# Psych 156A/ Ling 150: Acquisition of Language II

Lecture 4

Sounds II

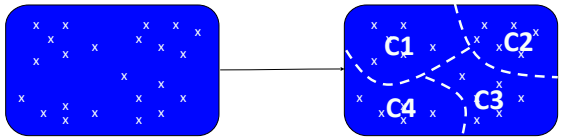
## Announcements

Be working on HW1 (due 4/17/14)

Be working on the sounds & sounds of words review questions

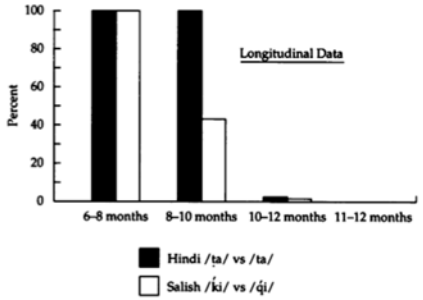
## What happens

Divide sounds into contrastive categories (phonemes)




## When it happens

Around 10 months




Werker & Tees (1984), testing English infants

## Maintenance & Loss theory

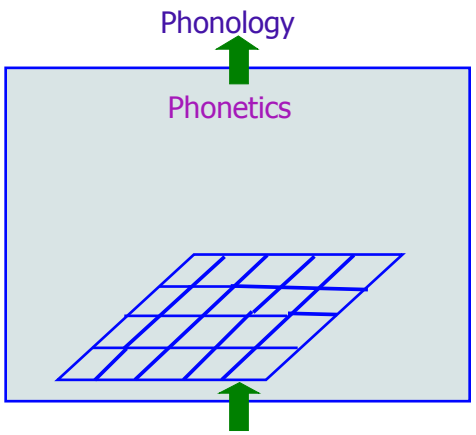
**"Use it or lose it"**

Infants maintain contrasts being used in their language and lose all the others.

Structure-changing

Patricia Kuhl

"Perceptual Magnet"

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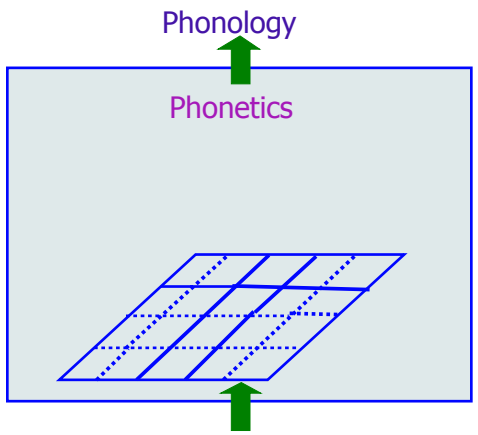



## Maintenance & Loss theory

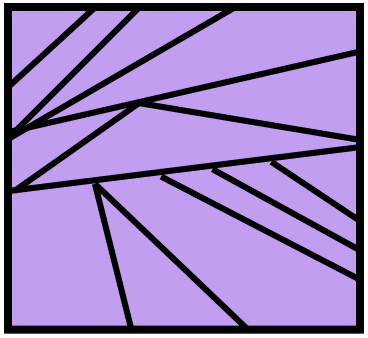
**"Use it or lose it"**

Infants maintain contrasts being used in their language and lose all the others.

Natural boundaries
(acoustically salient)

Patricia Kuhl

"Perceptual Magnet"



## Maintenance & Loss theory

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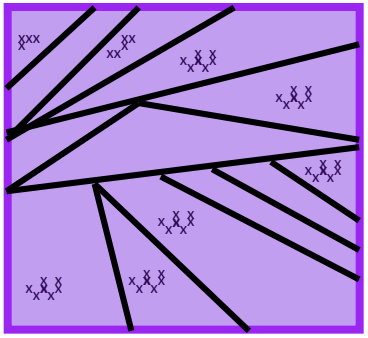
Sounds from Language 1

Patricia Kuhl

"Perceptual Magnet"



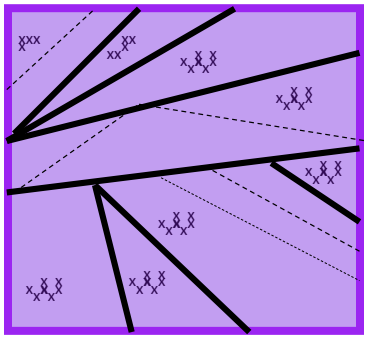
## Maintenance & Loss theory

**"Use it or lose it"**

Infants maintain contrasts being used in their language and lose all the others.

Category boundaries that are maintained to keep these sound clusters distinct

Patricia Kuhl



"Perceptual Magnet"

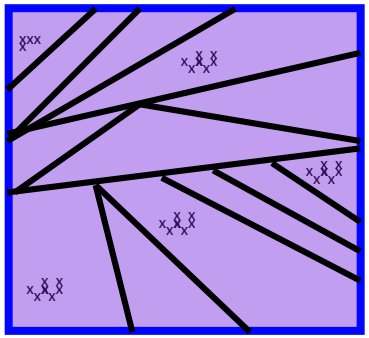
## Maintenance & Loss theory

**"Use it or lose it"**

Infants maintain contrasts being used in their language and lose all the others.

Sounds from Language 2

Patricia Kuhl



"Perceptual Magnet"

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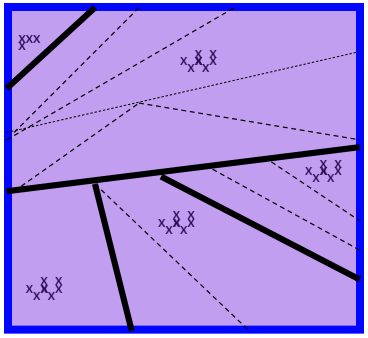


"Perceptual Magnet"

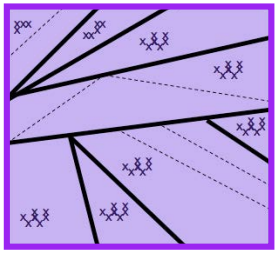
## Maintenance & Loss theory

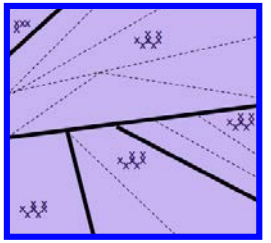
**"Use it or lose it"**

Infants maintain contrasts being used in their language and lose all the others.

Cross-linguistic variation in which contrasts are maintained, depending on language input

Patricia Kuhl





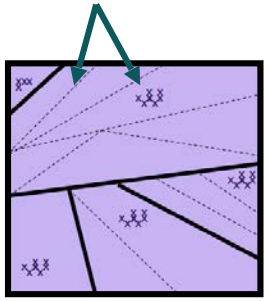
"Perceptual Magnet"

## Maintenance & Loss theory: Predictions

Prediction for performance on non-native contrasts over time:

Loss of discrimination ability is permanent and absolute

Should never be able to hear this distinction again



## Problems with the Maintenance & Loss theory

If it doesn't sound like speech, adults can tell the difference. Werker & Tees (1984) showed this with truncated portions of syllables of non-native contrasts. They told subjects the sounds were water dropping into a bucket, and to tell them when the bucket changed. Adults who could not perceive the difference when they heard the entire syllable could perceive the difference when they processed the consonant sounds separately as a non-linguistic sound - like water dropping into a bucket.

Non-linguistic perception

## Problems with the Maintenance & Loss theory

Pisoni et al. (1982), Werker & Logan (1985): adults can be trained if given enough trials or tested in sensitive procedures with low memory demands.

Maintenance & Loss would predict that this ability should be irrevocably lost - and it shouldn't matter how much training adults receive, or how the task is manipulated to help them.

## Problems with the Maintenance & Loss theory

Some non-native contrasts are easy for older infants and adults to discriminate, even though these sounds are never heard in their own languages. (Click languages (Zulu) - click sounds like "tsk tsk" nonspeech)

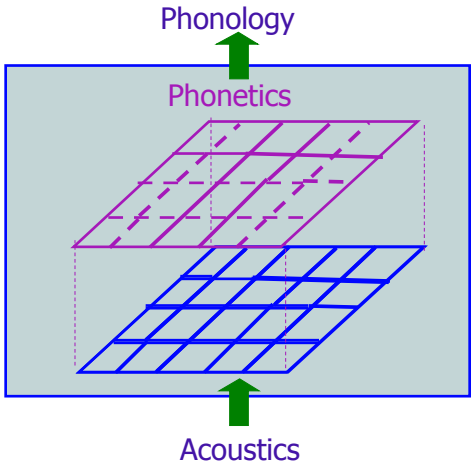

http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants/course/chapter6/zulu/zulu.html

## Functional reorganization

Janet Werker

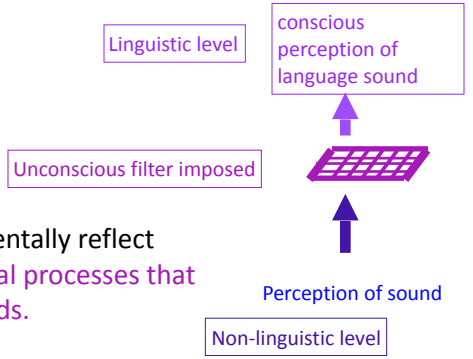
**Structure-building**

Native language phonemes built from universal sound distinctions




## Functional reorganization

Janet Werker




Changes attested experimentally reflect operation of postperceptual processes that activate for language sounds.

Data distributions determine what the category boundaries are in the filter. Importantly, constructing this filter does not affect base-level sound perception.

## Functional reorganization: The developmental story

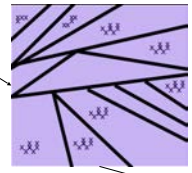
Very young infants respond to any detectable variation - so they can pick up any salient contrasts in surrounding language.

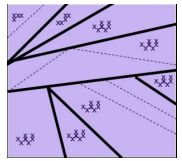
Adults have a bias for phonemic contrasts since those are the ones relevant to language.

If sounds are in a non-language setting, adults can distinguish non-native contrastive sounds because their postperceptual language filter isn't activated.

## How change happens: Comparison

Idea 1: Maintenance & Loss
Data distributions determine which boundaries are maintained and which ones are lost/ignored

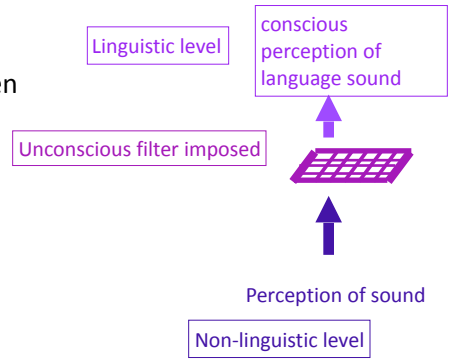




Problem: Doesn't seem to be permanent loss, and doesn't seem to affect sounds if processed as non-language

## How change happens: Comparison

Idea 2:
Functional Reorganization
Unconscious filter imposed when sounds are processed as language. Data distributions determine what the boundaries are in the filter.




Common theme: Data distributions determine construction of relevant category boundaries for language

## More about contrastive sounds

There are a number of acoustically salient features for sounds. All it takes for sounds to be contrastive is for them to have "opposite" values for one feature.

Example:
English sounds "k" and "g" differ only with respect to voicing. They are pretty much identical on all other features. Many contrastive sounds in English use the voicing feature as the relevant feature of contrast (p/b, t/d, s/z, etc.). However, there are other features that are used as well (air flow, manner of articulation, etc.).

Task for the child: Figure out which features are used contrastively by the language. Contrastive sounds for the language will usually vary with respect to one of those features.

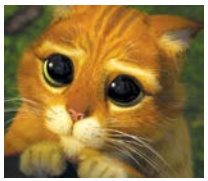
## Experimental study: Dietrich, Swingley & Werker 2007

Testing children's perception of contrastive sounds

Dutch and English contrastive features differ.

In English, the length of the vowel is not contrastive

"cat" = "caat"



In Dutch, the length of the vowel is contrastive

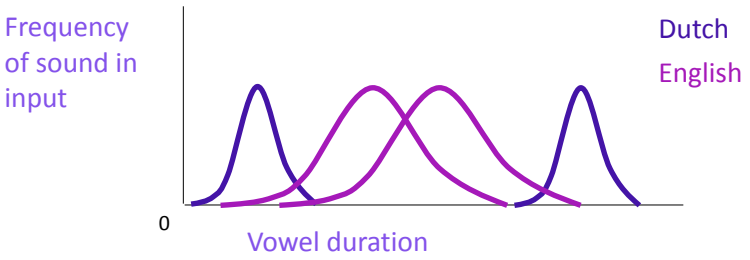
"cat" ≠ "caat"

(Japanese also uses this feature)

## Does the data distribution show this?

Dutch and English vowel sounds in the native language environment also seem to differ

"…studies suggest that differences between the long and short vowels of Dutch are larger than any analogous differences for English." – Dietrich et al. 2007



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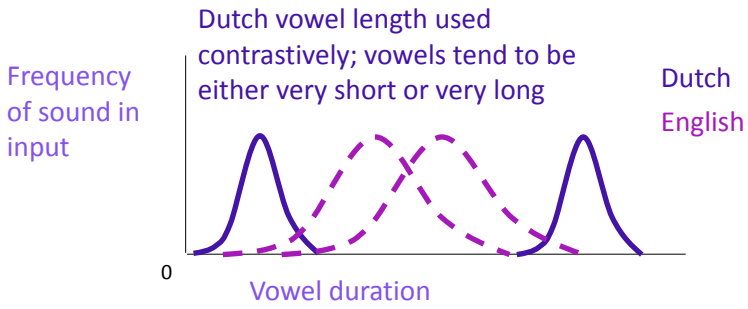


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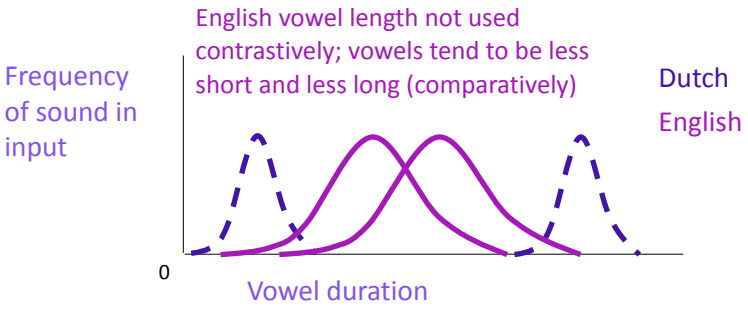


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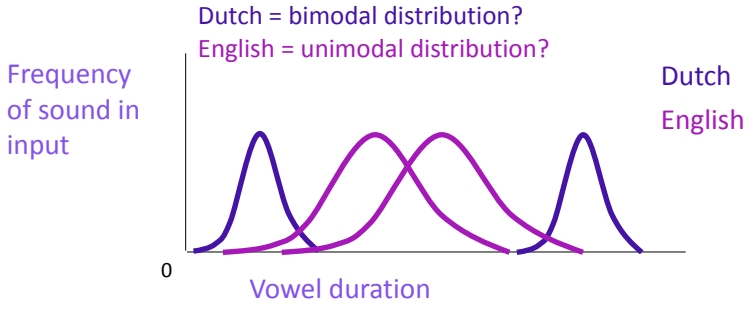


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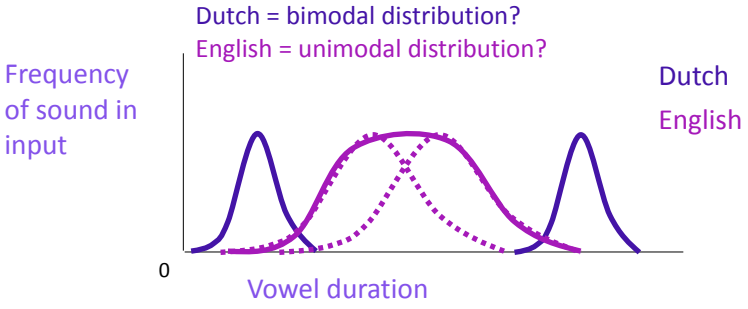
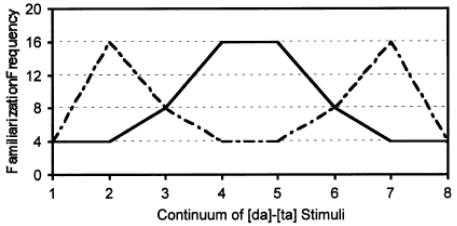


## Learning from real data distributions

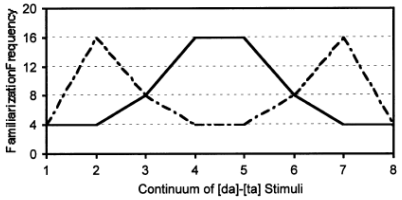
How do we know that children are sensitive to distributional information?

## Maye, Werker, & Gerken 2002



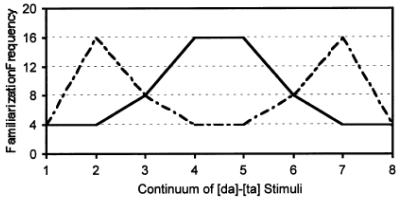

Created synthetic sounds ranging from [da] to [ta] that were non-native for the infants (because they were unaspirated – without the little puff of air after them).

## Maye, Werker, & Gerken 2002




- Familiarized 6- to 8-month-old infants to one of two sets
  - Bimodal Set: Sounds on the ends near [da] and [ta].
  - Unimodal Set: Sounds in the middle.
- Test preference for:
  - 3 6 3 6… (Alternating) vs. 3 3 3 3… (Non-alternating) stimuli

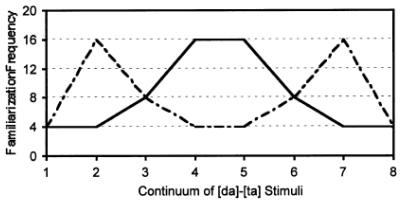
## Maye, Werker, & Gerken 2002




| | 3 6 3 6 … Alternating trials (s) | | 3 3 3 3 Non-Alternating trials (s) |
|---|---|---|---|
| 6 months Unimodal | 4.85 (0.47) | = | 4.53 (0.51) |
| 8 months Unimodal | 4.98 (0.63) | = | 5.20 (0.56) |
| 6 months Bimodal | 5.66 (0.44) | < | 6.41 (0.32) |
| 8 months Bimodal | 5.45 (0.52) | < | 6.15 (0.56) |

## Maye, Werker, & Gerken 2002

Infants trained on the Bimodal data had a novelty preference for non-alternating trials. They learned to expect alteration, and were surprised by non-alteration.




3 6 3 6 ... 3 3 3 3

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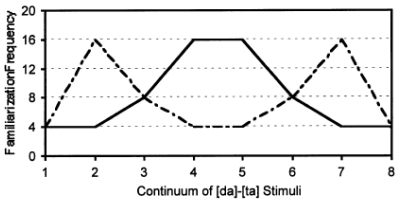
## Maye, Werker, & Gerken 2002

Infants trained on the Unimodal data did not prefer/disprefer one over the other. The did not seem to learn any expectation.

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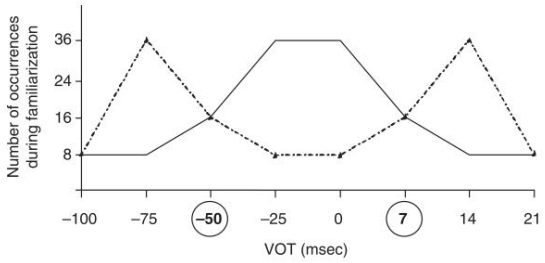
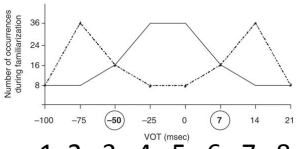
## Maye, Weiss, & Aslin 2008




Created sounds derived from Hindi speech sounds, ranging from [da] to [ta] and from [ga] to [ka], varying in voice onset time (VOT). All of these were non-native sounds for English speakers, since [da] and [ga] were prevoiced (VOT ~ -50ms) and [ta] and [ka] were unaspirated (without the little puff of air).

## Maye, Weiss, & Aslin 2008

The looking times for the final habituation trials indicate how long infants were willing to listen to the 7ms sound (token 6) played over and over again.




1 2 3 4 5 6 7 8

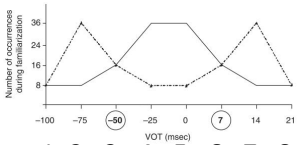
6 6 6 6...

| | Final habituation trials | | Change trials |
|---|---|---|---|
| Bimodal | 4807 (362) | < | 6844 (628) |
| Unimodal | 5362 (420) | ≈ | 4861 (360) |
| Control | 6466 (672) | > | 5540 (478) |
| Generalization | 5421 (453) | < | 6697 (740) |

**Looking time in ms**

## Maye, Weiss, & Aslin 2008

The looking times for the change trials indicate how long infants were willing to listen to the -50ms sound (token 3), after they had been listening to the 7ms sound (token 6).

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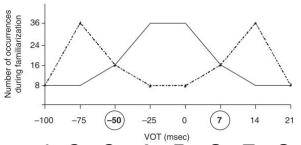
**Looking time in ms**

## Maye, Weiss, & Aslin 2008

If infants are able to discriminate the two sounds (token 3 and token 6), they should be interested when they perceive the sound change. This means the looking times in the change trials would be higher than in the final habituation trials.

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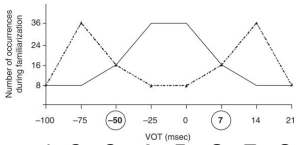
**Looking time in ms**

## Maye, Weiss, & Aslin 2008

Infants trained on a bimodal distribution did perceive the sound contrast.




1 2 3 4 5 6 7 8

6 6 6 6… 6 6 3…

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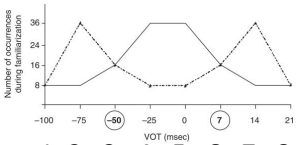
**Looking time in ms**

## Maye, Weiss, & Aslin 2008

Infants trained on a unimodal distribution did not perceive the sound contrast.

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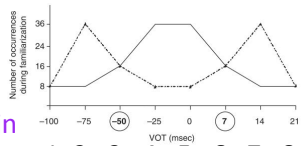
**Looking time in ms**

## Maye, Weiss, & Aslin 2008

Infants trained on non-language stimuli (used as a control) were very uninterested in the sound change – they did not detect it. (They're more interested in the sound itself, since they hadn't yet dishabituated.)

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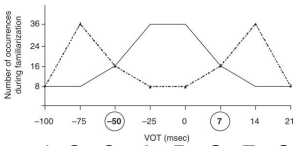
| Unimodal | 5362 (420) | ≈ | 4861 (360) |
| Control | 6466 (672) | > | 5540 (478) |
| Generalization | 5421 (453) | < | 6697 (740) |

**Looking time in ms**

## Maye, Weiss, & Aslin 2008

Infants trained on a bimodal distribution of one contrast (ex: [da] vs. [ta]) were able to generalize the VOT distinction to a sound contrast they had not heard before (ex: [ga] vs. [ka]).




That is, they recognized voicing as a contrastive feature.

6 6 6 6… 6 6 3…

| | Final habituation trials | | Change trials |
|---|---|---|---|
| Bimodal | 4807 (362) | < | 6844 (628) |
| Unimodal | 5362 (420) | ≈ | 4861 (360) |
| Control | 6466 (672) | > | 5540 (478) |
| Generalization | 5421 (453) | < | 6697 (740) |

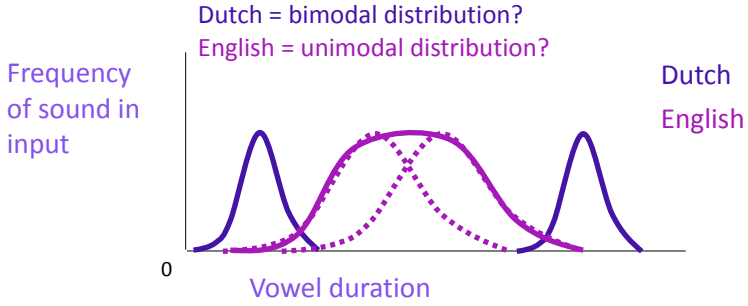
**Looking time in ms**

## Back to Dietrich, Swingley, & Werker 2007

Dutch and English vowel sounds in the native language environment also seem to differ

"…studies suggest that differences between the long and short vowels of Dutch are larger than any analogous differences for English." – Dietrich et al. 2007

Dutch = bimodal distribution?
English = unimodal distribution?




## Back to Dietrich, Swingley, & Werker 2007

Prediction if children are sensitive to this distribution

Dutch children should interpret vowel duration as a meaningful contrast because the distribution is more bimodal

Implication: Change to vowel duration = new word

English children should not interpret vowel duration as a meaningful contrast because the distribution is more unimodal

Implication: Change to vowel duration = same word as before

## Dietrich, Swingley, & Werker 2007

Tests with 18-month-old children who know some words (and so have figured out the meaningful sounds in their language)

"Switch" Procedure: measures looking time

…this is a *tam*…look at the *tam*

Habituation

Test

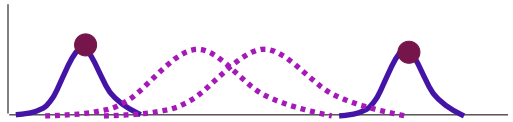
Same:
look at the *tam!*

Switch:
look at the *taam!*

## Dietrich, Swingley, & Werker 2007

Experiment 1: Testing English and Dutch kids on Dutch vowel durations

Frequency of sound in input




Dutch kids

5.04 sec 9.23 sec

difference

English kids

6.66 sec 7.15 sec

no difference

Test

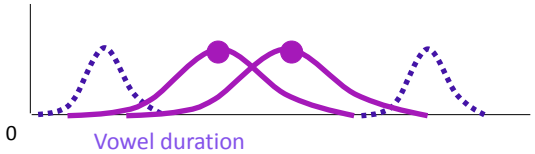
Same:
look at the *tam!*

Switch:
look at the *taam!*

## Dietrich, Swingley, & Werker 2007

Experiment 2: Testing English and Dutch kids on English vowel durations

Frequency of sound in input




Dutch kids

5.92 sec 8.16 sec

difference

English kids

7.34 sec 8.04 sec

no difference

Test

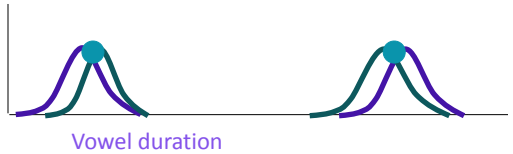
Same:
look at the *tam!*

Switch:
look at the *taam!*

## Dietrich, Swingley, & Werker 2007

Experiment 3: Testing English and Dutch kids on vowel quality contrast (a/e)

Frequency of sound in input




*(This is a control condition to make sure English kids can do the task when the sound is contrastive for them)*

Dutch kids

4.08 sec 5.72 sec

difference

English kids

6.31 sec 9.31 sec

difference

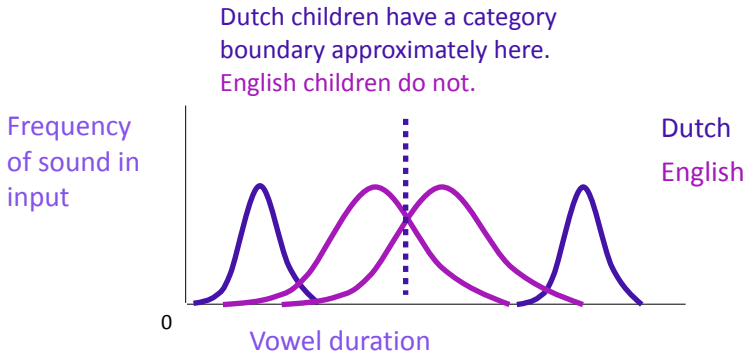
Test

Same:
look at the *tam!*

Switch:
look at the *tem!*

## Dietrich, Swingley, & Werker 2007

Implications of experiments 1, 2, and 3: Dutch children recognize vowel duration as contrastive for their language while English children do not. This can only be due to the data encountered by each set of children in their language.




## What drives children to learn the distinction?

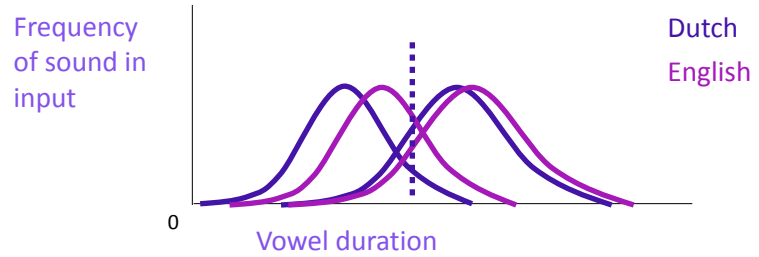
"One frequently raised hypothesis…is that it is driven by contrast in the vocabulary. Dutch children might learn that [a] and [a:] are different because the words [stat]…and [sta:t]…mean different things…however, children that young do not seem to know many word pairs that could clearly indicate a distinction between [a] and [a:]." - Dietrich, Swingley, & Werker (2007)

## Dietrich, Swingley, & Werker 2007

"The other current hypothesis is that children begin to induce phonological categories "bottom-up", based on their discovery of clusters of speech sounds in phonetic space…undoubtedly implicated in infants' early phonetic category learning, which begins before infants know enough words for vocabulary-based hypotheses to be feasible…"

## Dietrich, Swingley, & Werker 2007

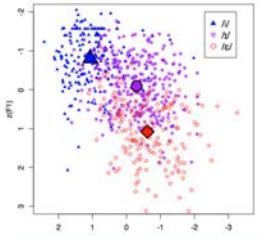
"A necessary condition for such learning to be the driving force behind Dutch children's phonological interpretation in the present studies is that long and short vowels be more clearly separable in Dutch than in English…preliminary examination of this problem using corpora of Dutch child-directed speech indicated that the set of long and short instances formed largely overlapping distributions."



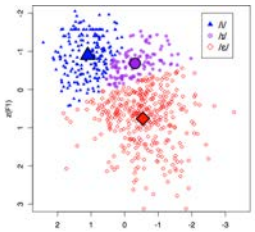

Implication: Dutch children need other cues to help them out

## Adriaans & Swingley 2012

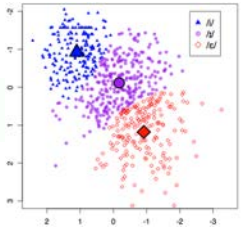
Motherese may provide exaggerated distributions when sounds are emphasized (given acoustic focus), which can help infants figure out the contrastive sounds.



Three vowel categories for English speakers



A learning model trained on all sounds in motherese



A learning model trained on "acoustically focused" sounds in motherese

## Swingley 2009

Another potential source of information: Keep some contextual information for each vowel sound (what word it came from, if it comes from a frequent word).

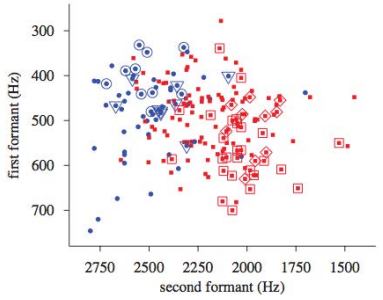
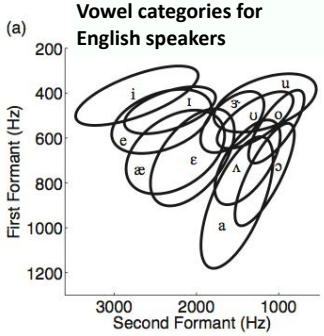



Figure 3. The vowels /i/ and /ɪ/ in first- and second formant space, as spoken by one mother to her infant. The /i/ instances are plotted as blue circles, /ɪ/ as red squares. Outlines around instances indicate tokens measured from the words *see* (open circles), *we* (open triangles), *dillon* (open squares), and *this* (open diamonds).

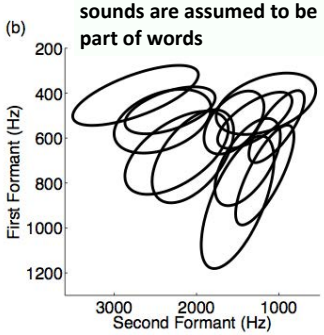
## Feldman et al. 2009, 2013

Assuming that sounds are part of words can be helpful – this suggests that learning about sounds and words at the same time is *easier* than learning sounds separately and then learning words. (Feldman, Griffiths, & Morgan 2009, Feldman, Griffiths, Goldwater, & Morgan 2013)

Vowel categories for English speakers




Vowel categories learned by a computational model when sounds are assumed to be part of words

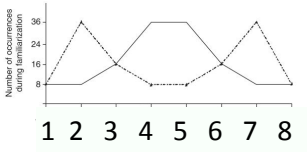



## Feldman et al. 2013b

Supporting experimental evidence: 8-month-olds do better at distinguishing sounds that are heard in different word contexts (Feldman, Myers, White, Griffiths, & Morgan 2013).

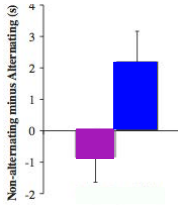
**"ah" /a/ vs. "aw" /ɔ/**

| | |
|---|---|
| **Minimal pair context:** | **gutah….gutaw** |
| **Non-minimal pair context:** | **gutah…litaw** |
| **Non-alternating trial:** | **3..3..3… or 6…6…6…** |
| **Alternating trial:** | **1…8…1…8** |




**ah……aw**

Infants who heard the sounds in the same "word" don't notice the sound change (sounds are not contrastive).




Infants who heard the sounds in different "words" notice the sound change (sounds are contrastive). They are surprised when the sounds don't alternate.

## Discovering contrastive sounds: What's the point of it again?

The idea is that once children discover the meaningful sounds in their language, they can begin to figure out what the words are.

Ex: An English child will know that "cat" and "caat" are the same word (and should have the same meaning).

As adults, we can look at a language and figure out what the contrastive sounds are by looking at what changes a word's meaning. But children can't do this - they figure out the contrastive sounds *before* they figure out many word forms and word meanings.

## Recap: Sounds

It seems that we learn to have a language filter that abstracts away from the raw acoustic signal when we think we're listening to language (a language sound filter that creates phonemes).

Children need to learn what the phonemes of their language are by listening to their native language input, and phonemes will be contrastive with respect to at least one feature (like duration or voicing).

Infants seems able to use the statistical distribution of sounds to help them infer which sounds are contrastive.

It may be helpful for children to keep track of where they hear particular sounds (that is, in which words) in order to figure out the phonemes of their language.

## Questions?

You should be able to do up through question 8 on HW1 and up through question 23 on the sound review questions.