Ling 151/Psych 156A: Acquisition of Language II

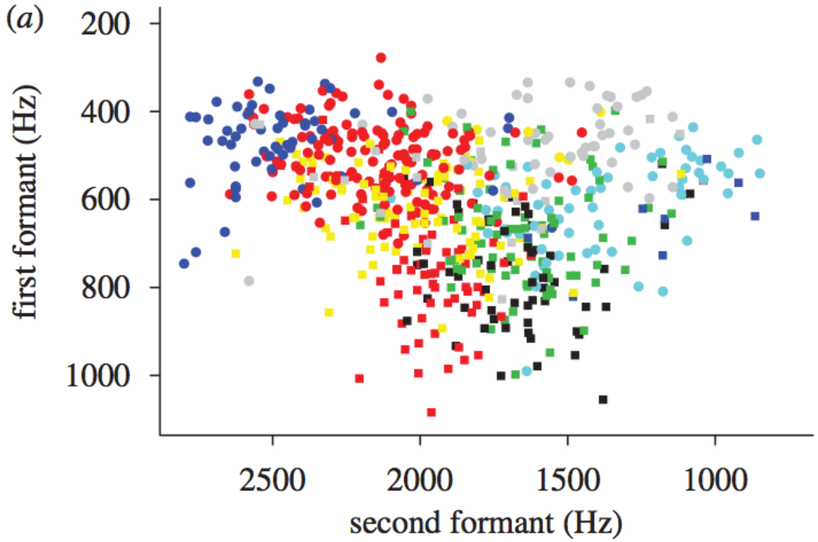
Lecture 6

Sounds III

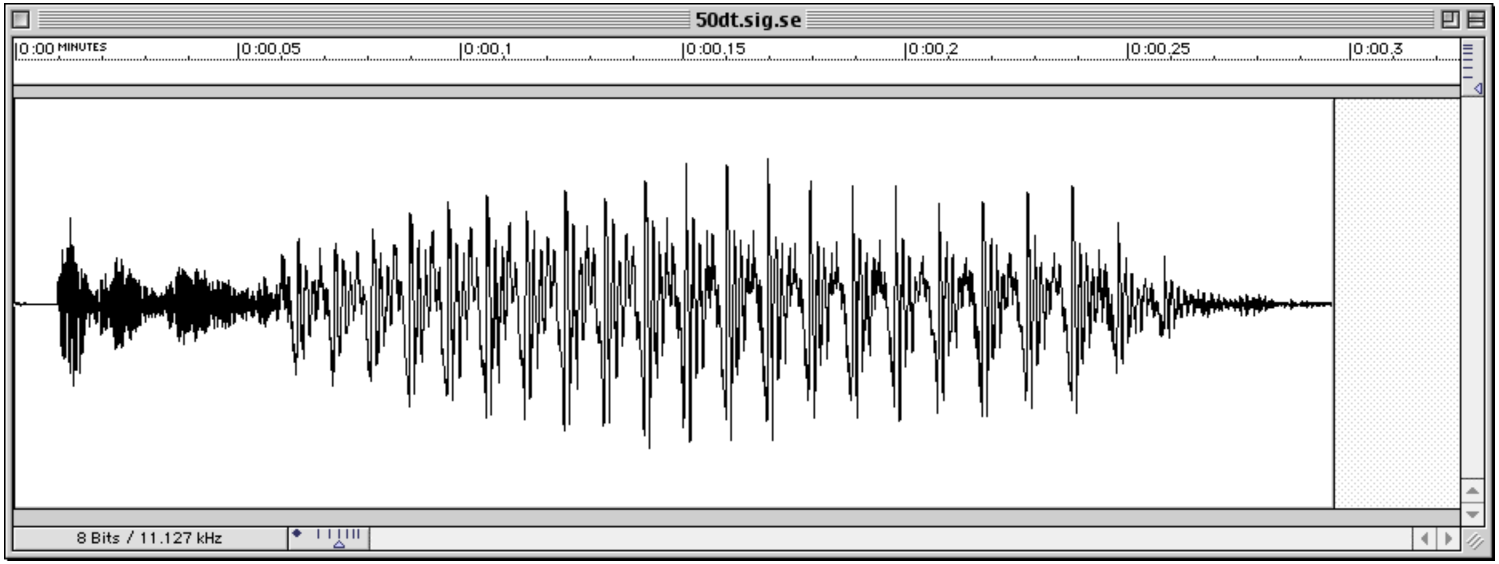
Announcements

Be working on HW2 (due 1/26/18)

Be working on the sounds & sounds of words review questions



Learning sounds



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.

More about contrastive sounds

Example:
English sounds "k" and "g" differ only with respect to voicing (VOT). They're 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.).

More about contrastive sounds

voicing

p/b, t/d, s/z

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.

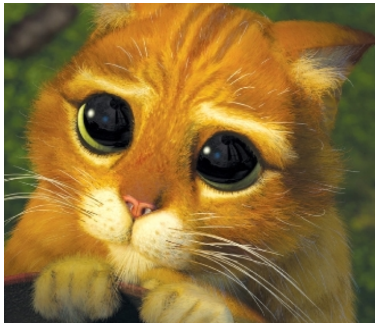
Experimental study: Dietrich, Swingley & Werker 2007

Testing children's perception of contrastive sounds

Dutch and English contrastive features differ.

In English, the **length** (duration) of the vowel is not contrastive

"cat" = "caat"



In Dutch, the **length** (duration) of the vowel is contrastive

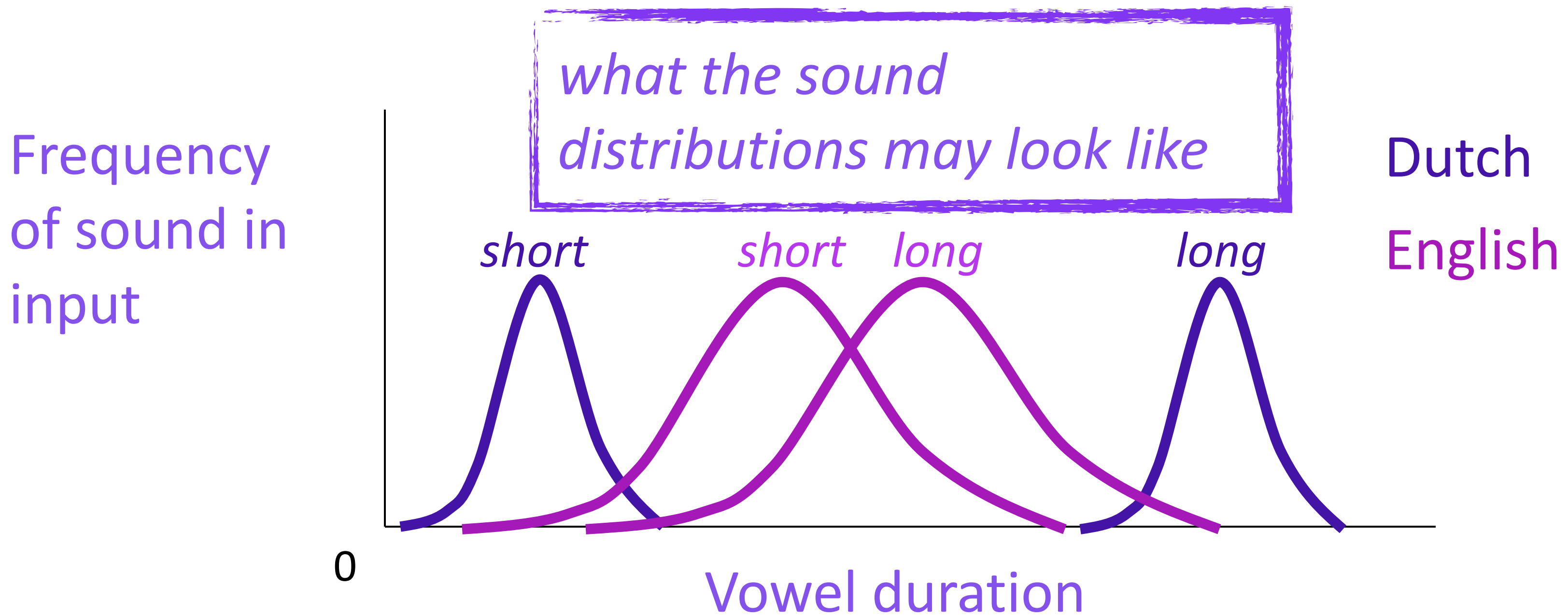
"cat" ≠ "caat"

(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

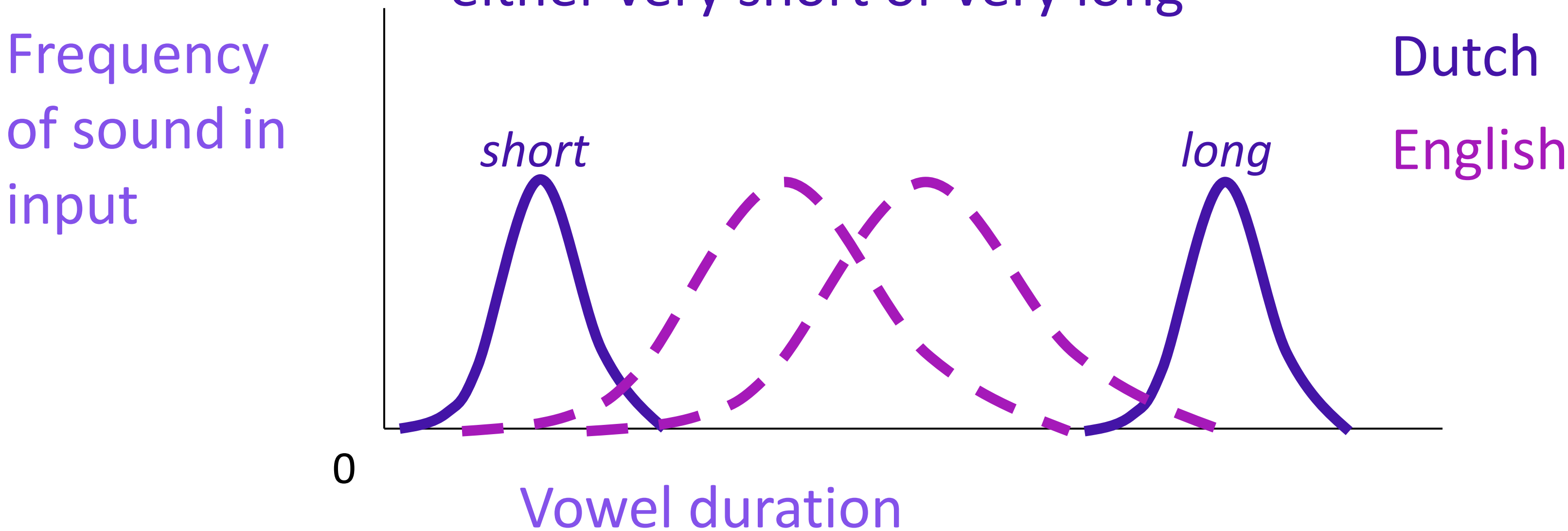
"…studies suggest that differences between the long and short vowels of Dutch are larger than any analogous differences for English." – Dietrich et al. 2007



Does the data distribution show this?

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

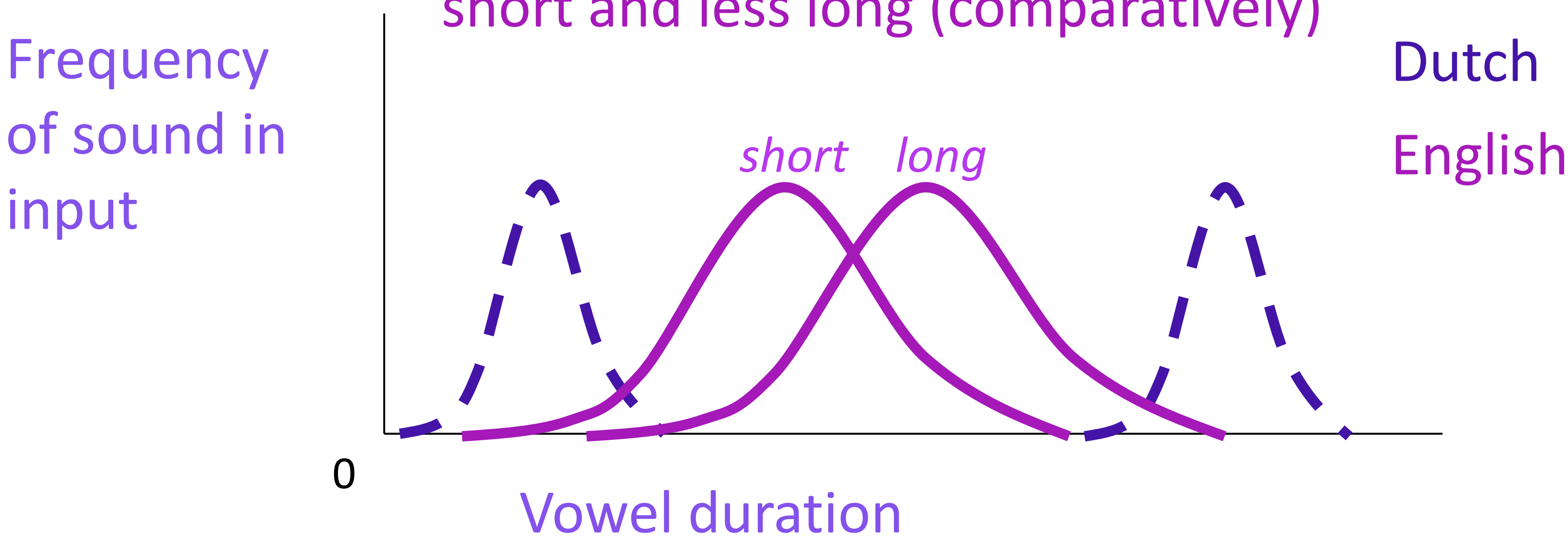
Dutch vowel length used contrastively; vowels tend to be either very short or very long



Does the data distribution show this?

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

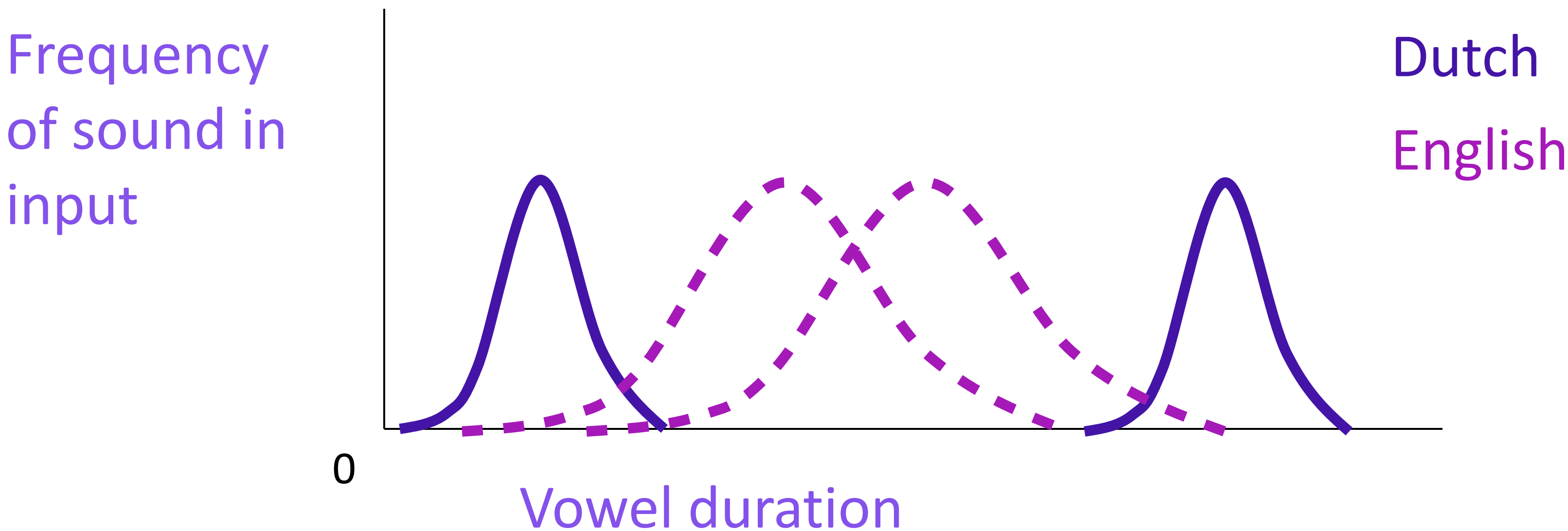
English vowel length not used contrastively; vowels tend to be less short and less long (comparatively)



Does the data distribution show this?

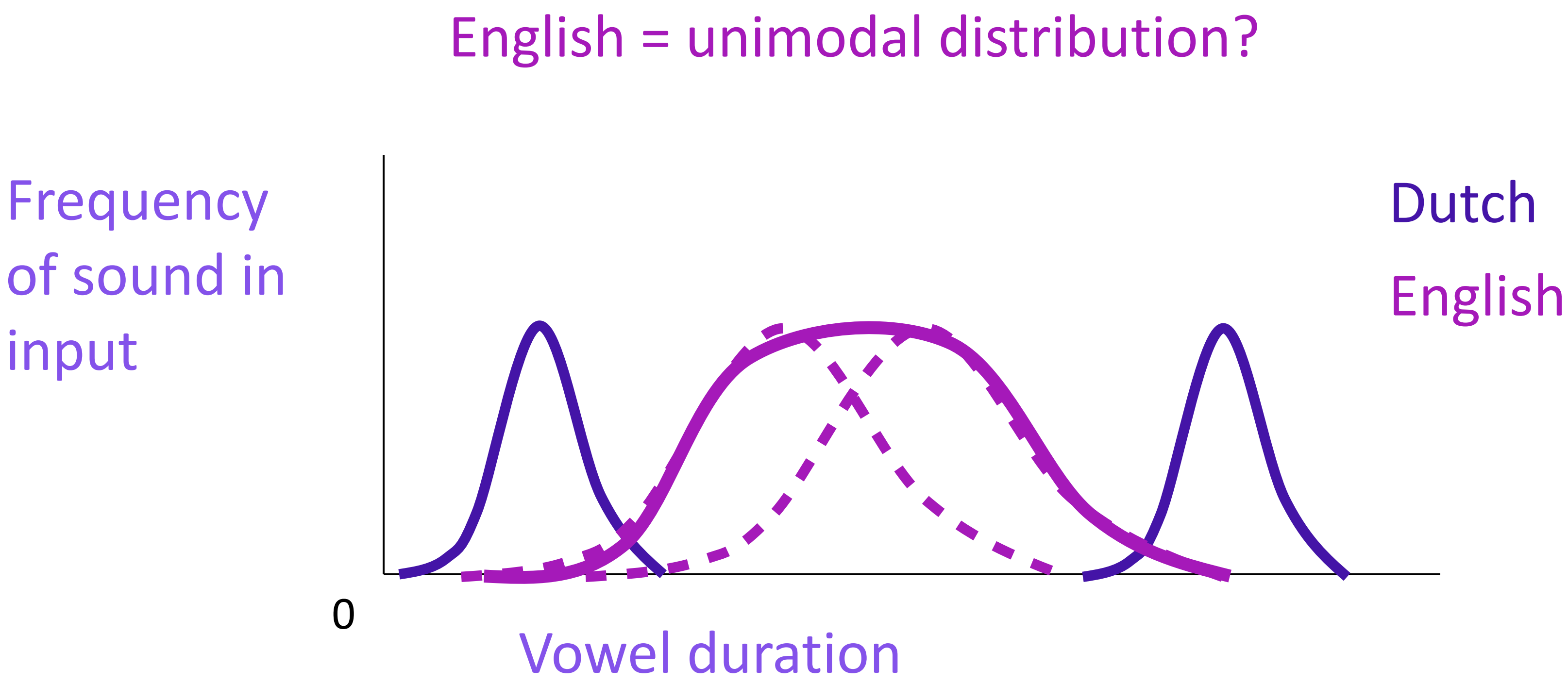
Dutch and English vowel sounds in the native language environment also seem to differ

Dutch = bimodal distribution?



Does the data distribution show this?

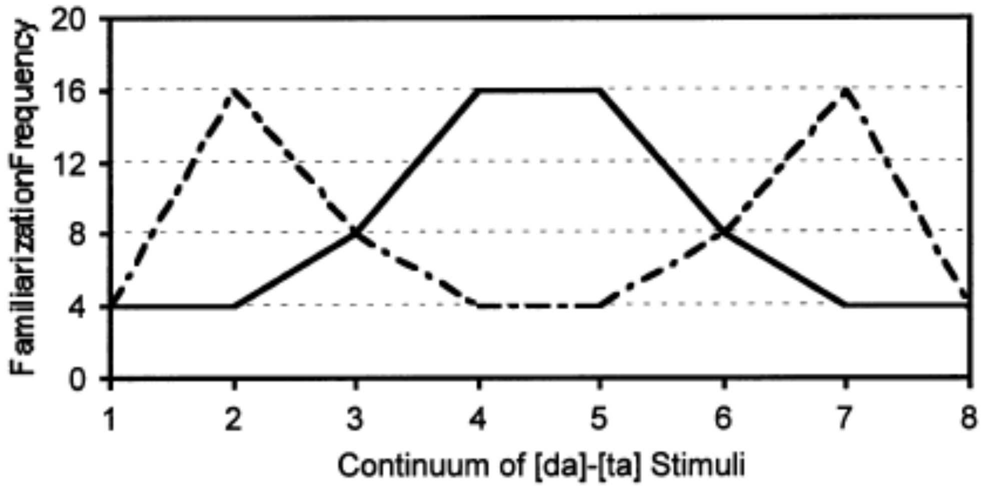
Dutch and English vowel sounds in the native language environment also seem to differ



Learning from real data distributions

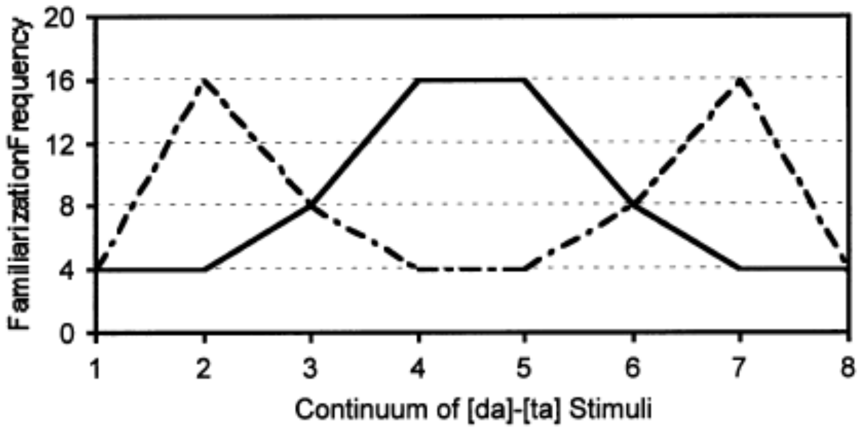
How do we know that children are sensitive to distributional information like this?

Maye, Werker, & Gerken 2002



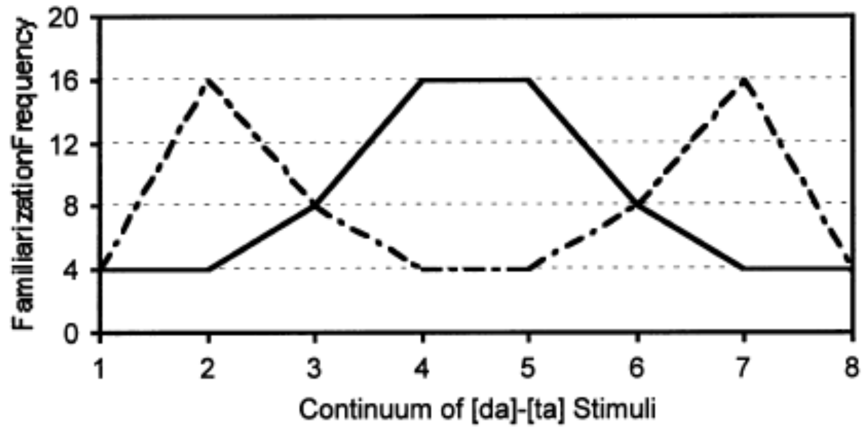
Created synthetic sounds ranging from [da] to [ta] that were non-native for the infants (because they were unaspirated – without the little puff of air after them).

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

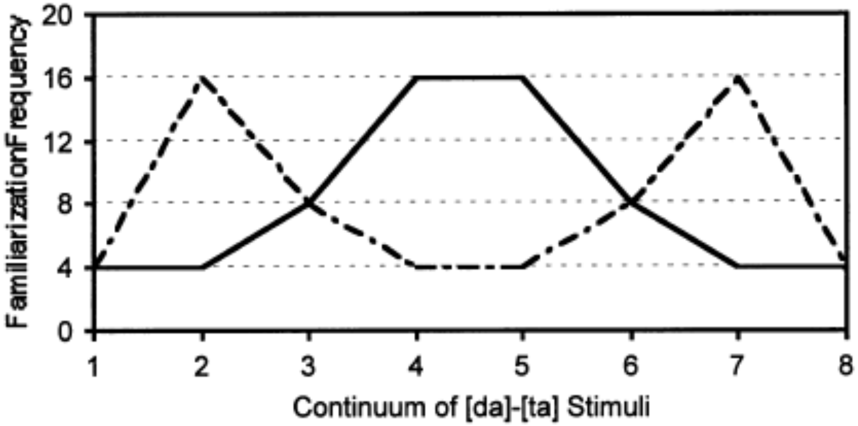
Maye, Werker, & Gerken 2002



	3 6 3 6 …		3 3 3 3
	Alternating trials (s)		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
	Alternating trials (s)		Non-Alternating trials (s)
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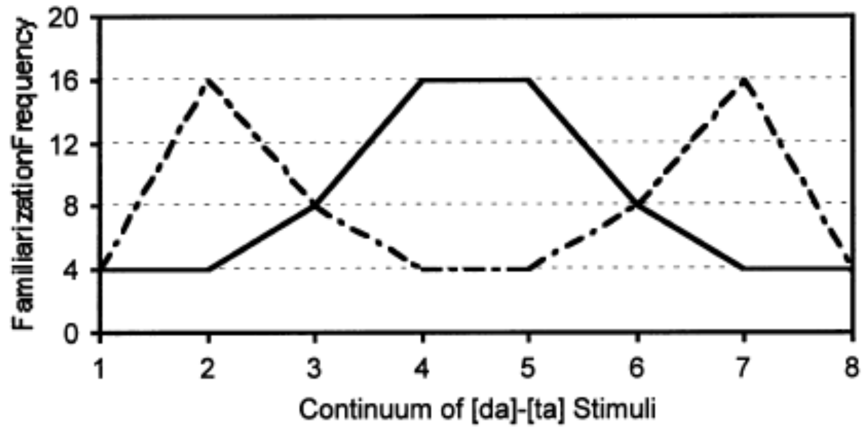
8 months Bimodal	5.45 (0.52)	<	6.15 (0.56)

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.



	3 6 3 6 …		3 3 3 3
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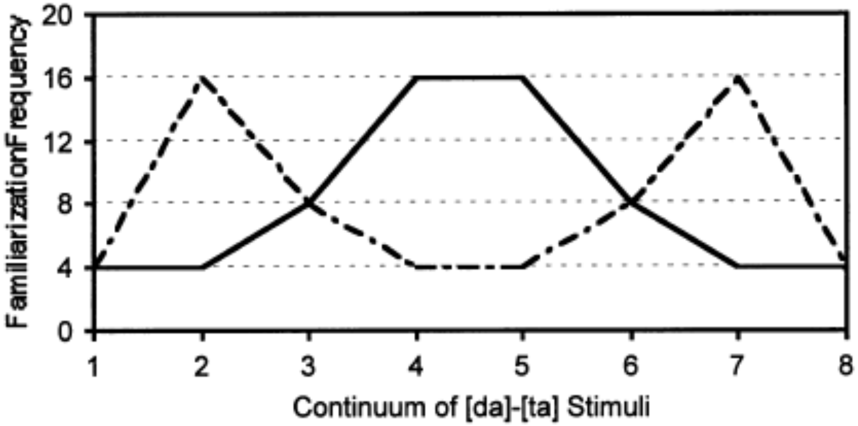
Maye, Werker, & Gerken 2002

One explanation: Infants expected all the sounds to be in one category so they were all the "same", whether it was alternating or non-alternating tokens.



	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)
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6 months Bimodal	5.66 (0.44)	<	6.41 (0.32)
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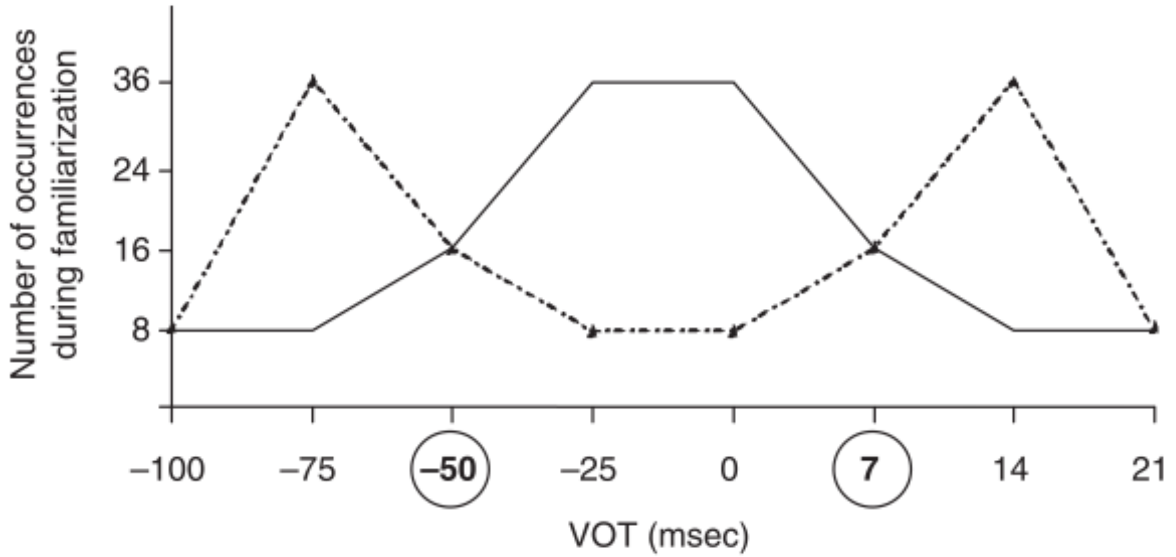
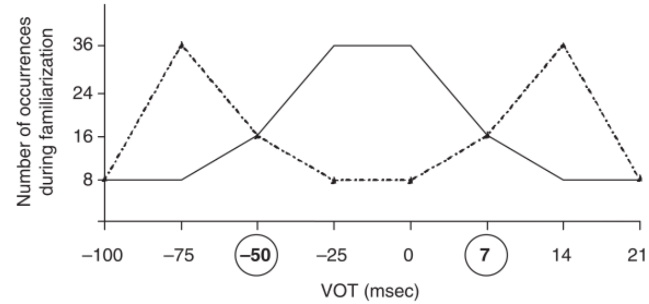
Maye, Weiss, & Aslin 2008



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

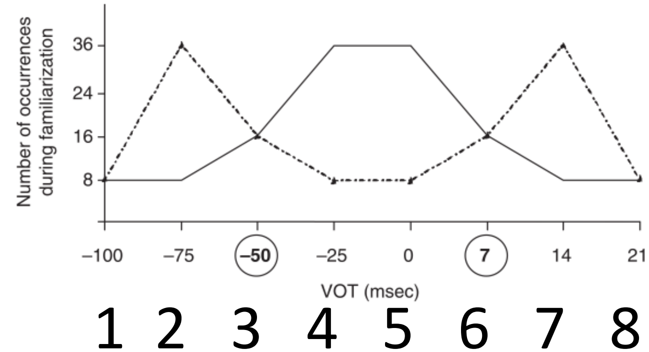
6 6 6 6…

	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).



	6 6 6 6… Final habituation trials		6 6 3… Change trials
Bimodal	4807 (362)	<	6844 (628)
Unimodal	5362 (420)	≈	4861 (360)
Control	6466 (672)	>	5540 (478)
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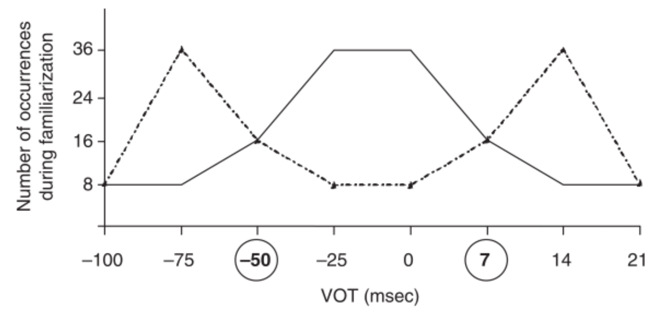
Looking time in ms

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.



1 2 3 4 5 6 7 8

	6 6 6 6… Final habituation trials		6 6 3… Change trials
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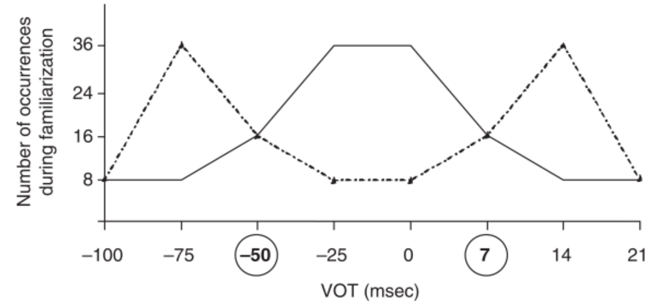
Looking time in ms

Maye, Weiss, & Aslin 2008

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



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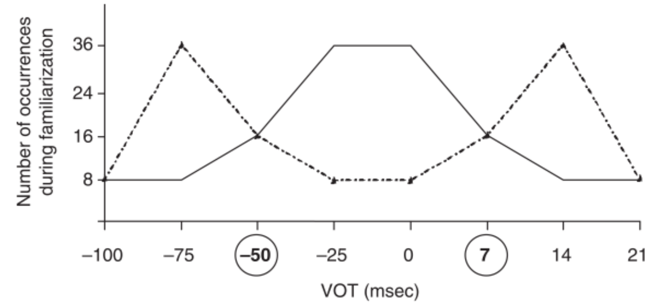
Looking time in ms

Maye, Weiss, & Aslin 2008

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

(Again, this may have been because they perceived all sounds as belonging to the same category.)



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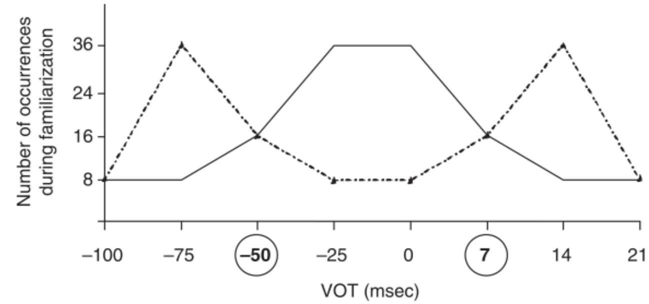
Generalization	5421 (453)	<	6697 (740)

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.)



1 2 3 4 5 6 7 8

	6 6 6 6… Final habituation trials		6 6 3… Change trials
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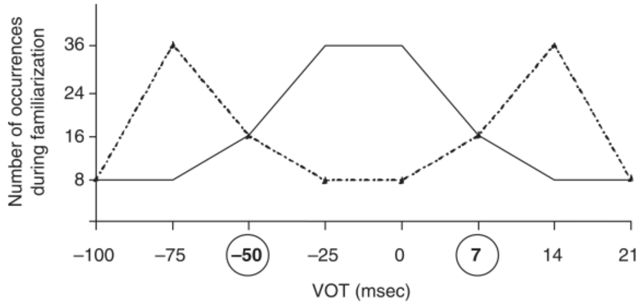
Control	6466 (672)	>	5540 (478)
Generalization	5421 (453)	<	6697 (740)

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]).



1 2 3 4 5 6 7 8

That is, they recognized voicing as a contrastive feature.

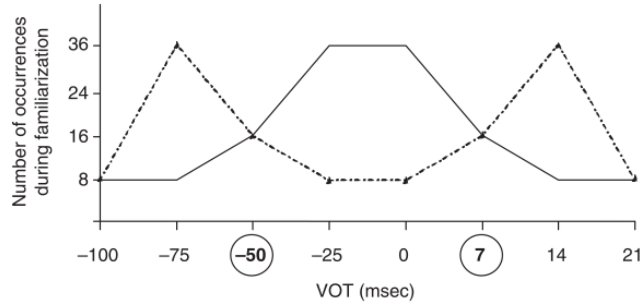
	6 6 6 6… Final habituation trials		6 6 3… Change trials
Bimodal	4807 (362)	<	6844 (628)
Unimodal	5362 (420)	≈	4861 (360)
Control	6466 (672)	>	5540 (478)
Generalization	5421 (453)	<	6697 (740)

Looking time in ms

Maye, Weiss, & Aslin 2008

These results suggest very young infants are capable of using the distributional information available in their input to categorically perceive sounds.

This can be perception of sounds as belonging to a single category [unimodal distribution] or to two categories [bimodal distribution].



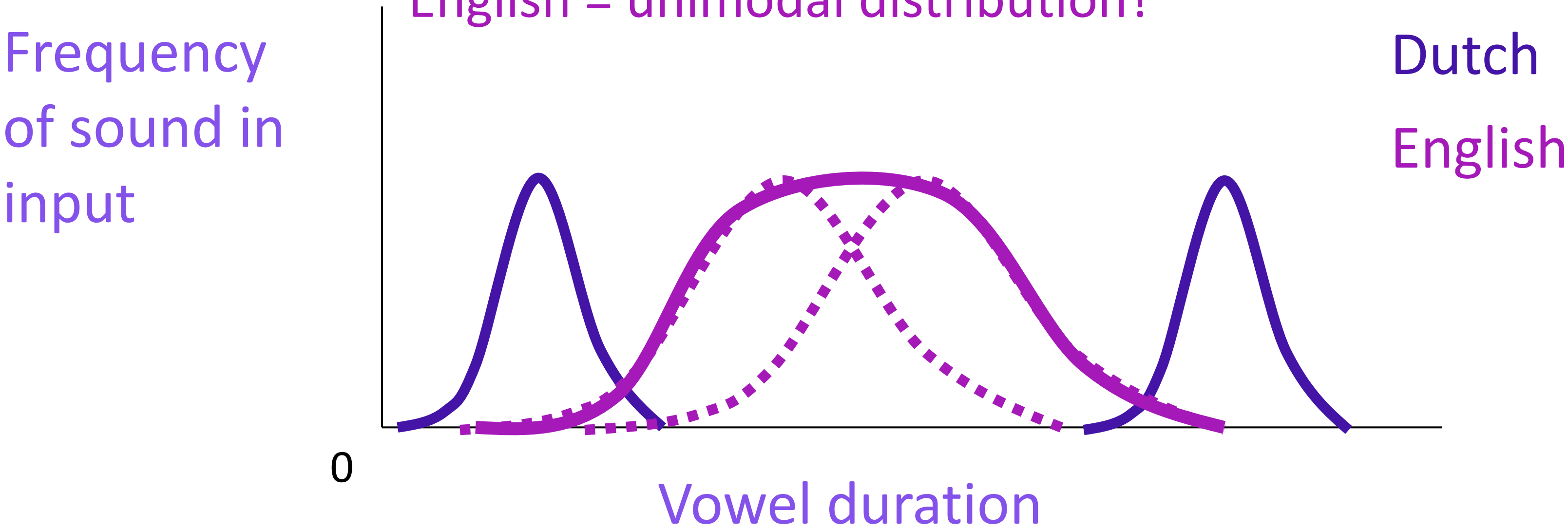
1 2 3 4 5 6 7 8

Back to Dietrich, Swingley, & Werker 2007

"…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

Back to Dietrich, Swingley, & Werker 2007

Prediction if children are sensitive to this distribution

Dutch children:

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

Back to Dietrich, Swingley, & Werker 2007

Prediction if children are sensitive to this distribution

Dutch children:

Change to vowel duration = new word

English children:

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)

Dutch

English

“Switch” Procedure: measures looking time

Dietrich, Swingley, & Werker 2007

Dutch

English

"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

Dutch

English

“Switch” Procedure: measures looking time

…this is a *tam*…look at the *tam*

Habituation

Test

Same:
look at the *tam!*

Should be relatively expected

Switch:
look at the *taam!*

Dietrich, Swingley, & Werker 2007

Dutch

English

"Switch" Procedure: measures looking time

…this is a *tam*…look at the ***tam***

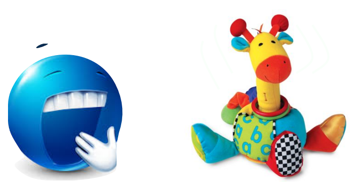
Habituation

Expected if these aren't contrastive

Same:
look at the *tam!*

Switch:
look at the ***taam****!*

Test



Dietrich, Swingley, & Werker 2007

Dutch

English

“Switch” Procedure: measures looking time

…this is a *tam*…look at the ***tam***

Habituation

Test

Same:
look at the *tam!*

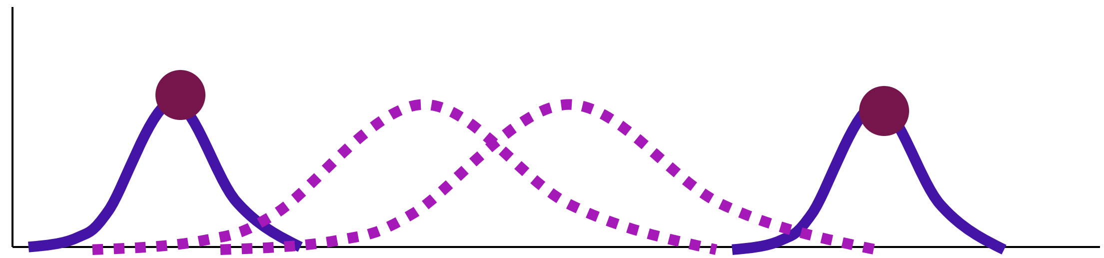
Switch:
look at the ***taam****!*

Unexpected if these are contrastive

Dietrich, Swingley, & Werker 2007

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

Frequency of sound in input



0

Vowel duration

Dutch

English

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

Dutch

difference

5.04 sec

9.23 sec

Same:
look at the *tam!*

Switch:
look at the *taam!*

Test

Dietrich, Swingley, & Werker 2007

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

Dutch

difference

English

6.66 sec

7.15 sec

no difference

Same:
look at the *tam!*

Switch:
look at the *taam!*

Test

Dietrich, Swingley, & Werker 2007

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

It seems like these Dutch duration differences are contrastive just for the Dutch kids.

Dutch

difference

English

no difference

Same:
look at the *tam!*

Switch:
look at the *taam!*

Test

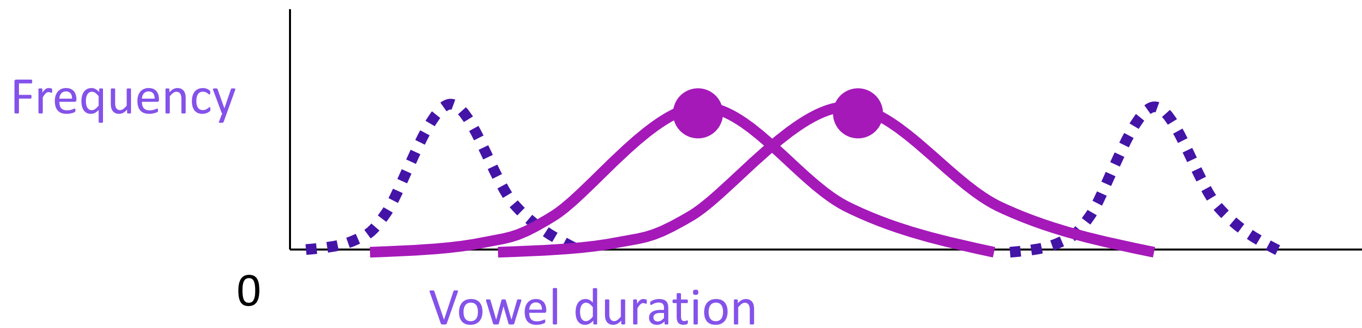
Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

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



Test

Same:
look at the *tam!*

Switch:
look at the *taam!*

Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

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

Dutch

difference

5.92 sec

8.16 sec

Same:
look at the *tam!*

Switch:
look at the *taam!*

Test

Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

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

Dutch

difference

English

7.34 sec

8.04 sec

no difference

Same:
look at the *tam!*

Switch:
look at the *taam!*

Test

Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

It seems like these English duration differences are contrastive just for the Dutch kids (even though the difference between them is less).

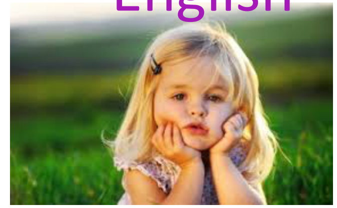
Test

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

Dutch

difference

English



no difference

Same:
look at the *tam!*

Switch:
look at the *taam*!

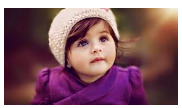
Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations


difference

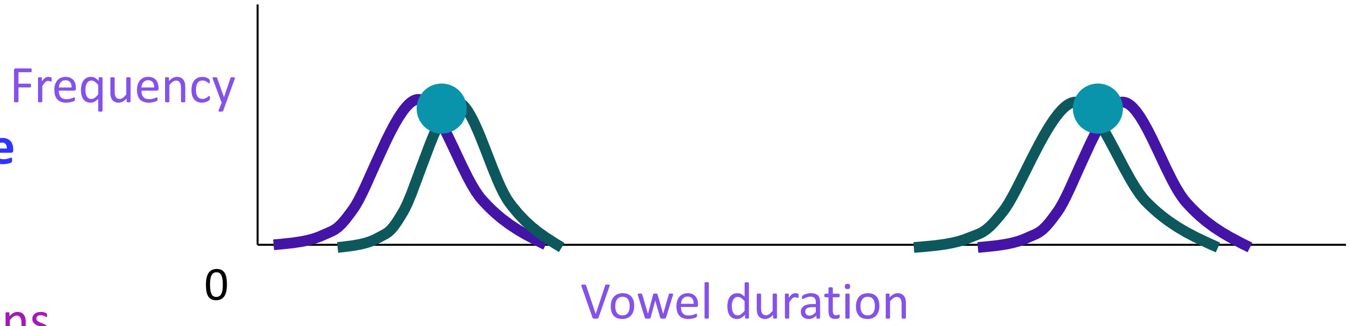

no difference

Exp 2:
English vowel durations


difference


no difference

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



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

Test

Same:
look at the *tam!*

Switch:
look at the *tem*!

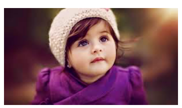
Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

Exp 2:
English vowel durations



difference

no difference

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

Dutch

difference

4.08 sec

5.72 sec

Same:
look at the *tam!*

Switch:
look at the *tem!*

Test

Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations

difference

no difference

Exp 2:
English vowel durations

difference

no difference

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

Dutch

difference

English

6.31 sec

9.31 sec

difference

Same:
look at the *tam!*

Switch:
look at the *tem!*

Test

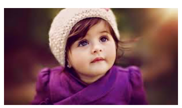
Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations


difference


no difference

Exp 2:
English vowel durations


difference


no difference

Phew — it looks like English kids can in fact do the task. They behave as they should when they perceive a contrast.

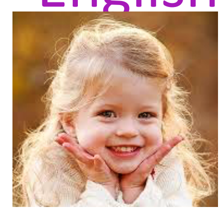
Experiment 3: Testing English and Dutch kids on vowel quality contrast (a/e)

Dutch




difference

English




difference

Same:
look at the *tam!*

Test

Switch:
look at the *tem!*

Dietrich, Swingley, & Werker 2007

Exp 1:
Dutch vowel durations


difference


no difference

Exp 2:
English vowel durations


difference


no difference

Exp 3:
Vowel quality


difference


difference

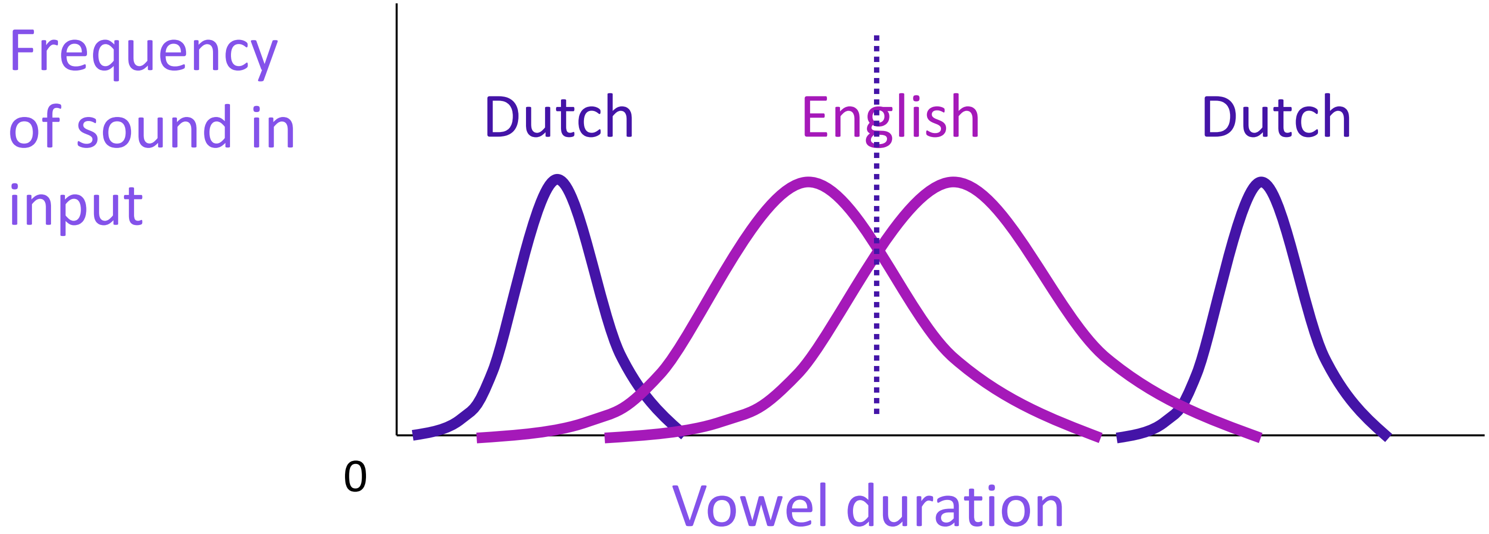
Implications of experiments 1, 2, and 3: Dutch children recognize vowel **duration as contrastive** for their language while English children do not.

This can only be due to the data encountered by each set of children in their language.

Dietrich, Swingley, & Werker 2007

This can only be due to the data encountered by each set of children in their language.

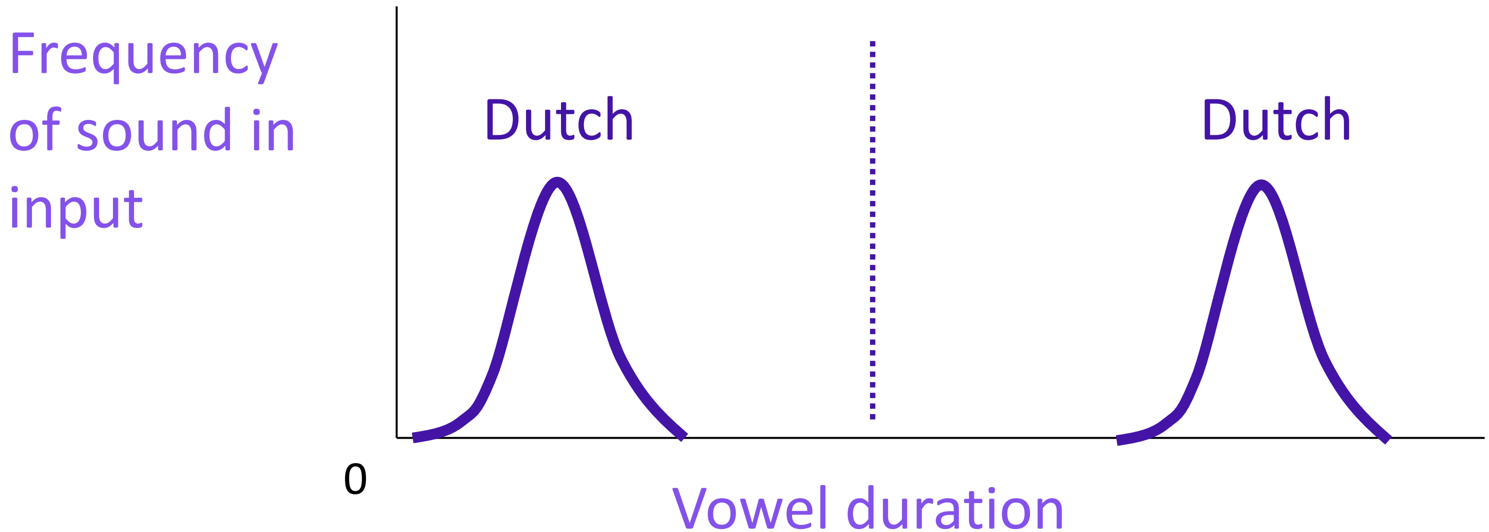
Dutch children have a category boundary approximately here.
English children do not.



Dietrich, Swingley, & Werker 2007

What drives children to learn this distinction?

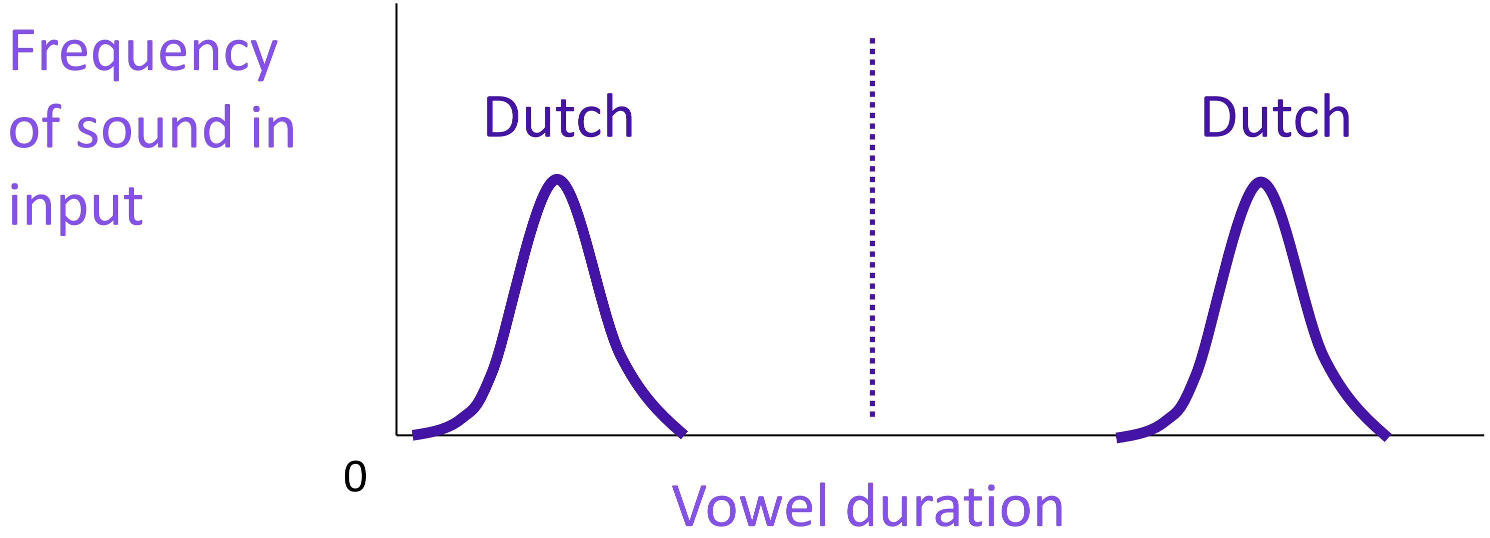
It can't be the words they know in their vocabulary — "children that young do not seem to know many word pairs that could clearly indicate a distinction"



Dietrich, Swingley, & Werker 2007

What drives children to learn this distinction?

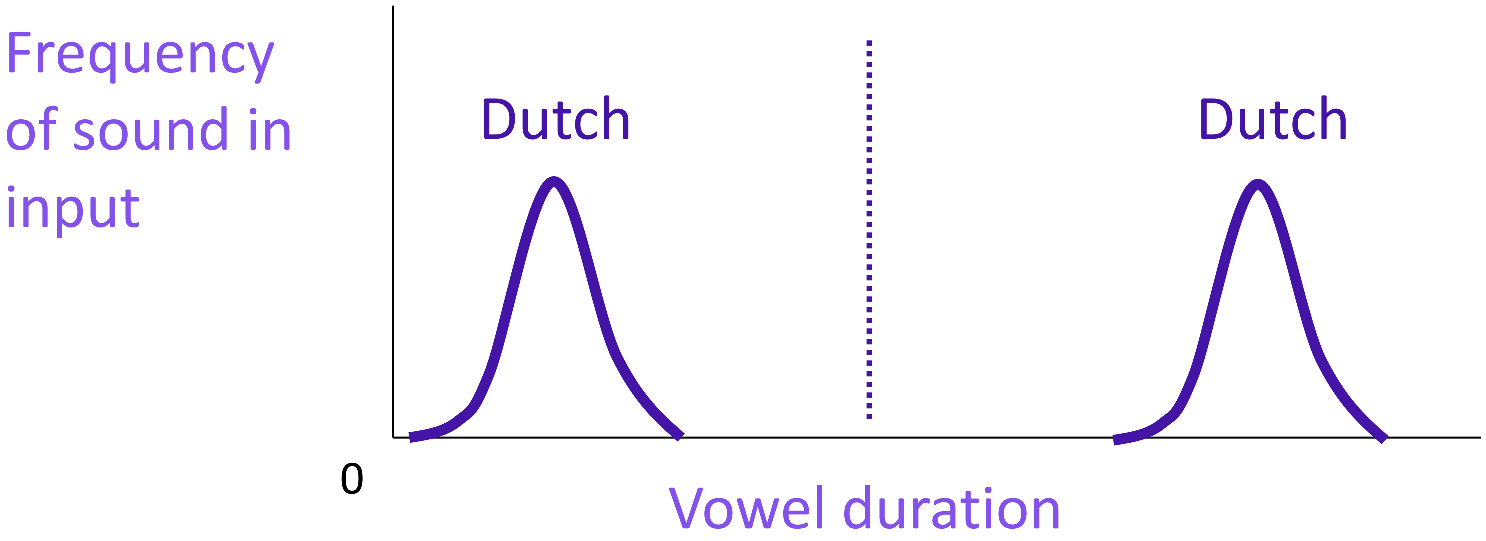
"children begin to induce phonological categories 'bottom-up', based on their discovery of clusters of speech sounds in phonetic space…"



Dietrich, Swingley, & Werker 2007

What drives children to learn this distinction?

“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”

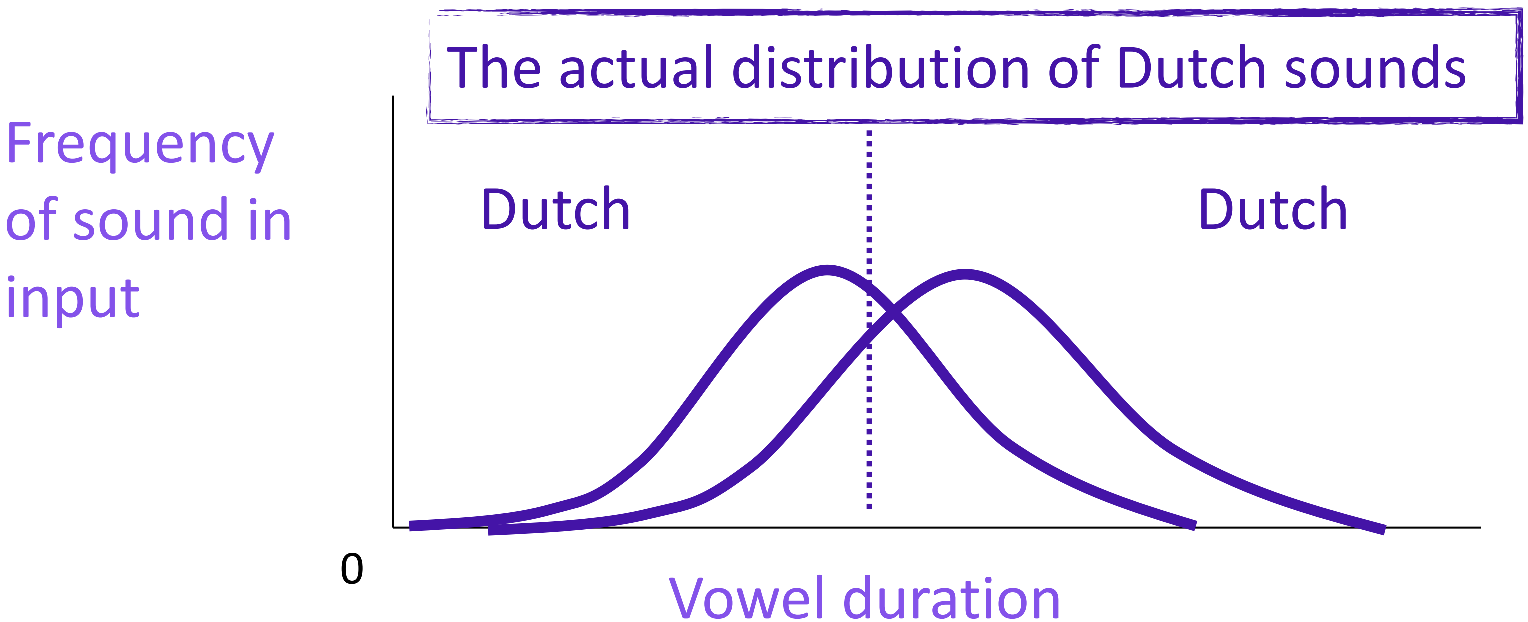


Dietrich, Swingley, & Werker 2007

What drives children to learn this distinction?

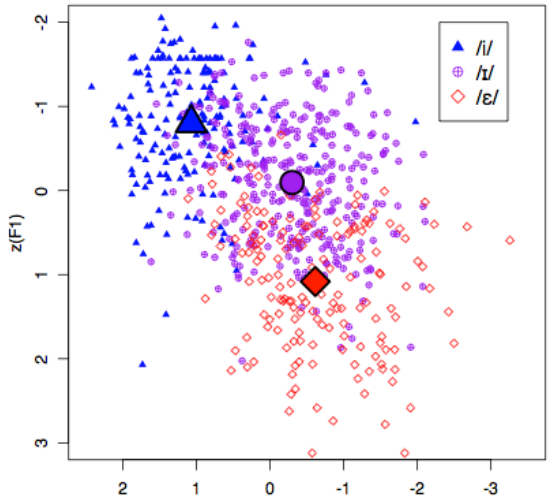
"…preliminary examination of this problem using corpora of Dutch child-directed speech indicated that the set of long and short instances formed largely overlapping distributions."

Uh oh!



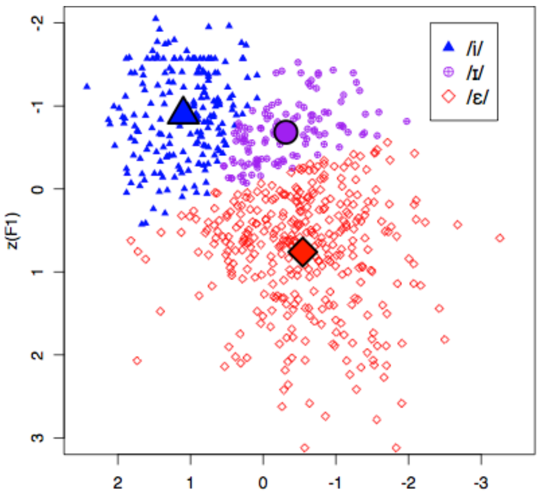
Adriaans & Swingley 2012

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

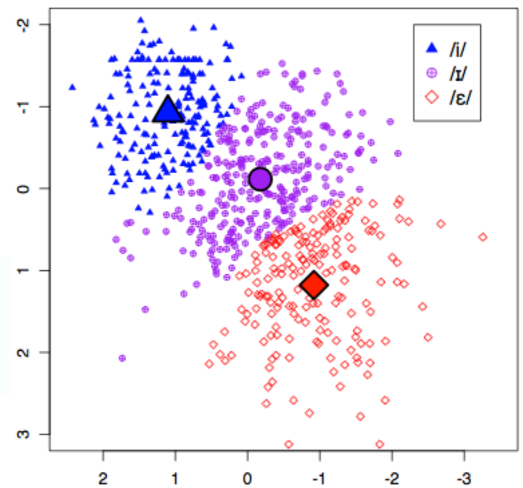


Three vowel categories for English speakers

This one looks a lot closer to the right categories.



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).

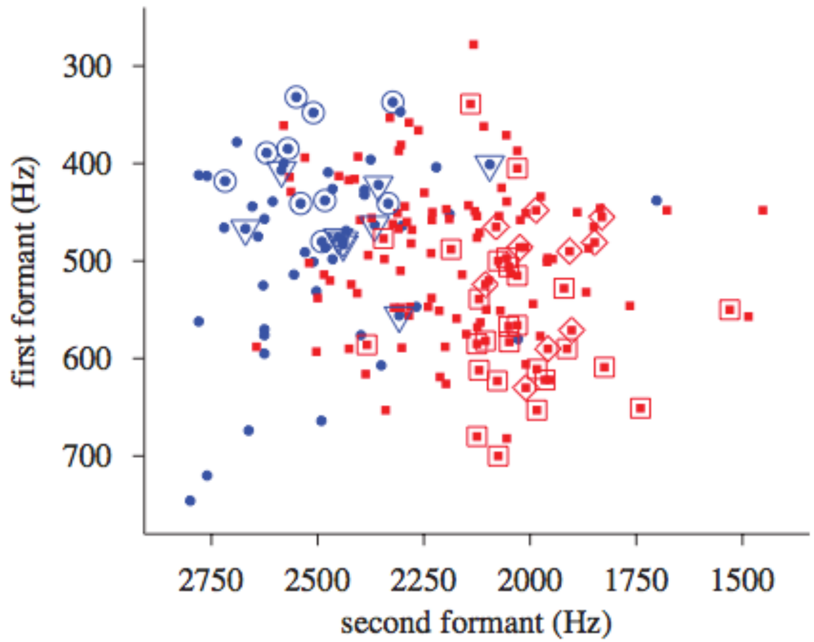


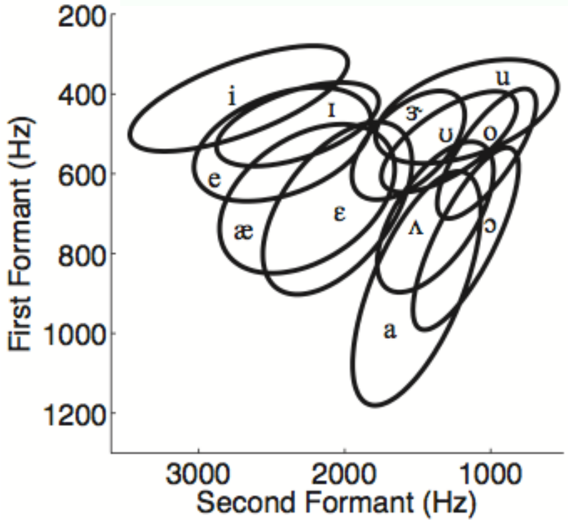
Figure 3. The vowels /i/ and /ɪ/ in first- and second formant space, as spoken by one mother to her infant. The /i/ instances are plotted as blue circles, /ɪ/ as red squares. Outlines around instances indicate tokens measured from the words *see* (open circles), *we* (open triangles), *dillon* (open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

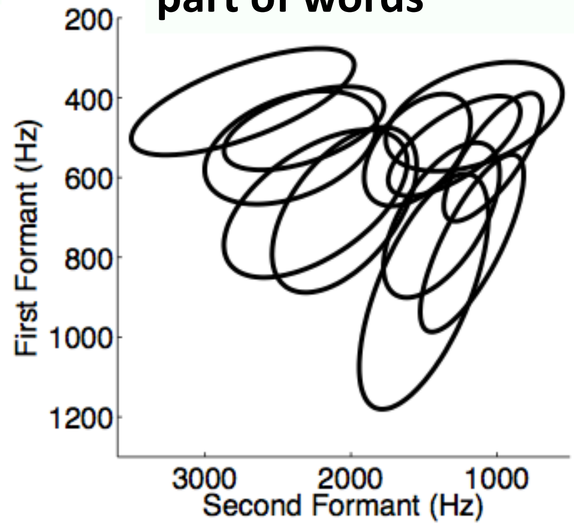
Vowel categories for English speakers

(a)



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

(b)



This looks pretty close!

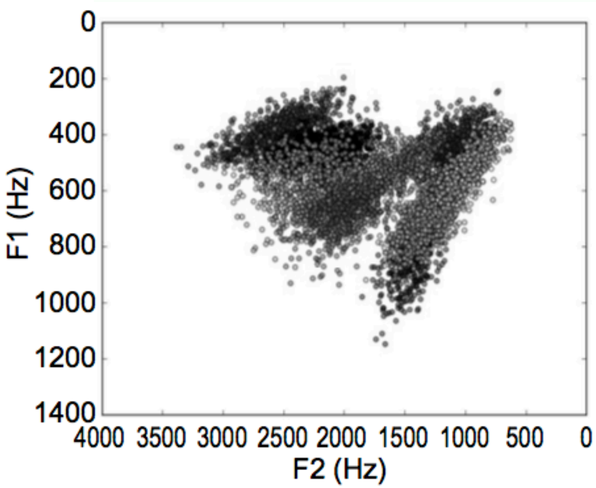
Antetomaso et al. 2017

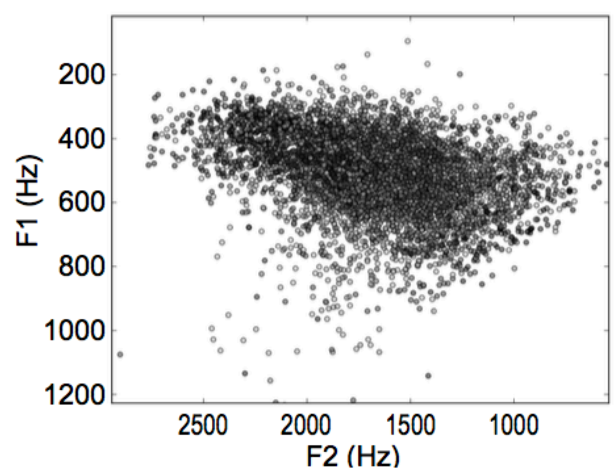
But…the actual data children face are *messier* than this particular model of simultaneous sound & word learning can currently handle (Antetomaso, Miyazawa, Feldman, Elsner, Hitczenko, & Mazuka 2017).

English vowel category samples in word contexts that the model learned successfully from before

English vowel category samples in word contexts from actual child-directed

English





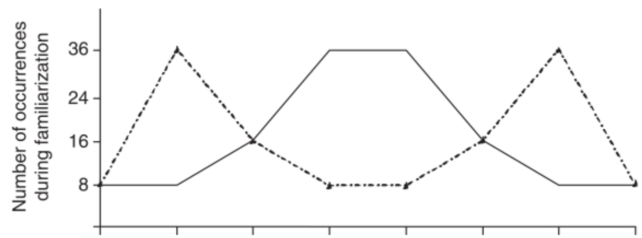
This looks a lot messier

Feldman et al. 2013b

Experimental evidence that infants are helped by word context when figuring out sounds are contrastive: 8-month-olds do better at distinguishing sounds that are heard in different word contexts (Feldman, Myers, White, Griffiths, & Morgan 2013).

Feldman et al. 2013b

Distinguishing sounds that are heard in different word contexts



1 2 3 4 5 6 7 8

ah…………………aw

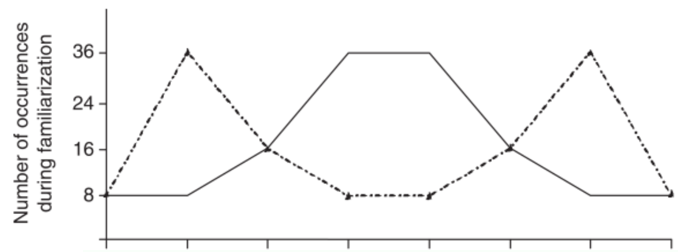
“ah” /ɑ/ vs. “aw” /ɔ/

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**

Feldman et al. 2013b

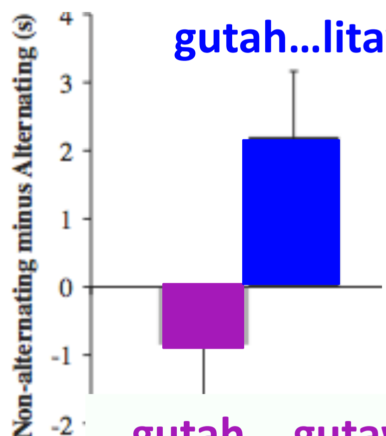
Distinguishing sounds that are heard in different word contexts



1 2 3 4 5 6 7 8

ah…………………aw

Non-alternating trial: 3..3..3… or 6…6…6…
Alternating trial: 1…8…1…8



gutah…litaw

gutah….gutaw

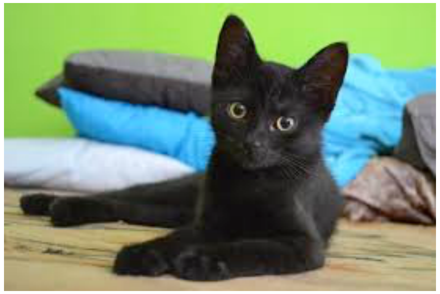
Infants who heard the sounds in different "words" notice the sound change (sounds are contrastive). They are surprised when the sounds don't alternate.

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

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

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 seem 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 3 on HW2 and up through question 25 on the sounds & sounds of words review questions.