PSY-2007S
Auditory Experimentation

week 11 – Categorical perception
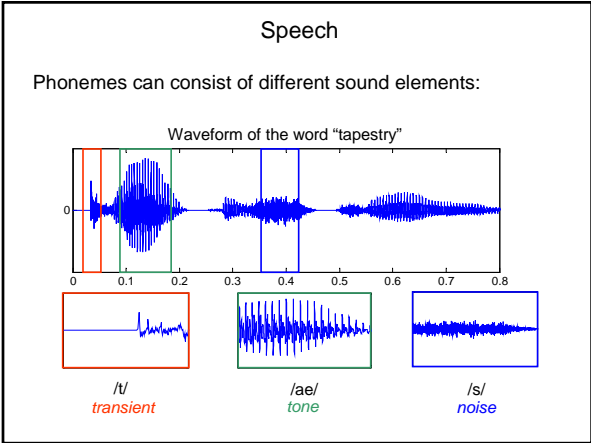

Speech

Smallest unit: the phoneme

40-50 phonemes in English and French

Range: 11 in Polynesian – 141 in Bushman

Total inventory across languages: thousands.
However, some are very common across all languages
(e.g., /m/, /n/, /t/, /d/, /k/, /g/, /s/, /z/)

Easy to produce, easy to distinguish

Speech

Phonemes can consist of different sound elements:

Waveform of the word "tapestry"

| /t/	/ae/	/s/
transient	*tone*	*noise*

Speech perception

Speech perception involves the mapping of acoustic
signals onto linguistic messages (phonemes, syllables,
words)

Speech perception is HARD!

There are 15-30 sounds, 8-10 phonemes, in every
second of fluent speech.
The sounds that make up the phonemes blend into
each other and vary with coarticulation, context,
speaker, speech rate and style, emotion, etc.

Lack of invariance!

Coarticulation

Formant transition
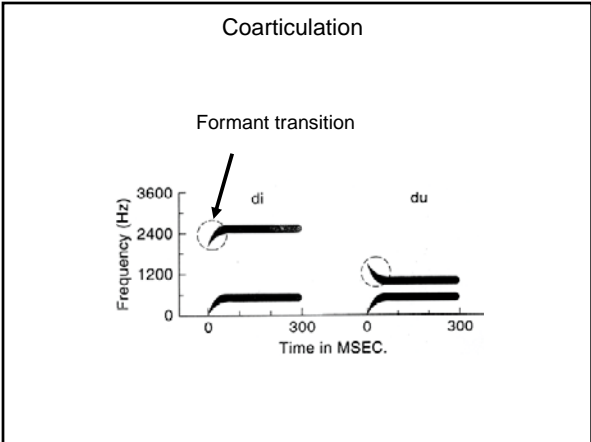
Speech style alone changes the phonemes dramatically

"I'm going to leave"	
[aɪmgoʊɪŋtəliv]	very careful, formal
[aɪm goʊəntəliv]	careful, formal
[aɪm gənəliv]	conversational style
[aɪŋgənəliv]	casual style
[aŋənəliv]	quite casual
[aŋnəliv]	really causal

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Segmentation problem

spokenwordsarenotseparate
dbyspacesliketheyareinprint

Categorical perception

A category is a set of things. Membership in the category may be all-or-none ('bird') or a matter of degree ('big').
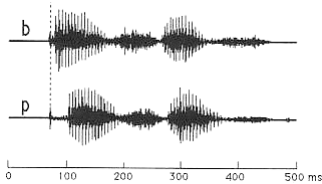
Categories are important because they determine how we see and act upon the world.
(William James noted: "we do not see a continuum of buzzing confusion" but an orderly world of discrete objects.)
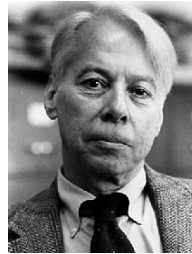
Categorical perception

The phonemes /b/ and /p/ differ in the time between the onset (stop) and voicing.

Voice onset time (VOT): /da/ (17 ms) vs. /ta/ (91 ms)
(phonemic boundary 35 ms)

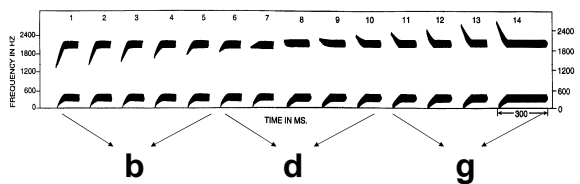## Categorical perception
Alvin Liberman (1917 – 2000)

Liberman and colleagues (1957) showed a phoneme boundary effect:

A smaller change in delay was necessary to distinguish /b/ from /p/, than to distinguish two phonemes within these categories.

Categorical perception

The phonemes /b/, /d/ and /g/ differ in the position and slopes of the formants.
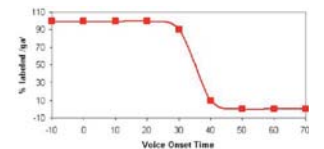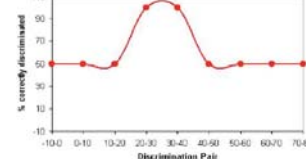

b   d   g

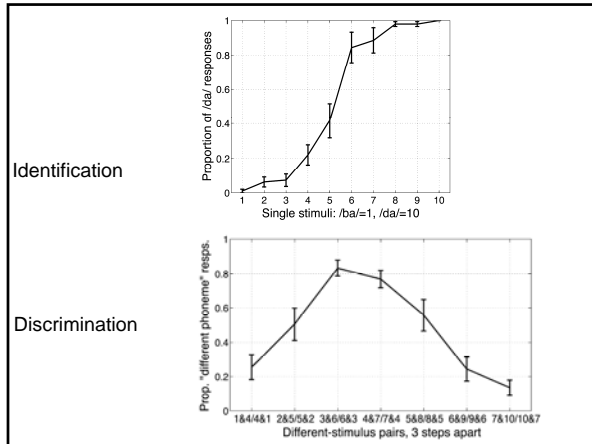Liberman (1957)

Categorical perception

We impose categories on physically continuous stimuli:
Voice onset time in the /ga/ - /ka/ continuum

Identification


Discrimination

Identification

Discrimination

Categorical perception

Computational modeling has shown that many types of category-learning mechanisms show CP-like effects.

Inputs that differ among themselves are compressed onto similar internal representations if they must all generate the same output; and they become more separate if they must generate different outputs.

Categorical perception with non-speech sounds

Categorical perception with non-speech sounds

Identification

Discrimination
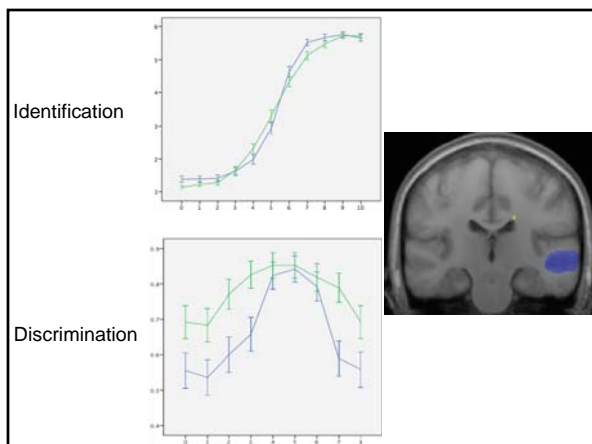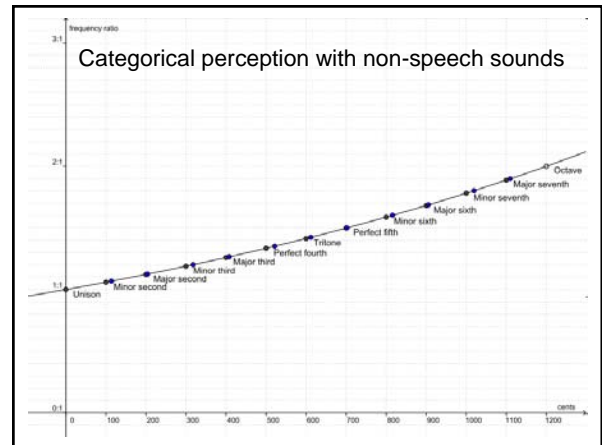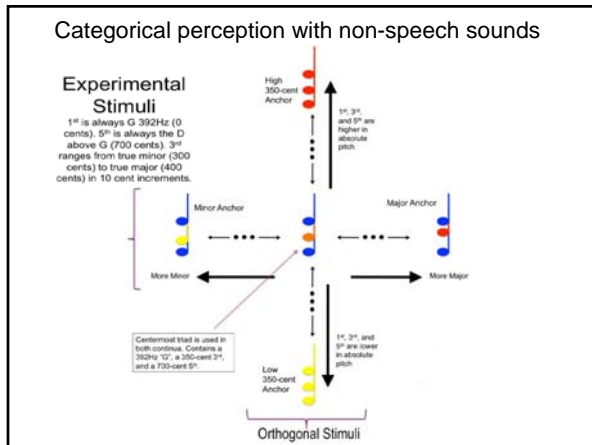
Other factors that help

Audio-visual integration: speech understanding is better if you watch the speaker. (McGurk effect)

Phonemic restoration:
The *eel was on the axle. (wheel)
The *eel was on the shoe. (heel)
The *eel was on the orange. (peel)

Speech and brain function

Kimura (1961): speech is processed more efficiently if heard through the ear that is contralateral to the language-dominant hemisphere.

Wada test: a barbiturate is injected into one of the internal carotid arteries. The drug reaches only the ipsilateral hemisphere, effectively shutting down half of the brain.

Interesting sideline: hair-whorl rotation is coupled to handedness and hemispheric speech dominance.
RH – clockwise, NRH – random.

Vocabulary

categorical perception
phoneme
phoneme boundaries
voice onset time
coarticulation
Wada test