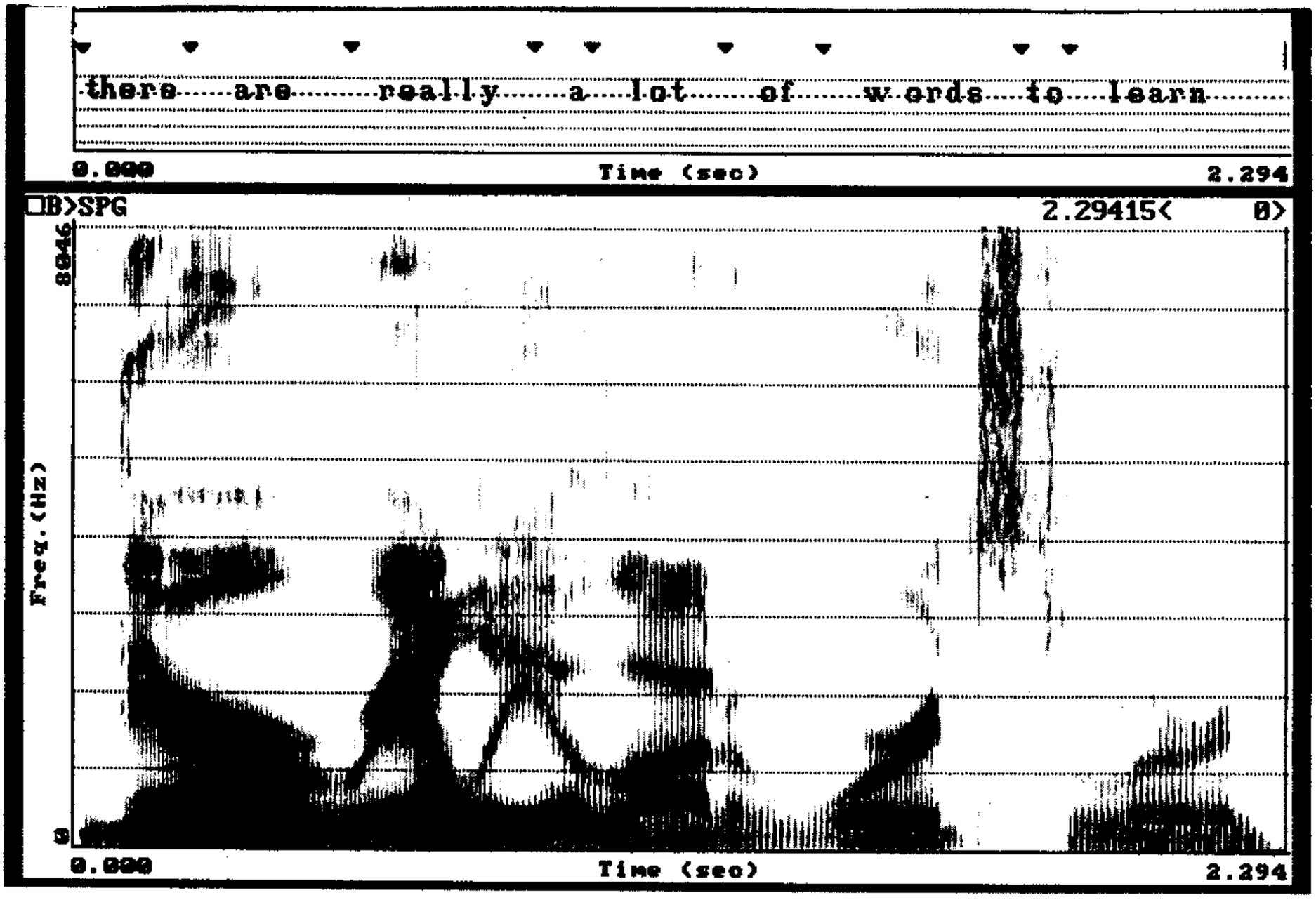

Figure 1.1
A sound spectrogram of the utterance, "There are really a lot of words to learn." Frequency is plotted on the ordinate; each horizontal line indicates a 1 kHz increase in frequency. Arrows at the top indicate the approximate locations of the word boundaries in the utterance. Notice that these boundaries are not always clearly marked by pauses and that some pauses actually occur in the middle of words.

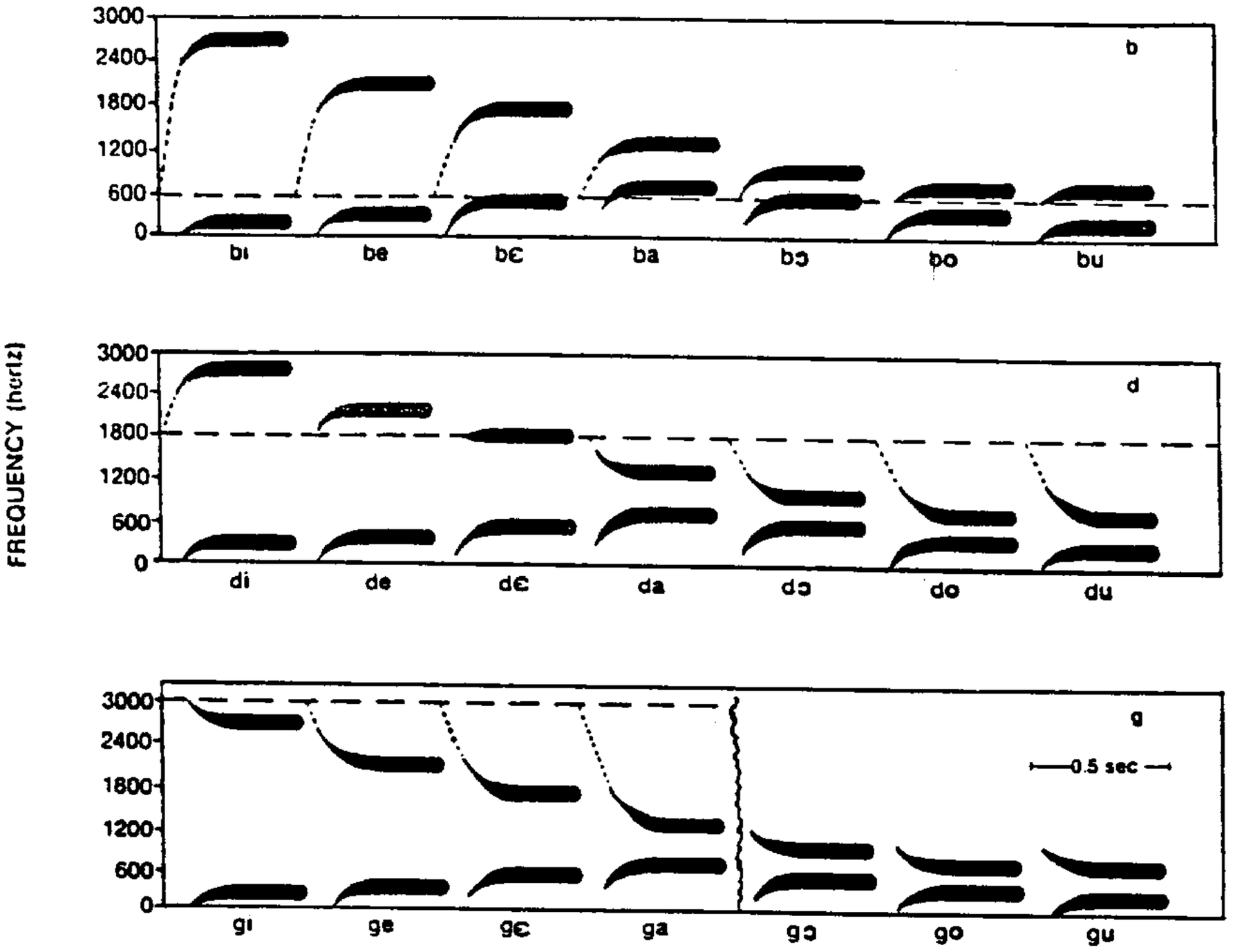

Figure 3.1
Schematized sound spectrograms corresponding to two-formant versions of synthesized syllables consisting of the voiced stop consonants [b] (top), [d] (middle), and [g] (bottom) before seven different English vowels. Note the great changes in shape and spectral frequencies in the second formant for each of the stops as they are paired with different vowels. Dashed lines indicate the "locus" frequency from which the second formants were hypothesized to have diverged.

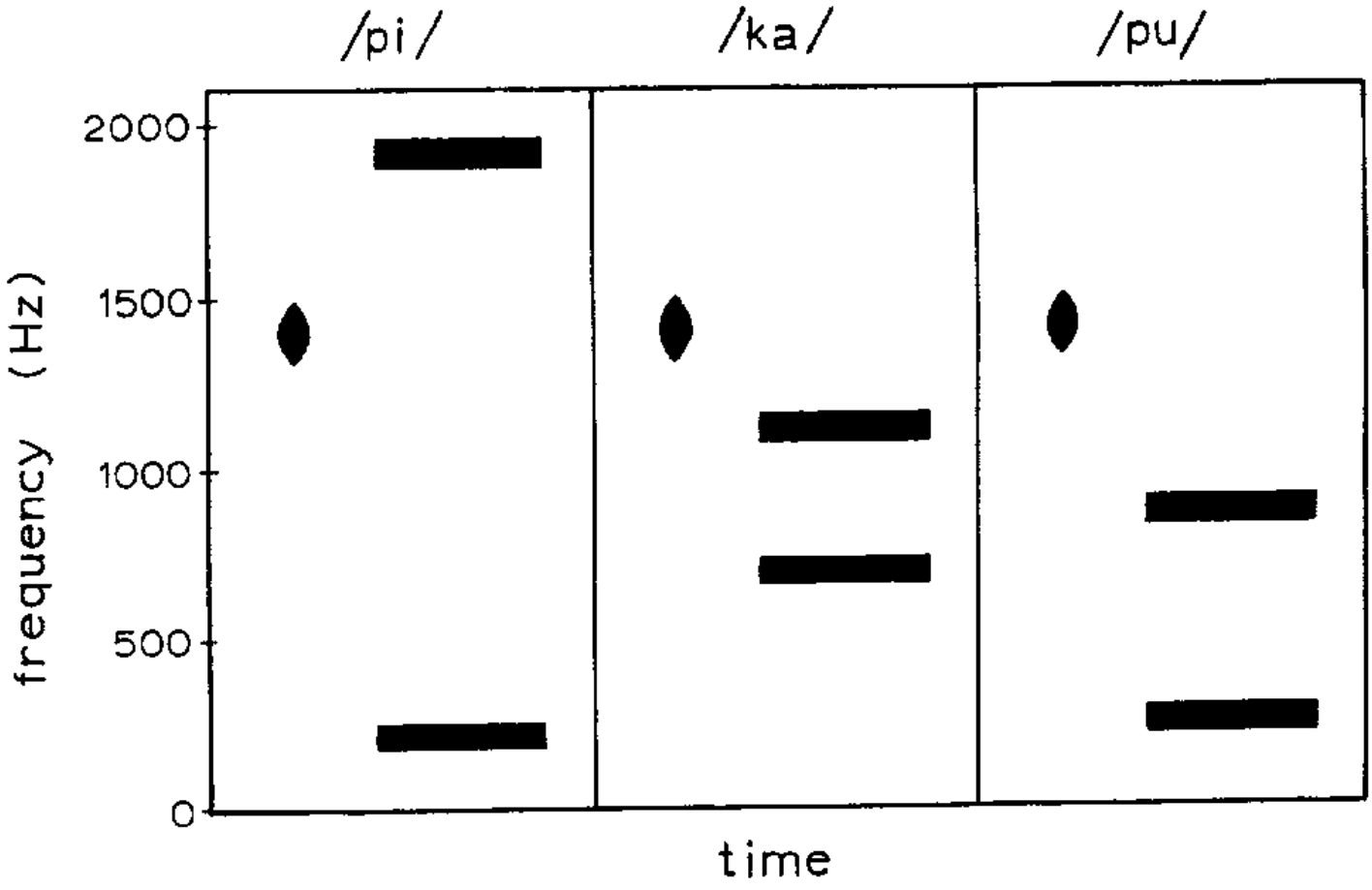

Figure 3.2
Schematic spectrograms of the syllables [pi], [ka], and [pu]. Notice that the football-shaped noise burst is identical in all three cases, yet it contributes to the distinctive consonants in the different vowel contexts. Removing this noise from the syllables would cause listeners to perceive the remaining portion of the signals as [i], [a], and [u], respectively.

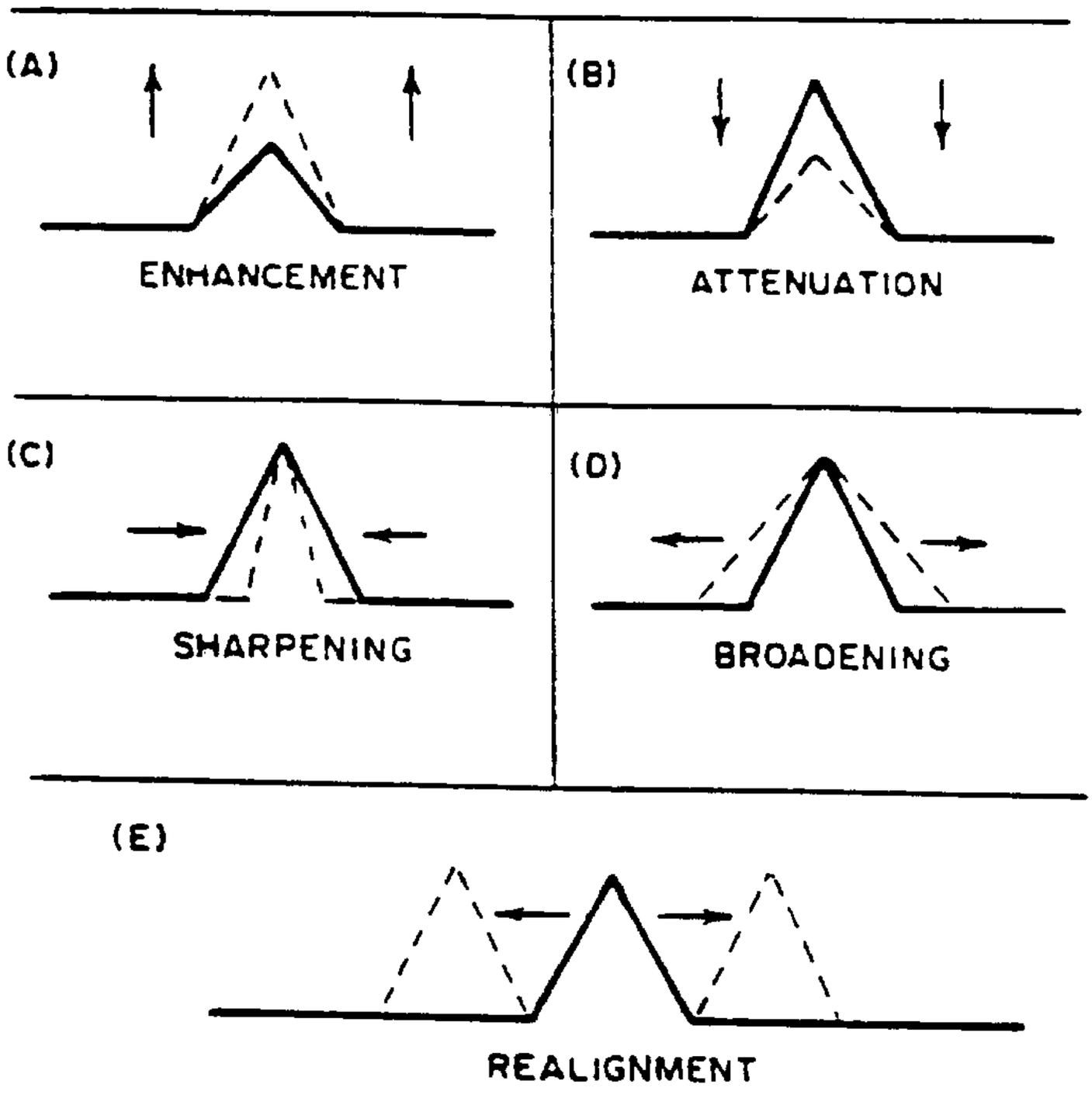

Figure 4.1
Five processes by which early experience in a particular language environment may selectively modify the relative discriminability of speech sounds. In each instance, schematized discrimination functions are plotted to show the types of changes that occur as a result of experience with a native language.

Zachary and Amahl at the ages of 2 years 3 months and 36 years respectively

11. When he was 2 ½ years old I had the following conversation with A, as I was puzzled by his ability to pronounce the nasal in ‘hand’ ([ɛn]), but apparently not that in ‘jump’ (APh: 10):

NS Say ‘jump’

A [dʌp]

NS No, ‘jump’

A [dʌp]

NS No, ‘jummmp’

A Only Daddy can say [dʌp]

1a. The child's performance is rule-governed but, as this way of expressing it suggests, the rules are a matter of performance rather than of competence.

b. The child has no system of his own; hence there are no output representations, no contrast between input and output lexicons, and no dual grammar. As a corollary, the child's lexical representations are in general equivalent to the adult surface form.

c. There is none the less a clear, if minor, role for perception, so not all the child's representations are 'correct'.

d. The distinction between realisation rules and phonetic detail rules is unmotivated, indeed undesirable. Both may be replaceable by a single, undifferentiated, neural network.

e. The drive for communication in the absence of a fully functioning phonological system is powerful. One manifestation of this is seen in the importance of gestures.

f. The children's metalinguistic ability is considerable and provides an insight into their phonological knowledge (and may make some of the other claims listed here problematic).

g. Most of the phenomena identified as being in need of explanation in APh are still salient. Apart from the predictability characteristic of all rule-governed activity, these include: the existence of grammatical constraints on phonological development, recidivism, the 'across-the-board' nature of change (albeit in somewhat attenuated form), the existence of systematic exceptions, and variation both in a single child and across children. These phenomena, suitably interpreted, simultaneously constituted the evidence for the various theoretical claims made in APh. Even where the phenomena are confirmed or extended, as in the amount and significance of variation which is greater than I had previously thought, their interpretation has changed in significant respects.

2a. The children's productions provide evidence for the units of analysis that the phonology needs to assume: distinctive features, syllables and, most strikingly with Z, the notion '(syllable) onset'.

b. On a performance analysis, the conspiratorial 'function' of realisation rules is an epiphenomenon. Conspiracies are formally unnecessary if there are 'no functional constraints beyond transparency'.

c. There is no rule ordering. This is strongly suggested by considerations of learnability and necessitates a certain amount of reanalysis of some of the data in APh.

3. The union of the properties in (1) and (2) requires a model which combines the best of several different theories. Central to such a model is an explicit statement of the rules and representations it is necessary to postulate. Whether any such unifying model is coherent and consistent is an interesting issue (see figure 3 below).

23a. The child's performance is rule-governed, hence largely predictable.

b. The child's lexical representations are adult-like, established on the basis of an acoustic transducer and subject to some perceptual filtering.

c. The child has no system of his own.

d. The child's output, produced by a set of realisation rules or, more plausibly, a neural network, is not 'represented'.

e. By parity of argument the child probably does not represent the adult input *prior to transduction* even though it forms the basis for the child to set up his own (lexical) representation.

f. The network (or set of realisation rules) is not represented but is emergent or 'architectural', and provides the basis for the idiosyncratic and partly random variation in different children's pronunciation.

g. The network (or set of realisation rules) implements one or more of a limited set of functional constraints or 'conspiracies': vowel and consonant harmony, cluster reduction, systemic simplification, grammatical simplification and template creation. As a corollary of (f) conspiracies are epiphenomenal and do not need to be explicitly catered for by the theory.

h. The child's developing phonology provides evidence for the units (e.g. distinctive features, syllable structure) and processes (e.g. syllable simplification, segment simplification) licensed by phonological theory, and how these interact (e.g. no rule ordering is necessary).

i. The child's metalinguistic judgements are a rich source of evidence for his competence and hence for the constructs of linguistic theory.

j. The conclusions pertaining to child phonology have suggestive implications for adult phonology – e.g. with regard to the representation of the output.

k. There is provision for taking account of (statistical) frequency effects in all of the acoustic transducer, the perceptual filter and the neural network.

l. If language is "a mirror of mind", language acquisition polishes that mirror.

Table 2.1
Pairs of languages used in studies of discrimination between the native language and a foreign language. Unless noted otherwise, the pairs of languages were discriminated.

Languages discriminated	Infants' native language	Age at testing	Source
French-Russian	French	4 days	Mehler et al. 1988
English-Spanish	Spanish, English	2 days	Moon, Cooper, and Fifer 1993
English-Italian	English	2 months	Mehler et al. 1988
English-Japanese	English	2 months	Christophe and Morton 1998
English-French	English	2 months	Dehaene-Lambertz and Houston 1998
English-Spanish	Spanish	4 months	Bosch and Sebastián-Gallés 1997
English-Catalan	Catalan	4 months	Bosch and Sebastián-Gallés 1997
Spanish-Catalan	Spanish	4 months	Bosch and Sebastián-Gallés 1997
Spanish-Catalan	Catalan	4 months	Bosch and Sebastián-Gallés 1997
English-Dutch (no discrimination)	English	2 months	Christophe and Morton 1998
English-Dutch	English	5 months	Nazzi, Jusczyk, and Johnson 2000

Figure 2.1
A typical experimental setting for the high-amplitude sucking procedure (HAS). Newborns are placed in a crib in a semireclining position and suck a pacifier linked to a pressure transducer connected to a computer that controls the delivery of stimuli from a loudspeaker. (Picture kindly made available by Jacques Mehler.)

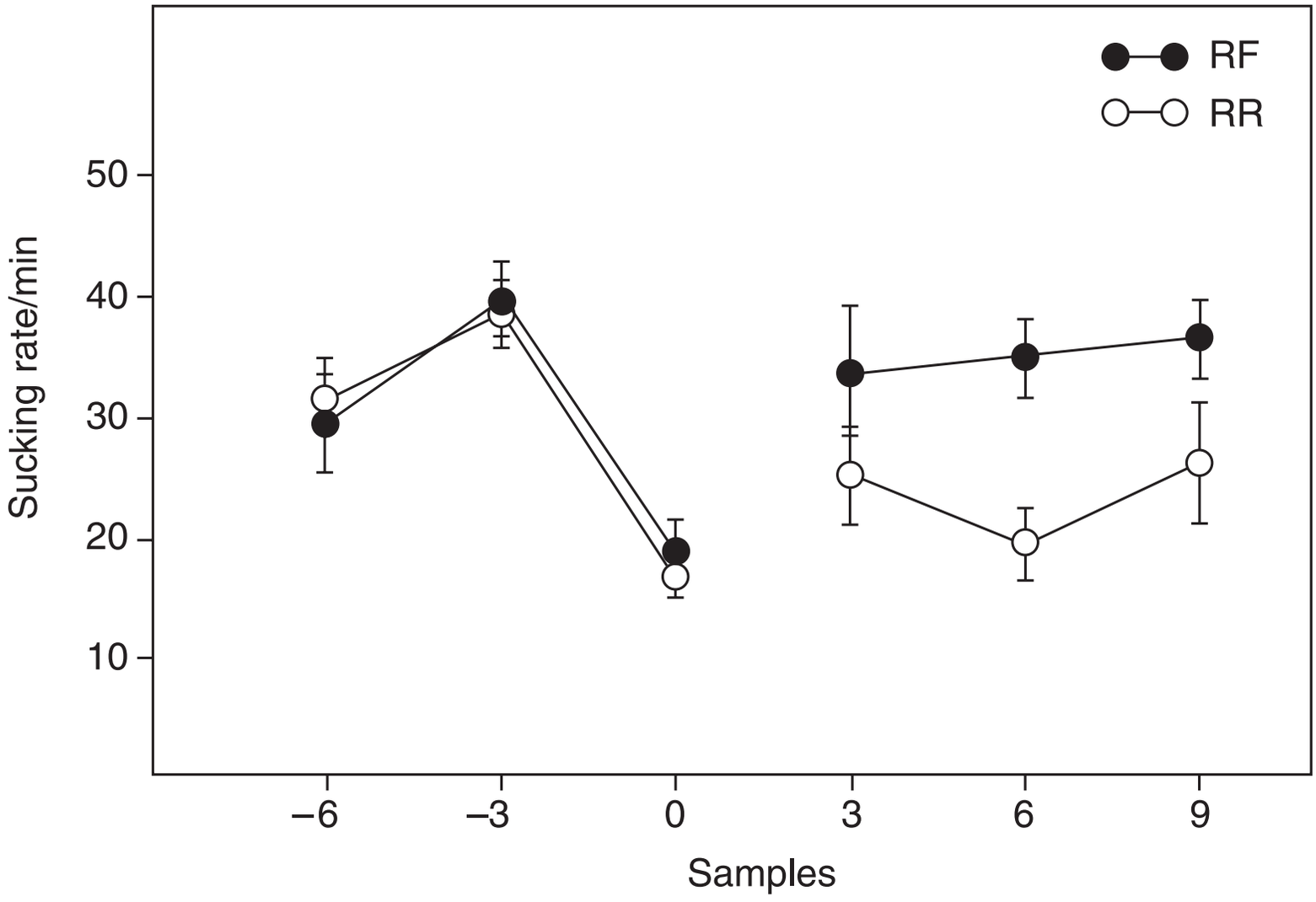

Figure 2.2
Sucking rate averaged over three consecutive samples during the habituation phase and the experimental phase of a study in which infant French learners heard utterances from Russian and French. The graph displays the sucking rates of infants who heard Russian during the habituation phase. Group RF heard French during the experimental phase and group RR continued to hear Russian. The bars above and below each point indicate the standard error of the mean. (Reprinted from *Cognition*, volume 29, Mehler, Jusczyk, Lambertz, Halsted, Bertoncini, and Amiel-Tison, "A Precursor of Language Acquisition in Young Infants," pp. 144–178. Copyright 1988, with permission from Elsevier Science.)

Table 2.2
Pairs of languages used in studies of infants' discrimination between foreign languages. Unless noted otherwise, the pairs of languages were discriminated.

Languages discriminated	Infants' native language	Age at testing	Source
English-Japanese	French	5 days	Nazzi, Bertoncini, and Mehler 1998
English-Italian	French	4 days	Mehler et al. 1988 (reanalyzed in Mehler and Christophe 1995)
Dutch-Japanese	English	2 months	Christophe and Morton 1998
French-Russian (no discrimination)	English	2 months	Mehler et al. 1988
French-Japanese (no discrimination)	English	2 months	Christophe and Morton 1998
English-Dutch (no discrimination)	French	4 days	Nazzi, Bertoncini, and Mehler 1998

Table 2.3
Summary of hypotheses, predictions, and results regarding language discrimination by babies

Hypothesis	Prediction	Result
Babies discriminate languages on the basis of the mean energy of the signal or pitch.	Babies should discriminate languages even when the stimuli are played backward.	Babies do not discriminate languages when the stimuli are played backward.
Babies discriminate languages on the basis of segmental properties.	Babies should not discriminate languages when the stimuli are low-pass filtered.	Babies discriminate languages even when stimuli are low-pass filtered.
Babies discriminate languages on the basis of word-level prosody or of some residual phonemic information available when the stimuli are low-pass filtered.	Babies should discriminate languages when words are artificially reassembled so as to maintain the prosody of the words, but not the prosodic coherence of the utterance (scrambled-order condition).	Babies do not discriminate languages in the scrambled-order condition.

Conclusion: Babies must discriminate languages on the basis of prosodic information at the utterance level.

(1) a. Stress-timed languages: Dutch, English, Russian, Swedish
b. Syllable-timed languages: Italian, French, Greek, Spanish
c. Mora-timed languages: Japanese, Tamil

(2) a. V V v V V v V stress-timed (e.g., English)

b. V V V V V V V syllable-timed (e.g., Spanish)

c. V V V V V V V V V mora-timed (e.g., Japanese)

(4) *P1:* Infants discriminate stress-timed from syllable-timed languages: *English-Catalan, English-Italian, English-French, English-Spanish, French-Russian.*

P2: Infants discriminate stress-timed from mora-timed languages: *English-Japanese*.

P4: Infants do not discriminate (at least initially) two syllable-/stress-/mora-timed languages from each other: *English-Dutch* (stress-timed languages).

Table 2.4
Summary of Nazzi, Bertoncini, and Mehler's (1998) experimental design

	Habituation phase	Experimental phase
Rhythmic group	Italian/Spanish Dutch/English	Dutch/English Italian/Spanish
Nonrhythmic group	English/Italian Dutch/Spanish	Dutch/Spanish English/Italian

Table 2.5
Summary of Bertoncini et al.'s (1988) experiments

Habituation phase	Experimental phase	Results
Same vowel [bi], [si], [li], [mi]	New consonant [bi], [si], [li], [mi], [di]	No detection of the new syllable
Same consonant [bo], [ba], [bi], [bə]	New vowel [bo], [ba], [bi], [bə], [bu]	Detection of the new syllable

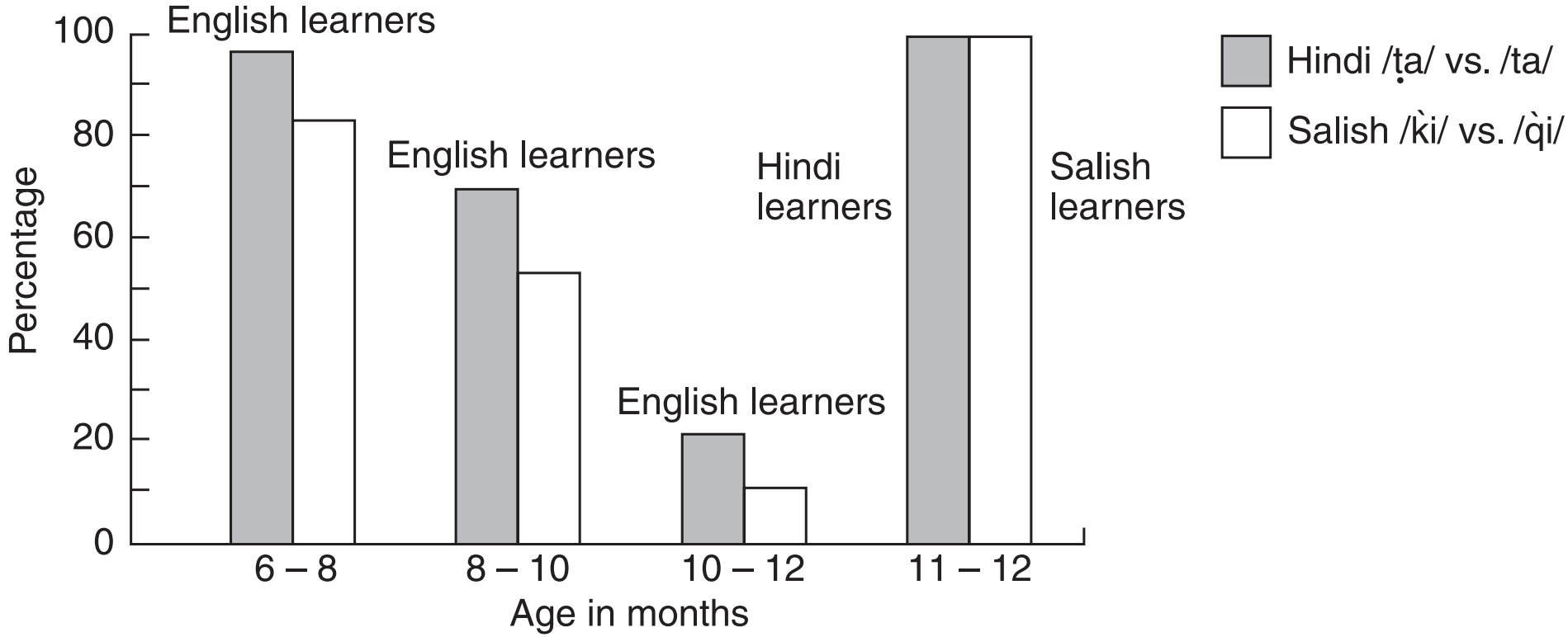

Figure 2.3
Proportion of American English learners from three age groups (6–8, 8–10, 10–12 months) and of Hindi and Salish learners (11–12 months) able to discriminate Hindi and Salish consonantal contrasts. (Reprinted from *Infant Behavior and Development*, volume 7, Werker and Tees, "Cross-Language Speech Perception: Evidence for Perceptual Reorganization during the First Year of Life," pp. 49–63. Copyright 1984, with permission from Elsevier Science.)

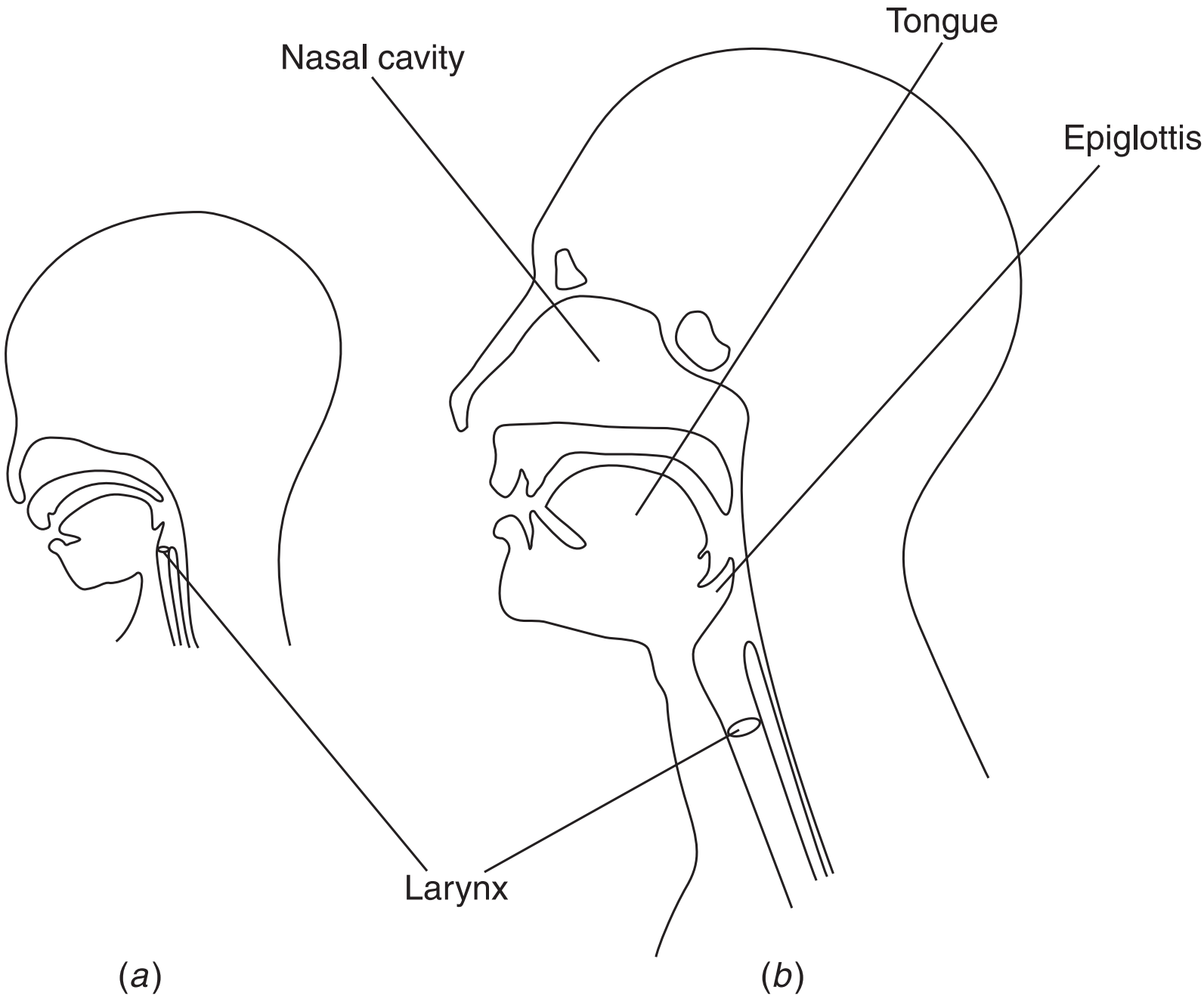

Figure 2.4
Configuration of the vocal tract of an infant (*a*) and an adult (*b*), sectioned along the midsagittal plane

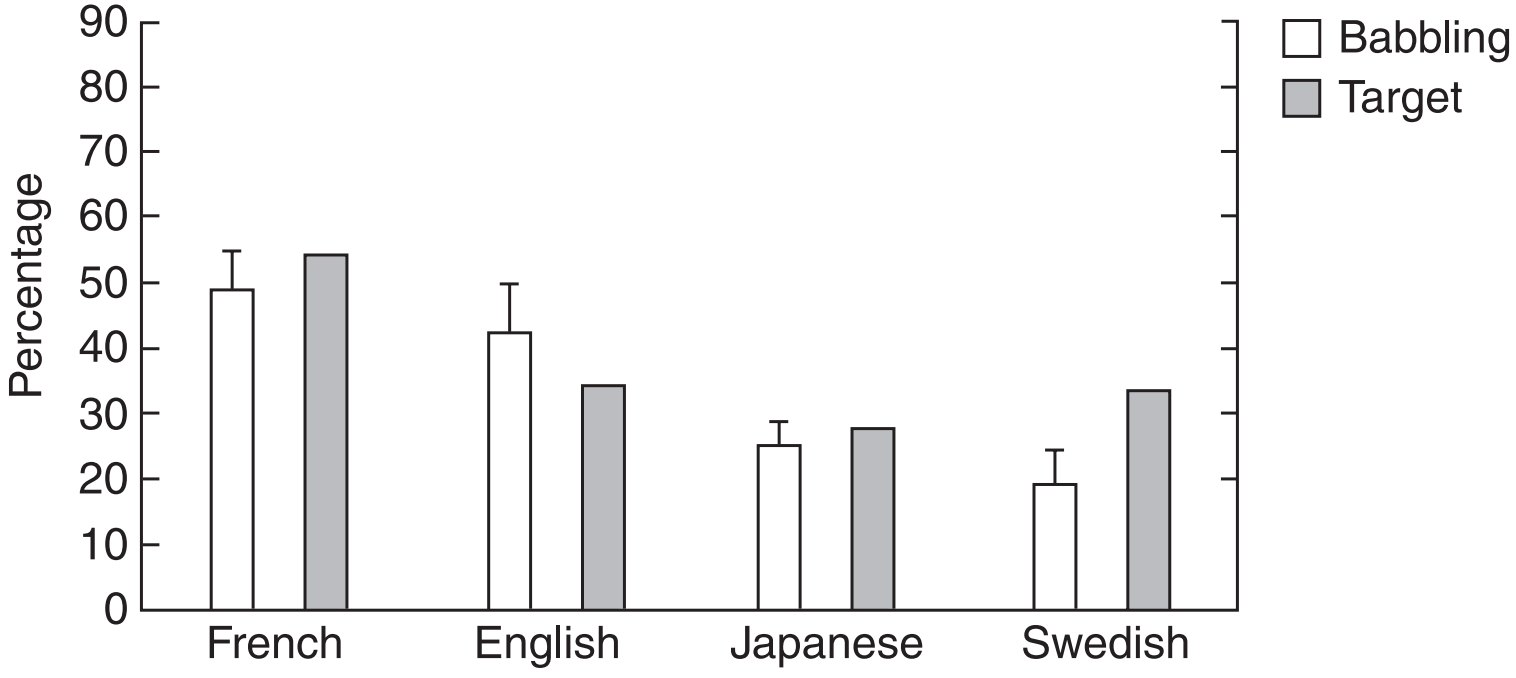

Figure 2.5
Distribution of labials in babbling and target words of the adult reference sample in four languages. (Adapted from Boysson-Bardies and Vihman 1991. Used with permission from the Linguistic Society of America.)

(1) a. C'était *son chat grin*cheux qui le rendait nerveux.
it was his cat churlish that him made nervous
'It was his churlish cat that made him nervous.'

b. C'était *son chagrin* fou qui le rendait odieux.
it was his sorrow foolish that him made hateful
'It was his foolish sorrow that made him hateful.'

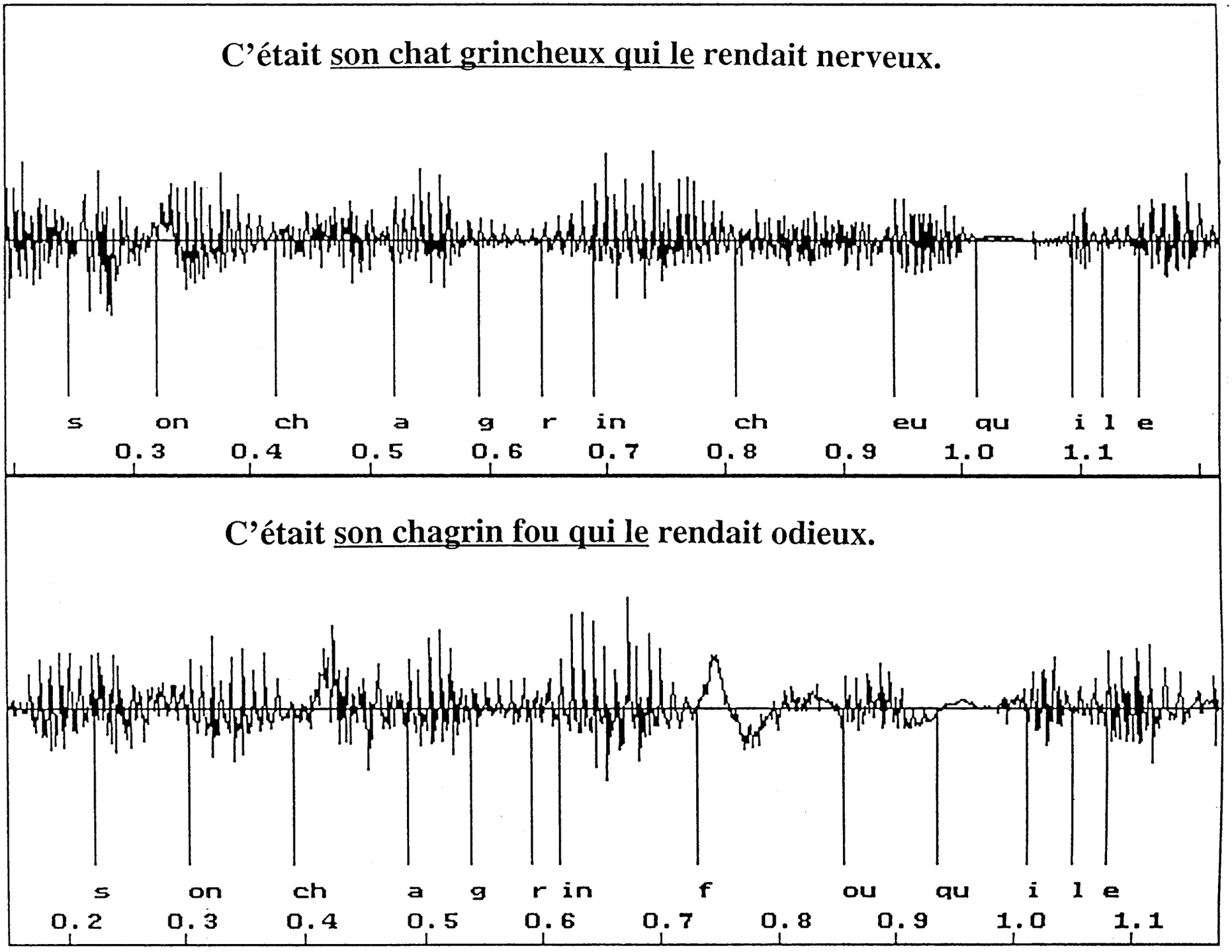

Figure 3.1
Spectrogram of the underlined parts of the French sentences *C'était son chat grincheux qui le rendait nerveux* (top) and *C'était son chagrin fou qui le rendait odieux* (bottom). The vertical lines mark the beginning of each phoneme. (Reprinted from Christophe and Dupoux 1996. Used with permission from Mouton de Gruyter.)

(2) a. speech is continuous (i.e., there are no consistent and reliable breaks between words),
b. words are not taught in isolation (though even if they were, the problem would remain, because there are words that are part of larger words and there can be multiple ways of segmenting a string),
c. infants are not born with a lexicon.

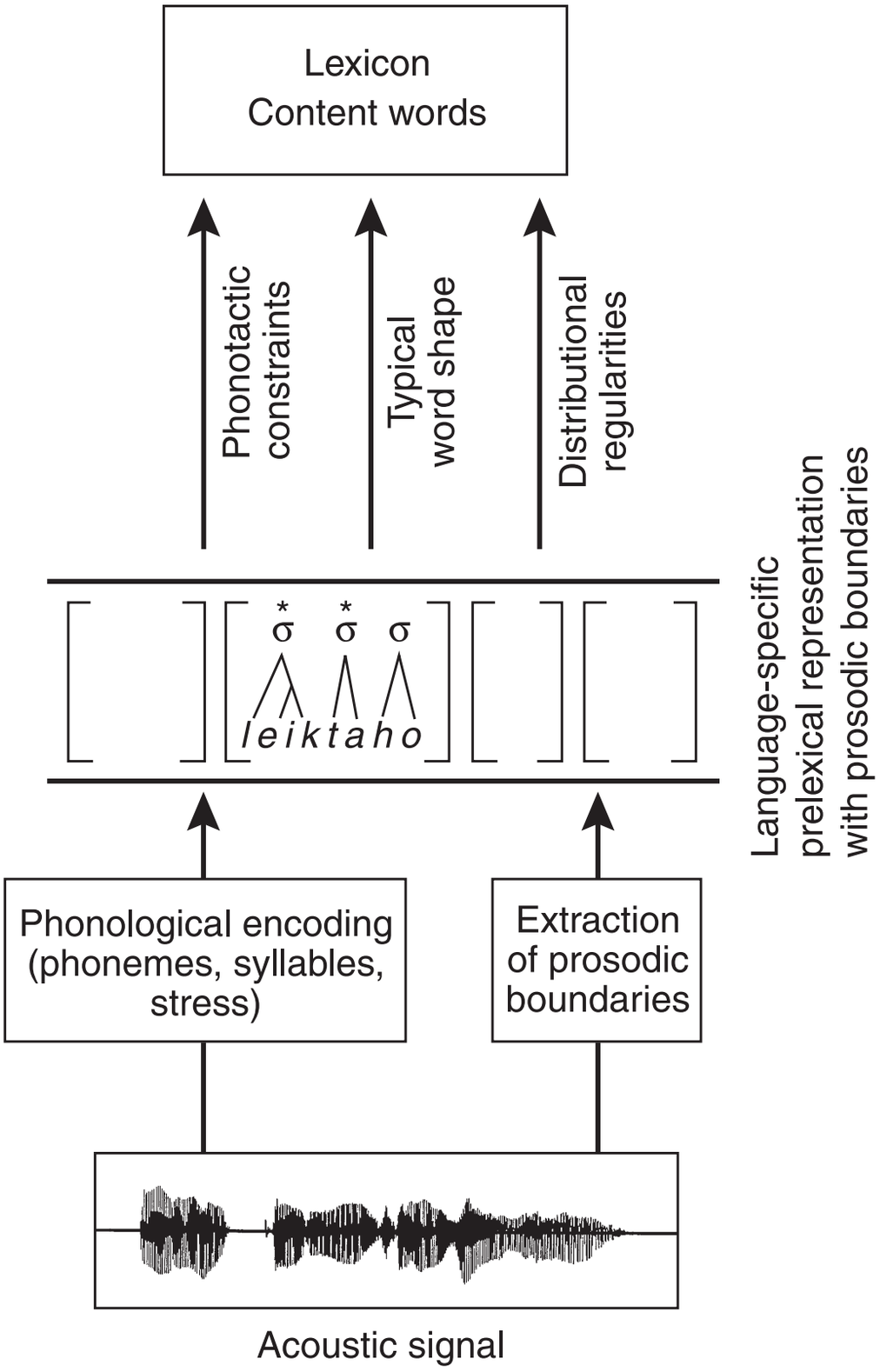

Figure 3.2
A possible model of phonological bootstrapping of lexical acquisition that rests on the prelexical prosodic segmentation hypothesis (see Christophe and Dupoux 1996; Christophe et al. 1997)

(9) *Coincident version*
Cinderella lived in a great big house/ but it was sort of dark/ because she had this mean, mean, mean stepmother/ and oh she had two stepsisters/ that were so ugly./ They were mean too.

(10) *Noncoincident version*
Cinderella lived in a great big house but it was/ sort of dark because she had/ this mean, mean, mean stepmother and oh she/ had two stepsisters that were so/ ugly. They were mean/ too.

(11) *Habituation phase*
Condition A: pabiku tibudo golatu daropi
Condition B: tudaro pigola bikuti budopa

A sample of what infants heard would be the orthographic string *pabikutibudogolatudaropi*. . . .

(12) *Testing phase*
pabiku tibudo tudaro pigola

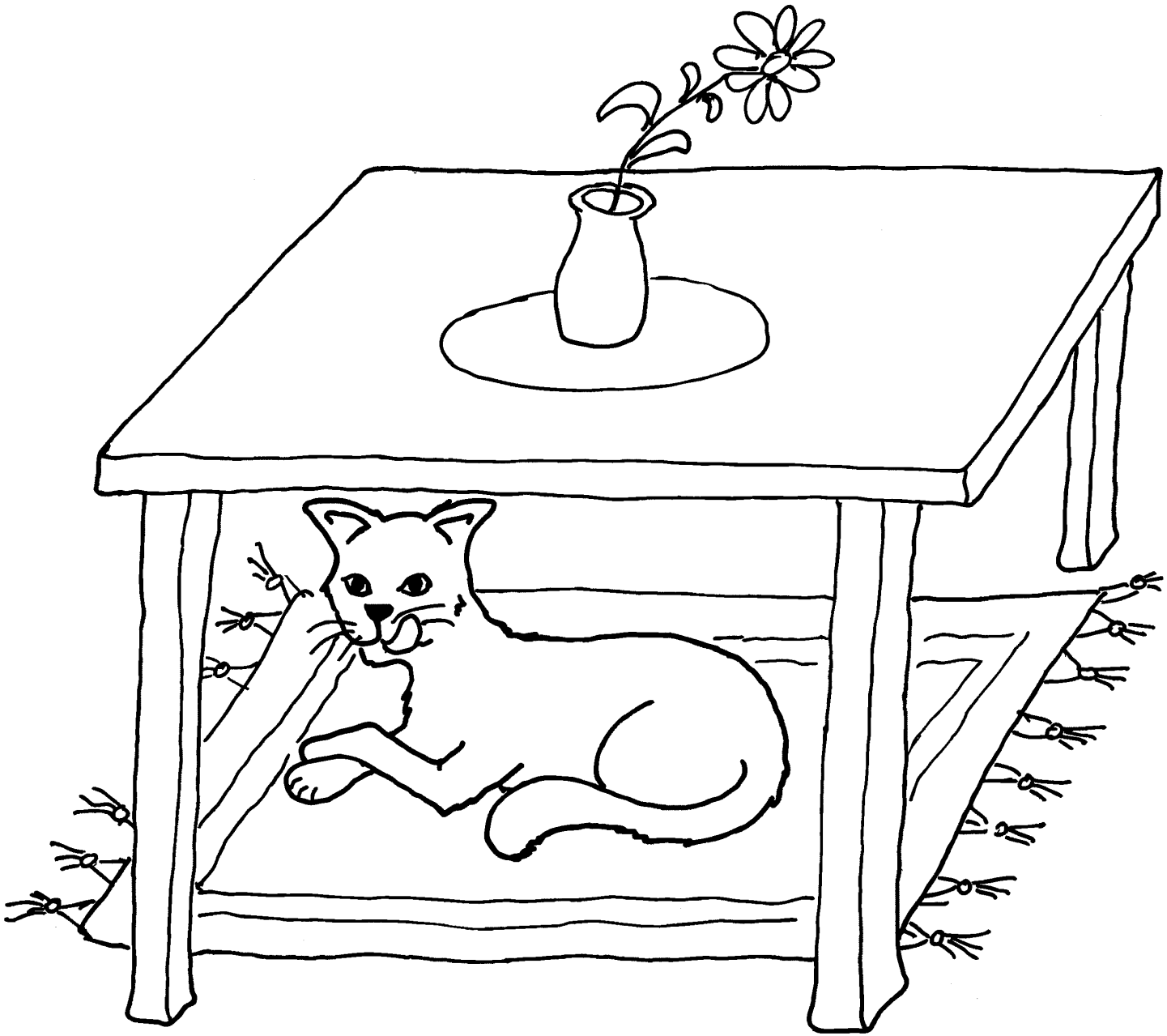

Figure 3.3
The same scene may be described in different ways: *The cat is under the table*, *The cat is on the mat*, *The mat is under the cat*.

Three **biases on word meaning** have been proposed: the **whole object bias**, the **mutual exclusivity bias**, and the **taxonomic bias** (see Markman 1994 for discussion).

(18) *Whole object bias*

"A novel label is likely to refer to the whole object and not to its parts, substance, or other properties." (Markman 1994, 155)

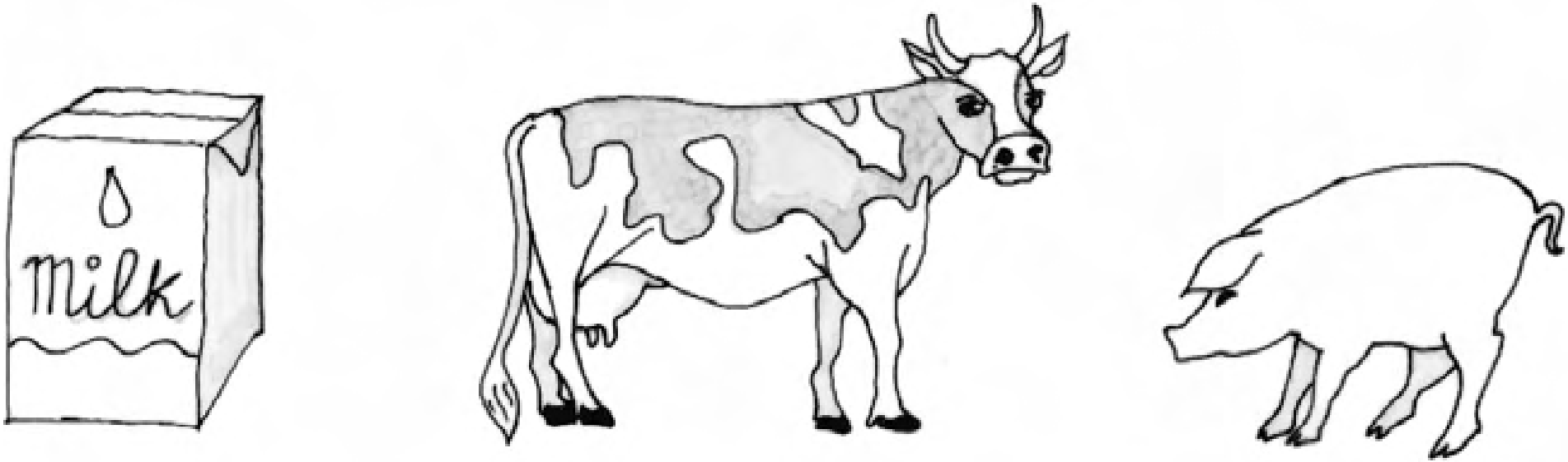

Figure 3.4
Sample of stimuli used in experiments testing how children extend labels. In the center is the target object, on the left a thematically related object, and on the right a taxonomically related object.

(20) *Mutual exclusivity bias*
"Words are mutually exclusive. . . . [E]ach object will have one and only one label." (Markman 1994, 163)

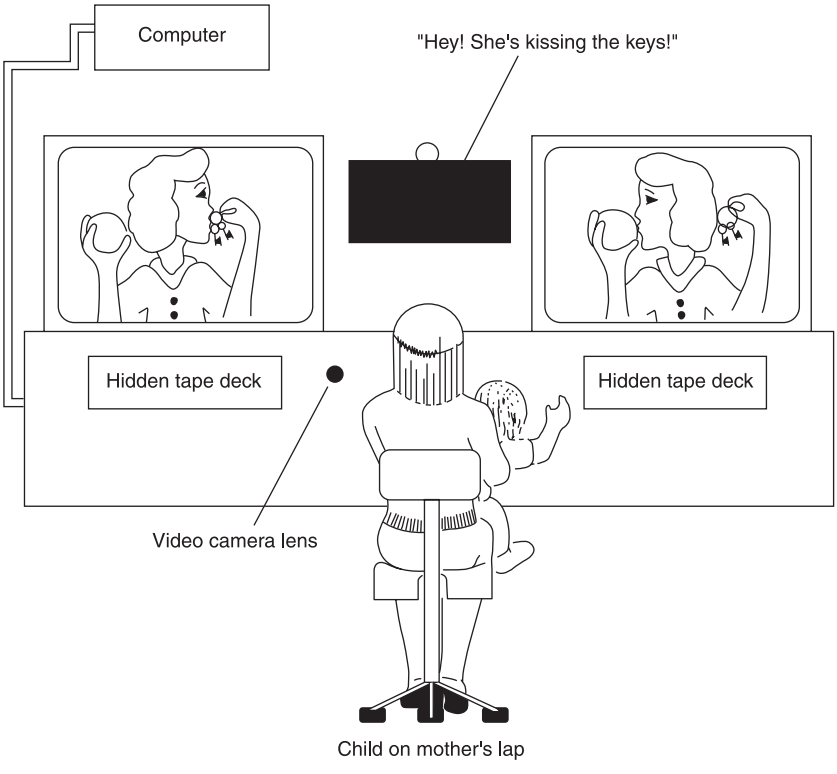

Figure 3.5
A depiction of the experimental setting for the preferential looking paradigm. The child sits on a parent's lap facing two video screens, one displaying a scene that matches an auditory stimulus ("Hey! She's kissing the keys!") and one displaying a scene that does not. Stimuli are delivered by a concealed audio speaker midway between the two video screens. (Reprinted from Hirsh-Pasek and Golinkoff 1996, 60. Used with permission from the MIT Press.)