffrin (1968)
- Multiple stages of memory
- STM plays a dominant role in active memory
- Requires transfer between STM (STS) and LTM (LTS)



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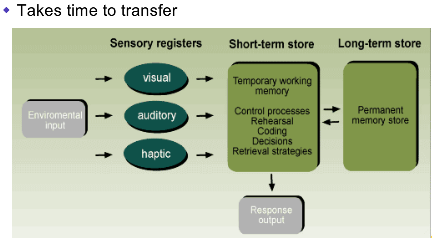
Modal Model of Memory

- When something is memorized
  - Items are first held in STM (temporary store)
  - Items *may* transfer to LTM (permanent store)
  - Takes time to transfer



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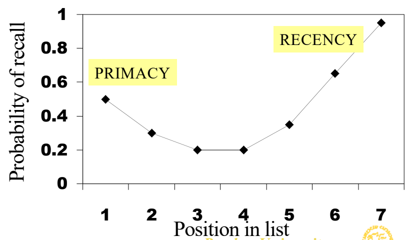
Free Recall Serial Position Curve

- Given almost any list of items
- Subjects remember the first and last few items best (free recall, not immediate serial recall)



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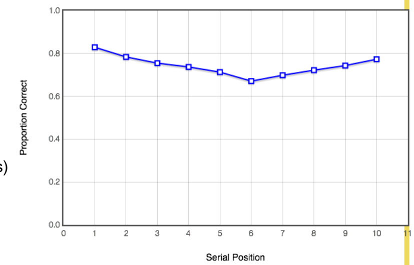
Serial position curve

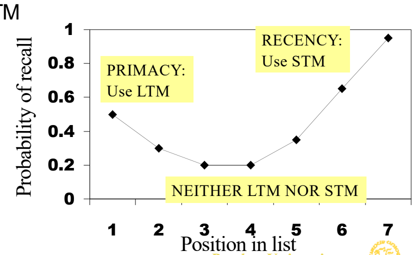
- The effect of position is robust across many types of lists
  - words
  - letters
  - numbers
  - pictures…
- Here's the CogLab data
  - (124 subjects)
- Demo



20

Serial position curve

- In some situations the serial position curve can be explained by different properties of STM and LTM



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Conclusions

- Short Term Memory (STM)
- Long Term Memory (LTM)
- STM / LTM distinction is one of the strongest conclusions of cognitive psychology
- Accounts for quite a bit of data
- Many details are unresolved

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Next time

- Expansion of STM into
- Working memory
  - central executive
  - phonological store
  - visuo -spatial sketchpad
- CogLab on Sternberg search due!
- *Why there is a gate at the first floor stairway in the Psych building.*

23

Working memory

PSY 200

Greg Francis

Lecture 15

Why there is a gate at the first floor stairway in the Psych building.

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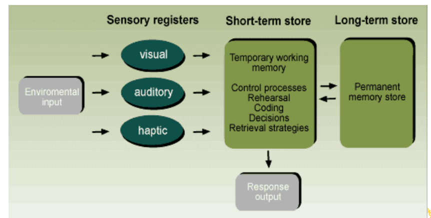
1

Modal Model of Memory

- Atkinson & Shiffrin (1968)
- Today we focus on the Short-term store (Short term memory)



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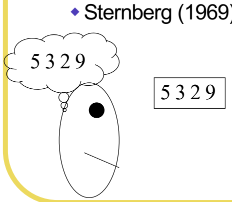
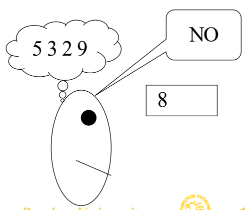
2

Search of memory

- How is memory searched?
  - Sternberg hypothesized three types of searches
- Explore by varying the number of items in memory set (similar to visual search experiments)
  - measure reaction time
  - Sternberg (1969)





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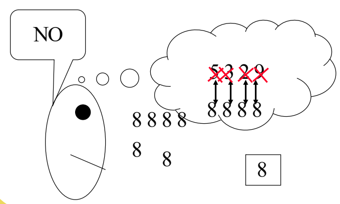
3

Types of searches

- (1) *parallel*: target item is compared to all the items in memory at the same time
  - the answer (yes or no) is returned after all items have been checked



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4

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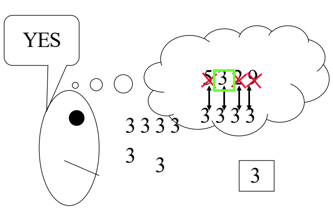

Reaction time is the same for a yes response

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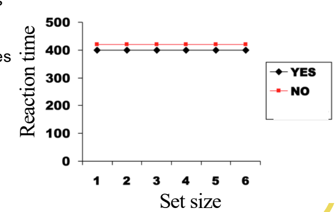
Memory search

- If *parallel search*
  - number of items does not matter
  - Yes and No responses are both flat



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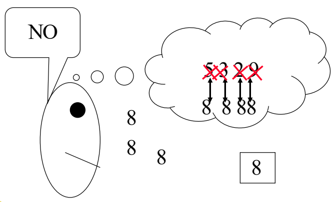
Types of searches

- (2) *serial terminating*: target item is compared to each item one after the other
  - the answer (yes or no) is returned after the target is found or all items are searched



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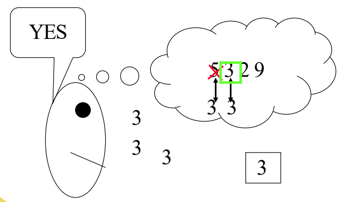

Reaction time is faster for a yes response

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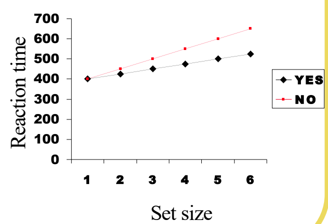
If self-terminating search

- Go through items one-by-one until find target
- RT increases with set size
  - YES RT's shorter than NO RT's
- Lines have different slopes



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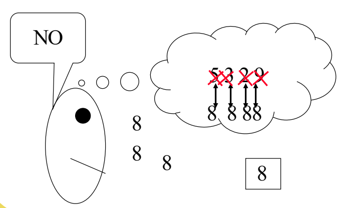
Types of searches

- (3) *serial exhaustive*: target item is compared to each item one after the other
  - the answer (yes or no) is returned after all items are searched (regardless of whether target is found or not)



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Types of searches

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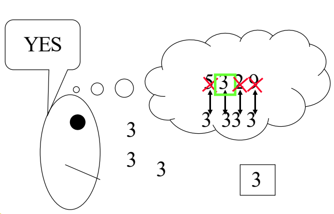
  - the answer (yes or no) is returned after all items are searched (regardless of whether target is found or not)



Reaction time is the same for a yes response as for a no response

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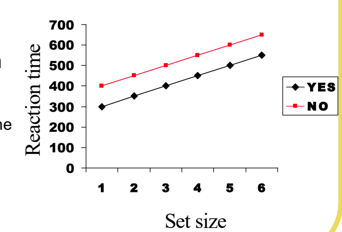
If exhaustive search

- Go through every item and then report answer
- RT's increases with set size
  - YES RT increases the same as NO RT's
- Lines are parallel



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Hypothetical searches

- So, we have three hypothetical ways of searching STM
  - They predict very different patterns of reaction time as a function of memory set size
- Sternberg runs the experiment to see how the data comes out
  - You ran a version of the experiment in CogLab

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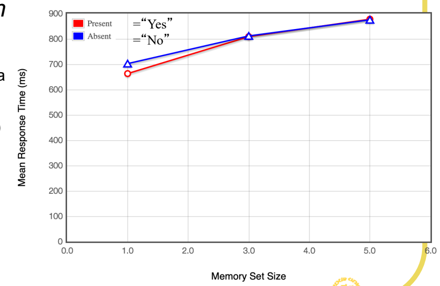
Search of memory

- Sternberg's data support *exhaustive search*
- Here's the CogLab data (153 participants)



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Search of memory

- Implications: Search of STM
  - 1) is serial, one item at a time
    - » and checking each item takes approximately the same length of time
    - » Approximately 40 milliseconds (CogLab data is a bit slower, 49 milliseconds)
  - 2) is exhaustive
    - » search always goes through *all* items

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Search of memory

- These results were a bombshell in 1969
  - finer analysis of cognition than anyone expected was possible
  - used a thought experiment about different types of searches to generate precise testable predictions about cognition
    - » subsequent research found that there were other types of searches that complicate the conclusions
  - counter-intuitive finding
    - » why should search be *exhaustive?*
    - » seems inefficient!

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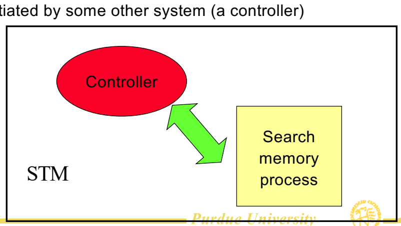
Interpretation

- Exhaustive search makes sense if search of STM is done by some process that is
  - very efficient (can search very quickly)
  - dumb (doesn't bother to stop itself)
  - initiated by some other system (a controller)



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Controller

- Controlling attentional system
  - supervises
  - coordinates
  - starts and stops relatively independent processes
- e.g.
  - Search short term memory
  - Search long term memory
  - walking down stairs
  - gate in psychological sciences building
  - Doors

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Other aspects of STM

- At about the same time, another study indicated important characteristics of phonological and visuo-spatial systems
- Brooks (1968)
  - two types of tasks (visuo-spatial and phonological)
  - two types of responses (visuo-spatial and phonological)
- Identifies two types of systems that are relatively separate

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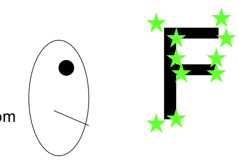
Separate systems

- A complicated experiment
- Part 1: spatial mental task (diagrams)
  - visual imagery
  - classify corners (top or bottom corner?)
  - "yes" if top or bottom
  - "no" if not top or bottom



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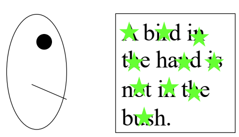
Separate systems

- Part 2: verbal mental task
  - read sentence
  - categorize words (noun or not?



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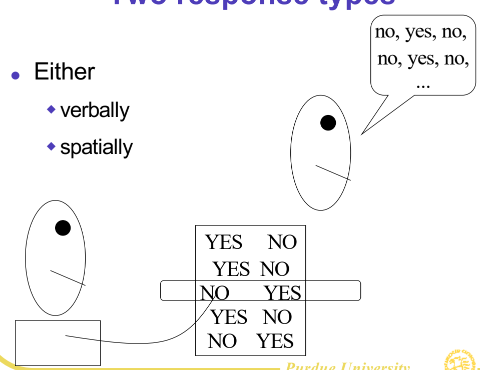
Two response types

- Either
  - verbally
  - spatially



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Results

- Measure time to finish mental task for each response type
  - diagrams -- pointing
  - sentence -- pointing
  - diagrams -- verbal
  - sentence -- verbal

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Results

- Results
  - when you have to respond by pointing, it is easier to work with sentence information than diagram information
  - when you have to respond verbally, it is easier to work with diagram information than sentence information

Response task	Mental task: Diagrams	Mental task: Sentences
Pointing	28.2s	9.8s
Verbal	11.3s	13.8s

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Significance

- The results suggest that there are two relatively separate systems
  - one deals with visuo-spatial information and must do the pointing response and mental diagram task
  - one deals with verbal information and must do the spoken response and the sentence task

Diagrams Pointing | Visuo-spatial information | Verbal information | Sentences Verbal

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Interference

- These system have only limited resources and capabilities
- Asking a system to do two things at once (e.g., pointing and mental diagram) slows down the system
- Splitting responsibilities across the systems (e.g., spoken response and mental diagram) can be done quickly

Diagrams Pointing | Visuo-spatial information | Verbal information | Sentences Verbal

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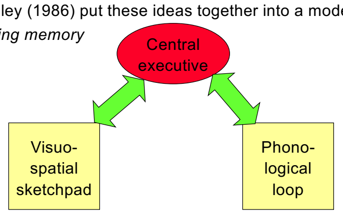
All together now

- Sternberg's study suggests the existence of a "controller" that tells other systems what to do
- Brook's study suggests separate systems that deal specifically with viso-spatial and verbal information, respectively
- Baddley (1986) put these ideas together into a model of *working memory*



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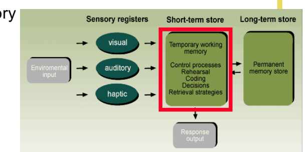
Working memory

- Current thought, awareness
  - extension of short-term memory
  - small capacity
  - rapid forgetting
- Processor of information
  - not a storage device
  - hypothesizes mechanisms that lead to memory properties

Working memory



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Conclusions

- Sternberg's study
  - controller system
- Brook's study
  - separate visual and verbal systems
- Baddley's working memory model
  - Central executive
  - Visuo-spatial sketchpad
  - Phonological loop

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Next time

- Properties of phonological loop
- Data
  - phonological similarity effect
  - articulatory suppression
  - word length effect
  - irrelevant speech effect
- CogLabs on Memory span and Phonological similarity due!
- *A problem with IQ tests.*

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Working memory

PSY 200

Greg Francis

Lecture 16

A problem with IQ tests.

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1

Working memory

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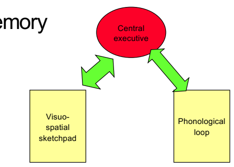

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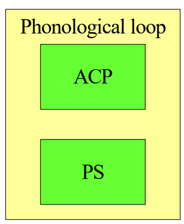
Phonological loop

- Two components
  - Articulatory control process (ACP)
    - » converts non-speech information into speech code
    - » rehearsal / refresh
  - Phonological store (PS)
    - » similar to how we first described STM (items decay from memory)
    - » Refresh restarts the decay process



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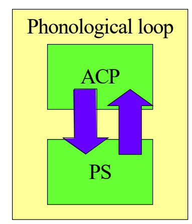
Loop capacity

- How many items can be kept in the phonological loop?
- Depends on two factors
  - Duration before decay from PS
  - Speed of rehearsal
- Spinning coins!



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Magic number?

- We earlier noted that memory span was about 7 items (+/- 2)
- The phonological loop suggests that it is not the *number* of items but their rehearsal duration
- To recall a list of items you must rehearse them *all* before any of them fade
  - The duration of decay in the PS
- Memory span should follow the equation
  - Span = (Rehearsal Rate) X (PS decay time)
- Measure memory span (s): around 7 items
- Measure verbal rehearsal rate (r): around 4 items per second for English speakers
- Estimate duration of decay in PS (d)
  - d=1.75 seconds

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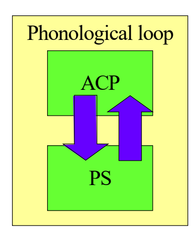
Effect of rehearsal rate

- Capacity of the phonological loop depends on the rate of rehearsal (r)
- A set of items that takes *longer* to rehearse should be *harder* to remember
  - more likely that some items will drop out before you get back to the first item



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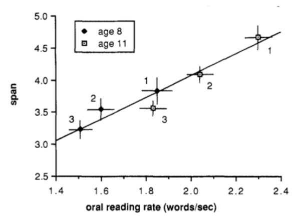
Effect of rehearsal rate

- Explains differences across groups of people
- Age effects in children
  - Hitch, Halliday & Littler (1989)
- This implies that it is not the loop size that changes with age, but the rate of rehearsal

Span=1.68(Oral Reading Rate)+0.71



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Word length effect

- Memory span is related to the length of words
  - Number of syllables
- Nicely matched by changes in reading speed
  - Rate of rehearsal

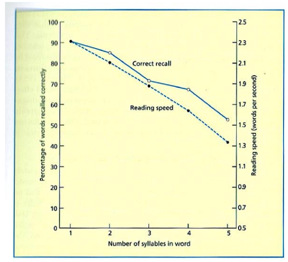

Figure 2.5 The relationship between word length, reading rate, and recall. Long words take longer to rehearse and also produce lower memory spans. From Baddeley, Thomson, and Buchanan (1975). Copyright © Elsevier. Reproduced with permission.

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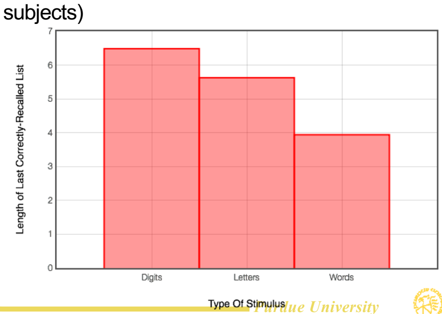
CogLab data

- The CogLab experiment on memory span shows data in agreement with our expectations (169 subjects)



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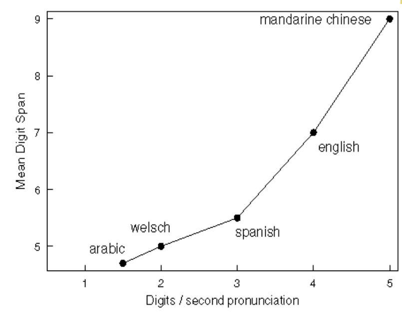
Language effects

- Some languages are spoken more quickly than others
- Should allow larger memory span
  - it does



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Relation to IQ

- Ellis & Henley (1980)
  - investigated complaints about WISC intelligence scores
  - Welsch children tended to score lower than English children
- Part of the exam checks memory span
  - and the slower rate of speech in Welsch partly explains the difference
  - bilingual Welsch students tested in English got better scores than when tested in Welsch

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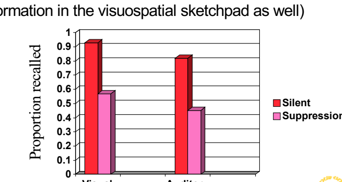
Articulatory suppression

- Subject sees (hears) a list of phonemes
- Also repeats a phrase over and over
  - e.g., "tippy-toe, tippy-toe, tippy-toe,...
- Recall is worse
  - True for both auditory and visual presentation
  - (Recall for visual may be better than auditory because there is some information in the visuospatial sketchpad as well)



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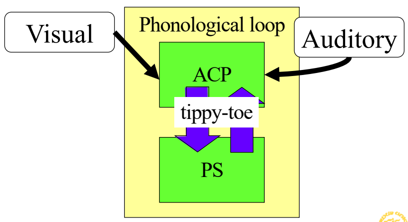
Articulatory suppression

- Repeating phrase ties up the ACP
  - Without rehearsal more forgetting occurs



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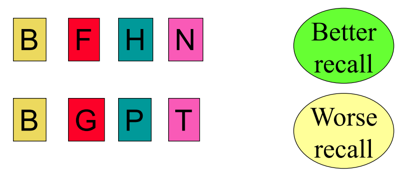
Phonological similarity

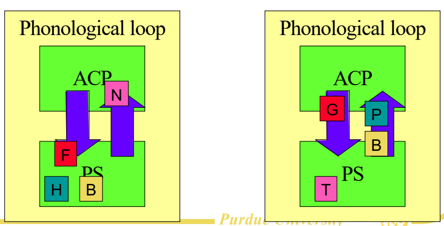
- Memory of a list of items is worse when the items sound the same



14

Phonological similarity

- All items are stored in phonological loop
  - similar sounding items interfere with each other in the phonological loop
  - two possibilities:
    - » **1) harder to rehearse (effect in the ACP)**
    - » 2) fade more quickly (effect in the PS)



15

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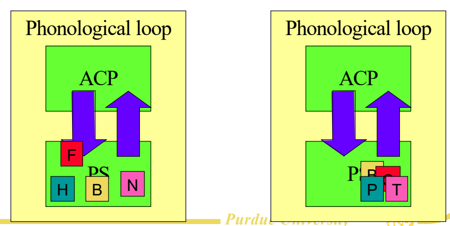

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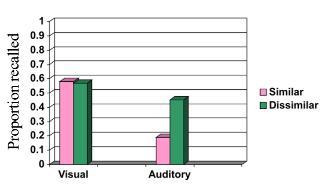
Locus of similarity effect

- Studies find a phonological similarity effect for auditory stimuli under articulatory suppression
  - We suggested two possibilities:
    - » 1) harder to rehearse (effect in the ACP)
    - » 2) fade more quickly (effect in the PS)
- Since the phonological similarity effect is there even when the ACP is not involved, it must be possibility 2 (in the PS)



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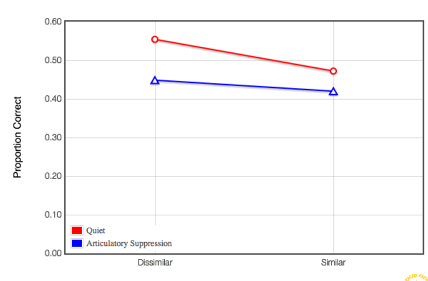
CogLab data

- The CogLab experiment on phonological similarity shows data in (somewhat) agreement with our expectations (161 subjects)
  - Ideally want parallel lines



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Irrelevant speech effect

- Does irrelevant "background" sound affect memory?
  - E.g., studying with the TV on
- Three groups of subjects recall consonants
  - 1) no background — best
  - 2) background = nonsense words — worst
  - 3) background = noise bursts

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Irrelevant speech effect

- The presence of *phonemes* in the background is critical to the effect
  - strong effect when background is spoken in German, even for English speakers
- Suggests that background phonemes interfere in the PS
- Study with classical music if you need something!

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Conclusions

- Data accounted for by phonological loop
  - word length effect
  - phonological similarity
  - articulatory suppression
  - irrelevant speech effect
- Don't listen to lyrical music while studying
  - Classical music is fine

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Next time

- Review for Exam 2
- After exam 2
- Encoding specificity
- CogLab on Encoding specificity due
- *What to do if you are drunk while studying for an exam.*

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Encoding specificity

PSY 200

Greg Francis

Lecture 17

What to do if you are drunk while studying for an exam.

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1

Context

- The context within which you learn and recall can have a profound impact on your memory
  - e.g., part-set cueing
  - given part of a set that has been learned, subjects recall *fewer* of the *remaining items* than with normal free recall
  - Interference of recall
    - » Have to keep checking if an item you recall is already on the list
- Demonstration

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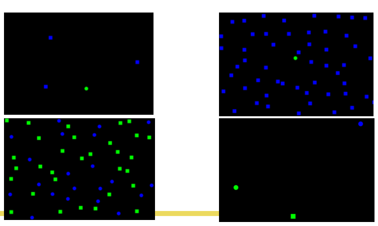
Context

- The effect of part-set cueing suggests that to measure memory you must consider the conditions at *test*
  - Memory is more often about *discrimination* of memory traces and not about the *strength* of memory traces
  - Similar to visual search experiments



Feature search

Conjunctive search

3

Context

- But memory is not exactly the same as visual search
- Information must be encoded in memory as well as recalled
  - Such encoding can alter what features are stored as part of the memory
  - Which changes the discrimination of subsequent recall
- It turns out, that to maximize recallability
  - the effort and conditions at the time of learning must be consistent with the properties and conditions of the test
- *Encoding specificity principle*

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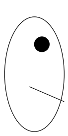
Representative study

- Subjects in two groups
  - see the same words, but have different tasks
  - This changes the *encoding* of information in memory

Semantic judgement

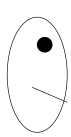
CHEESE



The man threw the ball to the ______.

Rhyme judgement

CHEESE



SNEEZE

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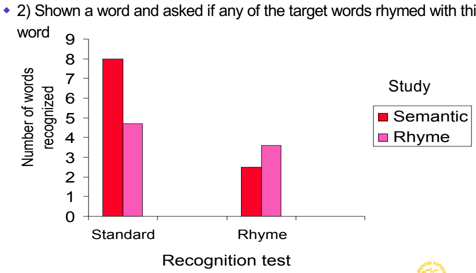
Test

- Each group is then split into two subgroups that vary in the *recall* of information
  - 1) Normal recognition task
  - 2) Shown a word and asked if any of the target words rhymed with this word



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Significance

- It is not that one learning strategy is better than the other
  - or that one testing strategy is better than the other
- Encoding (learning) of information and recall of information need to match
- This means it is very difficult to test for absolute memory
  - subject's performance depends on *many* factors

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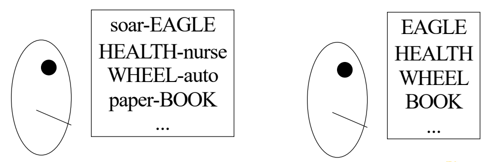
Encoding specificity

- Memory is better when the cues available during recall match the cues available during encoding
  - Tulving & Osler (1968)

Cue

No cue



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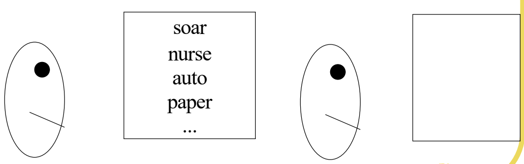
Encoding specificity

- Each group split into two groups for testing recall
  - cue is *always* related to target word

Cue

No cue



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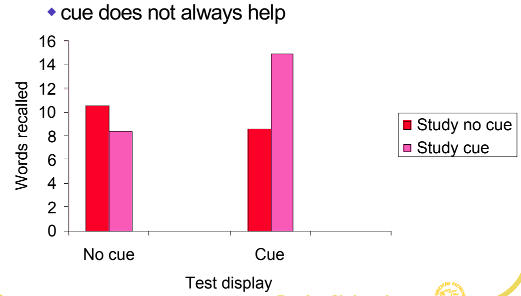
Encoding specificity

- Results
  - cue does not always help



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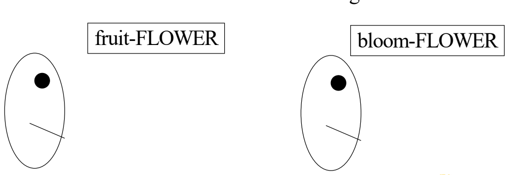
10

Encoding specificity

- CogLab has a variation of this experiment
- Instead of cue-no cue, we used strong or weak cue (48 word pairs to study)

Weak cue

Strong cue



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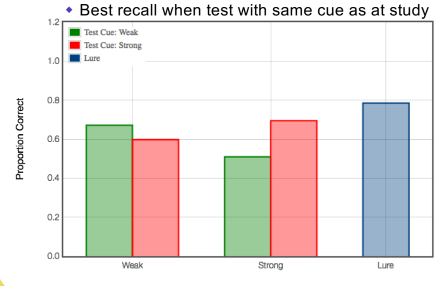
11

Encoding specificity

- Class esults (170 participants)
  - Best recall when test with same cue as at study



"Lure" is a word that was not studied

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12

Surrounding context

- Deep-sea divers learn words (Godden & Baddeley, 1975), either
  - on land (dry)
  - under water (wet)

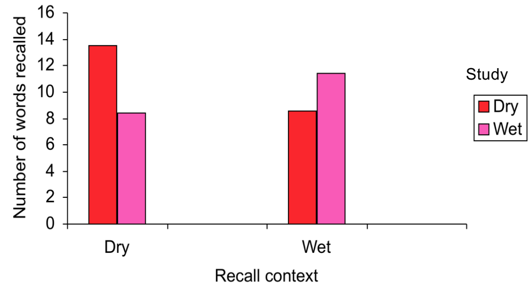
EAGLE
HEALTH
WHEEL
BOOK
...

EAGLE
HEALTH
WHEEL
BOOK
...

13

Surrounding context

- Test for recall on land (dry) or under water (wet)



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Significance

- Decompression tables for divers
  - want to remember when under water
  - generally study while on land
- Researchers working under water have difficulty recalling their details on land
  - E.g., counts of species
- How do you know if something is forgotten?
  - changing context may allow subject to recall seemingly forgotten information
  - forgetting = retrieval problem?

15

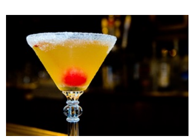
Forgetting

- Forgetting is not always a characteristic of a memory system, or your brain
  - although it could be in some cases, it is not always
- Forgetting *must* be defined operationally
  - specify the task and context of retrieval
  - You can never be certain that if you are placed in a different context you will still show forgetting

16

Internal context

- Goodwin et al. (1969)
- Subjects drink 10 oz. 80 proof vodka, mixed in sugar-free lemon-lime drink
  - or a similar tasting drink (bit of vodka on top of drink)
- Test memory 24 hours later
- Subjects are either:
  - Sober at study, sober at test
  - Drunk at study, sober at test
  - Sober at study, drunk at test
  - Drunk at study, drunk at test



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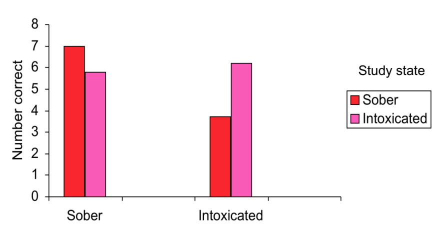
Internal context

- Best recall if study and test states are the same
  - Similar effects for marijuana cigarettes (Eich et al., 1975)



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Testing

- So, if you are intoxicated while studying for an exam
  - and you didn't study before
- You should be intoxicated while taking the exam

19

Mood

- Mood has a similar effect (Eich et al, 1994)
  - Mood induced by music and directed thoughts

20

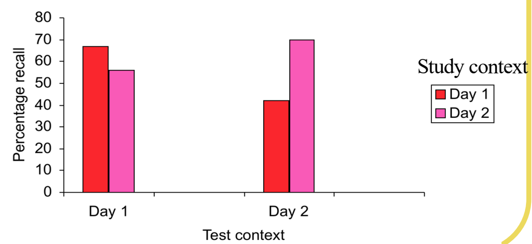
Classrooms

- Is memory better when you are tested in the same room as lectured?
  - significant for final exams!
- Smith et al. (1978)
  - Subject studied words in one of two contexts (on separate days)
  - Varied classroom and dress of experimenter

21

Classrooms

- Subjects recall all words either in the context of Day 1 or Day 2 (different contexts for different subjects)
- Recall was best for words that were studied in the test context



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Conclusions

- Context
- Encoding specificity
  - memory best if study and test are similar
- Cues
- Environment
- State
- Mood
- Classrooms

23

Next time

- Discrimination in memory
- Proactive interference (PI)
- Release from PI
- CogLab on False memory due!
- *How to take a test.*

24

Memory discrimination

PSY 200

Greg Francis

Lecture 18

How to take a test.

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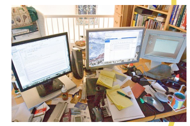
1

Discrimination

- Many cognitive tasks require you to discriminate between events/stimuli
  - Is this a real smile?
  - Is this fruit ripe?
  - Is there a stapler on the desk?
- The same kind of discrimination is required for memory





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2

Discrimination

- Discrimination is difficult because memories can come from lots of different sources
- Consider so-called "False memory" studies
  - as in CogLab
  - subject views a list of words
  - the list of words have something in common
    - » they are all related to a *target* word

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3

False memory

- An example list is
  - *smooth, bumpy, tough, road, sandpaper, jagged, ready, coarse, uneven, riders, rugged, sand, boards, ground, gravel*
  - the special target is *rough*, which is not shown to the subject
- After viewing the list, the subject must go through a set of words and identify which ones were in the just seen list
  - some words were in the list
  - some words were not seen
    - » including the special target

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False memory

- The main finding is that the special target is often identified as part of the just seen list
  - even though it was not
- Sometimes people will even report that they recall "seeing" the special target
  - but this is impossible because it was never shown
- CogLab data (163 participants)

Type of selected items	Percentage of recalls
In original list	78.5
Normal distractor (not in list)	7.9
Special distractor (not in list)	78.5

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False memory

- These types of findings suggest that our memories are
  - not necessarily accurate, we can remember things that never occurred
  - able to be manipulated, to a certain extent, I can make you have certain memories
- Why does the false memory effect happen?

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False memory

- With every to-be-remembered item you store some information, but not only information about the item
  - Other information is automatically generated as well
  - *smooth, bumpy, tough, road, sandpaper, jagged, ready, coarse, uneven, riders, rugged, sand, boards, ground, gravel*

Memory: Item 1
smooth
rough
baby

Memory: Item 2
bumpy
smooth
rough
baby
road

Memory: Item 3
bumpy
smooth
tough
rough
baby
nails
road

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False memory

- At the end of the trial, you have a lot of items in memory that are related to the list
  - Some of them are items that were actually on the list and some of them are items that were "generated" but not actually on the list
  - Reporting all items from memory is not going to lead to good performance
  - Both types of memory items are real, but only one type matches the physical stimuli
- Good performance on this task requires *discrimination* between memories generated by physical stimuli and memories generated by internal processes
  - Source monitoring

jagged
stones
bumpy
smooth
peaks
tough
rough
baby
sandpaper
nails
gravel
road
uneven

Memory

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Discrimination

- Good memory recall usually requires not only recall of an item from memory
- You also must identify the correct item relative to the appropriate context or time frame
  - The current trial
  - The context of the experiment
  - Relative to an earlier event
  - At a particular moment in time

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Interference

- Retroactive interference (RI)
  - new information prevents recall of previous information
  - e.g., Overwriting a computer file.
- Proactive interference (PI)
  - prior learning prohibits new learning
  - e.g., Learning new cultural customs.

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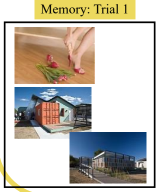
Proactive interference

- May be due to a variety of effects
  - One is that memory involves discriminating new from old
- Visual memory
  - See a set of photos
  - Then see a test photo and decide if new or old

Memory: Trial 1



Memory: Trial 2

Memory: Trial 3

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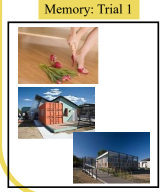
Proactive interference

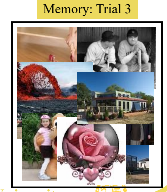
- Suppose you see this building as the test on the third trial
  - You have a match in memory, but is from trial 1, not trial 3
  - You may report it having been shown in trial 3
- In general, previous trials make memory discrimination more challenging

Memory: Trial 1



Memory: Trial 2

Memory: Trial 3



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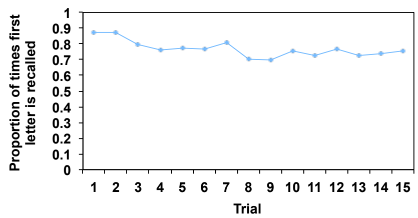
Proactive interference

- One finds proactive interference for lots of memory tasks
- CogLab serial position experiment
  - I looked at recall of the *first* letter in each list, averaged across all students



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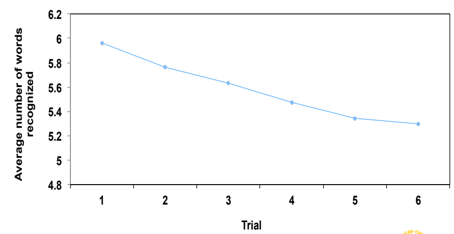
Proactive interference

- One finds proactive interference for lots of memory tasks
- False memory experiment
  - I looked at recall identification of the normal words in the list



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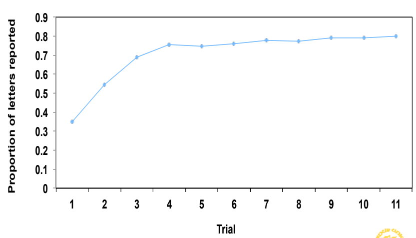
Proactive interference

- Inference does not happen for *all* experiments
  - Just those related to memory
- Partial report experiment (first 12 trials had the cue *before* the letter matrix – to give you practice)



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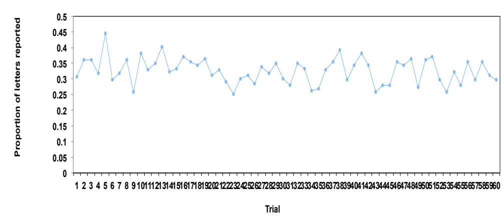
Proactive interference

- Inference does not happen for *all* experiments
  - Just those related to memory
- Attentional Blink experiment (detection of the first letter in the stream)



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Release from PI

- Proactive interference weakens for different stimulus types
- Run two Brown-Peterson type experiments

Control		Experimental
XJF	Trial 1	XJF
WRM	Trial 2	WRM
DBL	Trial 3	DBL
NRX	Trial 4	942

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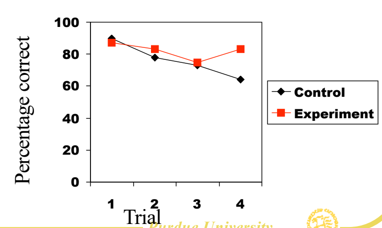
Release from PI

- Trials 1-3 show build up of PI
- Experimental group shows *release* of PI on Trial 4



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Release from PI

- Works for many kinds of memory tasks
- Many kinds of stimuli

5, 7, 9, 1
vs
5, 7, 9, HAND

NICE, SUNNY, ENJOY, PUPPY
vs
NICE, SUNNY, ENJOY, KILL

News stories

D, D, D, D
vs
D, D, D, F

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Memory system

- Every memory system must have at least two components/processes
  - Storage
  - retrieval
- We have described proactive interference as being due to difficulty discriminating new items from previous items
- But there is an alternative explanation
  - Proactive interference might prevent items from being stored and thereby make them unrecallable

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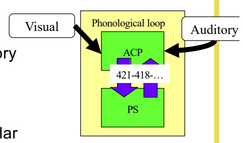
Working memory

- For example, working memory has a storage interference hypothesis for the phonological loop
- Working memory suggests that interference can occur
  - by blocking ACP rehearsal (articulatory suppression, Brown-Peterson task, word length effect)
  - within the PS when items sound similar (phonological similarity effect)
  - both of these interference types block the *storage* of items (items fall out of the loop)



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Testing models

- Test storage vs. recall of PI by changing instructions *after* the list is presented
- Experiment
  - stimuli are names of indoor and outdoor games
  - subjects usually do not notice that word on the fourth trial is an *indoor* game and others are *outdoor* games
- Take two groups of subjects
  - one has traditional PI type experiment
  - one is told of difference on fourth trial, at the time of test

Trial 1	FOOTBALL
Trial 2	SOCCER
Trial 3	BASEBALL
Trial 4 ★	WALLYBALL

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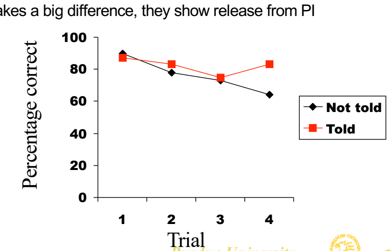
Interference at recall

- If PI prevented the last item from being *stored* your telling a subject that the fourth item was an indoor sport, should make no difference (other than guessing)
  - but it makes a big difference, they show release from PI



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How to take a test

- Avoid PI
- Answering successive questions on the same topic hurts recall
  - after answering unrelated questions
  - go back to questions you cannot answer
  - less proactive interference
  - should recall more

ACT

T1, T1, T1, T1
vs
T1, T1, T1, T2

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Conclusions

- Discrimination
- Retroactive interference
- Proactive interference
- Release from PI
- Strong effects
- Knowing about can help in everyday tasks

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Next time

- Constructive memory
- Flashbulb memories
- Memory misattribution
- Misleading questions

- *How good is eye-witness testimony?*

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26

Constructive memory

PSY 200

Greg Francis

Lecture 19

How good is eye-witness testimony?

1

Memory test

2

Discrimination

- The task is difficult because you have to do several things
  - Recall information that might be related to the task from memory
  - Determine if the memory is actually for the correct event
  - Determine if the memory is actually for the correct moment in time
  - Gauge your confidence in the memory's validity
- All of this suggests that performance on a memory task involves discriminating information
- To address the discrimination problem, people engage in a *constructive process* to report memories

3

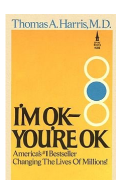
No forgetting?

- Brain surgeon (Penfield, 1959)
  - Epilepsy patients
  - stimulate brain regions before operating
  - want to know what is being removed
- Conscious patients report vivid memories
  - unable to recall normally
    - » "she saw herself as she had been while giving birth to her baby."
  - stimulation of temporal lobes
- In the image, numbers indicate places where stimulation evoked different reported experiences

4

No forgetting?

- Suggests that memories are stored but normally unreachable (context things again)
- Basis for ideas of memory repression (and a few self-help books)
  - The results are usually misunderstood
  - Actually only occurred for 5% of patients



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Penfield (1959)

- Even worse…
  - the memories are nearly impossible to verify
  - the few attempts find that the "memories" are not true
    - » people describe places they have never visited, impossible events, fantasy,…
  - The patients have epilepsy
    - » Stimulation may have triggered something like an epileptic seizure (which can have hallucinations)
- It is more likely that stimulation "feels like" a memory, even though it is not
  - your awareness of "remembrance" is a product of your brain
  - it can be stimulated, even without a real memory
- What do we mean by a valid **memory**?

6

Flashbulb memories

- Highly emotional events tend to produce strong memories
- e.g.
  - JFK assassination
  - Challenger explosion
  - Oklahoma City bombing
  - Earthquakes
  - September 11, 2001
  - ...

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Flashbulb memories

- People *vividly* recall details surrounding event
  - where they were when they heard
  - what people said
  - clothing worn
  - time of day,..
- People are *confident* about their reports
  - however...

More facts of nature: All forest animals, to this very day, remember exactly where they were and what they were doing when they heard that Bambi's mother had been shot.

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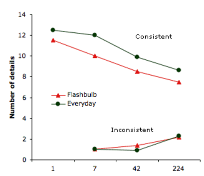
Flashbulb memories

- Talarico & Rubin (2003)
- On *September 12, 2001*
- Asked volunteers to answer questions about their memory of
  - The WTC attack
  - An ordinary event (volunteer's choice)
- Three groups for follow up
  - 7 days later
  - 42 days later
  - 224 days later
- Recalling of details was the same for WTC attack and ordinary event



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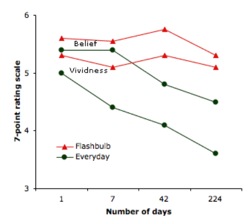
Flashbulb memories

- The memories of the WTC attack were more vivid
- Subjects believed those memories were more likely to be reliable
- Ordinary memories
  - Faded in vividness
  - Belief decreased over time



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Flashbulb memories

- Subjects *confidence* in their memory can be misleading
  - retelling of the story ("I remember vividly when Kennedy was shot. I was…") probably reinforced the *story*
  - Maybe not the true memory
- Flashbulb memories are a real phenomenon about the *experience* of memory,
  - but probably not "super-memory"

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Memory misattribution

- Donald Thomson was accused of rape and picked out of a lineup by the victim (Schacter, 1996)
- He was on live TV at the time of the rape
  - Ironically, he was discussing memory of faces for eyewitness testimony
- The victim
  - had the TV on at the time of rape
  - misattributed the face on TV for the face of her attacker
  - very accurate report of the crime, otherwise

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Eyewitness testimony

- I will show you a series of slides and then ask you some questions

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14

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21

22

Questions

- Did the bus, which came by, come from the left or the right?
- Did another car pass the Red Datsun while it was at the intersection with the stop sign?
- Did you see a bicycle?
- Did you see the taxi cab?
- Did you see if the policeman wrote anything down?

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Eyewitness testimony

- Later, show slides and ask subjects if they were part of the original set
- Key test is for a pair of slides (between subjects)
  - real slide contains YIELD sign
  - fake slide contains STOP sign

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Eyewitness testimony

- "Misinformation effect"
  - Loftus & Palmer (1974)
- Compare accuracy according to pre-test questions
  - Subjects without a misleading question--90% accurate
  - Subjects with a misleading question -- 20% accurate
  - In a follow-up, the experimenters asked those with misleading questions if they thought they were misled
    - » 90% say no
- Paying money for correctness also had no effect

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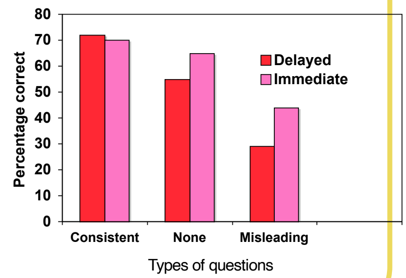
Eyewitness testimony

- Loftus, Miller & Burns (1978)
- The misinformation effect gets stronger with a week delay before the memory test



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Memory implants

- Loftus has a procedure that "implants" a memory of being lost in a mall
  - Basically just have subject read a plausible story (with some details that could be true)
  - Get family members to pretend the story is true
  - Later the subject "remembers" the story as something that happened to him/her
- It is very easy for a therapist to "implant" false memories into patients

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Conclusions

- Many techniques believed to provide accurate memories, do not
  - flashbulb memories
  - brain stimulation
- Memory is constructive
- Memories can be easily influenced by questions, interpretation, and context

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Next time

- Amnesia
- Anterograde amnesia
- Retrograde amnesia
- Unusual characteristics
- Repression
- CogLab on Forgot it all along due.
- *What's wrong with my wife?*

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Amnesia

PSY 200

Greg Francis

Lecture 20

What is wrong with my wife?

1

Fundamental fact

- There is no method other than object physical evidence to verify the accuracy of a memory
- Memory is a cognitive *experience*
  - Confidence in the memory is another cognitive *experience*
  - You can be very confident and still be wrong
- Of course, we must be correct fairly often, or our lives would be a total mess!

2

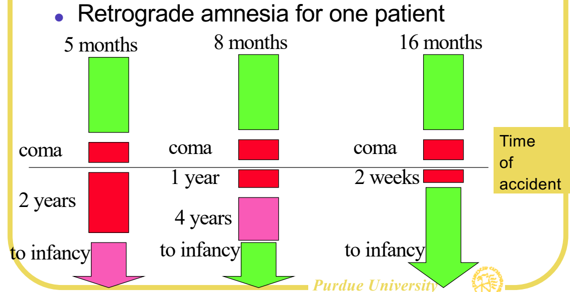
Amnesia

- Loss of memory or memory abilities
  - retrograde: forgetting events prior to the injury
  - anterograde: forgetting events after the injury
- In most cases amnesia is limited in scope and duration
  - like when my brother Joe slipped while playing frisbee

3

Amnesia

- Scope and duration
- Retrograde amnesia for one patient



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What's wrong with my wife?

- Nothing!

- But she cannot remember anything before her senior year in high school
  - motor cycle accident
  - complete *retrograde* amnesia

5

An unusual case

- Side issues
  - Sense of smell
  - Mild anomia
  - Odd aphasia (language deficit)
- She *is* able to learn and remember new information
- Remarkably unaffected by the loss of memories
  - Personality
  - Parents
  - college
  - makes study of retrograde amnesia difficult

6

What is lost?

- How can someone who loses their childhood memories go to college the next year?
  - memories cannot be "wiped clean"
  - perhaps they are just not directly accessible
  - forgetting = recall problem?

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What is lost?

- More generally,
  - while patients with retrograde amnesia forget their names, parents, addresses,…
  - they do **not** generally forget how to walk, talk, solve problems
    - » Although they may have problems…
  - Different types of memory systems
    - » controversial!

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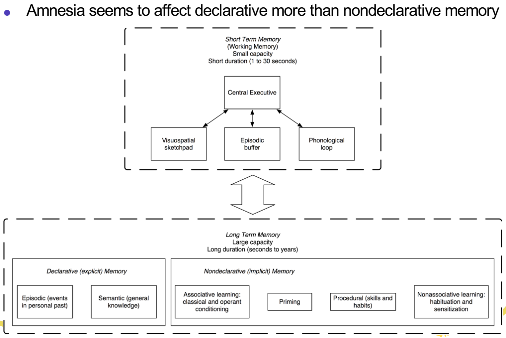
Memory systems

- There are many different types of memory
- Amnesia seems to affect declarative more than nondeclarative memory



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Anterograde amnesia

- Some patients have amnesia that preserves past memories but prevents formation of *new* memories
  - many are long-time alcoholics who did not eat properly
    - » which leads to a thiamine deficiency
    - » which leads to Korsakoff's syndrome
- Leonard in *Memento*

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Patient HM

- Surgery on hippocampus (to control epilepsy)
- anterograde amnesia
  - unable to learn anything new
- Thought it was 1953
  - shocked by age of face in his mirror
  - Could not stand to read newspapers
  - reintroduced himself to doctors, nurses,…
- *Could* carry on a conversation!

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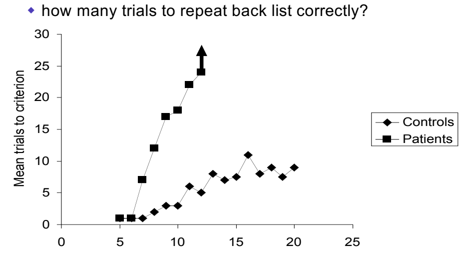
Anterograde amnesics

- Fairly normal STM digit span (~7 items)
- But very difficult to extend digit span
  - how many trials to repeat back list correctly?



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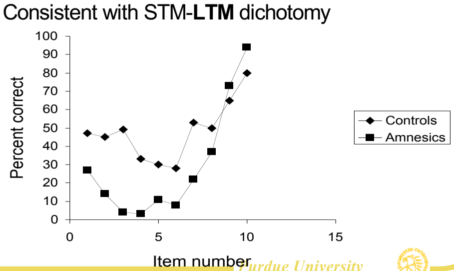
12

Serial position curve

- Normal recency
- Abnormal primacy
- Consistent with STM-**LTM** dichotomy



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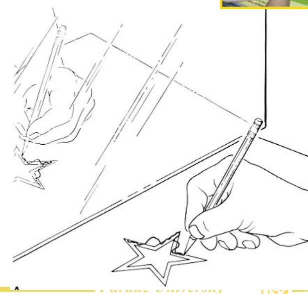
Patient HM

- Could learn some things!
  - E.g., location of hospital cafeteria
  - E.g. mirror drawing task



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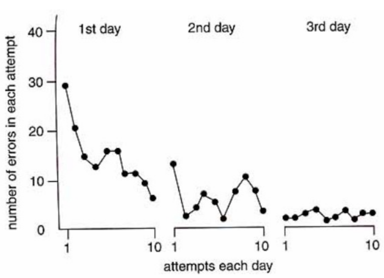
Patient HM

- Mirror drawing task (Milner, 1968)
- HM had no knowledge of doing the task before!



15

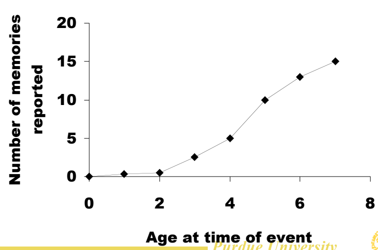
Amnesia-like memory

- Some aspects of memory seem very much like amnesia
  - infantile "amnesia"
  - repressed memories
- Careful studies are difficult to come by because the memories (and absence thereof) must be verified
  - remember the "fundamental fact" at the start of today's lecture

16

Infantile amnesia

- Most people report that they cannot remember anything that happened to them before age 4 years



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Infantile amnesia

- Reason is unknown, but the best theory goes like this…
  - children younger than 4-years-old view the world differently from adults
  - by encoding specificity, one needs to be in a similar state as study to best recall something
  - adults are *very* different from children, and this prevents recall of early memories

18

Repression

- Psychotherapists (e.g. Freud) suggested that infantile amnesia occurred because much of childhood is filled with painful events and memory of the pain is prevented by psychological defense mechanisms (repression)
- This is very unlikely
  - people do remember painful events well
  - laboratory studies find no evidence of repressed memories

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Repression

- In a laboratory, showing evidence of repression requires
  - being unable to remember something
  - being able to recover the memory through therapy
  - proving that the recovered memory is accurate

20

Repression

- In therapy, clinicians often claim evidence of repression with
  - dream interpretation
  - patterns in symptoms
  - recovering a memory through hypnosis
- None of these techniques demonstrate a verified memory
- Among carefully controlled memory research, there is no evidence of repression!

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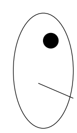
Discovered memories

- However, it is possible for information that was once known to be forgotten and then (re)discovered
- CogLab's Forgot it all along experiment demonstrates this property
- Phases I and II are like an encoding specificity experiment

Study with cue

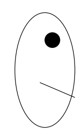
cup-DESK



Test with same or different cue

cup-D _ _K

pan-D _ _K



22

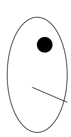
Discovered memories

- Phase III: judge your memory for an item in phase II
- We only care about the items that you correctly recalled in Phase II

Did you recall the upper case word?
(same or different cue)

cup-DESK

pan-DESK

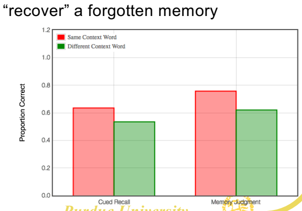


23

Discovered memories

- Results:
- Phase II (cued recall): encoding specificity effect
- Phase III (memory judgment): remembering recall is also affected by cue type
- Thus, it is possible to forget that you remembered, and a change of cue would allow you to "recover" a forgotten memory

Class data
172 participants



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Conclusions

- Retrograde amnesia
- Anterograde amnesia
- Learning in anterograde amnesics
- Infantile amnesia
- Repression

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Next time

- Encoding specificity
- Levels of processing (CogLab due!)
- Judgments of learning
- Practice testing
- Learning styles
- *How to improve your memory without spending $20.*

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Improving memory

PSY 200

Greg Francis

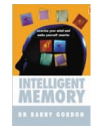
Lecture 21

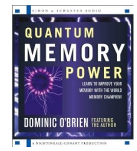
How to improve your memory without spending $20.

1

Memory

- We seem to be unable to control our memories
  - learn things we don't want to remember
  - unable to learn things we want to remember
- Is there any reliable cue that something will be remembered?
  - no
  - but there are several tricks you can use to improve memory in certain situations





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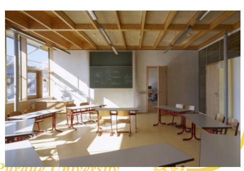
Encoding specificity

- We know that memory is best when study and test contexts are similar
  - For example, testing in the study classroom
- But variability in study promotes more general recall
  - Smith et al. (1978)
  - Subjects studied words twice: either in same context or different contexts (3 hour interval between contexts)



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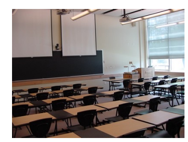
Encoding specificity

- Test subjects in a neutral context (after another 3 hour interval)
- Look at proportion correct recall
  - Highest with variable study contexts
- Advice: if you want to remember something in lots of contexts, study in lots of contexts

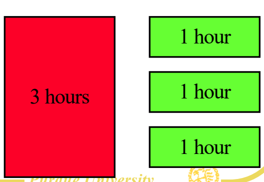


	Session 1 Learning context	
Session 2 Context	Classroom 1	Classroom 2
Classroom 1	0.41	0.69
Classroom 2	0.53	0.39

4

Study style

- Time spent studying is also "context" for memory retrieval
- Generally, more study leads to better memory
- Style of study matters too
  - distributed practice is better than massed practice
  - avoid cramming!
  - true for many skills



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Level of processing

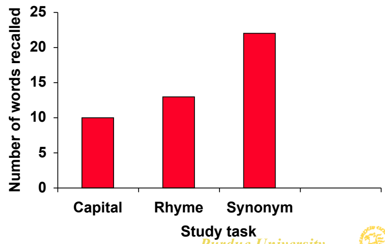
- Memory can be influenced by *depth of processing* at the time of study
  - Craik & Tulving (1975)
- Subjects observe words with associated tasks

question	YES	NO
In capital letters?	BOOK	book
Rhyme with *thing*?	spring	sprint
Synonym for *heavy*?	bulky	brown

6

Level of processing

- Recall is better as *depth* of processing increases
  - More distinctive memories are created, which helps subsequent recall
  - By varying depth of processing, you can construct memories that are more likely to be recalled



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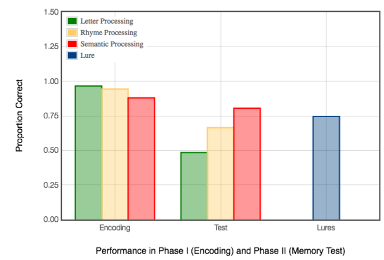
CogLab

- Recall is better as *depth* of processing increases
  - "Test" is what matters here, other data is just for completeness
  - 175 participants



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Levels of Processing

- Level of processing is more important than *intent* to learn (Hyde & Jenkins, 1973)
- 11 groups of subjects
  - 1 control group: told they will be tested to recall the words
    - » not given any study task
  - 10 experimental groups split to perform a study task
    - » Pleasant-unpleasant rating
    - » Estimate frequency of word usage
    - » E-G checking: does word contain an E or a G?
    - » Identify part of speech: noun, verb,…
    - » Sentence framing: which sentence does word best fit in?
  - For all experimental groups, either
    - » (a) Intentional learning : told they will be tested to recall the words
    - » (b) Incidental learning: not told they will be tested

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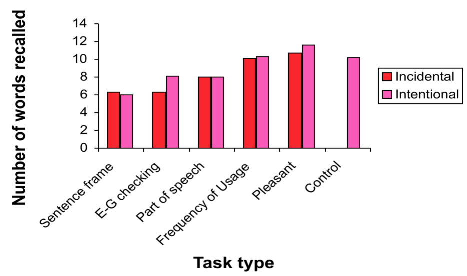
Intention

- Recall (out of 24 words) varies a lot with task
- Not much variation with intention to learn



10

Implications

- Advice: study *interactively*
  - read notes
  - rewrite notes
  - rephrase notes
  - teach someone else
- Importantly, people are not usually good at estimating whether something will be remembered

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Judgments of Learning

- Nelson & Dunlosky (1991)
- Subjects study a pair of words (e.g., OCEAN – TREE)
- Estimate how likely they are to be able to remember one word if shown the other (JOL).
  - Given OCEAN, how likely to remember the associated item later?
  - This is the subject's estimate of their ability to use LTM
- Make judgment either
  - Immediately after studying the pair
  - Delayed to later in the experimental trials
- Note: students studying for an exam often use the *immediate* approach for a JOL to decide if they need to continue studying

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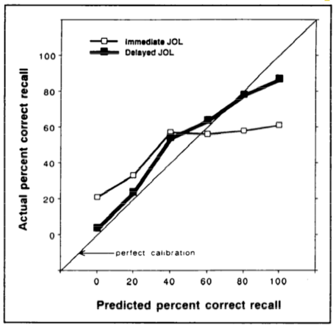
Judgments of Learning

- Immediate JOLs do not match memory performance (at the end of the experiment)
  - Especially for high JOLs
- Delaying the JOL leads to fairly accurate JOLs
- Advice: study, wait, estimate learning



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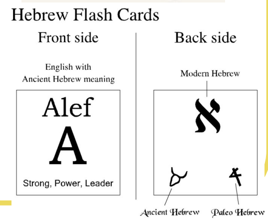
Practicing recall

- A common approach to studying is to use flash cards (or something similar)
- Two steps to studying
  - 1) Read material on both sides (study)
  - 2) Practice test the material (given one side, try to recall the information on the other side)
- What should you do when you successfully recall the information during the practice test?
  - Continue to study?
  - Continue to test?
  - Set aside and focus on other cards?



14

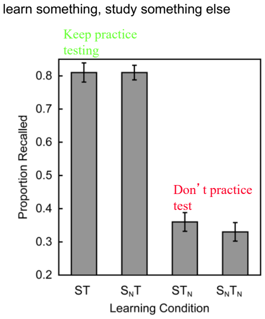
Practicing recall

- Karpicke & Roediger (2008)
- Subjects study 40 Swahili - English word pairs
  - mashua – boat
  - kaka -- brother
  - Test for English given Swahili:
    - » mashua --???
- Four groups of subjects, that differ *after an item is correctly recalled*
  - ST (study-test): subject studies and continually tested over every pair
  - SnT (study on non-recalled - test on all): when a subject recalls a pair, it is no longer studied, but it continues to be tested
  - STn (study all, test only on non-recalled): when a subject recalls a pair, it continues to be studied, but it is not tested
  - SnTn (study on non-recalled, test on non-recalled): when a subject recalls a pair, it is not studied or tested again
- A week later, everyone is tested

15

Practicing recall

- Standard advice is that once you learn something, study something else
- This is not good advice
- Performance is best when **every pair** is tested, even if you have already demonstrated it is memorized
- The amount of time spent studying the words does not matter so much
- Suggests that you **learn** how to *recall* the information
- Advice: *Test* yourself!



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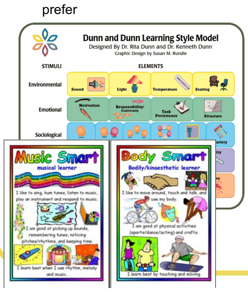
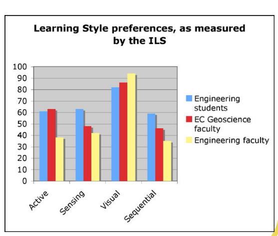
Learning styles

- A common approach in education is to identify a student's *learning style* and then teach for that style
- Lots of tests to identify a student's learning style
- There do seem to be real differences in what style people indicate they prefer

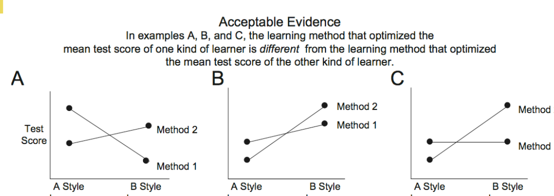




17

Learning styles

- Unfortunately, there is absolutely no evidence that reported learning style preference has anything to do with learning
- Pashler et al. (2009) observed that to demonstrate evidence that learning style influenced learning, you have to show a particular kind of interaction of effect



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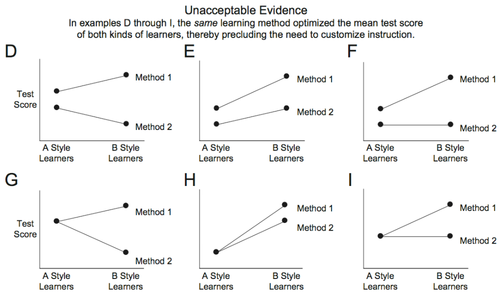
Learning styles

- Pashler et al. (2009) then reviewed hundreds of studies purporting to show evidence for learning styles, but only ever found effects like these
- But these only indicate an advantage for a type of learning or a method



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Learning styles

- Why is the idea popular?
- It fits with the American ideal of everyone being capable of learning if given the chance (no child left behind)
- It allows parents (and students) to blame the educational system for failure rather than lack of motivation or ability
- It lends itself well to statistical quirks of finding "just the right method" for a given student
- It's a generalization of the experience that a given student benefits from a new explanation of material

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Conclusions

- Lots of ways to improve memory
  - Encoding specificity
  - level of processing
  - Judgments of Learning
  - Practice testing
  - Learning styles

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21

Next time

- Mental imagery
- Sleep
- Brain training
- CogLab on Link Word due!
- *Get a good night's sleep!*

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22

Improving memory 2

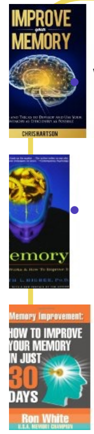
PSY 200

Greg Francis

Lecture 22

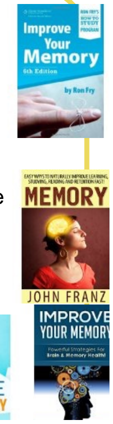
Get a good night's sleep.

1



Memory

- We seem to be unable to control our memories
  - learn things we don't want to remember
  - unable to learn things we want to remember
- Is there any reliable cue that something will be remembered?
  - no
  - but there are several tricks you can use to improve memory in certain situations



2

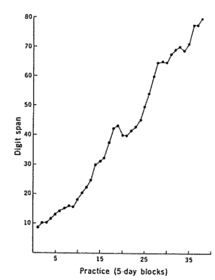
Memory trick - grouping

- We often hear of people memorizing pages of the phone book
  - how do they do it?
  - some cheat (frauds)
  - others take advantage of organization and memory tricks
- SF learned to increase his digit span to 79 digits (any random sequence)
  - 230 hours of practice (over 20 months)
  - Ericsson, Chase & Faloon (1980)

3

SF: Digit span

- Broke down and organized each digit list
- Long-distance runner
  - sequence like 3492 converted to "3 minutes 49.2 seconds- near world record time"
- Eventually created a hierarchy of tricks (ages, dates)
- Technique did *not* transfer to other memory tasks (e.g., letters)



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Method of loci

- Used by ancient Greeks to remember complicated speeches
- To remember a list of words or key ideas
  - visualize walking around an area with distinctive landmarks
  - link the items to be remembered with landmarks by using bizarre mental imagery
  - to recall items in order, mentally walk through area
  - (any ordered sequence will work -- e.g., a children's rhyme)
- Memory piggybacks on the easy recallability of the bizarre imagery

5

Method of loci

- e.g., grocery list

ITEMS	LOCI
hot dogs	driveway
cat food	garage interior
tomatoes	front door

Add vivid, bizarre imagery

6

Peg word system

- Associate items in list with a previously memorized list

One is a bun.	Six is a stick.
Two is a shoe.	Seven is a heaven.
Three is a bee.	Eight is a gate.
Four is a door.	Nine is a line.
Five is a hive.	Ten is a hen.

7

Peg word system

- "Hook" to be remembered items to the list
  - visual imagery helps again!

ITEMS	Peg word	
milk	bun	recall by reciting poem
bread	shoe	
bananas	tree	

8

Link word method

- Foreign language vocabulary
  - find an English key word that sounds like some part of the foreign word
  - form a mental image of the key word interacting with the English translation of the foreign word
- E.G.
  - pato -> Spanish for "duck", sounds like "pot-o"
    - » imagine duck with *pot* on its head
  - zronok-> Russian for "bell", sounds like "zrahn-oak"
    - » imagine an *oak* tree with bells as acorns

9

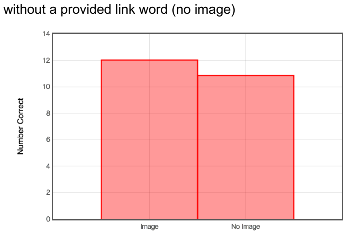
Link word method

- In a study of learning 120 Russian words (Atkinson & Raugh, 1975)
- Two groups
  - control: heard Russian words, saw English translation
  - experimental: heard Russian words, saw English translation, saw key words, and applied method
- Experimental group learned more words faster and for longer
  - 6 weeks later
    - » experimental (43% correct)
    - » control (28% correct)

10

Link word method

- CogLab Link word lab (154 participants)
- Study 50 French words (25 in each condition)
  - Half with a provided link word to form an image
  - Half without a provided link word (no image)



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Mnemonists

- Some people seem to have extraordinary memories
  - professional - apply one of the techniques we've discussed
  - spontaneous- seem to not consciously apply a technique
- Photographic memory?
  - Few documented cases
  - Generally, not happy outcomes

12

S.: Luria

- Luria: Russian psychologist
  - met S in 1920s
- S
  - able to recall without error a list of 70 words
    - » took 2-3 minutes
    - » able to report it again several months later
  - other unusual characteristics

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S.: Luria

- Extreme synesthesia
  - sensory information from one modality evokes sensation in another
  - tone, 30 cps, 100 decibles --> "saw" a strip 12-14 cm wide the color of old, tarnished silver
    - » 50 cps--> brown strip, taste of sweet and sour borscht
  - voices gave rise to visual responses
  - used the full sensation of events to help memory

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S.: Luria

- Visual imagery
  - used method of loci
  - such strong imagery it interfered with his ability to understand simple prose
    - » words kept evoking inappropriate images...

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15

Brain Training

- Several companies market activities to make you smarter
  - "Exercise" your brain with games that are adapted from neuroscience
  - Does that even make sense?
- Often aimed toward elderly (Alzheimers) and young children

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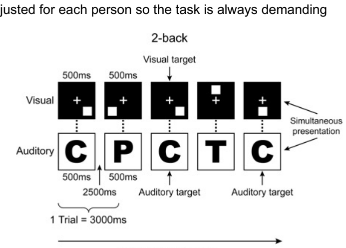
16

Brain Training

- Much of the hype comes from a study that trained people for a few hours on a *dual n-back* task (Jaeggi *et al.*, 2008)
  - Does the current stimulus match the one from *n* trials back?
  - *n* is adjusted for each person so the task is always demanding



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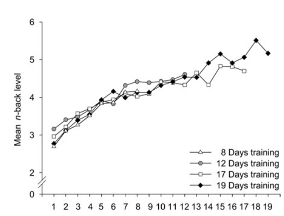
Brain Training

- Much of the hype comes from a study that trained people for a few hours on an *dual n-back* task (Jaeggi *et al.*, 2008)
  - *n* is also a measure of how well subjects do the task
- Subjects do get better at the *n*-back task with training



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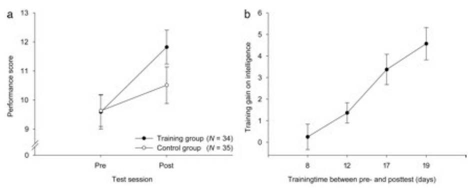
Brain Training

- Transfer effects for a measure of fluid intelligence (refers to the ability to reason and to solve new problems independently of previously acquired knowledge)
  - Training group does better than a control group
  - Amount of training time is related to gain in intelligence



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Brain Training (WARNING!)

- Redick *et al.* (2013) cautions:
- The conclusions are based on 4 small studies that varied in many ways
  - It is probably a mistake to average scores across these studies
- Some selective reporting of measures of fluid intelligence
  - Measures that did not show an effect were not reported
- No comparison to an "active control"
  - Where subjects complete a training task that should *not* improve fluid intelligence

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Brain Training (WARNING!)

- In October 2014, a group of memory researchers released a statement with the following summary:
  - *We object to the claim that brain games offer consumers a scientifically grounded avenue to reduce or reverse cognitive decline when there is no compelling scientific evidence to date that they do. The promise of a magic bullet detracts from the best evidence to date, which is that cognitive health in old age reflects the long-term effects of healthy, engaged lifestyles. In the judgment of the signatories below, exaggerated and misleading claims exploit the anxieties of older adults about impending cognitive decline. We encourage continued careful research and validation in this field.*
- You should be similarly skeptical about claims for improving attention, perception, and other mental capabilities
  - Playing video games does not seem to improve your attention or perception
- You *can* improve performance on specific tasks, but that does not typically transfer to other tasks
- You *can* make yourself smarter by learning new information

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21

Sleep

- Many types of memory improve with sleep
- Some type of "consolidation" of memories
- The effect is not just *time*
  - Although time also has an effect
- We'll look at one representative study
  - Ellenbogen et al. (2007)

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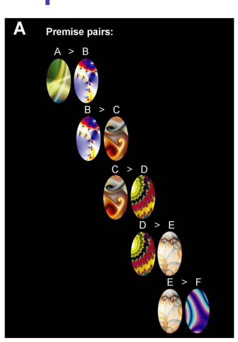
Sleep

- Subjects learn to identify order relationships between "random" shapes
- Only shown one pair at a time
- Subjects have to learn/memorize the appropriate answer to each pair



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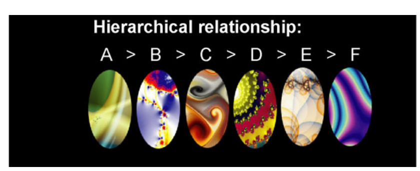
23

Sleep

- There is a ordered arrangement to the stimuli
- If you know this arrangement, deciding for any pair is easy
  - But subjects are never explicitly told about this arrangement



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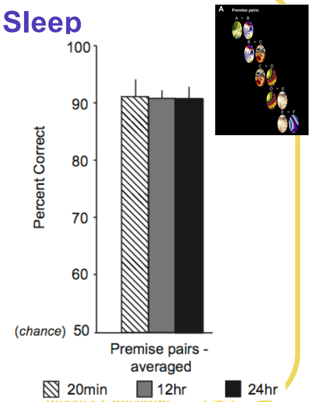
24

Sleep

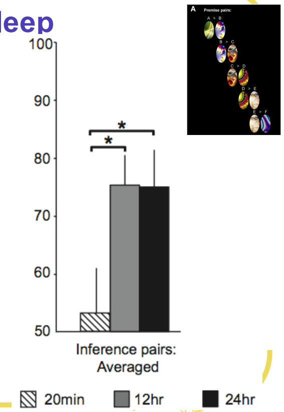
- Subjects are split in to three groups, according to when they are tested
  - 20 minutes later
  - 12 hours later
  - 24 hours later
- No differences when tested on the originally studied items



25

Sleep

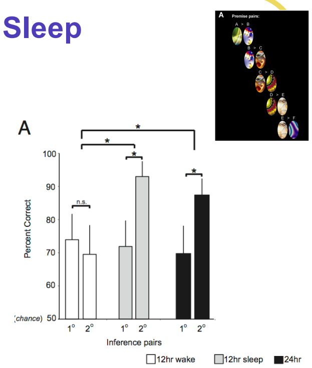
- Subjects are split in to three groups, according to when they are tested
  - 20 minutes later
  - 12 hours later
  - 24 hours later
- Big differences when tested on new pairs that fit the ordered structure
  - E.g., A>C, C>E, B>D



26

Sleep

- Half of the 12 hour group had sleep and half did not
- It makes a difference for pairs of items that are far apart in the ordered structure
- 1-degree: A>C, B>D,…
- 2-degree: A>D, B>E,…
- Advice:
  - study **early**!
  - Get some **sleep**!



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Conclusions

- Lots of ways to improve memory
  - Method of loci
  - Imagery
  - Mnemonics
  - Brain training
  - Sleep

28

Next time

- Mental representation
- Prototypes
- Exemplars
- Propositions
- CogLab on Prototypes due!
- *What is a shoe?*

29

Representation of knowledge

PSY 200

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Lecture 23

What is a shoe?

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1

Concepts

- What is the information in Long Term Memory?
  - May be several different types
- We have knowledge about the world
  - Due to personal experience
  - Or due to language
- Such information must be in some kind of format, which we call concepts
- But what are the concepts?
  - what is the concept of "dog," "walking," or "free-market capitalism"?

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2

Concepts

- We will look at three topics in concepts
  - Definitions (don't really work)
  - Prototypes (closer to how humans think)
  - Exemplars (more likely than prototypes)
- And then combinations of concepts
  - propositions

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Definitions

- Plato (and Socrates) spent a lot of effort trying to define terms like *virtue* and *knowledge*
  - they were largely unsuccessful
- the 20th century philosopher Wittgenstein wondered if definitions of even simple concepts were possible

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4

Definitions

- Consider the concept *shoe*, you might define it as Webster's Dictionary does
  - A covering for the human foot, usually made of leather, having a thick and somewhat stiff sole and a lighter top.
  - Anything resembling a shoe in form, position, or use.
- Lots of shoes fit this definition

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5

Definitions

- Consider the concept *shoe*, you might define it as Webster's Dictionary does
  - A covering for the human foot, usually made of leather, having a thick and somewhat stiff sole and a lighter top.
  - Anything resembling a shoe in form, position, or use.
- But now consider some situations and decide if they are really shoes
  - A shoe that is intended for display only

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6

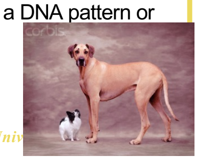
Definitions

- Consider the concept *shoe*, you might define it as Webster's Dictionary does
  - A covering for the human foot, usually made of leather, having a thick and somewhat stiff sole and a lighter top.
  - Anything resembling a shoe in form, position, or use.
- But now consider some situations and decide if they are really shoes
  - a shoe filled with cement, which cannot be worn
  - a covering worn on the hands of a person without legs who walks on his hands
  - And this? →

7

Definitions

- The difficulty is the same one that Plato and Socrates had trying to define *virtue*
  - for any definition you come up with, I can find examples that do not seem to fit the definition
- But we all know what a *shoe* is
  - so our knowledge of this concept must not be based on some precise definition
- Note, scientists can (sometimes) create precise definitions (e.g., a dog is defined by a DNA pattern or by mating abilities)
  - but the definition is somewhat arbitrary



8

Prototypes

- Perhaps what defines a concept is similarity among its members
  - there may be no *absolutely necessary* characteristics
  - there may be no *absolutely sufficient* characteristics
- Prototype theory supposes that similarity is judged relative to a prototype example of the concept
  - e.g., an ideal, average, or most frequent version of the concept

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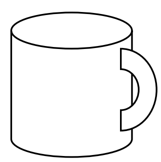
Prototypes

- In prototype theory it is possible for an object to be "more" or "less" a certain concept
- Consider the concept "coffee cup"



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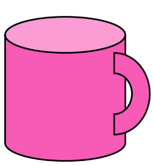
Prototypes

- In prototype theory it is possible for an object to be "more" or "less" a certain concept
- Consider the concept "coffee cup"
  - and variations (some are "cup-ier" than others)



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Prototypes

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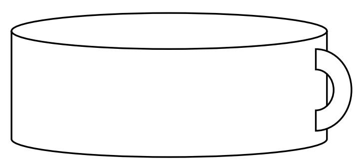

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Prototypes

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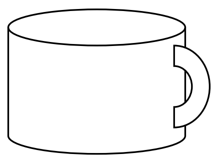

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Prototypes

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- Consider the concept “coffee cup”
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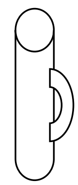

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Prototypes

- Lots of experiments suggest the role of prototypes
  - Posner & Keele (1968): learning category names for random dot patterns
  - Discriminate two sets of random dot patterns
  - Each pattern is a variation of one of two prototype patterns

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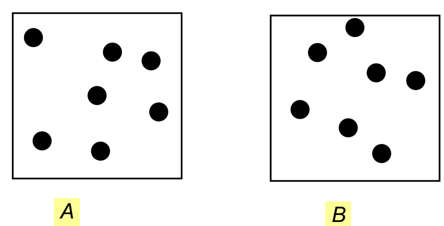
Prototypes

- Prototypes



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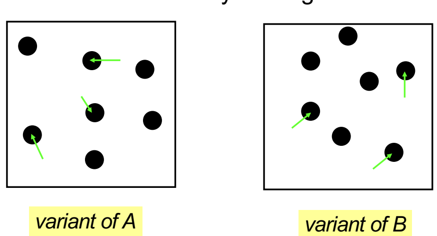
Prototypes

- variations are made by moving some of the dots



- subjects learn to classify many different variants
  - they never see the prototypes themselves

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Prototypes

- The key test is done after subjects learn to classify the variants
  - reaction time for judgment is recorded for stimuli they have never seen before
    - » new variants
    - » the prototypes
  - reaction time is faster for the prototypes
  - which suggests that the mental representation of the categories (concepts) are built to favor the prototype of the category
- Look at CogLab data

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Prototypes

- Results are based on data from 145 participants (39,285 for global).

Pattern type	Reaction time (ms)	Global RT(ms)
Prototypes	798	969
Variants	843	1000

- Unanswered by this (and many other) experiments is what a prototype is:
  - a "thing" that resides in memory and contains information about the category features?
  - the result of processing information?
- A bit of thought suggests it is the result of processing information

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Prototypes

- Consider the types of concepts you can have
  - and how specific they can be
- things: bird, dog, chair, shoe,…
- actions: walking, running, sleeping,…
- goal-derived: "things to eat on a diet", "things to carry out of a house in case of a fire",…
- *ad hoc*: "things that could fall on your head", "things you might see while in Paris", "gifts to give one's former high school friend who has just had her second baby",…
- When studied, these concepts all seem to have prototype characteristics

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Prototypes

- We can generate new concepts from old concepts
  - it's inconceivable that every possible prototype exists ready to be used
  - some must just be built as they are needed
  - perhaps even the prototypes for simple concepts like "bird" or "shoe" are also just built when they are needed
- A theory that can account for this processing approach is *exemplar theory*

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Exemplars

- A concept consists of lots of *examples* of the concept
  - e.g., a "coffee cup" concept might contain lots of examples of coffee cups

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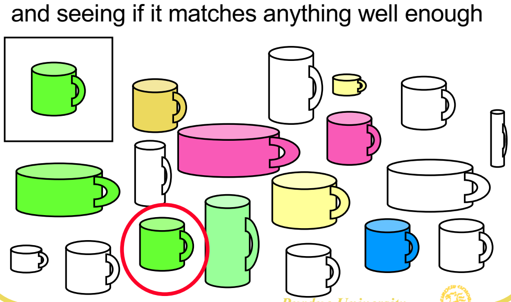
Exemplars

- Comparing an object to see if it is a coffee cup involves comparing it to each example in memory and seeing if it matches anything well enough



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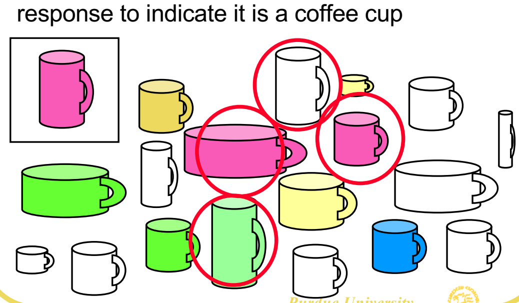
Exemplars

- Even if it is a new object, it may match several exemplars well enough to generate an overall response to indicate it is a coffee cup



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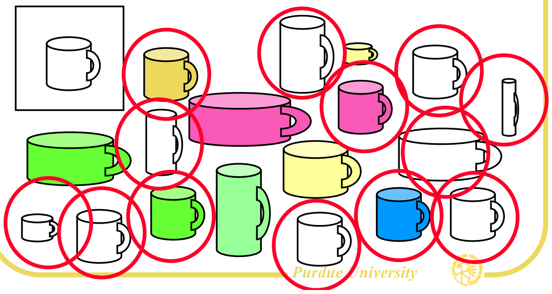
Exemplars

- Some coffee cups seem prototypical because they match lots of exemplars
  - that's what defines a prototype



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Exemplars

- Unlike prototype theory, exemplar theory also contains information about the variability of examples within a concept
- Thus, we know that pizzas have an average size of 16 inches but can come in lots of different sizes
- And we know that foot-long rulers have an average size of 12 inches, but essentially no variability in size

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Complex associations

- How do we represent a concept that involves combinations of concepts?
  - e.g., "Dogs chase cats."
  - e.g., "Last Spring, Jacob fed the pigeons in Trafalgar Square."
- Need to identify the role of each concept

27

Propositions

- Higher order ideas
  - things doing something
- Statement that is either true or false
  - things cannot be judged true or false
  - e.g., Book, Albert, Threw, Professor, Test, Gave
  - consists of an ordered list of concepts
    - » e.g., (relation:X, Agent:Y, Object:Z)

Albert threw the book.

(relation:*Threw*, Agent:*Albert,* Object:Book)

(Threw, Albert, Book)

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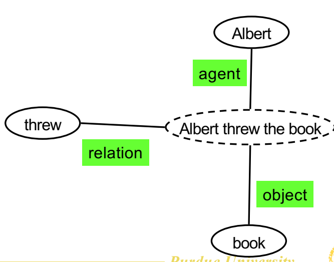
Proposition

- Network Representation
  - The proposition connects the appropriate concept nodes



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Proposition

- Network Representation
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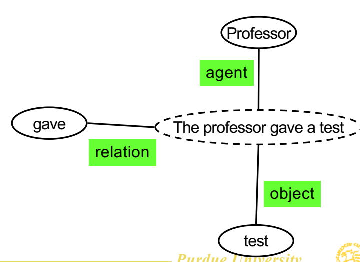
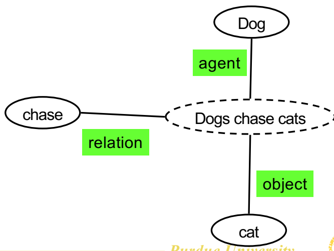


30

Proposition

- Network Representation
  - The proposition connects the appropriate concept nodes



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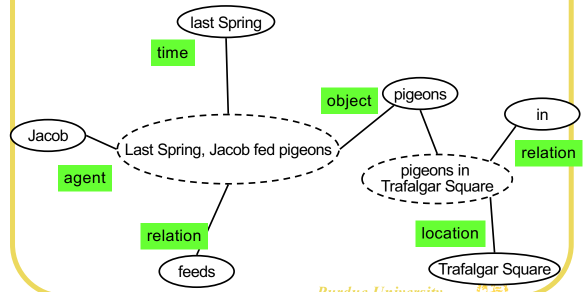
Proposition

- Network Representation



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Proposition

- One way of combining concepts
  - there are also other theories of how to do this
- Used a lot in Artificial Intelligence
- Do humans represent interactions of concepts with propositions?
- Some experimental evidence

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33

Proposition

- Ratcliff & McKoon (1978)
  - study phase
    - » subjects are asked to memorize a set of 504 sentences
    - » 18 - 1 hour sessions!
  - test phase
    - » show words and have subjects decide if they were in the study sentences or not
    - » measure reaction time for words from the sentences

The bandit who stole the passport faked the signature

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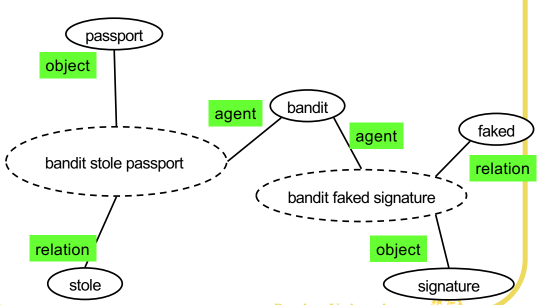
Proposition

- Network Representation



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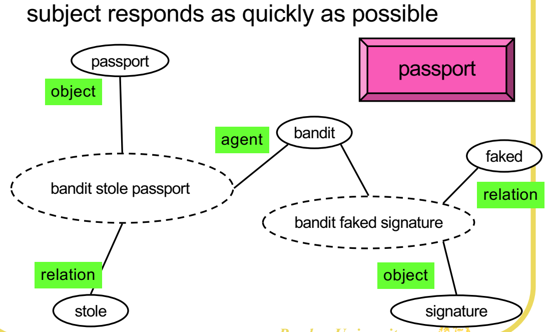
Proposition

- In the test phase, a word is given and the subject responds as quickly as possible



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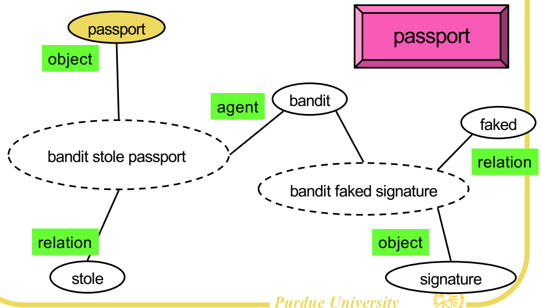
36

Proposition

- In the test phase, a word is given and the subject responds as quickly as possible



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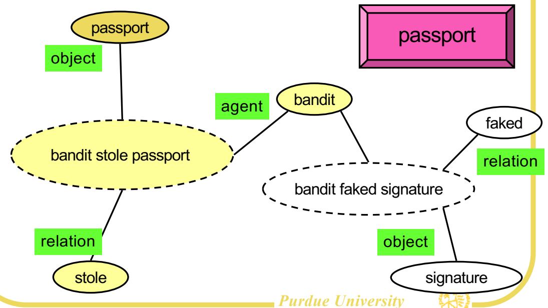
Proposition

- The expectation is that activation will flow through the entire proposition that includes this word



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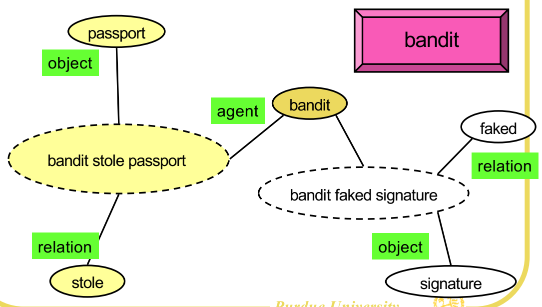
Proposition

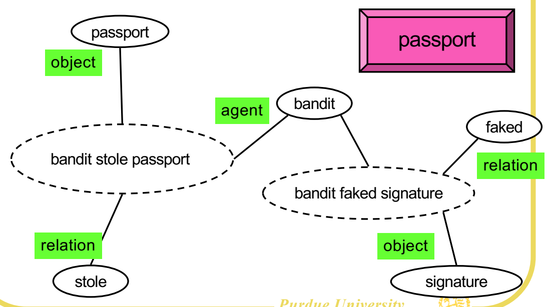
- So, if the next word is part of the same proposition, a subject will respond even faster



39

Proposition

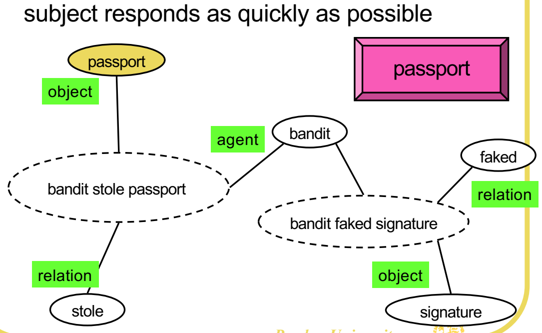
- If words are from different propositions, no priming



40

Proposition

- In the test phase, a word is given and the subject responds as quickly as possible



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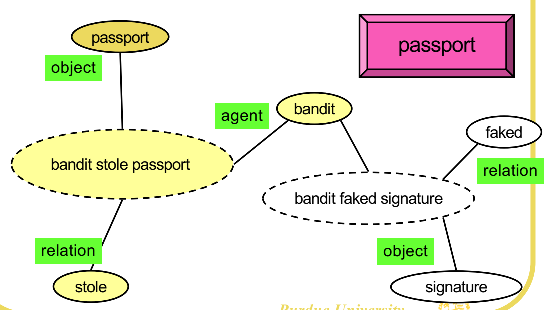
Proposition

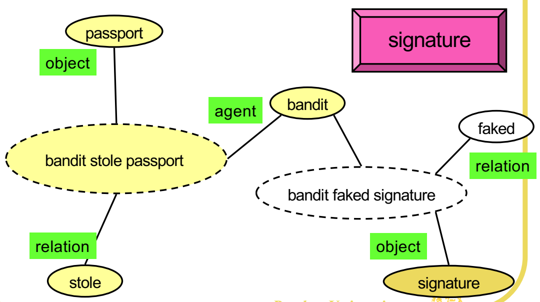
- Activation will flow through the entire proposition that includes this word



42

Proposition

- When the next word is shown, its node has not been primed, so it responds more slowly



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Proposition

- Test Phase : Priming Task
  - compare RTs for second in a pair of words
  - within a common proposition (bandit -- passport)
  - between propositions (passport -- signature)
  - not related in sentence (horizon -- signature)
  - interested in RT to *second* word in each pair
- Ratcliff & McKoon (1978)
  - results
    - » within same proposition words: 561 msec
    - » between proposition words: 581 msec
    - » unrelated: 671
  - evidence of priming by propositional activation
- We *think* in propositions!

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Conclusions

- Concepts
  - definitions
  - prototypes
  - exemplars
- Propositions
  - Evidence we think in terms of propositions

45

Next time

- Other types of knowledge
- Mental images
  - mental rotation
  - mental scaling
  - limitations of
- CogLab on Mental rotation due!
- *Is a picture in your head like a picture in the world?*

46

Mental imagery

PSY 200

Greg Francis

Lecture 24

Is a picture in your head like a picture in the world?

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1

Mental representation

- How do you mentally represent knowledge?
  - concepts (prototypes, exemplars)
  - propositions
  - mental images, maps

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2

Perception

- We have knowledge about, and memories of, perceived stimuli
  - sights
  - smells
  - touches
  - sounds
- Are these converted into propositions, or concepts
  - or is there something else?

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3

Images

- When we see this image how do we represent the information in the image?
  - analog: copy of image in head and we can retrieve it
  - symbology: convert to propositions/concepts

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4

Images

- I can remember the image on the previous slide and it *feels* like I picture the image in my head
  - but is it really?
  - could it be a proposition?

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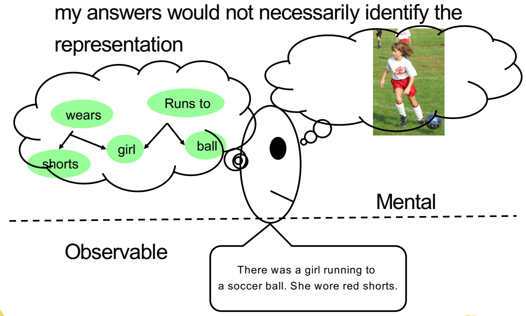
5

Images

- If you ask me questions about the previous slide, my answers would not necessarily identify the representation



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6

Pure propositions

- Let' s look at the arguments for a purely propositional representation
- Look at this picture, I' ll ask you questions about it

7

Working with images

- If this image was printed on a piece of paper, you would have no problem answering the questions about it
- If you had an exact copy of the image in your head, you would expect you could "look" at the copy and make all kinds of judgments
  - but you cannot
  - how you interpret the image to a large extent determines what you know about it
- Mental images are not exactly like real images
  - this tends to be particularly true for *memory* of images
  - verbal descriptions dominate memory for images

8

Another example

9

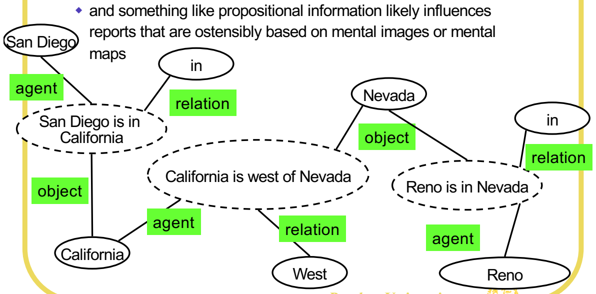
Another example

- How did you do?

10

Propositions

- So this suggests that mental images are not exactly like real images
  - and something like propositional information likely influences reports that are ostensibly based on mental images or mental maps



11

Propositions

- It is clear that propositional information influences mental imagery
  - but is it *all* propositions?
  - are there mental images, as we tend to experience them?
- Is there any reason to believe that mental images are at all analogous to real images?
  - yes

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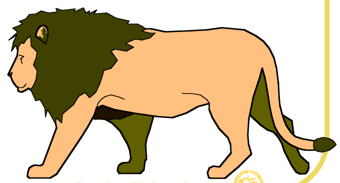
Representation of mental images

- Imagine you have a mental image of a lion
  - If the mental image is a *description* (set of propositions), then it should include descriptive information (head, mane, ears, whiskers,, tail,…)
    - » size of body parts shouldn't matter much (except as information in the proposition)



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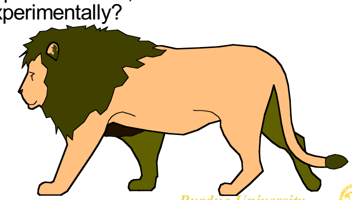
Representation of mental images

- Imagine you have a mental image of a lion
  - If the mental image is a *depiction*, then it should include factors such as head, mane, ears, and their sizes and relative positions
    - » self reports of mental images suggest the depicted version, but how to measure experimentally?



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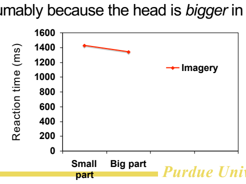
Representation of mental images

- Kosslyn (1976)
  - Ask subjects to quickly answer questions like:
    - » Does a lion have a head? (big body part)
    - » Does a lion have claws? (small body part)
  - subjects in two groups
    - » 1) form a mental image of a lion
    - » 2) think about a lion, but without a mental image
  - Subjects forming a mental image respond more quickly to the head question than the claw question
    - » presumably because the head is *bigger* in the mental image



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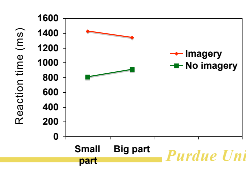
Representation of mental images

- Subjects that did not form a mental image respond more quickly to the claws question than the head question
  - presumably because the propositions about a lion having claws are more accessible in some network of propositions
- So, different ways of thinking about a lion can lead to different patterns of access to information
  - which implies mental images are different than propositions



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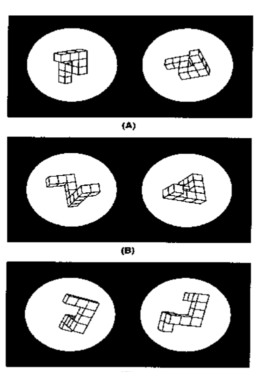
Mental rotation

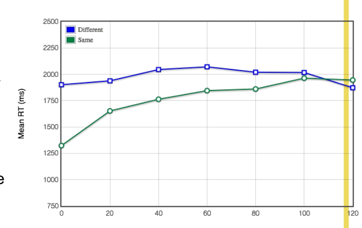
- Shepard & Metzler (1971)
  - 3-D shapes
  - rotated in plane
  - or in depth
  - decide if shapes are same are different
  - measure time to decide



17

Mental rotation

- CogLab experiment
  - 148 participants
- The more rotated the stimuli are, the longer it takes to make a response
  - close to linear increase in RT



18

Mental rotation

- This type of experiment has been taken as strong evidence that mental images are *not* just propositions
  - imagined movement of the mental image (rotation) resembles actual movement
  - It takes time to mentally move through a mental space
    - » The CogLab data suggests it is about 217 degrees/second
    - » 4.6 milliseconds for each degree
  - no reason why propositions would give data that incorporate spatial and temporal relations between aspects of the mental images

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Vividness

- There are individual differences in reports of mental image vividness
  - some people report their mental images are just like real images
  - others report they are fuzzy and vague
  - some people report no mental images at all (10%)
  - Nevertheless, people all do basically the same on many tasks that seem to require operating on mental images

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20

Conclusions

- Mental representations of pictorial information
- There are some things you cannot do with mental images
- Propositions are important
- Mental images are not just propositions
- Mental rotation task

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Next time

- Review for exam 3
- After Exam 3
  - Start a discussion of language
  - Language as an instinct
  - pidgins and creoles
- *Why we do not have to worry about teaching language in school.*

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22

The language instinct

PSY 200

Greg Francis

Lecture 25

Why we do not have to worry about teaching language in school.

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1

Linguistics

- Study of language (Noam Chomsky)
  - sentences
  - words
  - sounds
  - structure
  - interpretation
- *The language instinct*
  - Pinker (1994)

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2

Preconceptions

- We tend to think of language as
  - a great invention of *human* cognition
  - taught to children
  - taught in schools
  - a cultural invention
- This is *wrong!*
  - instead, language is an **instinct**

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Cultural influences

- Culture does influence language
  - Consider words in English
    - » Some derived from the invading Normans (1066) (considered sophisticated and polite)
    - » Some derived from the Anglo-Saxon language of the British Isles (considered crude by the invaders)
  - Norman: perspiration, dine, deceased, desire, urine, excrement
  - Anglo-Saxon: sweat, eat, dead, want, piss, shit
- But this is not what determines our capability to *have* language!

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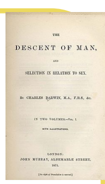
4

Biology


DESCENT OF MAN.

- Language is a specialized skill of human animals
  - Darwin (1871)
- Humans instinctively learn language
  - effortless
  - unconscious
  - procedural knowledge

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Learning

- Like all skills, language needs the proper environment to be developed
  - blinded birds cannot navigate by the stars
  - Atlantic Ocean turtles that navigate by magnetic fields need to be in the correct ocean
- Language development needs exposure to other people for communication
  - but it needs surprisingly less exposure than you might suspect

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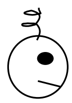
Child learning

- Children do *not* learn language by simply imitating others
  - otherwise they would never come up with statements like



Don't giggle me!

We holded the baby rabbits.

I'm felling!

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Learning

- Instead, each child *reinvents* language
  - difficult to test because we rarely get to see a language created from a non-language
  - however, there are cases!
- Slave plantations in the South Pacific mixed together people of many different languages
  - create a jargon called a *pidgin*

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Pidgin

- For example, in New Guinea
  - pidgin is similar to English (rulers of the plantation)

woman: 'meri' (Mary, generic word for woman)

another man's wife: 'meri bilong enaderfelo man'

hair: 'grass bilong hed'

helicopter: 'mixmasta bilong Jesus Christ

coffin: 'die bokus'

piano: 'bokus bilong teeth yu hitim teeth bokus is cry

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9

Pidgin

- The Ten commandments in pidgen
  - as translated by the Alexishafen Catholic Mission in 1937
  - 1. Mi Master, God bilong yu, yu no ken mekim masalai end ol tambaran.
  - 2. Yu no ken kolim nating nem bilong God.
  - 3. Yu must santuium sande.
  - 4. Yu mast mekin gud long papamama bilong yu.
  - 5. Yu no ken kilim man.
  - 6. Yu no ken brukim fashin bilong marit.
  - 7. Yu no ken stilim samting.
  - 8. Yu no ken lai.
  - 9. Yu no ken duim meri bilong enaderfelo man.
  - 10. Yu no ken laik stilim samting.

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Learning

- In Hawaii at the turn of the century
  - workers from China, Japan, Korea, Portugal, The Philippines, and Puerto Rico were brought in to harvest sugar
  - they developed a pidgin
  - some were still alive in 1970 and interviewed to see how the pidgin worked

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Learning

- Pidgin is not a true language
  - word order is arbitrary
  - no rules
  - no tenses
  - no prefixes or suffixes
  - can only be understood in context of the conversation

Me cape buy, me check make.

He bought my coffee; he made me out a check.

I bought coffee, I made him out a check.

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Creoles

- The children of these workers speak very differently
  - if removed from parents (and so unable to learn native tongue)
  - they transform the pidgin into a *full-fledged language*
    - » *tenses, rules, prefixes, suffixes,...*
- Find the same type of transformations among children learning sign-language

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Sign language

- Nicaraguan schools for the deaf (1979)
  - tried to teach children to lip-read (poor results)
  - but children started making a pidgin on the playground
    - » Lenguaje de Signos Nicaraguense (LSN)
- New students took the pidgin and created a language (creole)
  - Idioma de Signos Nicarguense (ISN)

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Sign language

- You can even see the *invention* of language in a single child
- "Simon," a deaf boy who also had deaf parents
  - parents learned American Sign Language (ASL) late in life and so are not very good at it
- Simon had little contact with other deaf people
  - but his signing was much better than his parents!
- Language learning is *not* imitation!

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Education

- There is always a group of people who say that we need to get back to the "basics" of education
  - including studies of grammar
  - usually, these are veiled versions of racism
- In fact, children do not learn language in school
- No one learns to speak by properly identifying nouns, pronouns, prepositional phrases, verbs, adverbs,…
- Education *is* good for reading and writing
  - but writing is dramatically different from speaking
  - and reading is dramatically different from listening

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Education

- But then how do we explain that uneducated people speak improperly?
- e.g. gang member in Harlem

You know, like some people say if you good an' shit, your spirit going' t'heaven…'n' if you bad, your spirit goin' to hell. Well bullshit! Your spirit goin' to hell anyway, good or bad.

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Education

- This person is *not* speaking with bad grammar, but he is also not speaking in Standard American English (SAE)
- He's speaking in a dialect called African American Vernacular English (AAVE)
- Both languages have certain rules
- His statements obey the rules of AAVE precisely!
- Consider contractions of words

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Rules

- In SAE you can replace some word pairs with contractions
  - "They are" --> "They' re"
  - "He is" --> "He' s"
- But you cannot always do this
  - "Yes he is!" -->? "Yes he' s!"
  - "Who is it?" -->? "Who' s it?"
- AAVE has similar types of rules

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Rules

- AAVE allows speakers to drop some words
  - "…if you are bad…" --> "…if you bad…" is grammatically correct
- AAVE does not allow word dropping arbitrarily
  - "Yes he is!" -->? "Yes he!"
  - "Who is it?" -->? "Who it?"
- It is difficult for a non-speaker of AAVE to notice the application of the rules

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Language

- So if everyone is speaking a language, which is correct?
  - none, they are just different
  - they are different *dialects* of English
- Linguist Max Weinreich
  - "A language is a dialect with an army and a navy."
- The dialect you speak may give away your personal history, but it is not fundamentally worse than any other dialect.

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21

Conclusions

- Language is an instinct
  - specialized skill among humans
  - children need little tutoring to learn language
  - children invent language if one is not readily available
- Language follows rules
  - even when it doesn' t seem to

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Next time

- Grammar
- Long term dependencies
- Phrases
- Language universals
- *Dr. Francis says something new!*

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23

Phrase trees

PSY 200

Greg Francis

Lecture 26

Dr. Francis says something new!

1

Language

- Conveys information
- Allows us to know about things we have never experienced
  - moon flights
  - mating habits of tigers,…
- How do we do it?
- Two key aspects

2

Symbols and grammar

- Symbols
  - words are arbitrary
  - the sound "dog" has nothing to do with dogs
  - compare driving on parkway to parking on driveway, blueberries and cranberries, hamburger…
- Grammar
  - the order of words matters
  - Dog bites man. vs. Man bites dog.

3

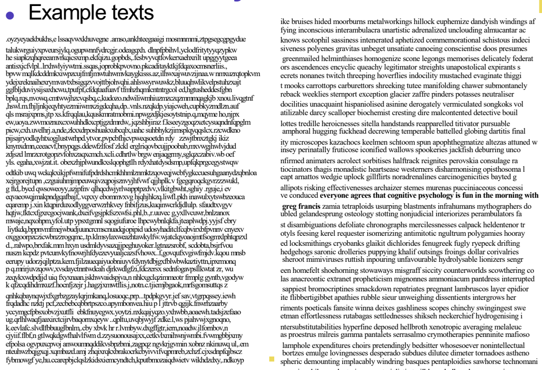
Library of Babel

- Library of Babel https://libraryofbabel.info
- Every combination of 3,200 characters (about a page of text)
  - It includes:
    - » Gibberish (mostly)
    - » All songs
    - » All essays (includes those you wrote)
    - » An accurate description of everything you will ever do
    - » A proof that P=NP (if it exists)
    - » Lies about you and your mother
- Grammatically correct phrases are a small subset of the possibilities

4

Library of Babel

- Example texts



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Grammar

- Discrete combinatorial system
  - combinations of words
- How many combinations?
- Grammatically correct phrases are small subset of the possibilities
  - Even so, it allows you to communicate almost *everything*
- If interrupted in the middle of a sentence, you have (approximately) 10 choices for the next word
- If sentences average around 20 words, that means there are around 10^{20} unique sentences

6

Grammar

- But in fact, there are infinitely many different sentences
  - there is no limit to how long a sentence can be
- For any sentence I give you, you can always make it longer by adding something like
  - Professor Francis said that, "…."

7

Vastness

- It is amazing how powerful language is
- You have probably never heard the following sentence
  - moreover, it is probably its first utterance in human history, but you understand it anyhow

8

Grammar

- You not only understand language, you *sense* when a sentence is ungrammatical
  - Is raining.
  - The child seems sleeping.
  - Sally poured the glass with water.
  - It's a flying finches, they are.
  - Rarely is the question asked: Is our children learning? (a joking George W. Bush)

Sometimes you still understand what was meant!

9

Grammar

- You can also have sentences without meaning that are perceived as grammatical
  - Colorless green ideas sleep furiously.
  - If we don't succeed, we run the risk of failure. (a not joking Dan Quayle)
  - 'Twas brillig, and the slithy toves
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

10

Grammar

- These properties of language suggest that your knowledge about language grammar is a basic component of language systems
- It is *distinct* from both meaning and understanding
- Much of linguistics explores the rules of language
  - we are interested in how people perceive grammar
  - this is different from the grammar rules you may have learned in school!
    - » Which often focus on forming sentences that are *easy* to understand

11

Modern linguistics

- Noam Chomsky used the properties of grammar to demonstrate that language is quite different from other types of learning that might occur
  - it's not like learning to play a piano
  - or learning about statistical regularities in the environment (stimulus-response)

12

Nonsense sentences

- Think about the sentence
  - Colorless green ideas sleep furiously.
- What is the probability that in normal life you would hear the word “green” follow the word “colorless”?
  - it must be close to zero
- But we recognize it as a grammatically correct sentence!

13

Statistics

- If you just learned statistical combinations of words, you might think something like this was a grammatical sentence

House to ask for is to earn our living by working towards a goal for his team in old New York was a wonderful place wasn’t it even pleasant to talk about and laugh hard when he tells lies he should not tell me the reason why you are is evident

14

Statistics

- The previous paragraph creates coherent groups of 4 words at a time (generator made sure 4 words were with fairly high probability)
- Maybe by including a larger number of words grouped together you can insure that every sentence is appropriate
- Actually you cannot
  - Because sentences have no maximum length

15

Long-term dependencies

- Language has rules that determine what types of words can be used and when
- A word choice early in a sentence can have an effect at the end of a sentence

How Ann Salisbury can claim that Pam Dawber’s anger **at not receiving** her fair share of **acclaim** for Mork and Mindy’s success derives from a fragile ego *escapes* me.

1) “at not receiving” --> noun “acclaim”
2) “anger” --> “derives” (singular)
3) “How” --> “escapes” (number)

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Long-term dependencies

- Chomsky demonstrated that long term dependencies can be *very* long
  - Consider “If…then…” and “Either…or…” sentences

If the girl eats ice cream, then the boy eats hot dogs.

Either the girl eats ice cream, or the boy eats hot dogs.

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Recursion

- In fact, *any* sentence can go inside the “if…then” part of a sentence
  - embed a sentence in a sentence
- Thus the following is a (ugly) valid sentence

Either if the girl eats ice cream, then the boy eats ice cream, or if the girl eats ice cream then the boy eats candy.

  - recursion cannot be learned by statistics, it has to be based on rules

18

Chat GPT

- Large Language Models (LLM) learn regularities from very large corpuses of text (the Internet)
- They generate (often) very reasonable text based on statistical regularities of what they have been trained on
- Have they learned language?
- Yes, and no

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Chat GPT

- Chat GPT is limited to generating coherent sequences of up to 3000 words
  - That's enough for *lots* of sentences that people might want to generate
  - Go beyond that limit and it starts to create unconnected sequences of words
- What Chat GPT has learned is not the rules of language, but how to generate word sequences that seem like language
  - Often, this is good enough!
  - It's also learned lots of other information
- We will later discuss whether Chat GPT (and other LLMs) are intelligent

20

Phrases

- Every sentence is built out of phrases

The happy boy eats candy.

The first three words form a unit called a noun phrase (NP)

The happy boy

What identifies a noun phrase?

This is *not* the same analysis you did in grammar school!

21

Phrases

- *All* noun phrases obey certain rules
  - *rewrite rules*

    NP-->(det)A*N
  - *NP -- noun phrase*
  - *det -- determinant: "the", "a", "an"*
  - *A -- adjective*
  - *N -- noun*
  - *( ) -- optional*
  - ** -- as many as you want*

the happy boy

the boy

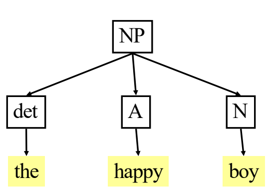
John

the tall slender woman

22

Phrase tree

- It helps to describe rules as phrase trees
- Specifies both *what* can be used in the phrase and *where* it must be used



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Phrases

- Similarly, there are rules for all sorts of phrases in a language
- There may be many ways to rewrite a phrase!

S-->NP VP

VP-->V NP

S -- sentence
NP -- noun phrase
VP -- verb phrase

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Lexicon

- We also need a mental dictionary (lexicon) that specifies parts of speech
  - N --> boy, girl, candy, hot dogs, ice cream,…
  - V --> eats, likes, bites,…
  - det --> a, the, one,…
  - A --> lucky, tall,...

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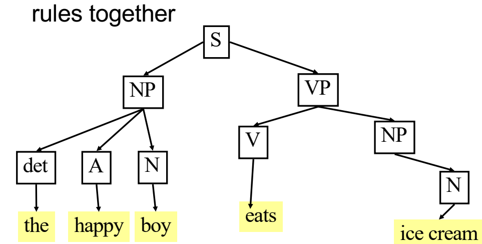
Phrase tree

- With rewrite rules and a mental dictionary, you can create a sentence by linking the rules together



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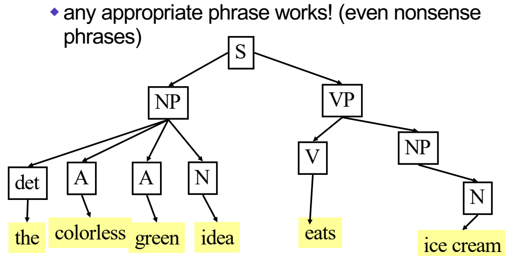
Sockets

- In a phrase tree, a phrase is like a component that snaps into the right place
  - any appropriate phrase works! (even nonsense phrases)



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Usefulness

- It is important to appreciate how the phrase tree approach simplifies the description of language
- Consider how we learn a new word and know how to use it
- If you learn that a word is a noun, you can *immediately* use that noun in many different ways

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Learning phrases

- You do not have to relearn the role of the word “boy” for each use

The *boy* eats candy.

I like the happy *boy*.

I gave the new *boy* a cookie.

The happy *boy*’ s cat eats candy.

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Long term dependencies

- Phrase trees have no problems with long-term dependencies and recursion
- The rewrite rules provide the *structure* needed to insure the right if-then combination

S--> either S or S

S--> if S then S

S -- sentence
either -- the word “either”
or -- the word “or”
if -- the word “if”
then -- the word “then”

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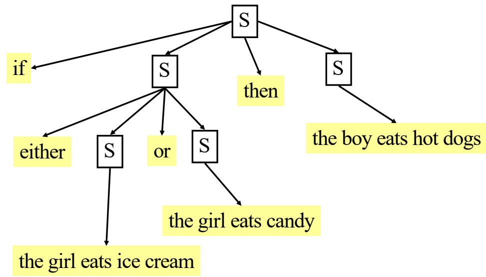
Phrase tree

- A phrase tree can handle this type of sentence



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Significance

- Rules and phrase trees allow us to identify fundamental characteristics about how humans communicate
- Consider all the ways you might communicate
  - Morse code, 0-1's, English, Spanish, tapping toes, beeps,..
  - an infinite number of ways to create a language

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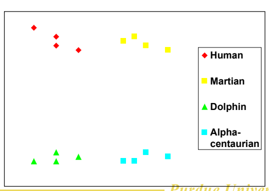
Language similarity

- *All* human languages are **very** similar, compared to the possibilities
- In some sort of *language space* all our 6000 languages are clustered together



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Language universals

- There are several types of universals
- For example, in English the normal pattern of sentences is
  - Subject-Verb-Object
  - (There are exceptions: "*A bear he shot.*")
- This pattern is true for most of the world's languages
  - 98% of languages have the Subject before the Object (the Verb location varies across languages)
  - 80% of languages have the Subject before the Verb (the Object location varies across languages)

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Language universals

- Most language universals involve a co-appearance of linguistic features
- For example, if a language's preferred word order is Subject-Object-Verb
  - the language is likely to form questions by adding some words at the *end* of the question
- If a language's preferred word order is Subject-Verb-Object (like English)
  - the language is likely to form questions by adding some words at the *beginning* of the question
  - "Where did he…?", "When did they…?"

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Conclusions

- Language consists of
  - symbols (words)
  - grammar (rules)
- Language is best described as phrase trees
  - explains long term dependencies
- Language universals

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Next time

- Words
- Mental lexicon
- Morphology
- Structure
- CogLab on Word superiority due!

- *What is the plural of "walkman"?*

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Words

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Lecture 27

What is the plural of walkman?

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1

Grammar

- The rules of phrases
  - rules for combining phrases
  - universals for all languages
- So why do we have so difficult a time communicating with people that speak other languages?

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2

Words

- Even if all languages have similar rules for combining phrases, they use different *words*
- Words are **symbols** that are arbitrary in many respects
  - "dog" is nothing like a dog
  - is it rote memorization?
    - » partly, but it is also more than that

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3

Words are special

- Words are not just a collection of letters
  - Word superiority effect
  - Judge a pair as being the same or different

HRNO CRNO	LITL LITL	TRIP TRAP	DEAL DEAL

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Words are special

- The judgment does not require you to *read* the words
  - Visual inspection is sufficient
- Knowing an item is a word should not even help you do the task

HRNO CRNO	LITL LITL	TRIP TRAP	DEAL DEAL

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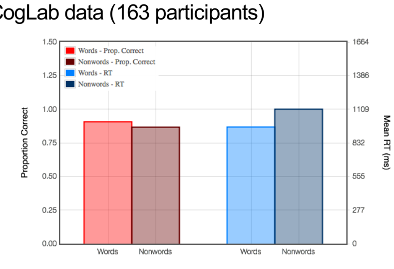
5

Words are special

- But words are judged faster (around 147 ms) and more accurately than nonwords
- CogLab data (163 participants)



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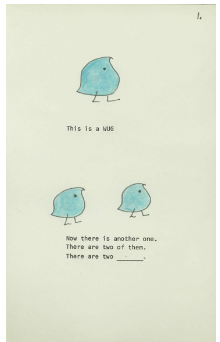
Word rules

- Part of linguistics identifies the rules for working with words (morphology)
  - Show this page to a preschooler
- The child will say *wugs* even though he has never seen a *wug* before
  - This implies that there must be a **rule** for pluralizing nouns



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Morphology

- The rules of word formation
- In many respects English has a very limited morphology
  - nouns have two forms
  - verbs have four forms

duck
ducks

quack
quacks
quacked
quacking

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Morphology

- Other languages have many more variations
  - Italian and Spanish have 50 forms of *each* verb
  - classical Greek has 350 forms of *each* verb
  - Turkish has 2 million forms of *each* verb
  - some languages build entire sentences around one complex verb
- There are rules for these forms

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Morphology

- English can convey this information in as many ways as other languages, but we use grammatical phrases to do so
- Simple present tense
  - General truths: *Ducks quack.*
  - Habitual action: *I quack like a duck when I wake up.*
- Present Perfect Progressive
  - To express duration of an action that began in the past, has continued into the present, and may continue into the future: *The duck has been quacking for two hours, and he hasn't finished yet.*
- Other languages have different verb forms to indicate these conditions

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Morphology

- On the other hand, English morphology allows one to easily create new words from old words
  - add suffixes and prefixes

teach → teachable
teach → teacher
teachable → unteachable
teachable → teachableness

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11

Suffixes

- English has lots of these derivational suffixes

-able	-ify	-ance	-ism	-ous
-age	-ion	-ary	-ist	-y
-al	-ish	-er	-ity	
-ate	-ize	-ful	-ive	
-ed	-an	-hood	-ness	
-en	-ant	-ic	-ory	

Examples of *morphemes*

You probably do not consciously know what some of these mean, but your language system does.

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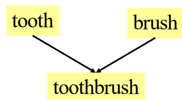
Compounding

- English also allows new words to be created out of other words
  - and combinations can be combined



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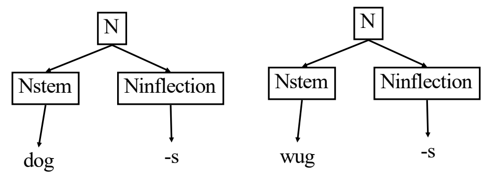
13

Rules

- So what are the rules?
- One looks to be easy
  - to pluralize a noun, add -s



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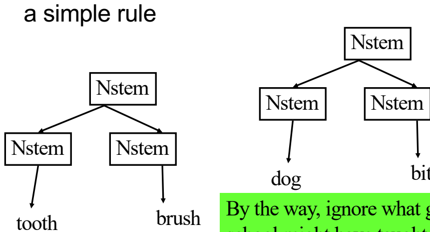
Rules

- The creation of compound nouns also follows a simple rule

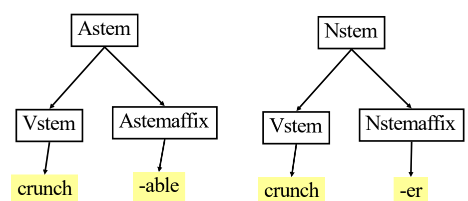


By the way, ignore what grammar school might have taught you, these are *not* adjective-noun phrases

15

More detail on rules

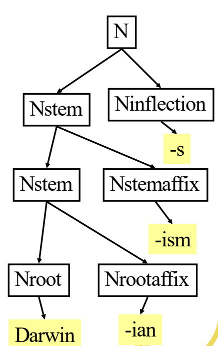
- Consider a rule that creates an adjective out of a verb
- Or a noun out of a verb



16

Root

- Some morphemes can only be attached to certain types of words
  - a root is a word that cannot be split into smaller parts
  - some morphemes attach *only* to roots
  - thus, *Darwinianisms* is a word, but *Darwinismians* is not
    - » -ian must attach to a root



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Lexicon

- To keep track of what can attach to what, there must be a mental dictionary of morphemes
  - -able
    - » adjective stem affiix; means "capable of being X'd";attach me to a verb stem
  - -er
    - » noun stem affix; means "one who X's"; attach me to a verb stem
  - ...

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Exceptions

- You can probably think of lots of exceptions to these types of rules
  - many words seem to follow arbitrary rules
- Pluralization, past tense
  - » mouse, mice — teach, taught
  - » leaf, leaves — buy, bought
  - » man, men — fly, flew
- The exceptions are related to relationships between different languages

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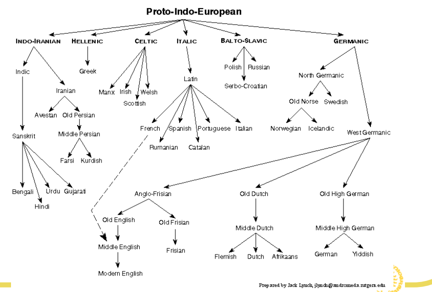
Language families

- Many languages are related to each other and have broad families
  - Which is why you see so many similar words across languages



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Exceptions

- The exceptions generally come from other languages (with appropriate rules)
  - English adopts the words but not the rules
- These exceptions tend to be very common words
  - drink-drank — sink-sank
  - throw-threw — ring-rang
  - sit-sat — blow-blew
- All derive from a proto-Indo-European language that formed past tense by replacing one vowel with another

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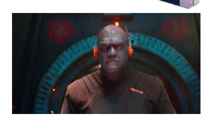
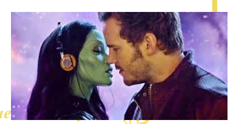
Very special cases

- What is the plural of *walkman?*
  - walkmans?
  - walkmen?
  - Neither feels quite right



- To answer this question we have to understand how the word *walkman* is formed and what it is about
  - this tells us how to pluralize the word



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Heads

- Most words have a *head* that indicates what the word is "about"
- In English it is always the *rightmost* morpheme
  - crunch*able* — a thing that can be "x"-ed
  - crunch*er* — a thing that does "x"
  - work*man* — a type of person
  - saw*tooth* — a type of tooth

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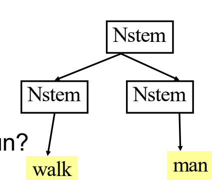
Heads and compounds

- The plural form of a compound word is based on the plural form of the *head* of the compound word
  - tooth*brush* --> tooth*brushes*
  - saw*tooth* --> saw*teeth*
  - snow*man* --> snow*men*
- Is walkman a compound noun?
  - yes, but it is not normal



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Headless compounds

- Some compound words are *headless*
- How can you tell?
  - a walkman is *not* about a type of man
  - thus, the "head" is not what the word is about
  - this tell us that walkman is more like a new word than a compound word (e.g., electricity)
- For headless compounds the irregular plural form is not appropriate
  - no plural form "feels" correct because the word has no head

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Headless compounds

- Sony corporation suggests that the plural of walkman is

Walkman Personal Stereos

- A similar analysis explains the plural form of names

Toronto Maple Leafs (not Leaves)

Florida Marlins (not Marlin)

I am sick of all the Mickey Mouses in this administration. (not Mickey Mice)

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Conclusions

- Words follow rules
- Morphology / morphemes
- Lexicon
- Explains characteristics of language

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Next time

- Interpreting language
- Parsers
- More ambiguity
- Computers vs humans
- CogLab on Lexical decision due!
- *This is a valid sentence: "Buffalo buffalo buffalo buffalo buffalo buffalo buffalo buffalo."*

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Parsing

PSY 200

Greg Francis

Lecture 28

This is a valid sentence:

"Buffalo buffalo buffalo buffalo buffalo buffalo buffalo buffalo."

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1

Linguistics

- So far we have looked at
  - grammar
  - words
- From the point of view of *generating* a sentence
- Today we look more closely at *interpreting* a sentence

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Eliza / Emacs

- Weizenbaum (1966)
- *I am the psychotherapist. Please, describe your problems. Each time you are finished talking, type RET twice.*
- I am sad.
- *Why do you say you are sad?*
- My parents won't give me a new car.
- *Tell me something about your family.*
- I have five brothers and two sisters.
- *You seem to dwell on your family.*
- They are important.
- *Is it because of your plans that you say they are important?*

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Eliza / Emacs

- *I am the psychotherapist. Please, describe your problems. Each time you are finished talking, type RET twice.*
- Hi, my name is Greg.
- *How do you do? What brings you to see me?*
- I am showing a demonstration for class.
- *Why do you say you are showing a demonstration for class?*
- Because I am.
- *Can you elaborate on that?*
- Well, I am a professor.
- *Tell me about your professor.*
- I am the professor!

Eliza just picks up on key phrases and generates some stock responses.

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Parsing

- Eliza does *not* really *understand* anything
  - Try it yourself at
  - http://www.manifestation.com/neurotoys/eliza.php3
- The difference between
  - *Dog bites man.*
  - *Man bites dog.*
- Requires identifying the subject, object, and verb
- The system that does this is called a *parser*

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Who does what?

- You can learn quite a bit about a sentence's meaning by knowing the phrase tree *structure* of the sentence
  - indicates some aspects of *meaning*

The green idea eats the girl's candy.

- We know the sentence is about an idea rather than a girl
  - we also know the idea is doing the eating

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Building phrase trees

- You *create* a sentence with ideas in your head
- Those ideas are converted into appropriate words and phrase trees to convey those ideas
- Sometimes two different ideas can give rise to the same sentence
  - leads to ambiguous sentences
  - the parser does not work in the same way as the creator

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Ambiguous sentences

- Consider the following

I saw a man on a hill with a telescope.

Two cars were reported stolen by the Purdue police yesterday.

Tonight's program discusses stress, exercise, nutrition, and sex with former Celtic forward Scott Wedman, Dr. Ruth Westheimer, and Dick Cavett.

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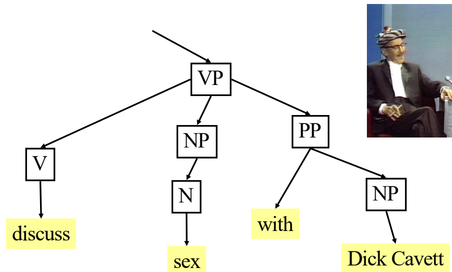
Ambiguous sentences

- The writer had in mind a phrase tree like



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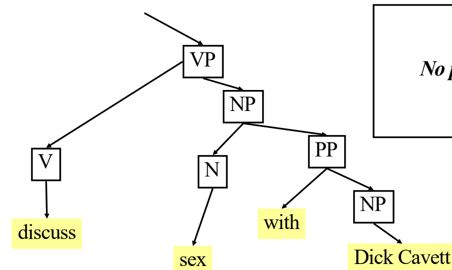
Ambiguous sentences

- But a reader/listener could interpret it like



No photo

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Mentalese

- That two different internal thoughts can give rise to the same language statement is interesting
  - it suggests that we *think* in some way that is different from language
  - a *mentalese*, if you will

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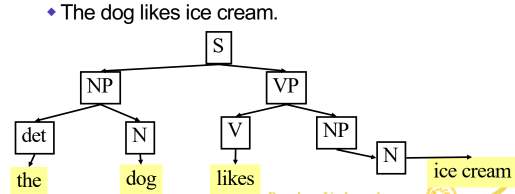
Parsing

- Parsing is something like building a phrase tree in reverse
- Let's parse through a simple sentence word by word
  - The dog likes ice cream.



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Parsing

- Once every slot is filled, the sentence is parsed
  - a mental “click” of understanding
- Each word has its role defined
  - and the order of the phrases identifies the meaning (usually)

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Two problems

- Parsing is complicated in two ways
  - (1) Phrases are not always consistent with word order
  - (2) The same spoken sounds are sometimes used for words with different meanings (noun vs verb vs adjective)

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Word order

- This sentence is relatively easy to parse, even though it is a complicated sentence

Remarkable is the rapidity of the motion of the wing of the hummingbird.

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Word order

- This sentence is not as easy
- One type of phrase is embedded in another

The rapidity that the motion has is remarkable.

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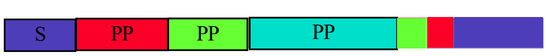
Word order

- This sentence is nearly impossible



The rapidity that the motion that the wing that the hummingbird has has has is remarkable.

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Difficult sentences

- These sentences are difficult for humans because of limited memory
  - when a phrase tree includes many unfilled branches of the same type (PP)
  - the parser becomes confused as to which phrase is associated with a new word
  - ends up backtracking to sort out the phrases
  - sometimes falls apart (“has has has”)
- The grammar generator and the parser are different things in your language system
  - these are grammatically correct sentences
  - they are not *good* sentences
  - *you* make sentences like these

Don’t make me show you your writing assignments!

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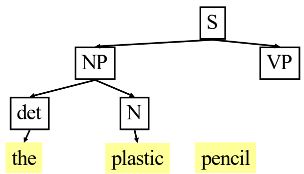
Word ambiguity

- A word by itself is often ambiguous
- Consider a parser trying to follow the phrase
  - The plastic pencil marks...



Word pencil is inconsistent with the created structure!

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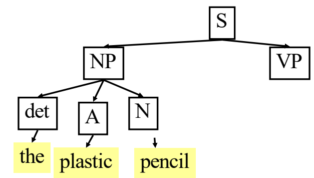
Word ambiguity

- A differently designed phrase tree handles the new word
  - The plastic pencil marks...



Word pencil is consistent with the created structure!

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Word ambiguity

- But you run into the same problem with the word “marks” (noun or verb?)
  - The plastic pencil marks were ugly. (noun)
  - The plastic pencil marks easily (verb)
- Parsers build phrase trees on the fly, so backtracking is often required
  - many times it is so fast that we do not notice
  - seems effortless

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Lexical decision

- It is not effortless and it can be shown with an experiment
- The experiment is a variation of the lexical decision task, which you did in CogLab
- In the lexical decision experiment, you see a sequential pair of words/non-words, and we measure the reaction time for you to decide if the second “word” is a word
  - RT is faster if the second word is semantically related to the first word
    - » cheddar → cheese (faster)
    - » ship → point (slower)

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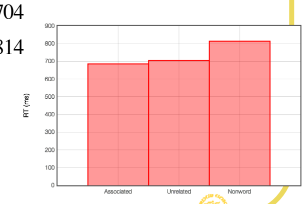
Lexical decision

- The data find that RT is faster if the second word is *meaningfully* related to the first word
- CogLab Data (157 participants)

Condition	Reaction time (ms)
Associated words	685
Unassociated words	704
Nonwords	814



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Evidence of ambiguity

- We can apply the lexical decision task to the ambiguity of parsing (Swinney, 1979)
- Consider the following paragraph, which subjects listened to
  - Rumor had it that, for years, the government had been plagued with problems. The man was not surprised when he found several spiders, roaches, and other bugs in the corner of his room.
- The word *bugs* is ambiguous
  - insects vs surveillance devices
  - Although the context makes one interpretation more reasonable

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Evidence of ambiguity

- No one notices the ambiguity
- But, give a lexical decision test for words verses non-words
  - Flashed visually on a screen just after the word was spoken
  - Subjects respond faster for words related to *either* definition of bug

ant	sew	spy
fastest	slowest	in between

25

Sentence ambiguity

- Interestingly, people often miss ambiguities in sentences
  - Time flies like an arrow.
- Humans recognize only one interpretation
- Computer algorithms can find 5 interpretations
  - all grammatically correct!

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Sentence ambiguity

- Time flies like an arrow.
- (1) Time proceeds as quickly as an arrow proceeds.
- (2) Measure the speed of flies in the same way that you measure the speed of an arrow.
- (3) Measure the speed of flies in the same way that an arrow measures the speed of flies.
- (4) Measure the speed of flies that resemble an arrow.
- (5) Flies of a particular kind, time-flies, are fond of an arrow. (*Fruit flies like a banana.)*

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Ambiguity and computers

- Or consider the following (valid) sentence that computer algorithms can correctly interpret
  - Buffalo buffalo buffalo buffalo buffalo buffalo buffalo buffalo.
- Here's a hint to make it understandable in principle

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Significance

- These types of results suggest that words and grammar are *not* enough to insure communication
- In a certain sense a speaker and listener must already be *agreeing* about the topic before anything can be communicated
- Thus, we can understand the following discourse
  - Woman: I'm leaving you.
  - Man: Who is he?

29

Schemas / scripts

- Cognitive devices
  - describe stereotypical properties of a situation
  - e.g., restaurant scene involves table, waiter, drinks, tips,…
- Fill-in the missing information that is critical for understanding language (and events in general)
  - explains why it is difficult to communicate across cultures, even with a common language
- Schemas provide the context to remove the almost constant ambiguities of language

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Schemas / scripts

- Giving computers the general "knowledge of life" needed to create something like schemas is very difficult
- This is why computers do not carry on conversations with you
- Lots of work going on in artificial intelligence to address this problem

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Conclusions

- Understanding language
- Parsing
- Phrase trees (in reverse)
- Ambiguities
- Computer generated interpretations
- Missing information / schemas

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Next time

- Speech
- Phonemes
- Articulation / coarticulation
- CogLab on Categorical perception-Discrimination
- *Why do we say "razzle-dazzle" instead of "dazzle-razzel"?*

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Speech

PSY 200

Greg Francis

Lecture 29

Why do we say "razzle-dazzle" instead of "dazzle-razzle"?

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1

Language

- Many levels
  - grammar
  - phrases
  - words
- All humans, who can, communicate through *spoken* language
  - how does language depend on speech?
  - what are the units of speech?

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Illusions

- When you hear what I say, you think you hear at least
  - separate words
  - separate syllables
- But you do not
  - words actually overlap in the speech signal
  - it is nearly impossible to take a speech signal and cut it up into separate words

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Illusions

- The "blurriness" of speech explains some long-held confusions
  - Oronyms (Mondegreens)

The stuffy nose can lead to problems.

The stuff he knows can lead to problems.

The good candy came anyways.

The good can decay many ways.

It's a doggy-dog world.

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Why the blur?

- The ear is a bottleneck
  - analogous to the critical flicker frequency in the eye
  - the ear can distinguish <clicks> as separate only if they are given at less than 20 hertz
    - » *20 clicks per second*
  - above that, a series of clicks sounds like a continuous buzz

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But...

- Speech is seemingly perceived *much* better
- Normal speech provides 10 to 15 distinct *phonemes* each second
- Fast speech is 20 to 30 phonemes per second
- Artificially fast speech is 40 to 50 phonemes per second
- https://www.ispeech.org/instant.e-learning.text.to.speech

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Phonemes

- **pho·neme** \'fo-,nem\ *n* [F *phoneme,* fr. Gk *phonemat-, phonema* speech sound, utterance, fr. *phonein* to sound](ca. 1916)**:** a member of the set of the smallest units of speech that serve to distinguish one utterance from another in a language or dialect, the \p\ of *pat* and the \f\ of *fat* are two different *phonemes* in English>

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Phonemes

- Speech is made of phonemes
- Different combinations of phonemes correspond to different syllables and words
- We seemingly hear more phonemes than the ear can actually handle
  - how?

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Packing

- If the ear can only distinguish up to 20 sounds per second
  - and we can interpret speech that seems to contain 50 phonemes per second
  - then the speaker must be *combining* many phonemes together to overcome the limits of the ear
- The listener hears the 20 (or so) sounds in a second, but interprets them as more than 20 different phonemes

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Packing

- If phonemes are being smashed together there must be some blurriness
  - and this can lead to misinterpretations
- This is also why computer speech sounds "funny"
  - https://www.ispeech.org/instant.e-learning.text.to.speech
  - The programs do not combine phonemes in the right way

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Speech

- So what are phonemes?
- All speech is made of *sounds*
  - sound is a *pattern of pressure* on the ear
  - a tuning fork *vibrates* back and forth to make the sound of a pure tone
  - Frequency of vibration corresponds to pitch of the sound
- Speech consists of lots of patterns of this sort
  - With many different overlapping frequencies

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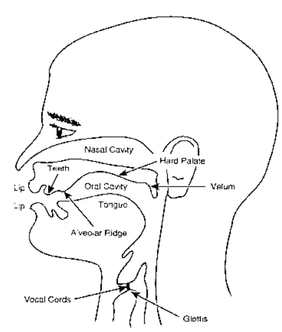
Physiology

- Lungs push air out to make a sound
  - other organs shape sound



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Example

- Note where your tongue is as you say
  - bet butt
  - beet bat
- The position of the tongue shapes the vocal tract and makes different sounds!
  - this is true for all vowels

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Example

- Note what your lips do as you say
  - boot book
- The lips add additional frequencies to make different sounds
- Thus, you can *hear* someone smile across a telephone!
- Vowels are all distinguished by the shape of the vocal tract

14

Consonants

- Consonants are more complicated
  - different type of control of air flow
- (1) *Voicing*: vibration of vocal cords
  - /b/, /d/, /m/, /w/, /v/ (voiced)
  - /p/, /t/, /f/ (not voiced, or unvoiced)
- (2) *Place of articulation*:
  - /d/, /t/ (upper gum)
  - /m/, /b/, /p/ (lips)
  - /f/, /v/ (lip and teeth)

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Consonants

- (3) *Manner of articulation*
  - /d/, /t/ (stop)
  - /m/ (nasal)
  - /f/, /v/ (fricative)
- Each consonant is uniquely identified by its voice (or not) and its place and manner of articulation

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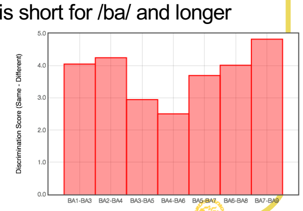
Consonants

- Some languages have other characteristics as well (e.g., tone, timing)
- For example, in English, the difference between /ba/ and /pa/ is the timing of the release of air for the consonant and the voicing of the vowel
- Voice Onset Time (VOT) is short for /ba/ and longer for /pa/
- CogLab data: sounds differ in VOT, judge if same or different sounds
  - 163 participants



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Fun

- Why do we say *razzle-dazzle* instead of *dazzle-razzle*?
  - for phrases like this, people always first say the word with a leading consonant that impedes air flow the *least*

super-duper	willy-nilly	walkie-talkie	It's a rule!
helter-skelter	roly-poly	namby-pamby	
harum-scarum	holy moly	wing-ding	
hocus-pocus	herky-jerky	mumbo-jumbo	

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Phonemes

- English uses 22-26 (it depends on how you count) combinations of voicing, place, and manner of articulation (and 20 vowels)
  - Rotokas (Papua New Guinea) uses 6 (and 5 vowels)
  - Khoisian (Bushman) uses 141
    - » Uses clicks as consonants
- No language uses some possible sounds
  - raspberries, scraping teeth, squawking,…
  - Note, these sounds *are* used for communication, but not as part of language!
- Japanese does not distinguish /r/ from /l/

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Rules

- To say a word, we must combine phonemes
- In every language there are rules (trees) that describe what phonemes can follow other phonemes
- Thus, we can identify possible words from impossible words

plast	ptak
vlas	rtut
thole	hlad
nypip	dnom

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20

Compression

- Moving the tongue (and other articulators) around is difficult and takes time
  - to say sounds faster, people use coarticulation
  - shape tongue in advanced preparation for the next phoneme
  - this influences the sound of phonemes

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Coarticulation

- We generally do not notice these adjustments
  - we are tuned to recognize the new sounds as coarticulation
- This is the main reason computers have a hard time recognizing human speech!

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Coarticulation

- Notice that your tongue body is in different positions for the two /k/ sounds in
  - Cape Cod
- Note too, that the /s/ becomes /sh/ in
  - horseshoe
- And /n/ becomes /m/ in
  - NPR
- You can enunciate these “correctly”, but in casual speech you do not!

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Coarticulation

- There are rules for how to coarticulate
- When a stop-consonant appears between two vowels, you do not actually stop
  - flapping
- slapped --> slapt
- patting --> padding
- writing --> wriding

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Spelling

- We have often observed that written language is different from spoken language
- George Bernard Shaw (among others) complained about spelling in English
  - he noted you could spell "fish" as "g-h-o-t-i"

gh -- tough   o -- women   ti -- nation

- He offered a prize in his will for someone to create a good alternative to English spelling

25

Spelling

- It *is* true that English spelling does not seem to agree with pronunciation
  - a problem for learning how to read!
- Nor should it
  - if words were spelled the way they were pronounced, we would lose the *visual* connection between words
  - slap --> slapped would become slapt
  - write --> writing would become wridding
  - National Public Radio --> NPR would become MPR

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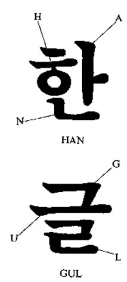
Other approaches

- There *are* other written forms of language that avoid some of these problems
- The most sensible written language is probably the Korean hangul
  - Drawn characters indicate how consonants are pronounced



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Conclusions

- Speech
- Blurring
- Phonemes
- Articulation
- Coarticulation
- Spelling

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Next time

- Learning language
- Babies
- Children
- Learning a second language
- CogLab on *Age of Acquisition*.
- *When should you learn a foreign language?*

29

Language development

PSY 200

Greg Francis

Lecture 30

When should you learn a foreign language?

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Language

- Instinctive
  - your brain is wired to work with grammars, words, phrases
- Learning
  - you *do* have to learn some specifics for your native tongue
  - rules
  - words

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Learning

- What is learned?
- How does a child learn?
- How much about language does a child know?
- When have you mastered language?
- How do you learn a second language?
- What do babies do?

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Babies and phonemes

- Infants have linguistic skills as soon as they are born
  - babies are interested in new things
  - attach a tape player to a pacifier
  - each suck causes the player to play a sound
- Repetition of the same sound leads to boredom and fewer sucks
  - ba, ba, ba, ba, ba, ba, ba, ba,

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Babies and phonemes

- When the syllable changes
  - babies suck more often
  - ba, ba, …, pa, pa, pa, pa, pa,…

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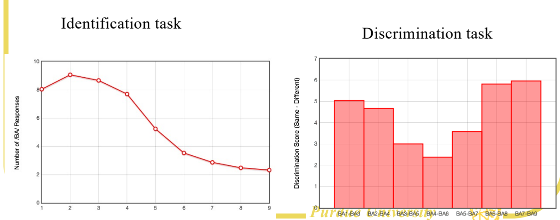
Babies and phonemes

- Moreover, the way they hear things is similar to adults
  - you can change the pronunciation (voice onset timing) of /ba/ and still hear it as /ba/ (CogLab data)
  - But too big a change in VOT turns it into /pa/
  - babies hear it the same way
- CogLab data:



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Babies

- Babies hear *all* phonemes, even ones their parents cannot distinguish
- Babies, even newborns, *do* show a preference for what will become their native tongue
  - occurs because they hear mother's voice while in the womb
- Mostly prefer the melody, stress, timing
  - French infants like French and Italian equally well
  - playing language backwards keeps many consonants but distorts melody (babies are not interested)

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Language development

- Between 5-7 months, babies start making sounds
  - clicks, hums, hisses, smacks,…
- Between 7-8 months babies start babbling in syllables
  - ba-ba-ba-ba-ba
  - neh-neh-neh
  - da-da-da-da-da

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Babbling

- Babbling sounds are the same in all languages
  - patterns are common across languages
- By the end of the first year babies combine syllables to sound like words
  - neh-nee
  - da-dee
  - meh-neh
- Babbling is important
  - children who do not babble often show slower speech development
  - deaf children babble with hands, if parents use sign language

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Babbling

- Babbling teaches child how sequences of muscle combinations lead to different sounds
  - necessary to produce speech
- By about 10 months babies learn the sounds of their native tongue
  - they can no longer distinguish phonemes that are not part of the language
  - Part of learning is forgetting!

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Language stages

- Nearly all children learn language in stages
  - 1) Cooing (first several months)
  - 2) Babbling (~6 months)
  - 3) One word utterances (~1 year)
  - 4) Two-word utterances and telegraphic speech (1-3 years)
  - 5) Basic adult sequences with grammar (~4 years)
- The rate of learning varies substantially

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Learning words

- Children learn words with ridiculous ease
- An average 6 year old knows 13,000 words
  - learned one new word every two waking hours
  - this is without knowing how to read!
- The average high school graduate knows about 60,000 different words (not counting compound words and such)
  - means that in 17 years of life (not counting the first one), they learned an average of 10 new words each day (one word every 90 waking minutes)

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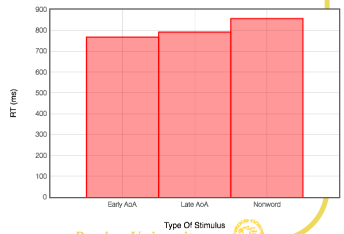
Age of Acquisition

- Word learning is an integral part of human knowledge, with lasting effects
- CogLab experiment used a Lexical decision task to measure reaction time to words that were
  - Learned relatively early in life (Early AoA: age 6 or sooner)
  - Learned relatively late (Late AoA: age 7 or later)
  - 168 participants



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Around 18 months

- Children learn simple rules of syntax
  - All dry. All messy. All wet.
  - I sit. I shut. No bed.
  - No pee. See baby. See pretty.
- Content is similar for all languages
  - objects appear, disappear, move,…
  - people do things, see things,…
  - ask questions, who, what, where,...

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All hell breaks loose

- After mastering 2-word strings, toddlers go crazy on language
- Consider changes in language (year;month)
  - (2;3) Play checkers. Big drum. I got horn.
  - (2;5) Now put boots on. Where wrench go? What that paper clip doing?
  - (2;7) Ursula has a boot on. Shadow has hat like that.
  - (2;9) Where Mommy keep her pocket book? Show you something funny.
  - (2;11) Why you mixing baby chocolate? I finishing drinking all up down my throat.
  - (3;1) You went to Boston University? Doggies like to climb up.

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Errors

- Three year olds make lots of grammatical errors
  - that is because there are lots of opportunities for errors
  - but pick any particular grammatical rule and you find most three year olds obey it most of the time
  - this is amazing because there lots of cases that you would expect would be difficult to learn

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Expected errors

- Consider a child hearing adults talk and how they might incorrectly apply what they learn
- Out of 66,000 sentences, children never made these errors

Grammatical	Not grammatical
He seems happy. --> Does he seem happy?	He is smiling. --> Does he be smiling?
He did eat. --> He didn't eat.	He did a few things. --> He didn't a few things.

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Errors

- Children *do* make errors, but the errors are consistent with rules of language
- Children often over generalize a rule
  - -s to pluralize a noun
    - » Mouses, leafs
  - -ed to make the past tense of a verb
    - » My teacher holded the baby rabbits and we patted them.
    - » Hey, Horton heared a Who.
    - » I finded Renee.
    - » Once upon a time a alligator was eating a dinosaur and the dinosaur was eating the alligator and the dinosaur was eaten by the alligator and the alligator goed kerplunk.

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Overgeneralization

- These past tense forms sound wrong because English has around 180 irregular verbs
  - inherited from other languages
  - These past-tense forms are not derived from rules
- Irregular forms have to be memorized, word by word
- If a child cannot remember (in its lexicon)
  - s/he defaults to the rule
- These errors are for the most difficult parts of a language to learn
  - Because they don't follow the normal rules

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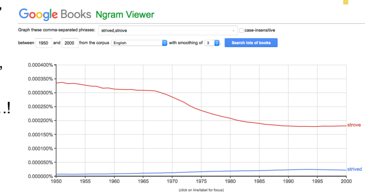
Overgeneralizations

- We know this is the most difficult part of language because adults make the same *kind* of mistakes
  - tread - trod strive -strove
  - dwell - dwelt slay-slew
  - rend - rent smite - smote
- Sound weird because we do not often hear them
  - many adults "regularize" the words
  - treaded, strived, dwelled, slayed, rended, smited
  - thus language changes…!



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Syntax errors

- Children make similar mistakes in applying grammatical rules
- In English there is a causative rule that applies to some verbs and not others
  - takes a verb meaning "to do something" and converts it to a verb meaning "to cause to do something"
- Thus you can say
  - The butter *melted*. --> Sally *melted* the butter.
  - The ball *bounced*. --> Hiram *bounced* the ball.
- But you can't say the second of each pair
  - I *like* sausage. --> I am *liked* of sausage.
  - I *giggled*. --> Sally *giggled* me.

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Syntax errors

- Children over generalize application of the causative rule to inappropriate verbs
  - I *go* to the bathroom. --> *Go* me to the bathroom.
  - Aunt Jane *died*. --> The tiger will come and eat David and then he will be *died* and I won't have a little brother anymore.
  - I *drink* with a cup. --> Yawny Baby - you can push her mouth open to *drink* her.
- Many of these errors would be fine in other languages!
- The situation is similar to the special past tense verbs
  - This rule must be memorized as applying to some verbs and not others

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Syntax errors

- Adults also misapply the causative rule
  - *Sparkle* your table with Cape Cod classic glass-ware.
  - Well, that *decided* me.
  - This new golf ball could *obsolete* many golf courses.
  - If she *subscribes* us up, she'll get a bonus.
  - *Boiler* up!
- Children's errors tend to track the more difficult aspects of a language, relative to other languages
  - Adults make the same kinds of mistakes for still more difficult to remember cases

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Second language

- It is difficult (and rare) for an adult to become fluent in a second language
  - children do it easily
- What accounts for the difference?
  - most likely it is age
  - there seems to be a critical period during which language can be learned
  - beyond age six (or so) it becomes more difficult to learn a language (first or second)

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Second language

- High school and college (or later) is too late for most people to completely learn a second language
- It should be in kindergarten or preschool
  - There is still value in learning a second language as an adult, just have realistic expectations!
- Immigrants who arrive after age 6 may never *fully* learn a second language
- Children who fail to learn any language by age 6 never do
  - they might create a pidgin of some sort

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Conclusions

- Language development
- Stages of learning
- Errors
- Second language

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Next time

- Language & brain
- Broca's aphasia
- Wernicke's aphasia
- Anomia
- Language ability of chimps
- *What's the big deal about Nim Chimpsky?*

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Language and the brain

PSY 200

Greg Francis

Lecture 31

What's the big deal about Nim Chimpsky?

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Language

- Properties
  - grammar
  - phrases
  - words
- Instinct
  - different from other types of learning
  - special areas in the brain related to language
  - evolution: can similar brains learn language?

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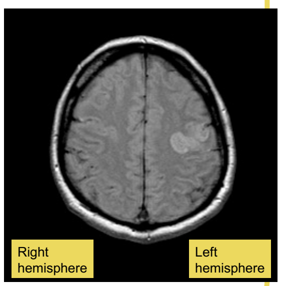
Broca's aphasia

- Some stroke patients show agrammatical speech
- Seem to know what they want to say
  - But are unable to say it



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Broca's aphasia

- Some stroke patients show agrammatical speech
  - repetition
  - short sentences
  - true for both written and spoken
  - no problem controlling mouth
    - » e.g. blowing out candles

Do you drive home on weekends?

Why, yes…Thursday, er, er, er, no, er Friday…Barba-ra…wife …and, oh, car…drive… purnpike…you know… reset and…teevee.

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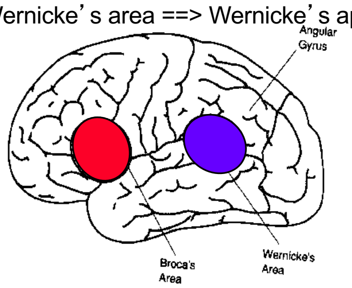
Brain damage

- Broca's area ==> Broca's aphasia
- Wernicke's area ==> Wernicke's aphasia



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Broca's aphasia

- Mr. Ford
  - omitted endings (-ed, -s)
  - omitted function words (or, be, the)
  - skipped function words when reading (or, be, the) but read similar sounding words (oar, bee)
  - named objects and recognized names
  - high (nonverbal) IQ

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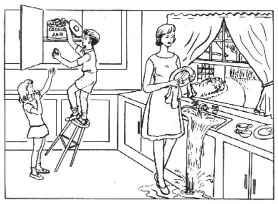
Broca’s aphasia

- Difficulty getting ideas across
- Patient BL was asked to describe this picture



B.L.: Wife is dry dishes. Water down! Oh boy! Okay Awright. Okay ...Cookie is down...fall, and girl, okay, girl...boy...um...
Examiner: What is the boy doing?
B.L.:Cookie is...um...catch
Examiner: Who is getting the cookies?
B.L.: Girl, girl
Examiner: Who is about to fall down?
B.L.: Boy...fall down!

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Broca’s aphasia

- Could understand questions if gist could be deduced from content words
  - Do you use a hammer for cutting?
  - Does a stone float on water?
- Failed to understand anything requiring grammatical analysis
  - The lion was killed by the tiger, which one is dead?

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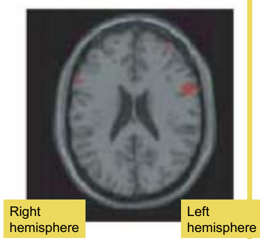
Broca’s area

- Plays a role in learning the rules of a language
- Musso et al. (2003)
  - fMRI while subjects judge whether Italian sentences are grammatically correct or not
  - At start, subjects did not know rules of Italian
  - Broca’s area is activated
  - Signal correlates with correct identification



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Wernicke’s aphasia

- Other stroke patients also show agrammatical speech
- Seem to be able to say things
  - But what they say is almost meaningless

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Wernicke’s aphasia

- Patients show
  - poor comprehension
  - poor vocabulary
  - “empty” speech

What brings you to the hospital?

Boy, I’m sweating, I’m awful nervous, you know, once in a while I get caught up, I can’t mention the tarripoi, a month ago, quite a little, I’ve done a lot well. I impose a lot, while on the other hand, you know what I mean, I have to run around, look it over, trebbin and all that sort of stuff...

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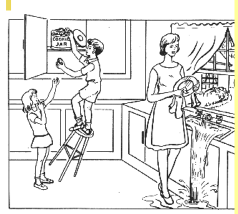
Wernicke’s aphasia

- Difficulty getting ideas across



H.W.:First of all this is falling down, just about, and is gonna fall down and they're both getting something to eat...but the trouble is this is gonna let go and they're both gonna fall down...but already then...I can't see well enough but I believe that either she or will have some food that's not good for you and she's to get some for her too...and that you get it and you shouldn't get it there because they shouldn't go up there and get it unless you tell them that they could have it. and so this is falling down and for sure there's one they're going to have for food and, and didn't come out right, the uh, the stuff that's uh, good for, it's not good for you but it, but you love it, um mum mum (smacks lips)...and that so they've...see that, I can't see whether it's in there or not.

Examiner:Yes, that's not real clear. What do you think she's doing?

H.W.:But, oh, I know. She's waiting for this!

Examiner:No, I meant right here with her hand, right where you can't figure out what she's doing with that hand.

H.W.:Oh, I think she's saying I want two or three, I want one, I think, I think so, and so, so she's gonna get this one for sure it's gonna fall down there or whatever, she's gonna get that one and, and there, he's gonna get one himself or more, it all depends with this when they fall down...and when it falls down there's no problem, all they got to do is fix it and go right back up and get some more.

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Wernicke's aphasia

- Most aphasias involve damage to more than just one specific area

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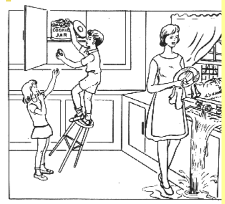
Anomia

- Damage *around* Wernicke's area produces a deficit in the ability to *name* things
  - e.g., after a stroke in this area CB cannot retrieve *nouns* he wants to use



C.B. Uh, well this is the...the...of this. This and this and this and this. These things going in there like that. This is...things here. This one here, these two things here. And the other one here, back in this one, this one...look at this one.

Examiner Yeah, what's happening there?

C.B. I can't tell you what that is, but I know what it is, but I don't know where it is. But I don't know what's under. I know it's you couldn't say it's ... I couldn't say what it is. I couldn't say what that is. This shu-- that should be right in here. That's very bad in there. Anyway, this one here, and that, and that's it. This is the getting in here and that's the getting around here, and that, and that's it. This is getting in here and that's the getting around here, this one and one with this one. And this one, and that's it, isn't it? I don't know what else you'd want.

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Anomia

- Sometimes anomia can be remarkable specific
- Some patients have difficulty with only certain types of nouns
  - concrete vs abstract (chair vs trust)
  - nonliving vs living (table vs dog)
  - animals and vegetables vs food and body parts
  - colors
  - proper names

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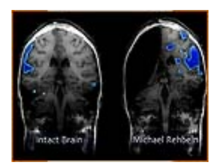
Brain and language

- Recall that the left side of the brain is more involved in language than the right side
  - Broca's and Wernicke's areas are on the left hemisphere
- However, the right hemisphere can also work with language
  - left handed people
  - hemispherectomies (age matters!)



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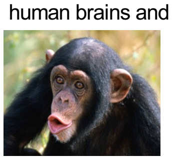
Brain and evolution

- We've argued that language is an evolved instinct
  - differences in brains account for differences in abilities
- One might hope to find proto-language abilities in "close" animals to humans
  - Chimpanzees, apes
- Anatomically, there are many similarities between human brains and apes and chimpanzees



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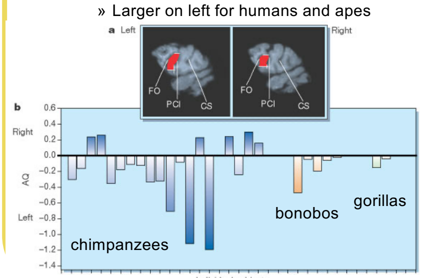
Brain and evolution

- Cantalupo & Hopkins (2001)
  - Broadmann's area 44 (part of Broca's area in humans)
  - Compare area on left and right hemispheres
    - » Larger on left for humans and apes



Implies hemisphere asymmetries that underlay language began at least 5 million years ago

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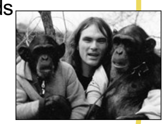
Chimpanzee language

- In the 1960s several research groups reported teaching chimpanzees American Sign Language (ASL)
  - after failure to teach spoken language
  - other groups taught chimps to press symbols on a computer keyboard or string magnetized plastic shapes on a board
- Claimed to teach chimps hundreds of words
  - and chimps created new compound words
    - swan -> water bird
    - stale Danish -> cookie rock
    - There's a movie
    - https://www.youtube.com/watch?v=u4T8ZeZy22M



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Problems

- Just like with Eliza (the computer therapist) it is easy to attribute language ability where it does not really exist (9 month old children)
- You can teach an animal a lot using simple conditioning tricks
- Researchers were quick to excuse mistakes as "play", "jokes", "puns", "metaphors",...

20

Word counts

- For example, a deaf student on one research team later commented that she saw fewer signs than the non-deaf students
  - seems the researchers counted almost *any* hand movement as a sign
- Like
  - scratch --> "scratch"
  - pointing --> "you"
  - finger to mouth --> "drink"
  - hugging --> "hug"
  - reaching --> "give"
  - kissing --> "kiss"

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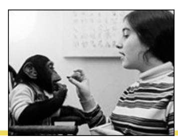
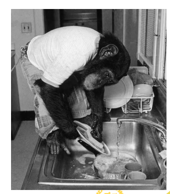
Nim Chimpsky

- A relative of other "signing" chimps
  - with more careful judging probably learned approximately 25 words
  - moreover, the "signs" were variations of the natural movements of chimps in the wild
- The chimps did *not* learn ASL





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Grammar

- Chimps failed to learn the rules of ASL grammar
  - unable to understand complex signs
- Seemingly able to understand complex sentences
  - Would you please carry the cooler to Penny?
- But really, the chimp need only understand two words: cooler and Penney
  - the rest can be guessed!

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Grammar

- Likewise, the chimps never produced complex sentences
- They tended to "say" things like the following
  - Nim eat Nim eat.
  - Drink eat me Nim.
  - Tickle me Nim play.
  - Me eat me eat.
  - Me banana you banana me you give.
  - Banana me me me eat.
  - Give orange me give eat orange me eat orange give me eat orange give me you.

they *communicate* but not with real language

24

Evolution

- Note, it would have been interesting if chimps could learn language
  - and not inconsistent with the idea that we have a language instinct
- But the failure of chimps to learn language does not go against the idea that language evolved in humans
  - as some people have proposed

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Evolution

- Chimps *are* the closest living evolutionary relatives of humans
  - so if any non-human living animal could learn language it would probably be chimps
- But in evolutionary history, chimps and humans split from a common ancestor millions of years ago
- Humans evolved a language skill and chimps did not

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Conclusions

- Language and the brain
- Broca's aphasia
- Wernicke's aphasia
- Anomia
- Chimps

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Next time

- Consciousness
- Dualism
- Artificial intelligence
- Qualia
- *Do you see red like I see green?*

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Consciousness

PSY 200

Greg Francis

Lecture 32

Do you see red like I see green?

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1

What is consciousness?

- Awareness of events, stimuli, thoughts, self
- A sequence of meaningful items
- Stream of thoughts
- Distinct from unconscious processing (e.g., hearing a sentence, retrieving information from memory,…)

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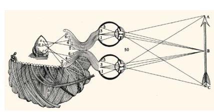
History

- Descartes' dualism (Cartesian dualism)
  - pineal gland link between body and spirit
  - how they could connect was a real problem



- Mind-body problem
- Materialism (the brain *is* the mind)
  - or the mind derives from the brain

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Materialism

- Nearly all scientists are materialists, but old ideas die hard
- A lot of work (e.g., fMRI) looks for the *site* of consciousness
  - a special physical transformation
  - thalamus
  - reticular formation
  - quantum mechanics
  - distributed awareness

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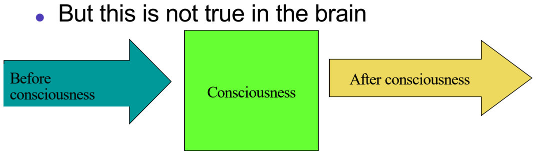
A turning point

- A common view is that there is a moment/ place which/where before something was *not* conscious and which after it *is* conscious
- But this is not true in the brain



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Distributed processing

- Information processing is spatially and temporally *distributed* in the brain
- Processing changes with new stimuli
- There really is no "moment of consciousness"
  - different brain areas know different things at different times

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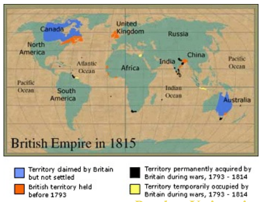
An analogy

- When did the British empire learn of the end of the War of 1812?
  - treaty signed in London months before the Battle of New Orleans
  - word was not received by British troops in America until two weeks after the Battle of New Orleans (January 8, 1815)



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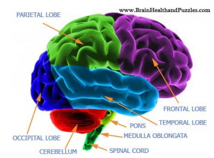
An analogy

- For complicated systems like the British empire (and human brains)
  - different parts know different things at different times
  - there is no official moment of knowledge
  - no official moment of consciousness!
- Demonstration
  - when does the class know/understand?



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How / Why?

- There is no “moment” because information is *distributed* in the brain
  - Both in space and time
- Can distributed processing really produce consciousness, or must there be something else to “put it all together”?
  - can consciousness arise from non-conscious processors? (artificial intelligence?)

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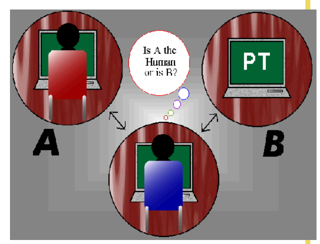
Turing test

- How do you know a person is conscious/intelligent?
  - They behave in a way that we interpret as consistent with a conscious being
- Turing test: apply the same logic to a computer
  - if a conversation with a computer is indistinguishable from a conversation with a human
  - Then conclude the computer is intelligent



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Artificial intelligence

- No computer has (formally) passed anything but a weak form of the Turing test
  - lack sufficient schemas, creativity, general knowledge
  - Many people expect a version of Chat GPT(-5?) will be able to pass the Turing test
- It is worth noting that other things would also not pass a Turing test
  - children
  - mentally impaired people
  - mute people
  - people who speak a language we do not understand
- Passing a Turing test is not *necessary* for consciousness

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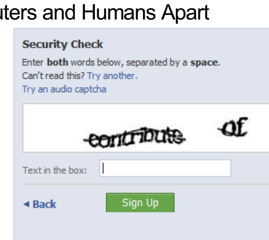
Captcha

- The basic ideas are implemented in several methods for computer security
- Completely Automated Public Turing test to tell Computers and Humans Apart



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Turing test

- The Turing test is only one way to demonstrate intelligence
  - and a rather strict one at that
  - not passing the Turing test does not mean that a computer is not intelligent
  - of course, it doesn't mean the computer *is* intelligent either
- Variations on Turing test
  - discriminate conversation between a child and a computer
  - look at a conversation and decide which was the computer
  - ...

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Doubters

- Many people have suggested that computers cannot, in principle, become intelligent
  - they argue that purely symbolic computations cannot lead to consciousness
  - and humans use emotion, insight, intuition, intentionality instead of simple computation
  - This is often the basis of arguments that Chat GPT is not "intelligent"
- Let's look at two arguments against "strong AI"

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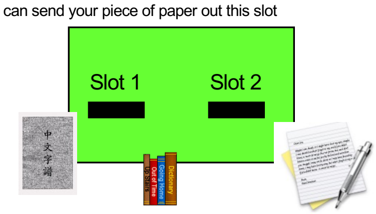
1. The Chinese room (Searle)

- Imagine you are in a room with two slots and a book
  - Slot 1: someone sends you notes with Chinese characters on them
  - Book (written in English): in the book you can look up the Chinese characters and write down corresponding Chinese characters on another piece of paper
  - Slot 2: you can send your piece of paper out this slot



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1. The Chinese room (Searle)

- If the book provides rules on how to answer questions in Chinese
  - then you can answer written questions in Chinese
  - even though *you* do not know Chinese!
- Consciousness (in general, understanding) is not a function of the thing (or person) who *implements* the rules
- But consider it from the point of view of a person outside the room
  - Who is sending messages in

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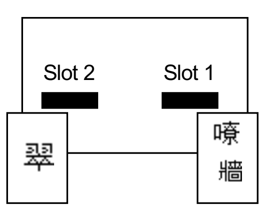
1. The Chinese room (Searle)

- You are having a conversation with someone
  - You have to decide if the person understands what you are saying (it's the Turing test)
  - You ask them to describe the wall of their room
  - They report it is green
  - …and so on…



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1. The Chinese room (Searle)

- Searle's point is that
  - We know the person in the room does not understand Chinese
  - We might be fooled into thinking they do based on their responses to the questions
  - Thus, the Turing test is a bad test
- Because the Turing test is essentially the same structure
  - The computer plays the role of the person in the room

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However,…

- Searle has set up a deceptively simple scenario
  - the Chinese room may be an impossibility
- You can *imagine* a situation where one has a book with rules to answer questions in Chinese
  - but only if you do not think too hard
  - in reality, there may be no such book!
  - if the questions can be on almost any topic, then understanding is *required* for that type of complex processing
- And understanding is generally restricted to consciousness
  - Or maybe one needs to conclude that such an advanced book has *potential* consciousness

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And moreover…

- At a smaller level of computation, it is hard to see how consciousness could *not* be (theoretically) possible in computers
- Each cell in your head is data in - data out
  - suppose cells were gradually replaced by tiny computers that kept *all* processing the same
    - » Neuromorphic chips
  - would you claim that at some point you are no longer conscious?
- This suggests there is nothing fundamental about *organic* consciousness

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2. Qualia

- Some researchers object to the very idea that computers could become conscious
  - They argue that some things in consciousness are *not* just computation
  - e.g., consider the color red
  - There seems to be a particularly subjective experience of seeing something red

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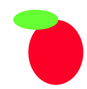
2. Qualia

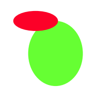
- Consider two people who see the world in color opposites

Qualia for person 1



"A red apple with a green leaf"

Qualia for person 2



"A red apple with a green leaf"

22

2. Qualia

- Clearly, there's a big difference in the perceptual experience of these people, but their behavior is essentially the same
  - And there seems no way to distinguish one experience from the other
  - It's the unmeasureable experience that is a qualia

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2. Qualia

- Qualia proponents argue, for example,
  - you can learn all there is to know about light waves, photoreceptors, neural transduction and coding of color,…
  - But suppose you never see any red objects
  - Your knowledge will not tell you what you will experience when you first see the red of an apple
  - Indeed, you could be tricked into believing a green apple was red (if you had never seen green either)

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2. Qualia

- But this is a defeatist argument, or a pointless one
  - *if* I knew *everything* about light, photoreceptors, and neural representation of colors, then I *would* be able to know what I will experience when I see red
  - it is difficult (maybe impossible for any single human) to know (or even imagine knowing) all that information in an academic sense
  - but that doesn't mean that such information does not exist
- It's partly an empirical question
  - But no one can do the experiment

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Conclusions

- Consciousness
- distributed processing in the brain
  - no *site* of consciousness
  - no *time* of consciousness
- Chinese room
- Qualia
- Artificial Intelligence
- Daniel Dennet *Consciousness Explained* (1991)

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Next time

- Review for exam 4
- After exam 4
  - Decision making
  - Framing effects
  - Risks
  - Alternatives
  - CogLab on Monty Hall
- *What every consumer should know before they buy.*

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Decision making

PSY 200

Greg Francis

Lecture 33

What every consumer should know before buying.

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1

Decision making

- We have to make lots of *choices*
  - course selections
  - elections
  - housing
  - job
  - cancer treatment

- What affects our choices?
- How do we make choices?

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2

It's difficult to do well

- Making good decisions is very challenging for most people
- The optimal way to do it (utility theory) involves evaluating the cost/benefit of all possible outcomes and weighting by the probability of each each outcome
  - Nearly impossible to do
  - how to characterize all alternatives?
  - Personal utilities are unknown even for you, personally
- Even when choices and utilities are clear, there are surprising properties of decision making

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High-Low money game

- The local radio station WASK (98.7) sometimes runs a high-low money game
- A caller guesses the amount of money in a "pot"
- If correct, the caller wins the money
- Otherwise, the radio DJ announces whether the guess was high or low
- Suppose previous guesses have been: \$112.03 (high), \$97.83 (high), \$52.72 (low)
- You call in, what should you guess?

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High-Low money game

- To maximize utility (\$), guess one penny lower than the previous high guess:
  - \$97.82
- The true amount could be anywhere between \$97.82 (one penny less than the lowest high value) and \$52.73 (one penny more than the highest low value)
- Each possible value (to the penny) has a probability of

$$\frac{1}{4510}$$

- You may as well guess the choice that gives you the most money!
  - You are probably not going to win

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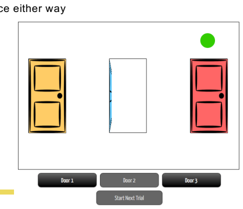
5

More confusion

- Even without utilities, probability is difficult to work with
- In the Monty Hall CogLab, you make a sequence of choices while trying to find a prize
- Choose one of three doors
  - Another door without the prize is opened
- You can now choose the other door or stay with your original choice
  - Seems like 50% chance either way



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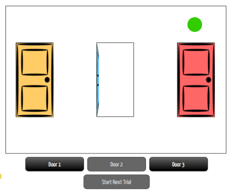
More confusion

- You will win more often if you switch
  - 66% win when you switch
  - 33% win when you don't switch
- To see, why suppose your initial pick did *not* have the prize
  - This will happen 66% of the time just by chance
- The program has to open the door without the prize
  - Thus, you win 66% of the time by switching to the other door



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Heuristics

- Since people are not good at making optimal decisions, they use other approaches
- These other approaches make people sensitive to a variety of influences
  - framing effects
  - risks
  - alternatives
  - loss aversion
- Effects are often related

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Framing effects

- Your decisions are influenced by the way a set of choices is presented
- The child custody problem
  - two versions, essentially the same
  - lead to different choices

9

Version 1: award frame

- Imagine that you serve on the jury of an only-child sole-custody case following a relatively messy divorce. The facts are complicated by ambiguous economic, social, and emotional considerations, and you decide to base your decision entirely on the following few observations. To which parent would you **award** sole custody of the child?
- **Parent A:** average income, average health, average working hours, reasonable rapport with child, relatively stable social life
- **Parent B:** above-average income, very close relationship with child, extremely active social life, lots of work-related travel, minor health problems

64%

10

Version 2: deny frame

- Imagine that you serve on the jury of an only-child sole-custody case following a relatively messy divorce. The facts are complicated by ambiguous economic, social, and emotional considerations, and you decide to base your decision entirely on the following few observations. To which parent would you **deny** sole custody of the child?
- **Parent A:** average income, average health, average working hours, reasonable rapport with child, relatively stable social life
- **Parent B:** above-average income, very close relationship with child, extremely active social life, lots of work-related travel, minor health problems

55%

11

Framing effects

- So Parent B is the choice to *award* custody and to *deny* custody
  - but one necessarily precludes the other!
- Subjects are biased by the task at hand
  - focus on different characteristics depending on whether they are considering awarding or denying

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Framing effects

- Your decisions are influenced by the way a set of choices is presented
- The Asian disease problem
  - two versions, essentially the same
  - lead to different choices

13

Version 1: Saving frame

- Imagine that the US is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
- If program A is adopted, 200 people will be saved. 70%
- If program B is adopted, there is a 1/3 probability that 600 people will be saved and a 2/3 probability that no people will be saved.

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Version 2: Dying frame

- Imagine that the US is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
- If program A is adopted, 400 people will die.
- If program B is adopted, there is a 1/3 probability that nobody will die and a 2/3 probability that 600 people will die. 61%

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Choices and framing

- The two problems are essentially identical, except that the choices are phrased differently
  - 200 people saved = 400 people dead
  - 2/3 probability that no one is saved = 2/3 probability that 600 will die
- But the phrasing makes a difference in the choices of subjects
  - why?

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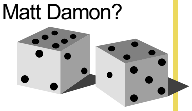
Risks

- Risk corresponds to those events that occur with probability
  - will I like the next movie starring Matt Damon?
  - will I live to be 50?
  - will the dice show double sixes?



- Events that occur with certainty are without risk
  - the sun will rise tomorrow
  - I will be older tomorrow
  - I will give you an A if your grade is 90 or above

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Risk

- Humans sometimes prefer risky options over non-risky options
  - and vice-versa
- When the choices are perceived as losses
  - subjects tend to be *risk-seeking*
- When the choices are perceived as gains
  - subjects tend to be *risk-averse*
- Decision making is open to manipulation
  - subjects can contradict themselves

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Risk: monetary choices

- Assume yourself richer by $300 than you are today. You have to choose between
- A) a sure gain of $100. 72%
- B) 50% chance to gain $200 and 50% chance to gain nothing.
- Subjects tend to prefer the sure gain
  - risk averse with perceived gains

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Risk: monetary choices

- Assume yourself richer by $500 than you are today. You have to choose between
- A) a sure loss of $100.
- B) 50% chance to lose nothing and 50% chance to lose $200. 64%
- Subjects tend to prefer the risky option
  - risk seeking with perceived losses

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Notice

- Selecting A) in either situation means you end up with $400
  - $300 + $100
  - $500 - $100
- Selecting B) in either situation means you end up with either $500 or $300
  - $300 + $200 or $300 + $0
  - $500 - $0 or $500 - $200
- People do not just look at the "bottom line"
  - which is why businesses emphasize that approach

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Alternatives: version 1

- Imagine you are shopping for a new car and have narrowed down your choices to three models. According to a consumer magazine, the cars' ride quality (RQ) and gas mileage (GM) are rated as

Model	RQ	GM	
Asteroid	100	27	69%
Bravo	80	33	29%
Comet	**100**	**21**	2%

- Which car do you select?

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Alternatives: version 2

- Imagine you are shopping for a new car and have narrowed down your choices to three models. According to a consumer magazine, the cars' ride quality (RQ) and gas mileage (GM) are rated as

Model	RQ	GM	
Asteroid	100	27	19%
Bravo	80	33	79%
Clarion	**60**	**33**	2%

- Which car do you select?

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Notice

- Subjects hardly ever select the Comet or the Clarion
  - you might think they do not enter the decision making process at all!
  - but they do
- The comparison of Asteroid and Comet clearly favors the Asteroid
  - it is less clear for the Bravo and Comet
  - it is the reverse for Clarion

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Consumer beware

- Stores are very aware of this type of behavior
- Thus, they often stock merchandise for the sole purpose of influencing your purchasing behavior
  - usually towards a more expensive model
- Likewise companies make low-end models simply to bias you toward higher end models and against the competition

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Loss aversion

- Another general property of decision making is that people tend to be more sensitive to losses than to gains
  - thus people rarely take an "even-bet"
  - the loss of $10 is more significant than the gain of $10
- This is also why fans of sports teams think the referees treat their team unfairly
- In a game of basketball, each team will
  - have fouls called on them when they shouldn't have (a loss)
  - Commit fouls that are not called (a gain)
- But the gains don't count as much as the losses
  - So in a truly fair game *both* teams (and their fans) feel as if they were treated unfairly
  - of course one team wins, so it feels that it overcame the injustice

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Loss aversion

- The same phenomenon ruins many marriages/relationships
- When your partner does something for you (a gain) it doesn't count as much as when your partner does something against you (a loss)
  - Thus, you perceive your relationship as overall not being worth the trouble (even if your partner is good as often as bad)
  - That's why therapists suggest that in successful relationships people must learn to forgive

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Loss aversion

- By definition a choice is a loss or a gain depending on where you start
- As a result, loss aversion dramatically affects many types of choices by magnifying those characteristics of a choice that leads to a perceived loss
- Consider *choosing a job*

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Choosing a job: 1

- You have decided to leave your current job. It is located so far away from your apartment that it requires an 80-minute commute each way. But you do like the fact that your job involves much pleasant social interaction with your coworkers. Your search for a new job has given you two options and now you must choose between them. Which job would you prefer?
- Job A: Limited contact with others, commuting time 20 minutes.
- Job B: Moderately sociable, commuting time 60 minutes.

67%

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Choosing a job: 1

- You have decided to leave your current job. The job involves only a ten-minute commute, which you rather like. But your job leaves you isolated from coworkers for long periods of time. Your search for a new job has given you two options and now you must choose between them. Which job would you prefer?
- Job A: Limited contact with others, commuting time 20 minutes.
- Job B: Moderately sociable, commuting time 60 minutes.

70%

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Loss aversion

- In each case the subjects tend to choose the option that produces the *least loss*
  - keep sociable coworkers in version 1
  - minimizing commuting time in version 2
- Note, this means subjects are *not* just choosing what they perceive to be the best job overall (again, not looking at the bottom line)
  - but are instead choosing the best job relative to the current situation!
  - a very strange phenomenon!
- Note, some scientists suggest that "loss" is not the issue here; there are other situation-specific factors that explain these effects
  - It is true that there are some situations where loss aversion is not observed

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Conclusions

- Influences on decision making
- Framing effects
- Risk aversion (perceived gains)
- Risk seeking (perceived losses)
- Loss aversion

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Next time

- Problem solving
- Expertise
- Analogy
- Set effects
  - functional fixedness
- Insight
- *What does that "aha!" feeling mean?*

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Problem solving

PSY 200

Greg Francis

Lecture 34

What does that "aha" feeling mean?

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1

Problem solving

- A hallmark of intelligence
  - often used as a definition of intelligence
- Seem to get something from nothing
- We will not explain exactly how it happens
  - but we can look at some characteristics of problems and problem solving
    - » what makes for an easy (or hard) problem?
    - » what makes for a good (or bad) problem solver?

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2

Logic

- Some problems are completely handled with logic
- Unfortunately, most people are not logical in many situations
- The CogLab Wason selection task demonstrates challenges with logic
  - People do quite poorly at tasks of this type with abstract elements

Which cards do you need to turn over to verify the rule, "If a card has an even number on one side, it is red on the other."

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Logic

- People do better if the task is related to some overall theme

Each card has a person's age on one side and their drink on the other. Which cards do you need to turn over to verify the rule, "If a person is under 21 then they cannot be drinking alcohol."

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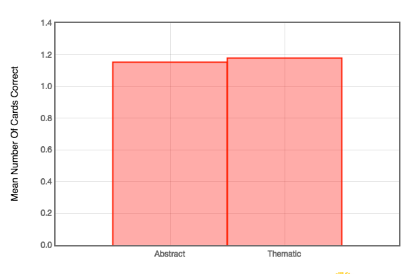
Logic

- CogLab data
- Count number of correctly chosen cards (2 is max)

Class data (166 participants)



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Topics

- Similar to characteristics of decision making a lot of problem solving techniques are heuristics
- We will look at a number of factors that influence our ability to solve problems
  - expertise
  - analogy
  - set effects
    - » priming
    - » incubation
    - » *functional fixedness*
  - insight

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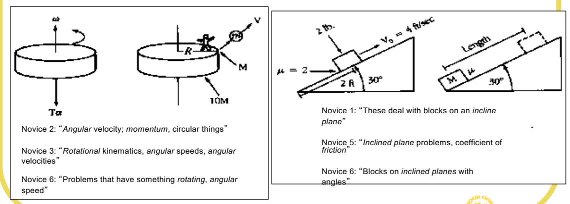
Experts

- Some people learn how to solve particular types of problems
- What makes an expert different from a novice?
- Experts know how to describe problems
  - other than that, there seems to be no fundamental difference (even for geniuses!)

7

An example of experts

- Chi, Feltovich & Glaser (1981)
- Take second year physics students (novices) and ask them to classify a bunch of physics problems
  - they tend to group them by surface similarities



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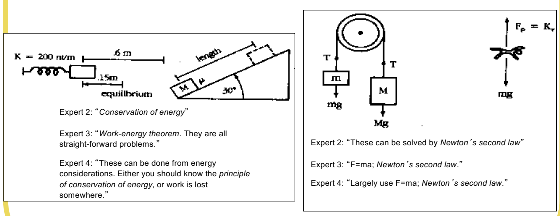
An example of experts

- Have experts (PhDs) classify the same problems
  - grouped according to how to solve



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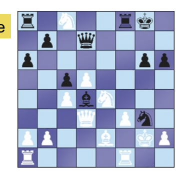
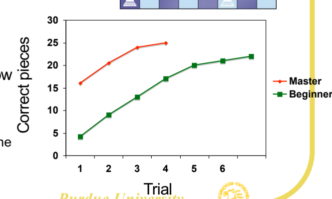
Chess experts

- Chase & Simon (1973)
- Show subjects a chess board and then clear it
  - have subjects recall positions of the chess pieces on the board
- Master players are better than beginners when the pieces are positioned as in the middle of a real game
- Experts have *schemas* that allow them to organize the piece positions
  - They only need to remember the schema

game





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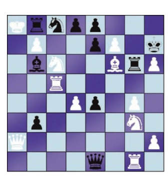
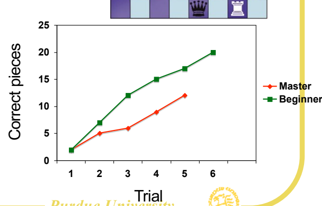
Chess experts

- Chase & Simon (1973)
- Show subjects a chess board and then clear it
  - have subjects recall positions of the chess pieces on the board
- Master players are *worse* than beginners when the pieces are positioned randomly
- Experts try to use the schemas, but they end up misremembering the actual piece positions

random





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Expert schemas

- In general, experts have lots of problem solving schemas specific to their domain of expertise
  - given such and such; do such and such
  - allows them to organize information in a way that allows for easy recall and easy use
- Expertise in one domain does not transfer to another
  - except for especially useful skills

12

Analogy: Attack-Dispersion Story

- The many roads to a dictator's fortress are mined so that small groups of men may pass, but a large group will be destroyed. A general knows that his army can defeat the fortress if he can get his entire army to attack at once, but he cannot take his army down a single road all at once without losing too many men.
- What should he do?

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Solution

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Analogy: Parade-dispersion

- A dictator wants to show off his army so he tells a general to plan a parade of the army. He demands that the general insure that the army is seen and heard across the entire kingdom simultaneously. The dictator also demands that the parade be the most impressive ever at the fortress. Splitting up the army would allow it to be seen everywhere, but would make the display at the fortress unimpressive.
- What should the general do?

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Analogy

- The solution is the same
- Glick & Holyoak (1980)
  - subjects read stories like these and were asked to solve the problems
  - even when shown one solution and told that it could be applied by analogy to another
  - subjects used analogies only 20% of the time

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Analogy

- Analogies are actually very difficult to apply
  - need to identify what is common between two problems
- Analogies are often applied *after* two problems are solved and well understood
  - it is then easier to see what is common
- One of the problems handed out can be solved by analogy to these two problems

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Set effects

- "Set" refers to "mind set" (or something like that)
  - negative set: bias toward solving a problem makes it more difficult
  - positive set: bias toward solving a problem makes it easier
- You can be biased by lots of things
  - problem statement
  - previous methods of reaching solution
  - general knowledge

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18

Past experience

- Buddhist monk problem
  - One morning, exactly at sunrise, a Buddhist monk began to climb a tall mountain. The narrow path, no more than a foot or two wide, spiraled around the mountain to a glittering temple at the summit. The monk ascended the path with an average speed of 3 mph. He reached the temple shortly before sunset. After several days of fasting and meditation he began his journey back along the same path, starting at sunrise and walking an average speed of 5 mph. Is there a spot along the path that the monk occupied on both trips at precisely the same time of day?

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Self-imposed limits

- Nine dots problem
  - Draw four straight lines, passing through all nine of these dots, without lifting your pencil from the page.

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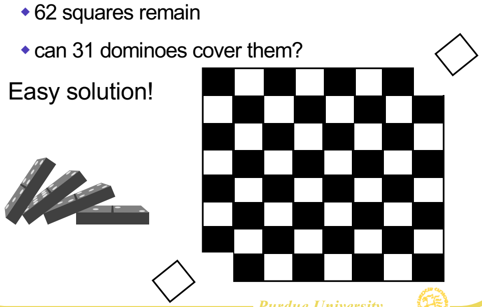
Set effects: Representation

- Mutilated chessboard
  - 62 squares remain
  - can 31 dominoes cover them?
- Easy solution!



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Set effects: Priming

- Safren (1962)
- Unscramble the following anagrams
- 12.2 seconds per word

KOBO CTURK STTE
CHUOC ANCYD DRINEF

7.4 seconds per word

KMLI GRAUS RECMA
FOEFCE TEESW IKRDN

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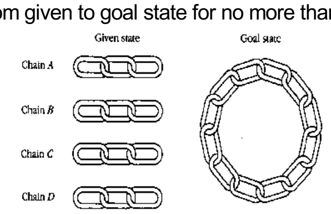
Set effects: Incubation

- Cheap necklace problem
- Opening a link costs $2
- Closing a link costs $3
- Go from given to goal state for no more than $15



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Set effects: Incubation

- Silveira (1971)
- Control: Work on problem for half an hour
  - 55% solve problem
- Exp A: Work on problem for half an hour in 15 minute sections, half-hour distracter task
  - 64% solve problem
- Exp B: Work on problem for half an hour in 15 minute sections, 4 hour distracter task
  - 85% solve problem

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Set effects: Incubation

- Subjects often get stuck using an approach that goes nowhere (set)
- After a break they are more likely to try a different approach
- Brainstorming tries to avoid set effects by allowing free “dreaming” of solutions
  - most of the ideas are worthless, but the approach is still beneficial

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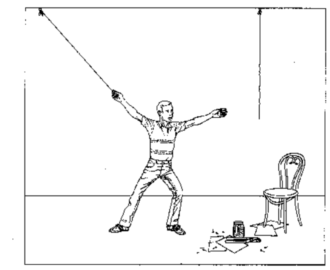
Set effects: Functional fixedness

- How can you tie two strings together?
- Dunker (1945)
  - “MacGyver”



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Insight

- Intuitively, we sometimes feel as if we have a strong insight into a problem and its solution becomes obvious
  - the “aha” feeling
  - is it real?
  - what does it correspond to?

- Using problems like the “Bronze coin” and the “Tree planting” problems (Metcalf, 1986)
  - subjects judge their progress with a “warmth” rating, every 10 seconds, over 5 minutes

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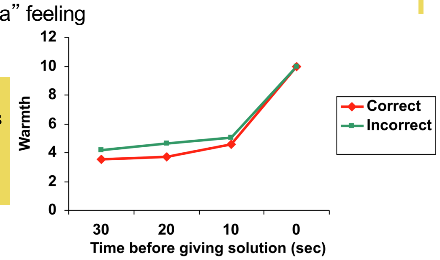
Insight

- Warmth stays mostly steady, right up to proposing a solution
  - the “aha” feeling

Unfortunately, the feeling does not necessarily indicate a correct solution



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Conclusions

- Effects on problem solving
- Expertise
- Analogy
- Set effects
- Insight
- Solve remaining problems
  - Tumor problem

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Next time

- Wrapping up the course
- Other courses to take/avoid
- Paths to pursue
- Graduate school
- *Advice for further exploration*

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Current topics

PSY 200

Greg Francis

Lecture 35

Advice for further exploration

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Studying cognitive psychology

- There is a Brain and Behavioral Sciences Major in psychology
  - More natural sciences than typical psych degree
- Most of psychology requires experimentation, you need
  - PSY 201: Introduction to statistics in psychology
  - PSY 203: Introduction to research methods in psychology
- More statistics
  - PSY 202 Introduction to Quantitative Psychology
  - STAT 225 Introduction to Probability Models
  - STAT 311 Introduction to Probability
  - STAT 350 Introduction to Statistics
  - STAT 511 Statistical Methods

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Research

- PSY 390 Research in…
  - Actively participate in a research laboratory
  - Details vary dramatically across labs
  - Advisors can identify some positions
  - Talk to faculty about possibilities
- Research Focused Honors program
  - 3 semester sequence (starts Spring of penultimate year)
  - Design and carry out your own research study (with guidance from a faculty member) https://hhs.purdue.edu/undergraduate-students/honors-program/psychological-sciences/

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Useful background

- Computers
  - Most experiments are run on computers
  - Models are simulated on computers
  - Learn to program in a computer language
    - » MatLab, C / C++, Java, JavaScript, Python, Julia
  - Possible courses
  - CS 15800 C Programming
  - CS 17700 Programming With Multimedia Objects
  - CS 18000 Problem Solving/Object-Oriented Programming
  - CS 24000 Programming In C
  - CNIT 105 Introduction to C Programming
  - CNIT 15500 Introduction to Object-Oriented Programming
  - CNIT 17500 Visual Programming

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Useful background

- Mathematics
  - Many psychologists have little mathematical background
  - But it is especially useful for cognitive psychology
  - Take as much mathematics as you can, especially
    - » Calculus (MA 161, 165 or 223)
    - » MA 375 Discrete Mathematics
    - » Linear (matrix) algebra (MA 262, 265)
    - » Differential equations (MA 266)

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Further study

- Brain characteristics
  - PSY 222: Introduction to behavioral neuroscience
  - PSY 322: Neuroscience of motivated behavior
  - PSY 324: Introduction to cognitive neuroscience
  - PSY 352: Introduction to Neuropsychology
  - SLHS 401: Language and the Brain
  - PSY 512: Neural systems

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Further study

- Perception and attention
  - PSY 310: Sensory & perceptual processes
  - PSY 376: Attention and Cognitive Control
  - PSY/ECE 511: Psychophysics
  - PSY 520: Attention & performance
  - PSY 577: Human Factors in Engineering
- Memory:
  - PSY 311: Human Memory
  - PSY 314: Introduction to learning

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Further study

- Language (many courses in Speech, Language, and Hearing Sciences - SLHS)
  - SLHS 227: Elements of linguistics
  - SLHS 309: Language development
  - PSY/SLHS 401: Language & the brain
  - PSY 403: Psycholinguistics
  - PSY 426: Language development
  - PSY 484: The Psychology of Consciousness
- Problem solving & decision making
  - PSY 514: Introduction to mathematical psychology

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Hot topic 1

- Relating cognition to the brain (and vice-versa)
- Several big initiatives
  - Human Brain Project
    - » https://www.humanbrainproject.eu
    - » €1.2 billion over 10 years
    - » Develop technologies to bring together disparate neurophysiological, anatomical, molecular, and behavioral data
    - » Database (big data)
    - » Modeling (supercomputers, specialized hardware)

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Hot topic 1

- Relating cognition to the brain (and vice-versa)
- Several big initiatives
  - Human Connectome Project
    - » http://www.humanconnectomeproject.org
    - » Building a "network map" that will shed light on the anatomical and functional connectivity within the healthy human brain

- Connections to cognitive psychology are (hopefully) in the future

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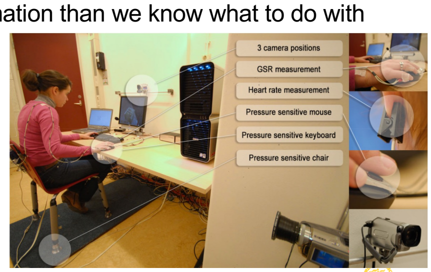
Hot topic 2

- Big data
- Technology allows gathering of *way* more information than we know what to do with



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Hot topic 2

- Big data
- Technology allows gathering of *way* more information than we know what to do with

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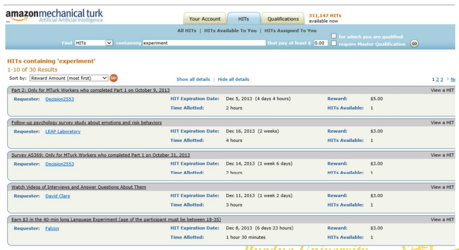
Hot topic 2

- Big data
- Many experiments can be run on-line with thousands of subjects



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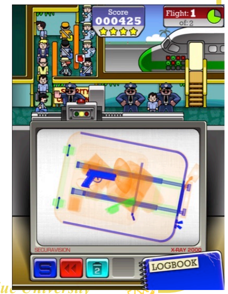
Hot topic 2

- Big data
- Data can be gathered in novel ways
- *Airport Scanner*
- 1 billion trials of visual search!



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Hot topic 3

- Data analysis
- Big data requires a different kind of statistics than has been used for simple experiments
- Moreover, there seem to be problems with present statistics even for simple experiments
- Areas of science that depend on statistics (e.g., psychology, biology, medicine) are facing a crisis as findings that satisfied old criterion are found to be false
  - And unbelievable findings meet the statistical criteria
  - "Pre-cognition"

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Graduate school

- Grades
- Financing
- After graduation

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Next time

- Review for final exam

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