Learning 4

Wednesday's Chapter Test

Statistical Learning:

Word Boundaries

Chapter Test #1 on Wednesday

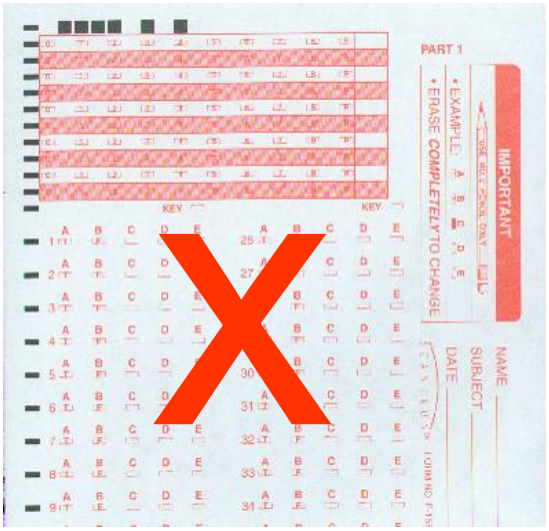
- It will cover material in the lectures, readings, and the Zap through TODAY'S class
- The exam will consist of
  - About 25 multiple-choice questions
  - Equal coverage of the readings and lectures
  - Emphasis on concepts and understanding rather than details
- Help for studying
  - Review questions
  - Discussion sections
  - Piazza
  - Office hours

What you need to Bring and Do

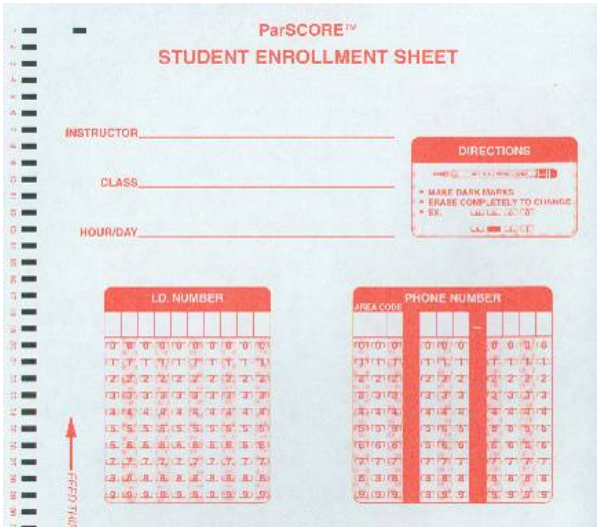
- Minimize what you bring into the exam
- Your will need
  - Scantron Form F-288 (red and white 5” x 11”)
  - Two sharpened #2 pencils
  - Your **UCI student ID** card
- Please arrive on time
  - If you are early, please wait outside until we are ready to let you in (7:55)
  - The exam will start by 8:05.
  - Everyone will have at least 40 minutes

Wrong and Right Scantron Forms

F-158 Wrong!



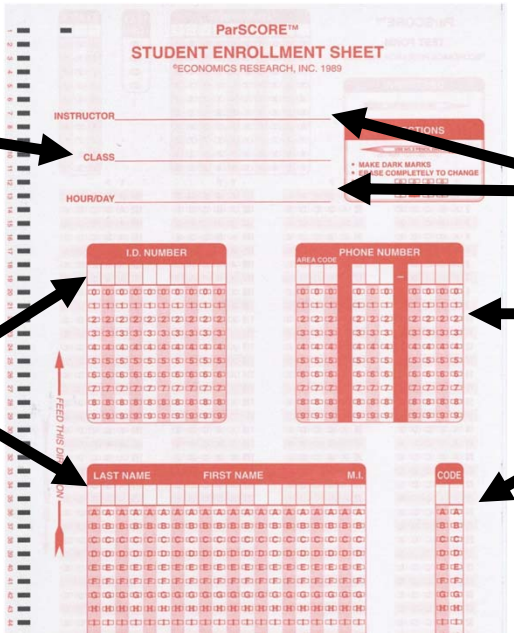
F-288 Right✓



Filling Out the Front of the Scantron Form (F-288)

Discussion Section Number

Very Important



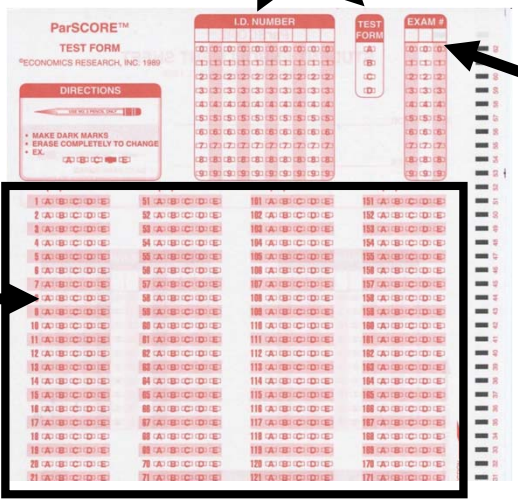
None of these fields matter

Discussion Sections

Dis 1	68051 54051	SSTR 103	M 12:00 – 12:50	Daniel Stehr
Dis 2	68052 54052	ET 202	M 2:00 -2:50	Daniel Stehr
Dis 3	68053 54053	SST 120	M 5:00-5:50	Laris Rodriquez
Dis 4	68054 54054	SST 120	M 6:00-6:50	Laris Rodriquez
Dis 5	68055 54055	SE2 1304	Tu 8:00-8:50	Kier Groulx
Dis 6	68056 54056	SST 220A	Tu 12:00-12:50	Kier Groulx
Dis 7	68057 54057	SSL 228	Tu 5:00-5:50	Veronica Chu
Dis 8	68058 54058	SL 228	Tu 6:00-6:50	Veronica Chu

Filling Out the Back of the Scantron Form (F-288)

Very Important



Not Important

Answers Go Here

Knowledge and abilities acquired *without* experience are said to be _____ .

A. Classically conditioned
B. Innate
C. Learned
D. Native

How do Newborns Know What They Need to Survive?

- All species have evolved highly constrained neural mechanisms to ensure that, at least some, environmental information is properly interpreted.

  Innate

- But some species are highly dependent on a period of interaction with the environment to do two things
  - Clarify the information to which attention should be directed
  - Learn the consequences of behaviors guided by that information.

  Learned

Infants Learning Language

- Language acquisition involves both
  - Experience-independent mechanisms -- Innate
  - Experience-dependent mechanisms -- Learned
  - The debate concerns the relative importance of each
- Young humans as poor learners, suggesting a more important role for innate factors in the acquisition of language.
- Saffran, Aslin, Newport (1996)
  - Suggests that infants are better learners than had been previously assumed

Problem: Identifying Word Boundaries in an New Language

"One task faced by all language learners is the segmentation of fluent speech into words. This process is particularly difficult because word boundaries in fluent speech are marked inconsistently by discrete acoustic events such as pauses … it is not clear what information is used by infants to discover word boundaries … there is no invariant cue to word boundaries present in all languages."

- Saffran, Aslin, & Newport (1996)

- Try locating the words in this sample of an Eskimo language spoken in the Artic
  http://globalrecordings.net/en/language/321

For Adults, “Top-Down,” Meaning Cues Help Hide the Problem

The White House is under attack.

The white house is under a tack.

Another Example

"Boy, he must think we're pretty stupid to fall for that again."

How Might Infants (or Anyone) Solve this Problem?

- Adults can use top-down information
  - Our knowledge of words and the world
  - To help with word segmentation.
- How can infants identify the words in continuous speech so that they can learn them?

Information from Statistical Regularities

- Hypothesis: Are infants sensitive to the statistical regularities (i.e., patterns) contained in sequences of sounds?

"Over a corpus of speech there are measurable statistical regularities that distinguish recurring sound sequences that comprise words from the more accidental sound sequences that occur across word boundaries."

- Saffran, Aslin, & Newport (1996)

Example of Statistical Regularity

- Consider the phrase

  to the castle beyond the goblin city

  - In English, the sound combinations in *castle* are common
    - /k/ /ah/ cat
    - /ah/ /s/ hassle
    - /s/ /ul/ sultan

Example of Statistical Regularity

- Consider the phrase

  to the castle beyond the goblin city

  - The sound combination /*ul*/ /*b*/ is rare
  - Generally, combinations of sounds that cross word boundaries are less common than those occurring within words

Measuring Statistical Regularities: Transitional Probability

TrProb(AB) = Prob(B | A)

Transitional probability of sequence AB is the conditional probability of B, given that A has been encountered.

TrProb(“gob” ”lin”) = Prob(“lin” | “gob”)

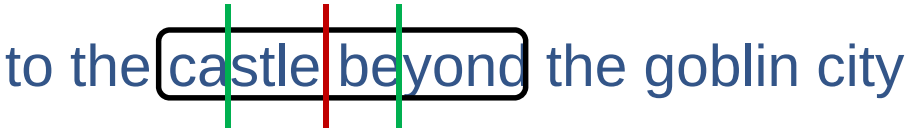
Read this as “the probability of ‘lin’, given that ‘gob’ has just been encountered”

Measuring Statistical Regularities: An Example

Example of how to calculate TrProb:
Starting with *gob* …
In (my) English there are 6 options for what could follow:
…*ble*, …*bler*, …*let*, …*lin*,
but also (maybe)
…*bled-ygook*, …*sto-pper*
So
TrProb(“gob” “lin”) = Prob(“lin” | “gob”) = 1/6

Example of TrProb Within Versus Between Words

- Recall the phrase



  - TrProb("*stle*" | *"ca"*) = high
  - TrProb(*"be"* | "*stle*") = low
  - TrProb("*yond*" | *"be"*) = high
- According to the statistical regularities hypothesis, word boundaries are expected at *local minima* of TrProb
- Note: It doesn't matter what the probability at the boundary actually is, so long as it's small compared to the probabilities surrounding it

Interim Summary

- We have been exploring TrProbs because
  - Saffran, Aslin, and Newport (1996) hypothesized that infants may be able to use statistical regularities to locate words in continuous speech
  - TrProbs are one way of characterizing statistical regularities
  - Word boundaries tend to occur where there are local minima in TrProbs

A thought question:

Do you think that infants can detect statistical regularities in continuous speech and use that information to locate words (and that we can study this if they do)?

A. Yes
B. No – How could infants possibly be computing TrProbs
C. No – Even if they can determine TrProbs how would they know to use them to look for words in speech?
D. No – Even if infants can use statistical regularities to locate words how could they tell us that they do?
E. No – All of B-D above seem like serious issues

Can Infants Detect Statistical Regularities to Locate Words?

- Almost seems like a foolish question
- Insight: Contingency, which determines the strength of CS-US associations are like TrProbs!
- Research Strategy
  - Familiarize 8-month old infants to speech sequences containing transitions with different TrProbs
  - Use habituation to assess what they have learned

Stimuli: Artificial “Language”

- Composed of 4 made-up “words” with 3 syllables each

  tu/pi/ro go/la/bu bi/da/ku pa/do/ti

- Each of these 4 words was repeated 45 times in a randomly-ordered sequence lasting 2 minutes

go la bu pa do ti tu pi ro bi da ku pa do ti go la bu …

Hear a sample at http://whyfiles.org/058language/images/baby_stream.aiff

Within- versus Between-Word TrProbs

go la bu pa do ti tu pi ro bi da ku pa do ti go la bu …

- Within words, TrProbs of the syllables = 1.0

Within- versus Between-Word TrProbs

go la bu pa do ti tu pi ro bi da ku pa do ti go la bu …

- Across word boundaries, TrProbs of the syllables = 0.33
- This is true because each of the other three words is equally likely any particular word

Testing Infant Sensitivity to Statistical Regularities

- Each infant was cued to look to one side or the other by a light
- A test “word” was then presented repeatedly from a loudspeaker at that location until the infant looked away
- Looking time was measured
- This process was repeated 4 times
  - 2 times with “real” words
    for example: tu/pi/ro and go/la/bu
  - 2 times with “part” words made combining the final two syllables from one word with the initial syllable from another
    for example: pi/ro/go and da/ku/pa

- Assume that the statistical regularities hypothesis is correct – i.e., that these infants can detect word boundaries based on differences in TrProb.
- Recall that part of the research strategy was to use habituation.
- Which test stimulus should the infants listen to longer?

A. The "Real" words: e.g., tu/pi/ro and go/la/bu
B. The "Part" words: e.g., pi/ro/go and da/ku/pa

Result

- Infants listened longer to the less familiar items: i.e., the part-words
  - 6.77 seconds for real words
  - 7.60 seconds for part-words
- Infants noticed the difference between real words and part-words from hearing the artificial language for only 2 minutes!
- They are sensitive to the TrProbs – transitional probabilities

Recap: Saffran, Aslin, & Newport (1996)

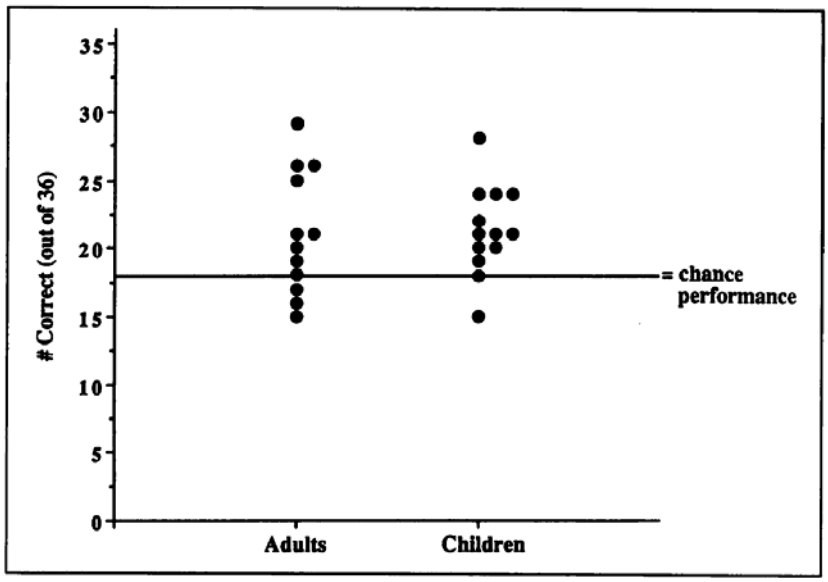
- Experimental evidence suggests that 8-month-old infants can track statistical information such as the transitional probability between syllables.
- This could be what helps them solve the task of word segmentation.
- Evidence comes from testing children in an artificial language paradigm, with very short exposure time.

Is Sensitivity to Statistical Regularities Unique to Infants?

- Saffran, Newport, Aslin, Tunick, Barrueco (1997)
- They studied 1st grade and college students
- The procedure was similar, but not identical
  - Artificial language had more words and syllables were repeated
  - Familiarization was 21 minute on each of 2 days
  - Testing was done by asking to indicate which of two “words” sounded like what they had heard during the familiarization

Results

- Both adults and children were sensitive to the statistical regularities
- There was no difference between the groups



Is Sensitivity to Statistical Regularities Unique to Speech?

- No
  - Both infants and adults can segment nonlinguistic auditory sequences (musical tones) based on the same kind of transitional probability cues - Saffran et al. (1999)
  - Similar results have been obtained in the visual domain using
    - temporally ordered sequences of stimuli - Kirkham et al., 2002
    - spatially organized visual “scenes” - Fiser & Aslin, 2002
  - Similar results have been obtained using touch - Conway & Christiansen (2005)
- Implication: sensitivity to statistical regularities applies across a variety of sensory domains and stimulus formats
  - This is a general ability that is innate

Is Sensitivity to Statistical Regularities Unique to Humans?

- No
  - Cotton-top tamarins exposed to the same kind of artificial speech stimuli used in Saffran et al. (1996) were able to perform the task as well as infants. - Hauser et al. (2001)
  - Tamarins could also learn simple grammatical structures based on statistical information, but were unable to learn patterns as complex as those learned by infants. - Saffran et al. (2008)
  - Rats were able to segment a speech stream based on syllable co-occurrence frequency - Toro & Trobalon (2005)
- Implication: This is not a uniquely human ability, but there are suggestions that humans can do more with this information than other species.

Summary

- Infants, as well as older humans and non humans, are sensitive to *statistical regularities*
  - One example is *transitional probabilities*
- This ability may help explain how infants find word boundaries in continuous speech
- This ability is not limited special to speech
  - It appears to be important for learning in many other domains
- This ability is
  - Innate
  - It may be related to classical conditioning

Looking Ahead

- Chapter Test WEDNESDAY
- For Friday:
  - Gleitman: Ch. 8, pp. 301-313.
  - Zap #2: Brown-Peterson Task
  - Zap #3: Memory Span
  - Zap #4: Serial Position
- Coffee at Phoenix Grill anyone?