Week 4 Tuesday Morning Session

- Innateness and the Poverty of Stimulus Argument
- Cracking the Speech Code
- Break
- Video: Human Language: Language Acquisition
- Discussion

Early Chomsky: language is a complex activity for which the human brain, and only the human brain, is specialized.

To know a human language would be an extraordinary intellectual achievement for a creature not specifically designed to accomplish this task. A normal child acquires this knowledge on relatively slight exposure and without specific training.

Chomsky,*Reflections on Language* 1975

It would be surprising indeed if we were to find that the principles governing [linguist phenomena] are operative in other cognitive systems…there is good reason to suppose that the function of the language faculty is guided by special principles specific to this domain.

Chomsky, *Rules and Representation,* 1980

Passages such as these suggest that Chomsky is committed to

1. Innateness theses about language

2. A position that language (or some important) aspect of language in uniquely human

In a 2002 article in science, Hauser, Chomsky and Fitch, Present a modified version (some suggest a radical revision)* of this original version that

a) restricts the (narrow) language faculty to areas that recursion (in a strong sense)

b) and treats only those as the "uniquely human" components of language

*Pinker & Jackendoff, *The faculty of language: what's special about it*

Poverty of Stimulus Argument for Language

To know a human language would be an extraordinary intellectual achievement for a creature not specifically designed to accomplish this task. A normal child acquires this knowledge on relatively slight exposure and without specific training.

Chomsky,*Reflections on Language* 1975

The argument, such as it is, appears to be an example of "inference to the best explanation," discussed by Taylor in *Ape, Language and the Human mind*

The best explanation of language competence given slight exposure, without specific training, is an innate (language specific) language faculty (for which the human brain is specialized)

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For the early Chomsky, the only alternative account was empiricist, associationist, and their more mathematical cousins (Markov, probability models). They did not provide as good an explanation of language acquisition as an approach attributed complex, specialized functioning.

In a 2002 article in *Science,* Hauser, Chomsky and Fitch, *The faculty of language: what is it, who has it, and how did it and how did it evolve?*

Present a modified version (some suggest a radical revision) of this original version that

a) restricts the (narrow) language faculty to areas that recursion (in a strong sense)

b) and treats only those as the "uniquely human" components of language

Cracking the Speech Code

World's Languages contain approximately 600 consonants and 200 vowels—each language uses a unique set of about 40 distinct elements, *phonemes*

Phonemes are actually non-identical sounds, *phonetic units*

Infant's Problem: learning which phonetic units are combined to form a phonetic category in their language

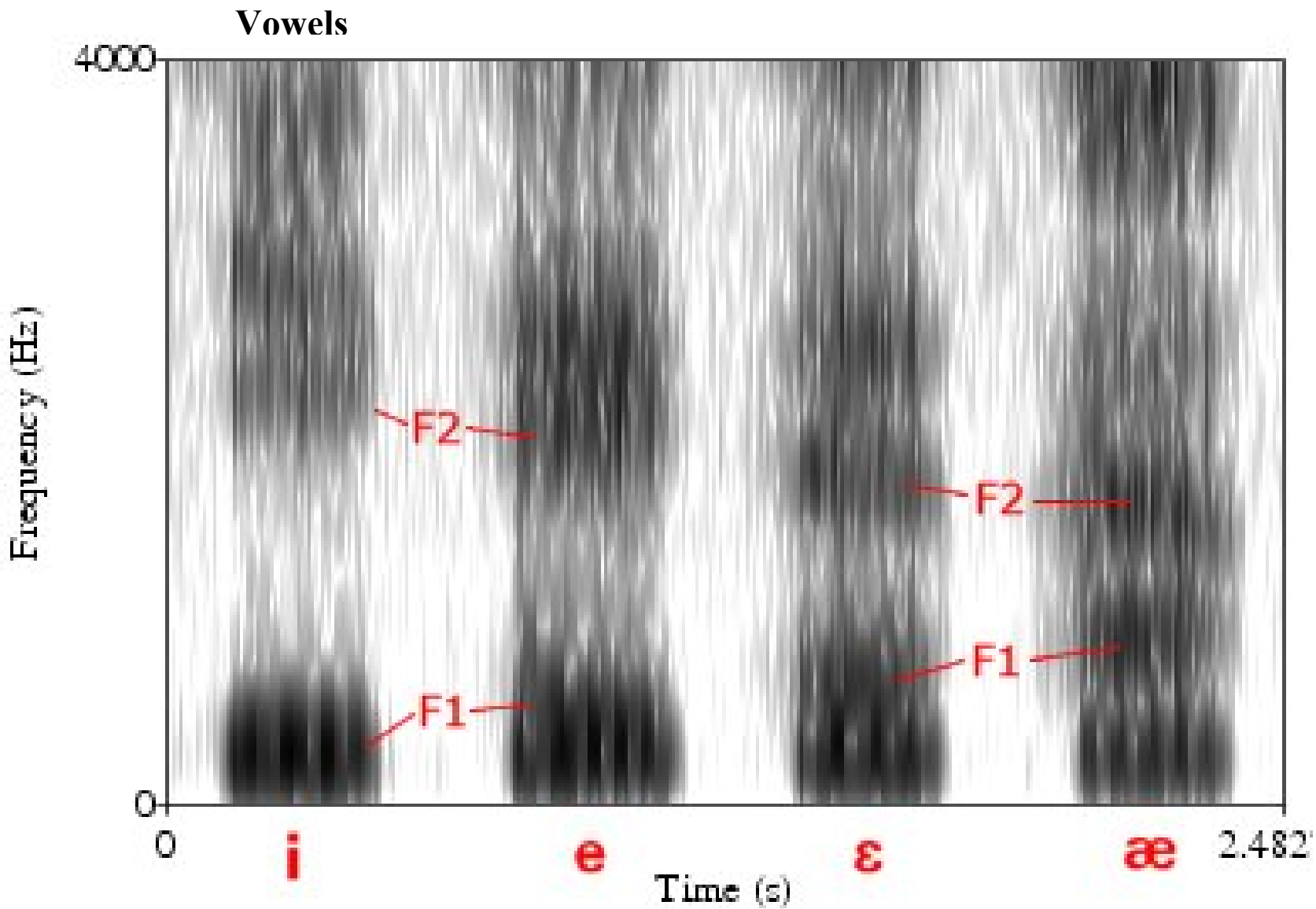
Psychologists' Problem: Explaining how infants do it.

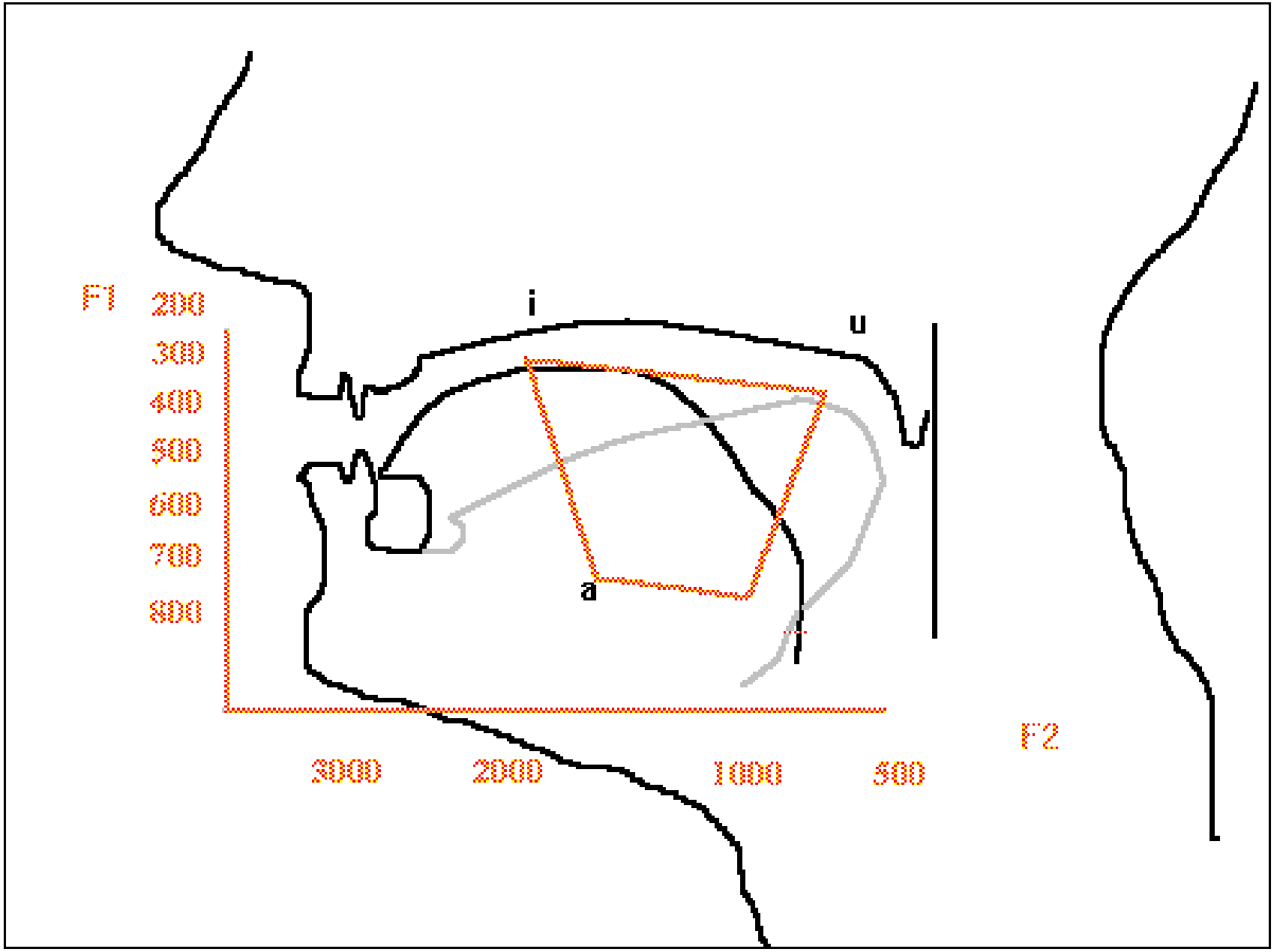
- Pick out speech sounds.
- Speaker Normalization
- Categorical Perception of phonemes

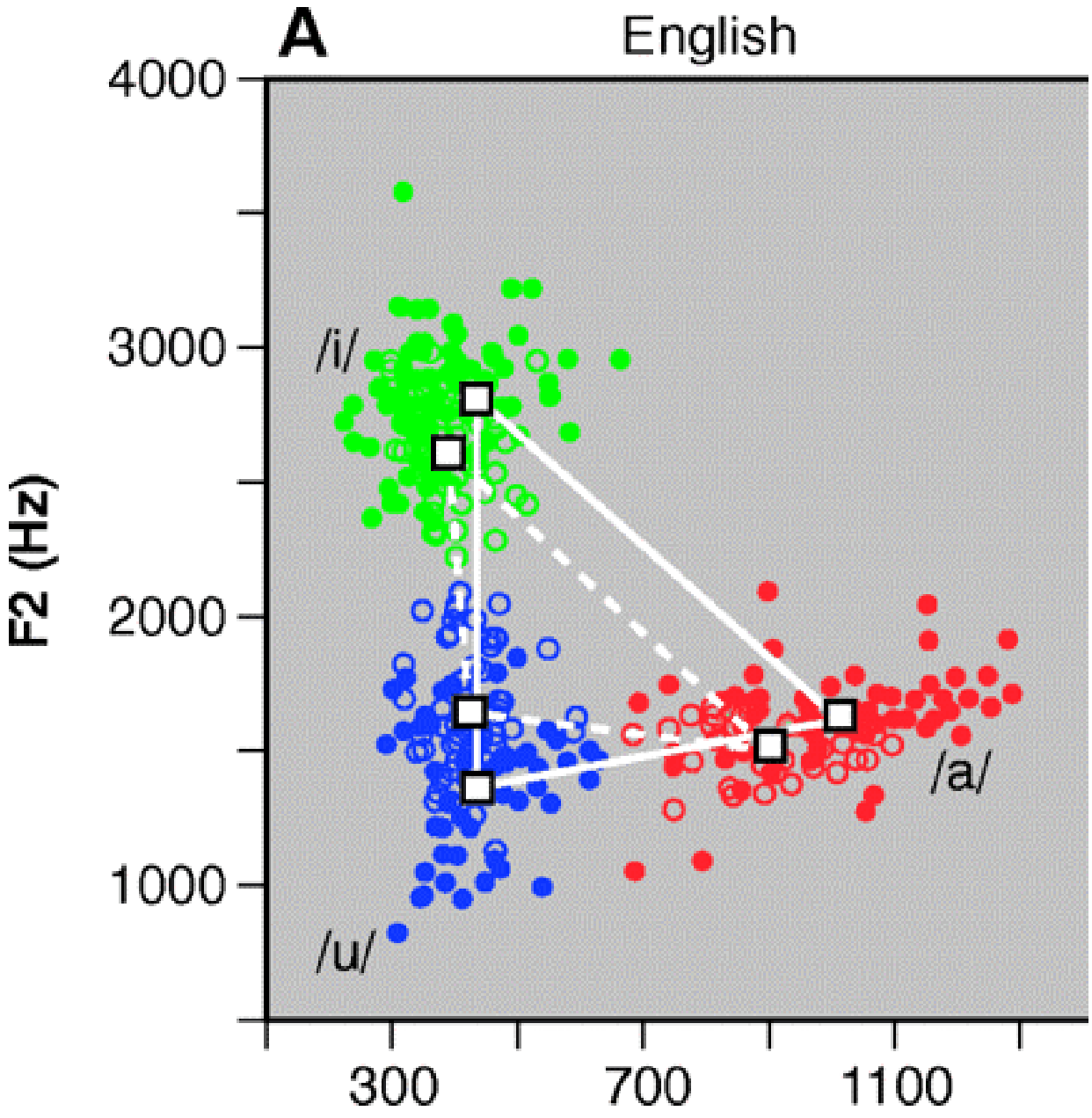
TABLE 2.2. Formant frequencies for typical vowels.

ARPABET Symbol for Vowel	IPA Symbol	Typical Word	F_1	F_2	F_3
IY	/i/	beet	270	2290	3010
IH	/ɪ/	bit	390	1990	2550
EH	/ɛ/	bet	530	1840	2480
AE	/æ/	bat	660	1720	2410
AH	/ʌ/	but	520	1190	2390
AA	/a/	hot	730	1090	2440
AO	/ɔ/	bought	570	840	2410
UH	/U/	foot	440	1020	2240
UW	/u/	boot	300	870	2240
ER	/ɝ/	bird	490	1350	1690

•**Formant** - energy peaks that determine the quality of sounds (esp. vowel sounds) and which are the result of resonances in the vocal tract; they are a consequence of resonance but not resonance itself.




F1
200
300
400
500
600
700
800
i
u
a
3000
2000
1000
500
F2


A
English
4000
3000
2000
1000
F2 (Hz)
/i/
/u/
/a/
300
700
1100

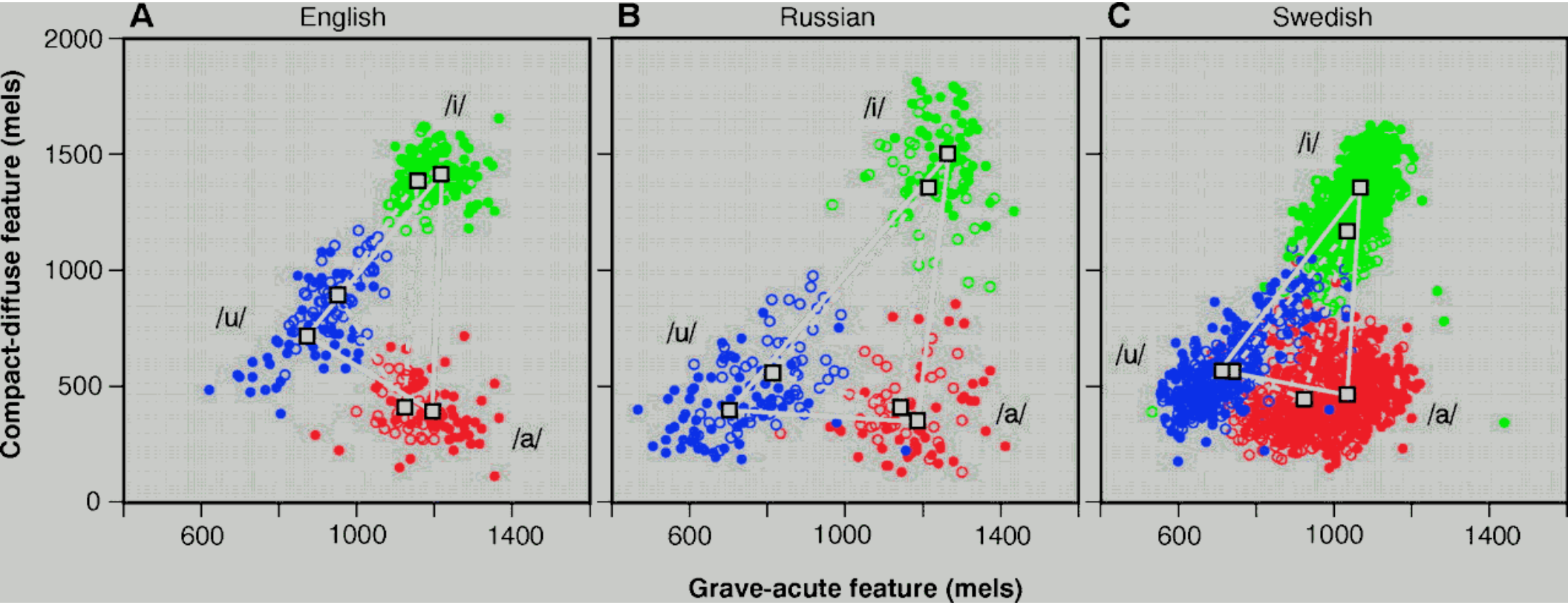


Fig. 2. Formant measures converted to spectral features (in mels) for infant-directed and adult-directed speech. Spectral features describe the acoustic components of vowels in a non-frequency-specific metric (31), and mels take into account the fact that at higher frequencies, larger differences are necessary to detect change (32). The vowel /i/ has component frequencies that are broadly distributed across the spectrum ("diffuse") and relatively high ("acute"), whereas component frequencies in the vowel /a/ are acute but more concentrated ("compact") and components of /u/ are maximally low ("grave"). The formula for calculating the compact-diffuse feature is F2 F1; for the grave-acute feature, (F1 + F2)/2

Box 2 | Why is speech categorization difficult?

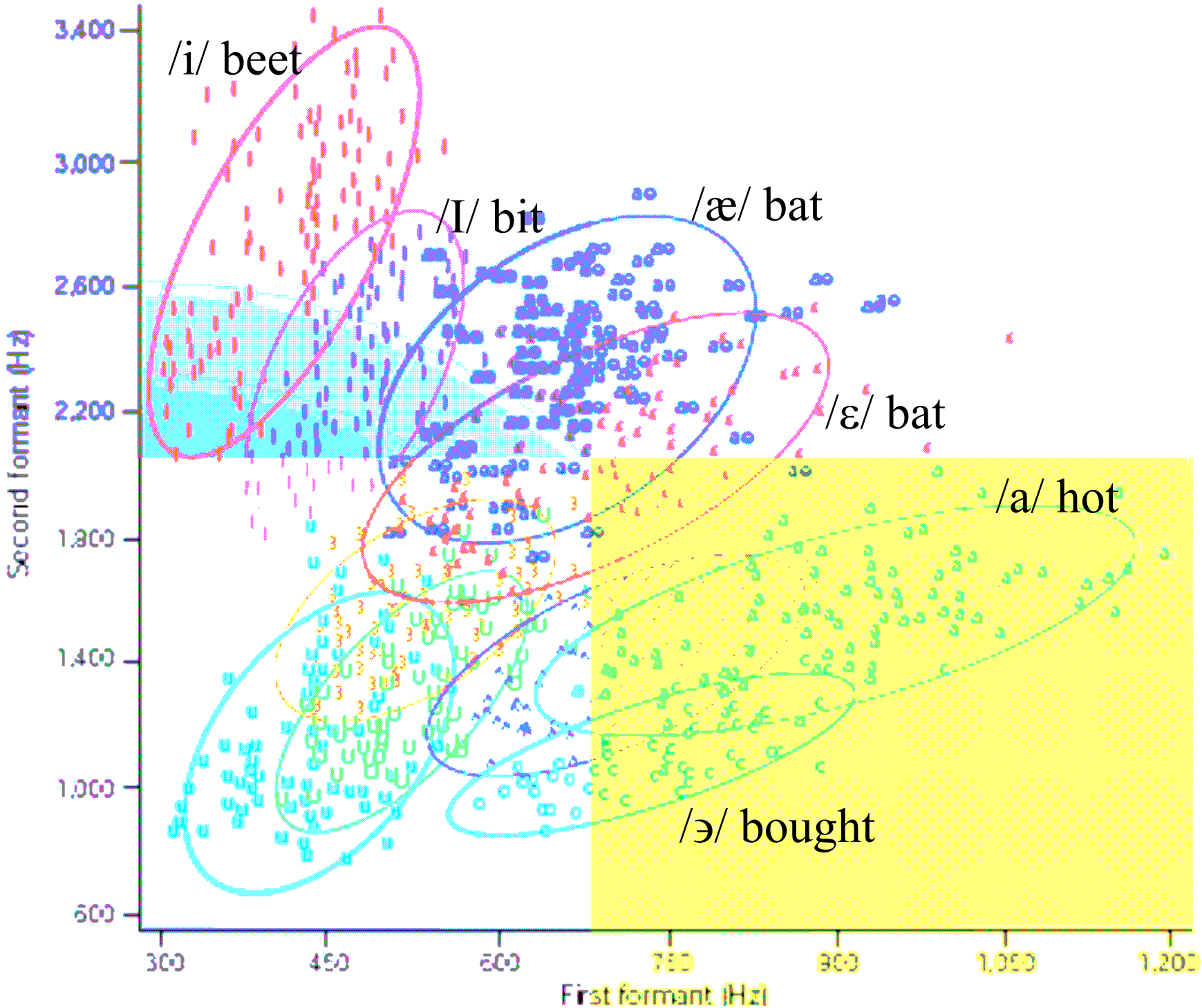


Figure 2.15 Spectrograms of the vowel sounds.

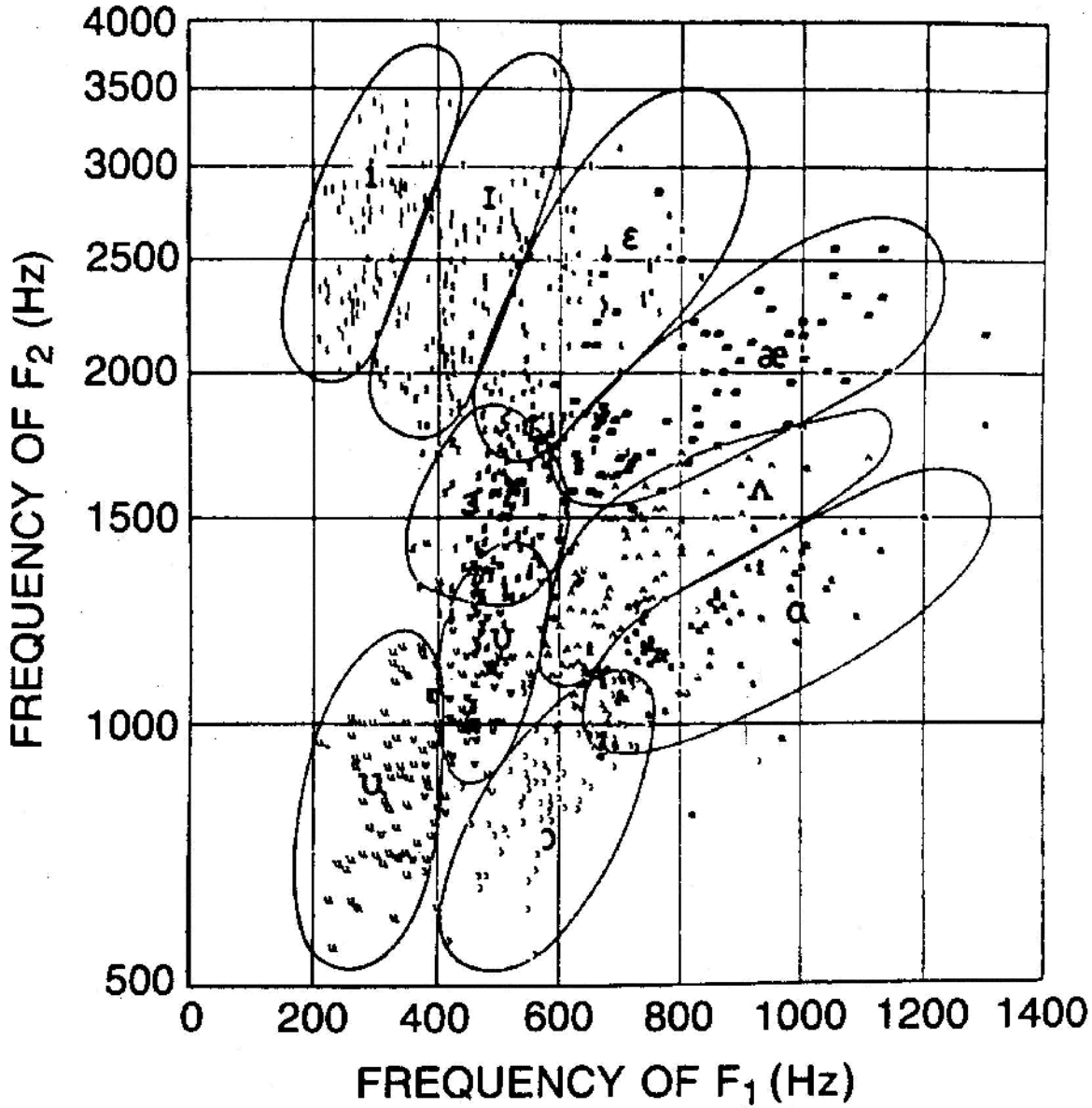
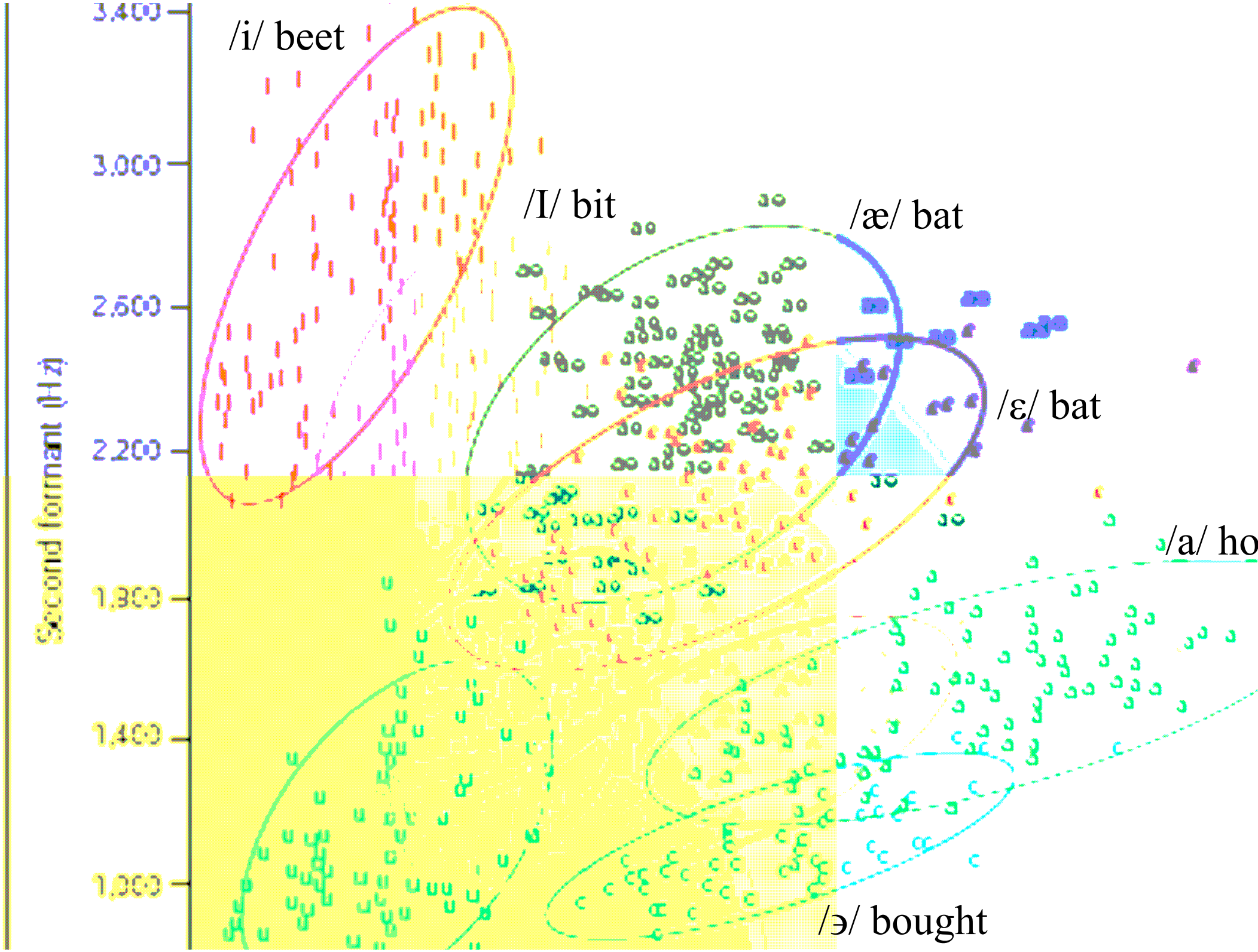


Figure 2.16 Measured frequencies of first and second formants for a wide range of talkers for several vowels (after Peterson & Barney [7]).


/i/ beet
/I/ bit
/æ/ bat
/ɛ/ bat
/a/ ho
/ɔ/ bought
Second formant (Hz)
3.400
3.000
2.600
2.200
1.800
1.400
1.000

Cracking the Speech Code

Patricia Kuhl: Hearing and Speech Science, UW
Bezos Family Foundation for Early Childhood Learning

Early work with sound discrimination in chinchillas

Developed experimental techniques for working with very young children Video clip

Applied these techniques to development of language sound acquisition in children

Argued for the magnet theory of sound categorization in natural language

Extended the magnet theory and incorporated EEG, MEG fMRI imagining techniques.

Timeline summarizing Kuhl Theory

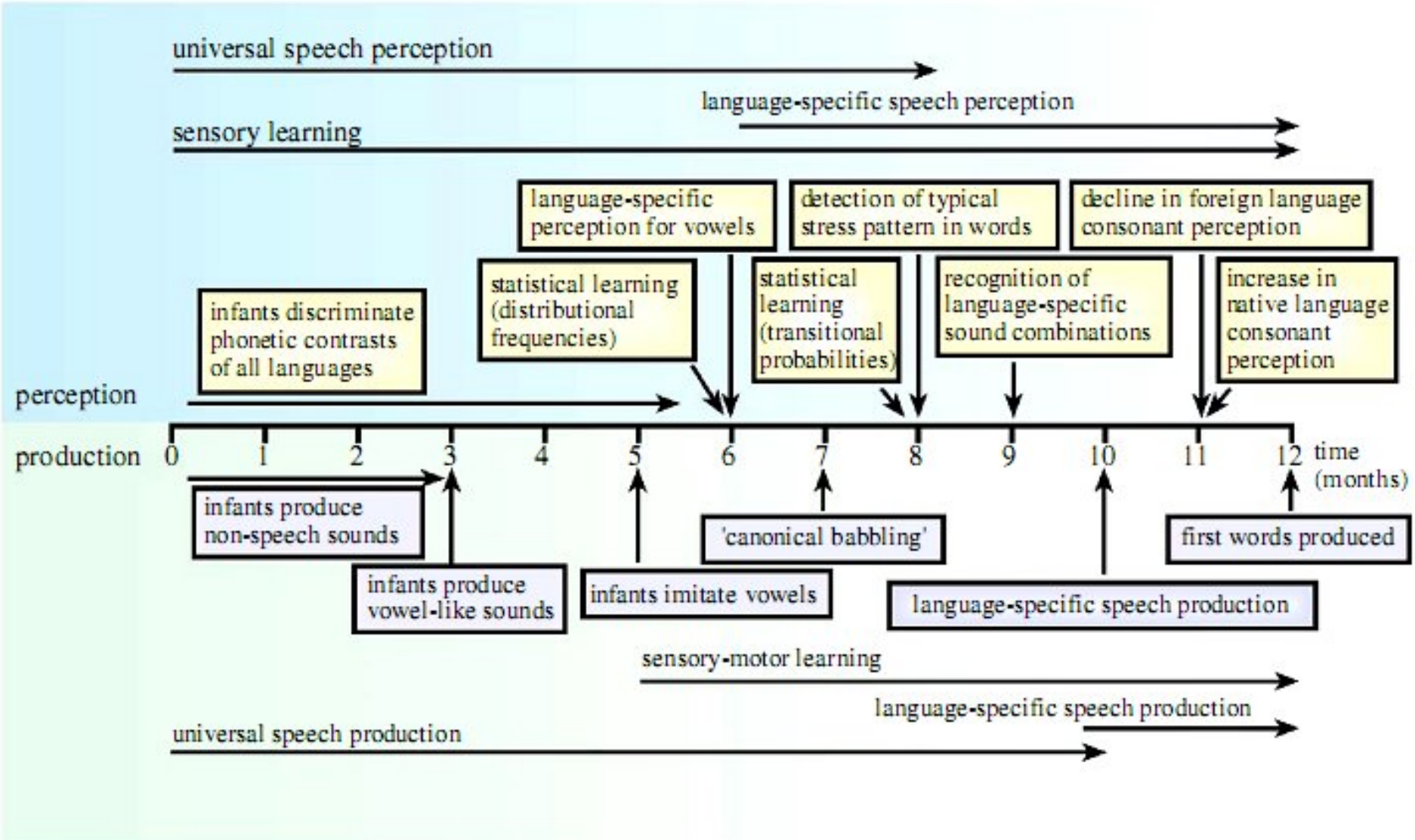


Figure 1. Universal timeline of infants' perception and production of speech in the first year of life. Modified from Kuhl (2004)

Innate perceptual abilities.

Speaker Normalization

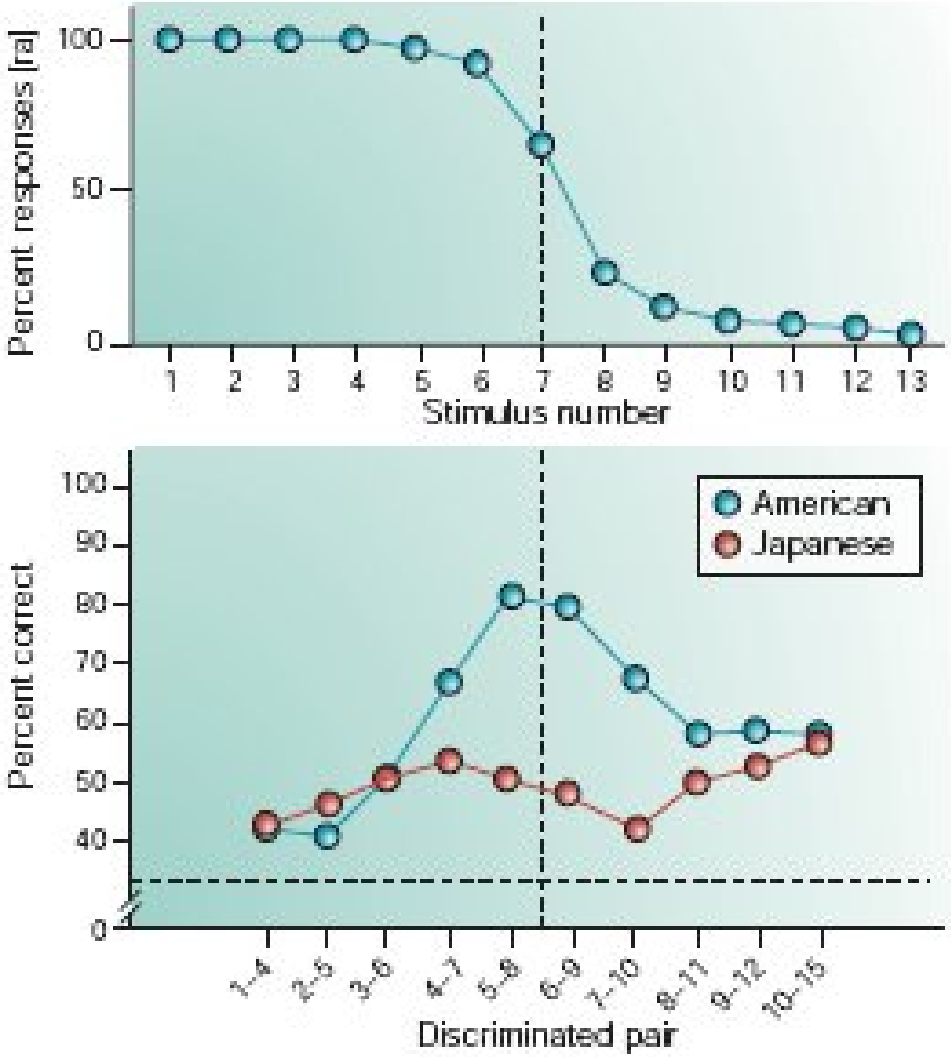
Categorical Perception of phonemes

Box 1 | **What is categorical perception?**

Categorical perception is the tendency for adult listeners of a particular language to classify the sounds used in their languages as one phoneme or another, showing no sensitivity to intermediate sounds. Laboratory demonstrations of this phenomenon involve two tasks, identification and discrimination. Listeners are asked to identify each sound from a series generated by a computer. Sounds in the series contain acoustic cues that vary in small, physically equal steps from one phonetic unit to another, for example in 13 steps from /ra/ to /la/.

In this example, both American and Japanese listeners are tested[7]. Americans distinguish the two sounds and identify them as a sequence of /ra/ syllables that changes to a sequence of /la/ syllables. Even though the acoustic step size in the series is physically equal, American listeners do not hear a change until stimulus 7 on the continuum. When Japanese listeners are tested, they do not hear any change in the stimuli. All the sounds are identified as the same — the Japanese 'r'.

When pairs of stimuli from the series are presented to listeners, and they are asked to identify the sound pairs as 'same' or 'different', the results show that Americans are most sensitive to acoustic differences at the boundary between /r/ and /l/ (dashed line). Japanese adults' discrimination values hover near chance all along the continuum. Figure modified, with permission, from REF. 7 © (1975) The Psychonomic Society.



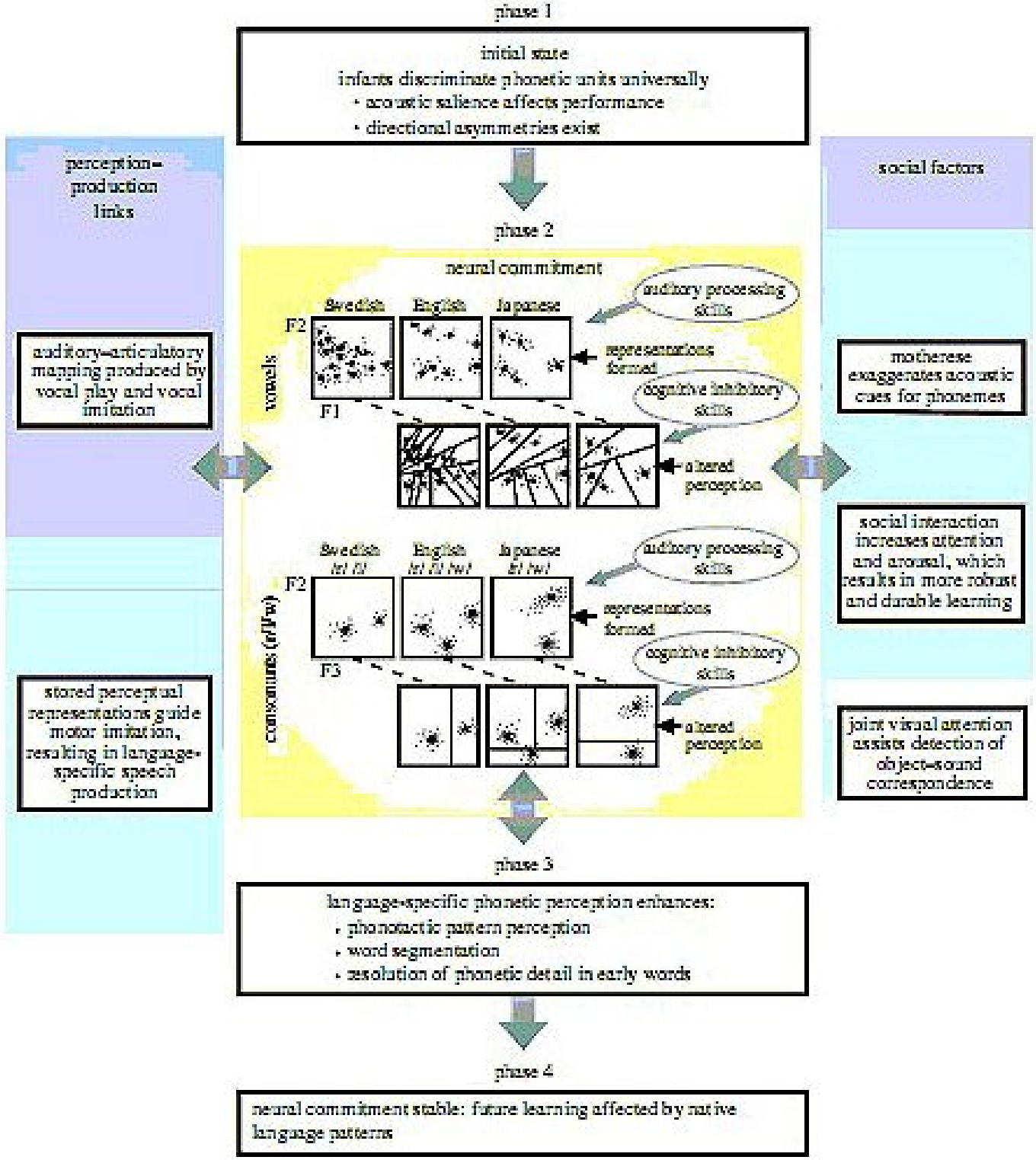
Constraints

Perceptual

Computational

Social

Neurological



phase 1

initial state

infants discriminate phonetic units universally

- acoustic salience affects performance
- directional asymmetries exist

perception–production links

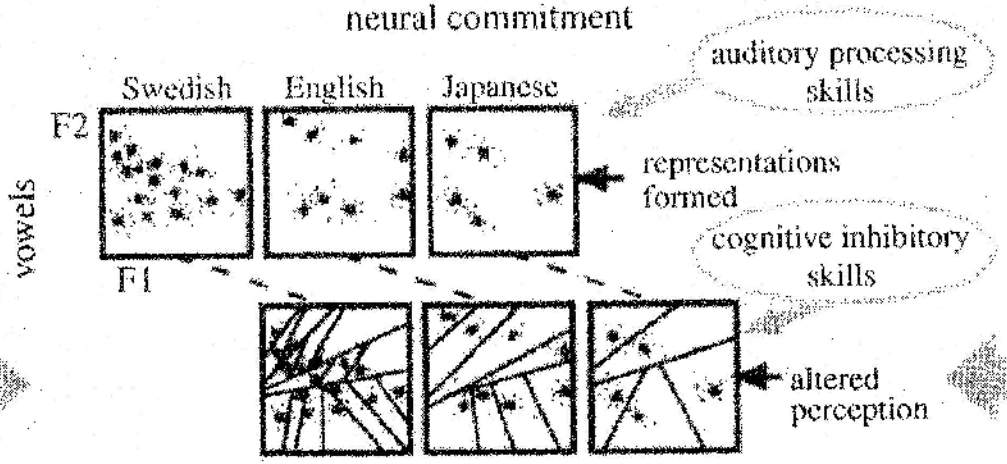
social factors

phase 2

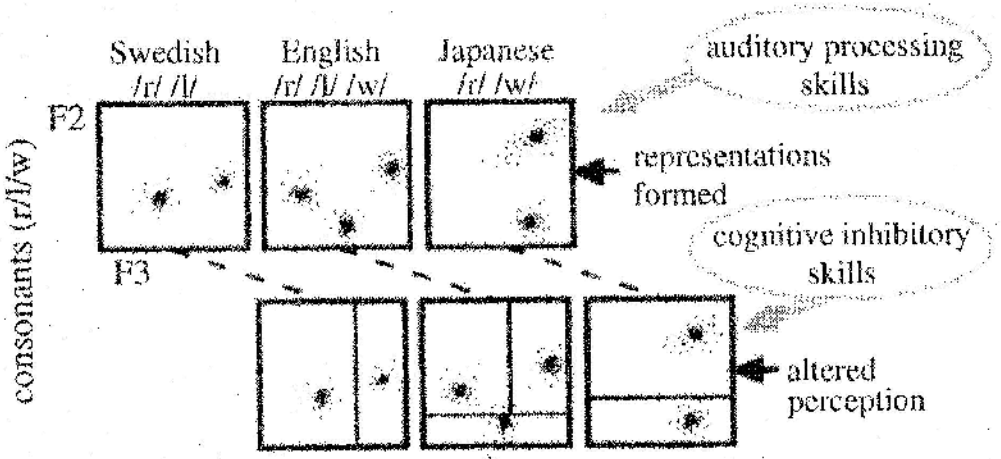
neural commitment

auditory–articulatory mapping produced by vocal play and vocal imitation

motherese exaggerates acoustic cues for phonemes

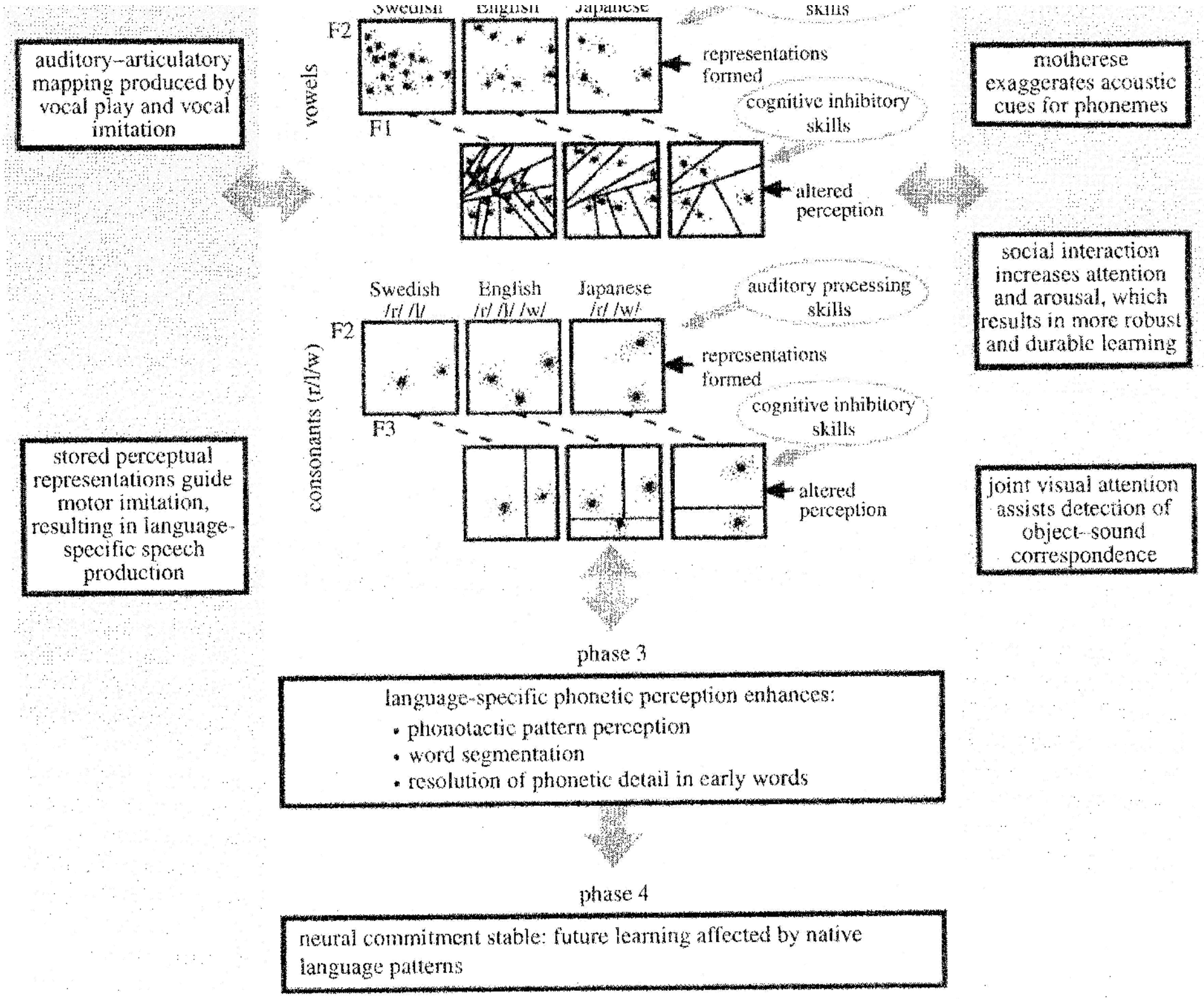


social interaction increases attention and arousal, which results in more robust and durable learning



stored perceptual representations guide motor imitation, resulting in language-specific speech production

joint visual attention assists detection of object–sound correspondence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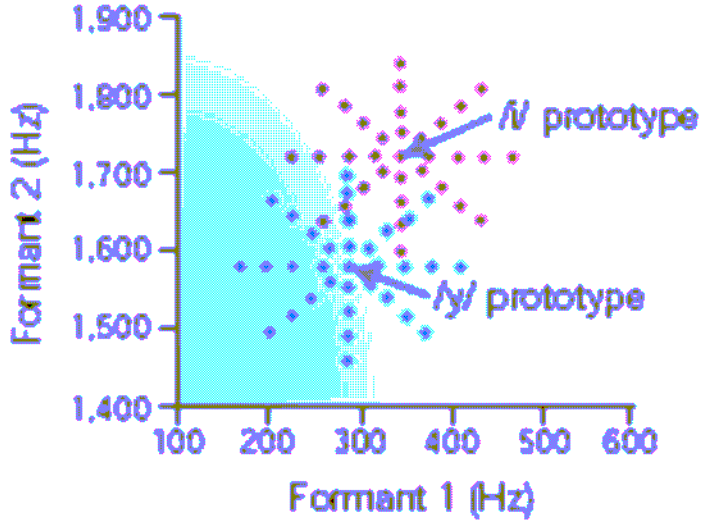
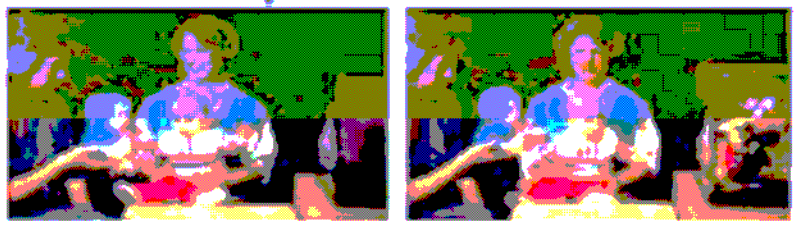
Swedish
English
Japanese
vowels
F2
F1
representations formed
cognitive inhibitory skills
altered perception
Swedish /r/ /l/
English /r/ /l/ /w/
Japanese /r/ /w/
consonants (r/l/w)
F3
auditory processing skills
phase 3
language-specific phonetic perception enhances:
• phonotactic pattern perception
• word segmentation
• resolution of phonetic detail in early words
phase 4
neural commitment stable: future learning affected by native language patterns

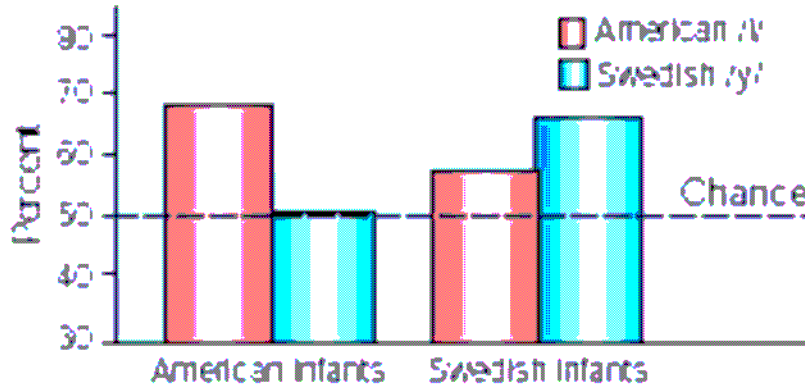
a Vowel stimuli



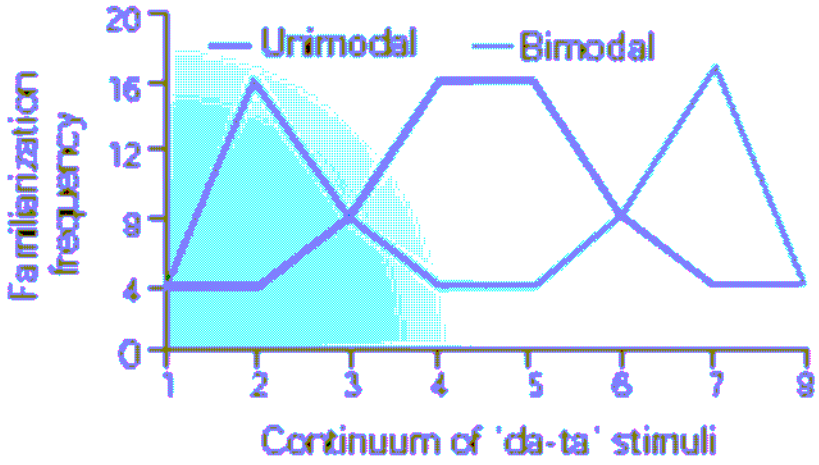
b Head-turn procedure



c Percent of variants equated to prototype



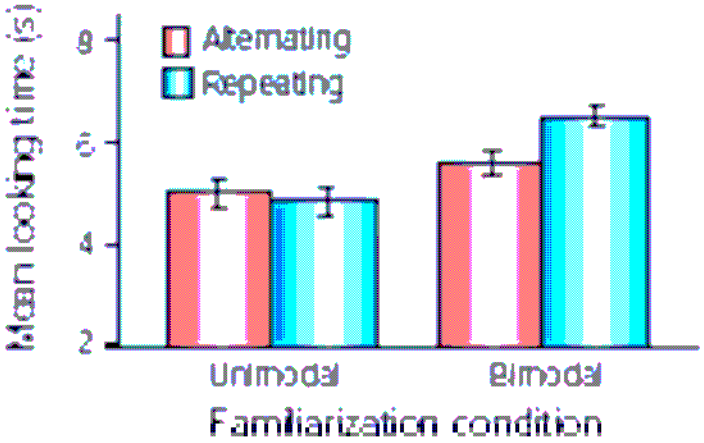
d Familiarization stimuli



e Auditory preference procedure

Test stimuli: token 3 or 6 (repeating); tokens 1 and 8 (alternating)

f Mean looking time by familiarization and trial types



Stages:

1. Innate perceptual boundaries exist that are tailor made for language processing at the phonetic level

2. Exposure to ambient language results in stored representations that reflect the distributional properties of a particular language

3. Stored Representations act recursively to alter the innate boundaries which profoundly affect later perception and production in a permanent way

Early representation part of a more general cognitive system that is polymodal to which the sensory as well as the motor system has access.

Speech demands a special interaction with conspecifics that exposure to language from a tape recorder would not satisfy.

This is a specific interweaving of “given by nature” and “gained from experience.”

Kuhl's Conclusions

"Infants are neither the tabula rasas that Skinner described not the innate grammarians that Chomsky envisioned. Infants have inherent perceptual biases that segment phonetic unites without providing innate descriptions of them."

Six tenets:Infants initially parse the basic units of speech

1. The developmental process is not selectionist in which innately specified options are selected on basis of experience
2. Rather, a non-Skinnerian learning exploits statistical properties
3. Vocal imitation links speech perception and production early
4. Auditory , visual and motor information are coregistered
5. Adults alter their speech to match infant learning strategies
6. Critical period demands neural commitment from experience

That's All Folks