Analyzing speech: Approaches and methods

Štefan Beňuš

What do linguists do?

- Common perception
  - They tell us what's correct
- Alternative approach
  - Language provides a window into our minds
  - By trying to understand how language works, we may learn about what goes on in our minds
  - We may better understand our behavior and ultimately, learn more about ourselves

Spoken vs. written language

- Spoken language is primary
  - Historically
  - Socially
    - Individual identity
    - emotions
  - Biologically
- Hence, spoken language may be better suited for trying to understand our minds
- Look for: systematic patterns in functions/meaning/distributions of sound contrasts that we produce and perceive in speech

Scientific approach (general)

- Identify an interesting point/question/issue
  - Try to form a question or a hypothesis
- Do research, read available literature on the topic, se what's already known
- Adjust/focus your question to something that is still not known and is manageable
- Identify the type of data and the way to collect them
- Determine the preferred ways of analyzing data, suggest features that should be measured/counted/labeled, determine **dependent and independent variables**
- What would the outcome (both positive and/or negative) of the analysis mean for broader issues, for our understanding of the system of spoken language?

Basic approaches

- Look for discrete differences
  - Design a labeling scheme if different functions
  - Count
  - Non-parametric statistics
- Look for continuous differences
  - Measure
  - Parametric statistics
- Same approach for the environment if interested in distributions
- Production and/or perception data

Potentially interesting & doable areas for your theses

- Phonology
  - Systematic distributional differences: Cju (BE) vs. Cu (AE), sC (SE) vs. Cs (AAVE),…
  - Inventories, processes (e.g. voice assimilation),…
- Socio-linguistics
  - Effect of social variables on speech
    - Dialect, age, sex, socio-economic status,…
- Aspects of foreign language speech
  - Quality of segments (e.g. effect of environment?), suprasegmental features,…
  - Interference factors
  - Aspects affecting acquisition (TEFL methods)
- Discourse & pragmatics
  - Filled pauses, turn-taking, politeness, intentions, given-new, dialogue acts, …
- ???

What do Americans know?

American	British
am[yu]se	am[yu]se
b[yu]ty (beauty)	b[yu]ty
c[yu]be	c[yu]be
d[u]pe	d[yu]pe
f[yu]me	f[yu]me
l[u]rid	l[yu]rid
n[u]ws (news)	n[yu]ws
p[yu]ny (puny)	p[yu]ny
pre[zu]me (presume)	pre[zyu]me
st[u]pid	st[yu]pid
s[u]t (suit)	s[yu]t

How to get production data

- Record speech yourself
  - Somewhat spontaneous: interviews, collaborative tasks, stories, cartoons,…
  - Reading (lists, sentences, texts)
- Record/extract speech of native speakers available on the internet
  - Radio, TV, movies, speeches, blogs, …
- May use corpora available to me
  - Buckeye (AE)
  - Columbia games
  - ICE (both)
  - Santa Barbara corpus (AE)
- Use Praat or any available software (e.g. audacity is good)

How to get perception data

- Stimuli
  - Extract tokens with different functions in context
    - Difficult to control but more natural
  - Manipulate the signal to control the target feature
    - More control, less natural stimuli
  - Commonly fillers are also needed, frequency commonly plays a role
- Record the responses
  - Pen-paper or questionnaires good for mass test administration
  - Invest time in programming an application to also get reaction times (possible in Praat)

Protocol

- Instructions
  - Clear, uniform, non-biased
  - honest? written?
- Number of repetitions needed
- Subjects
  - Selection (pooling)
  - Control for potential independent variables

How to label data

- I like using Praat, but many other options available and possible
- Transcription and alignment
  - Needed?
- If functions are labeled, how can objectivity be facilitated?
  - More annotators, clear examples,…

Extract data from acoustic signal

- Determining boundaries of target segments allows for automatic extraction of data using Praat
  - Compared to manual measurements, automatic one is more objective but may introduce errors
- Durations (e.g. vowels, VOT), formants (quality of vowels and some consonants), center of gravity (e.g. fricatives), intensity, pitch,…

Labeling & Extracting data with Praat

- Record
- Transcribe & Label
- Extract continuous features & categorical labels
- Manipulate signal for perception experiments
- Demo??

Crash course to basic statistics

(adapted from J. Brotherton's slides, http://www.cc.gatech.edu/classes/AY2002/cs4750_fall/lectures/statistics.ppt)

- Principles of Testing
  - Populations and samples
  - Generating a hypothesis

- The Tests
  - Describing a population
  - Comparing two populations
    - t-Test
    - Paired t-Test
  - Relationships
  - Correlations
  - X^2 test (chi-squared)

Before we begin…

- Which method is better, A or B?
- Typical answers in Bc/Mgr theses...

- *Method* is an independent variable (=factor), *Task completion time* is dependent variable
- Examples of factors and dependent variables for speech research?

- How to prove our finding?

Task Completion Time (ms)		
Subject	Method A	Method B
1	200	200
2	210	20
3	190	400
4	201	5
5	199	390
6	195	10
7	205	200
8	200	80

Works for Questionnaires Too!

- Are students who answer A,B for Q#1 more likely to answer D,E for Q#2?

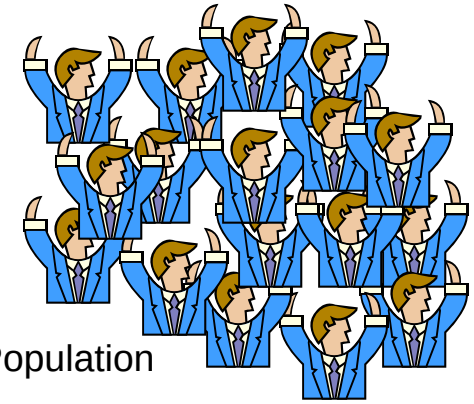
- How to prove it?

Questionnaire Response		
Subject	Q #1	Q #2
1	A	E
2	B	B
3	A	D
4	C	C
5	B	D
6	A	E
7	D	A
8	D	A

Populations and Samples

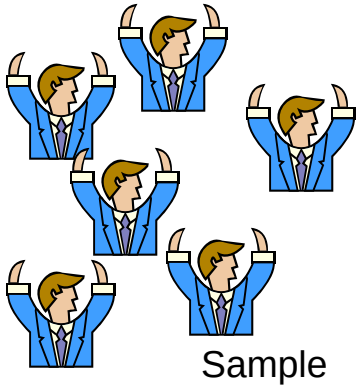
We want to know about these:

We have this to work with:



Population

Random Selection



Sample

Parameter μ

(Population mean)

Inference

$\bar{x}$ Statistic

(Sample mean)

Generating a Hypothesis

- Research Hypothesis
  - Students at Tech perform differently than students at Georgia
    - (tech != georgia)
      - (or could be one direction)
        - » tech > georgia
- Null Hypothesis
  - They perform the same
    - (tech = georgia)
- Example hypotheses from speech?

Tasks We Can Do

- Describe a population
- Compare one population to another
  - T-test
- Compare one population to itself (before and after effects), also same target in different environments
  - Paired t-test
- Validate trends, correlations
  - Chi-Square
  - correlation
  - Regression
- Stat software?
  - R, Excel, SPSS,…

Describing a Population

- We look for the central tendency of the data set
  - Mean
  - Median
  - Mode

Variance and Standard Deviation

- Mean, median, mode not enough!
- Variance is the sum of each samples' distance from the mean.
- Standard Deviation is the square root of the variance.
- Standard Deviation measures the variability in the data.

Comparing Two Populations

- T-test
  - Basically, are the means sufficiently different to reject H0

- How to report results?
  - A {one, two}-tailed t-test showed that factor (=Method in our case) does not significantly affects Task completion time [$t(1) = 2.36$, $p = 0.54$].
  - Method A leads to significantly faster Task completion time [$F(1,14) = 14.6$, $p = 0.02$] (for Anova)

Comparing Before and After

- Paired t-test
- Other ways of pairing than before/after?

- How to report results?

Looking for a trend / correlation

- CHI-Square test
  - Discrete data (counts)
    - E.g.: males said 3.35% FPs and females 1.78% Are these two observed proportions/ratios different?
  - Online chi-square calculators (excel possible but cumbersome)
    - http://www.opus12.org/Chi-Square_Calculator.html
    - http://faculty.vassar.edu/lowry/newcs.html
  - Observe different results for different N
  - Jprag example

Correlations

- Scatter plots for data description
  - E.g.: What is the relationship between vowel duration and quality?
  - SpPros example
- Regression Analysis for more factors (more complex)

What You Should Take Away

- Be able to identify hypothesis, variables, and determine which test is useful for which task.
  - T-test, Paired t-test, correlation, X^2
- Getting your hands dirty with data is difficult, time consuming, but also rewarding (you understand what's going on) and guarantees the authenticity of your work