

Ling 151/Psych 156A:  
Acquisition of Language II

Lecture 7  
Sounds of Words

# Announcements

- Be working on HW2 (due 1/26/18)
- Be working on review questions for sounds and sounds of words

# Word forms

Acquisition task (computational-level description):

Map variable word signals to more abstract word forms



fwiends



friends

friends

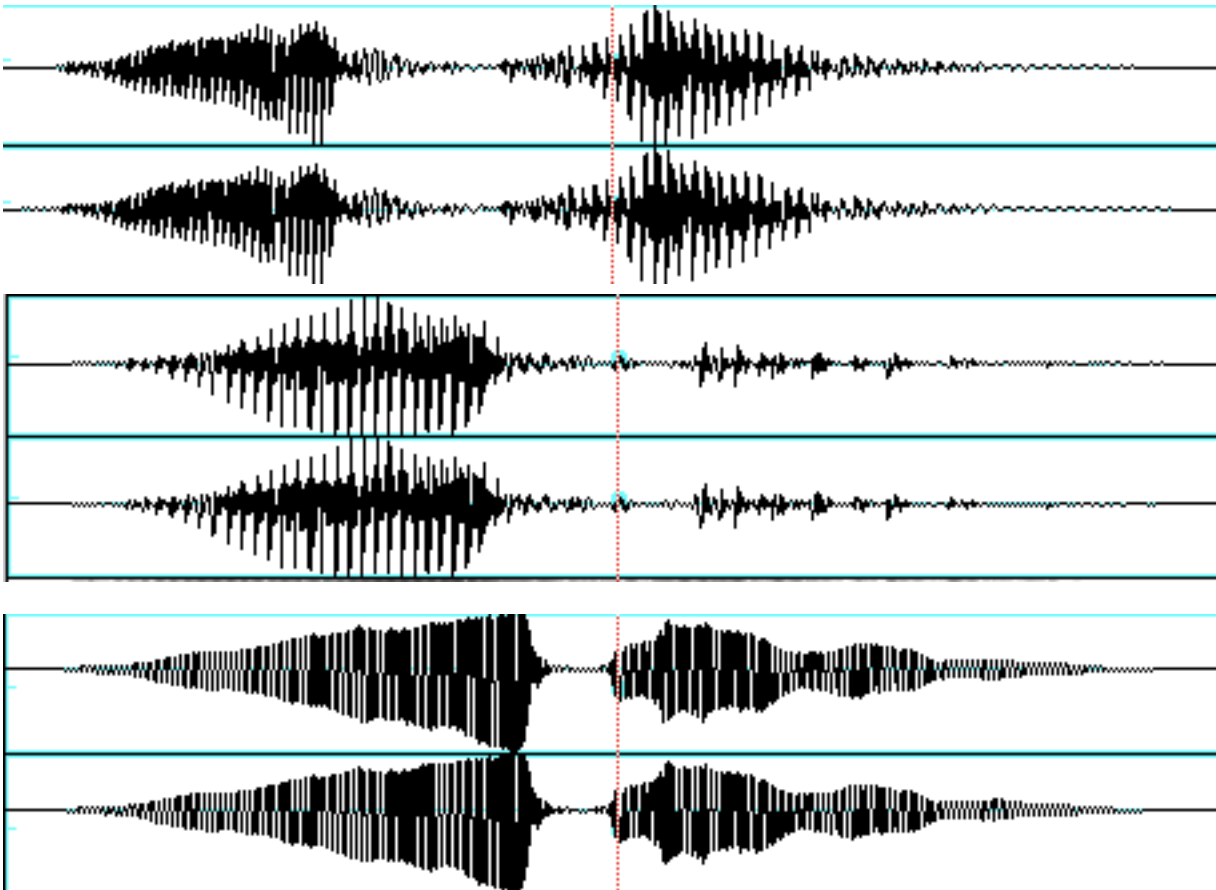


**“friends”**

# What's involved in word learning

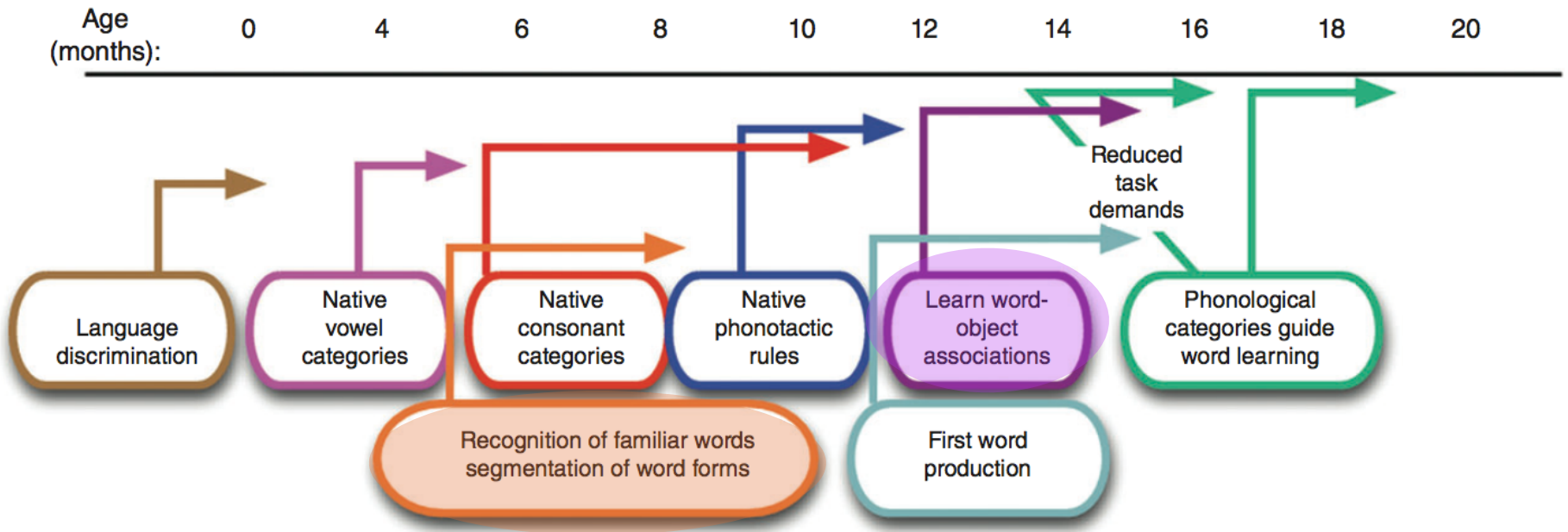
Word learning: mapping between concept, word, and  
word's variable acoustic signal

“goblin”



# Timeline

from Curtin & Zamuner 2014



Learning word forms starts pretty early (just before 6 months)

Learning word-object associations comes several months later (reliably at 12 months)

# Stager & Werker 1997

Learning nonsense words that are **minimal pairs** (differ by one phoneme):  
'bih' vs. 'dih'. Comparing against words that are not: 'lif' vs. 'neem'



**“Switch” Procedure:** measures looking time

*...bih...bih*

**Habituation**



Same:

*bih!*

**Test**

Switch:

*dih!*



# Stager & Werker 1997

Experiment 1

14-month-olds



...dih...dih



Habituation

...bih...bih



Test

bih!



dih!



# Stager & Werker 1997

Experiment 1

14-month-olds



*...dih...dih*

*...bih...bih*



*Expectations if children recognize the details of these word forms*



Expected

Test

Unexpected



*bih!*

*dih!*





# Stager & Werker 1997

Experiment 1

14-month-olds



...dih...dih

...bih...bih



*Expectations if children recognize the details of these word forms*

Expected because this is the same object that was called "bih" before.



bih!

Test

Unexpected

dih!



# Stager & Werker 1997

Experiment 1

14-month-olds



*...dih...dih*

*...bih...bih*



*Expectations if children recognize the details of these word forms*



Expected

*bih!*



Test



*dih!*



Unexpected because this object is now being referred to by the other object's word.

# Stager & Werker 1997

Experiment 1

14-month-olds



*...dih...dih*

*...bih...bih*



*Expectations if children recognize the details of these word forms*



Expected

Test

Unexpected



*bih!*

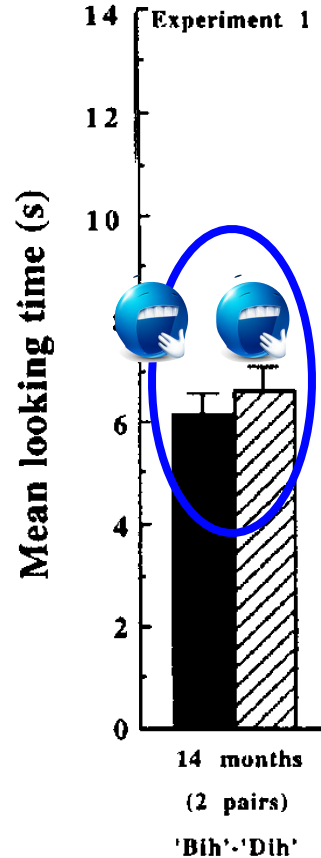
*dih!*



# Stager & Werker 1997

Experiment 1

14-month-olds

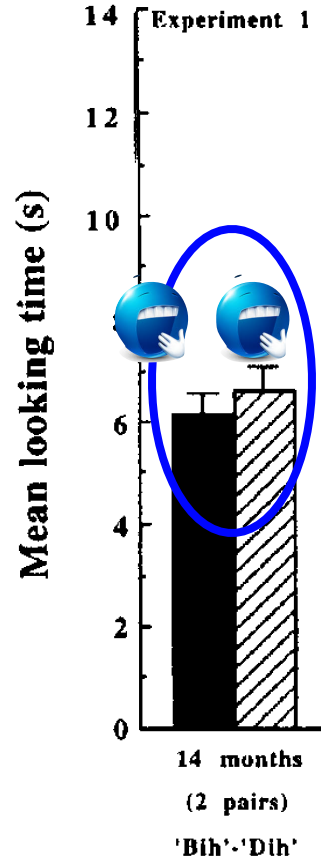


No looking time difference  
= 14-month-olds didn't  
notice the difference!

# Stager & Werker 1997

Experiment 1

14-month-olds



Stager & Werker (1997) were surprised by this. They thought maybe the task was too hard for 14-month-olds, so they simplified it.



# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



'Bih'



'Bih'



'Dih'

...bih...bih

Habituation



bih!

Test

dih!



# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



'Bih'



'Bih'



'Dih'

...bih...bih

Habituation



*Expectations if children recognize the details of these word forms*



Expected

*bih!*

Unexpected

*dih!*



Test



# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



'Bih'



'Bih'



'Dih'

...bih...bih

Habituation



*Expectations if children recognize the details of these word forms*

Expected because the same word is again used to refer to this object.



bih!

Test

Unexpected

dih!





# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



'Bih'



'Bih'



'Dih'

...bih...bih

Habituation



*Expectations if children recognize the details of these word forms*



Expected

*bih!*

Test

*dih!*



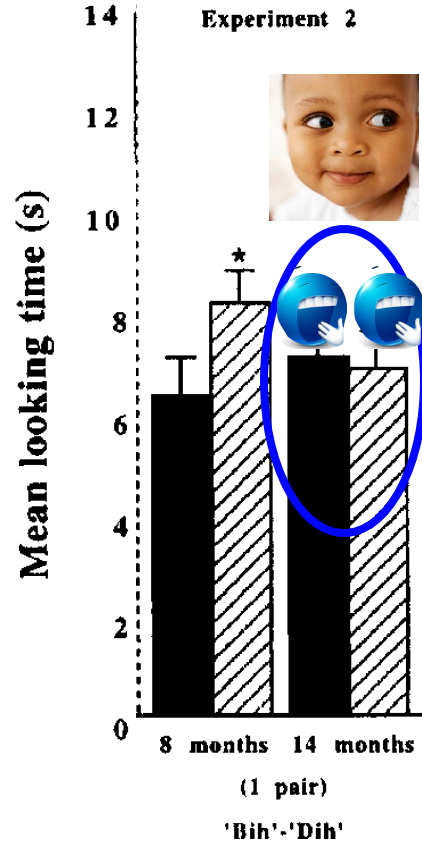
Unexpected because a different word is used to refer to this object.



# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2

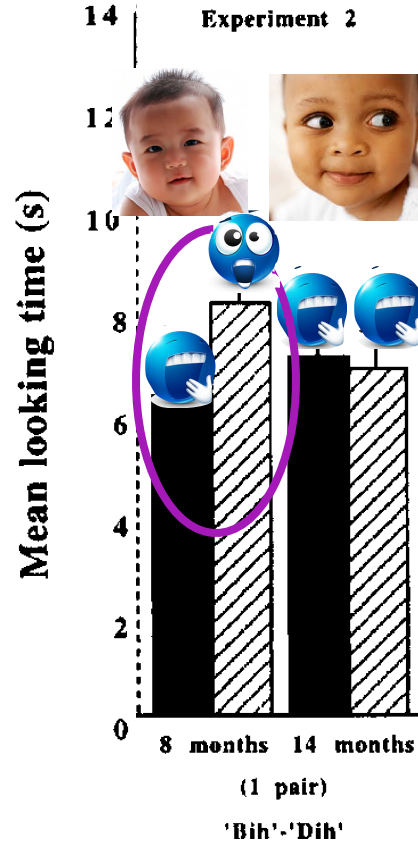


No difference in looking time =  
14-month-olds didn't notice  
the difference again!

# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



But 8-month-olds did!  
They have a difference in  
looking time. They look  
longer at the “bih” object  
when it’s labeled “dih” - so  
they must know “b” and  
“d” are different.

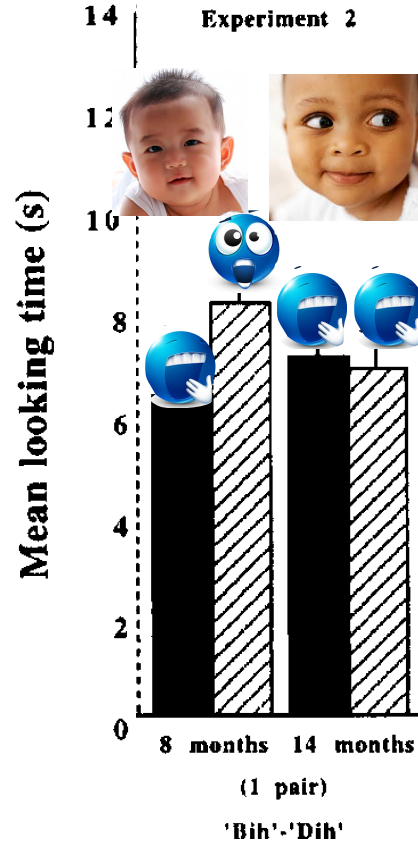
# Stager & Werker 1997

8-month-olds &  
14-month-olds

Experiment 2



What could be going on?  
Why were they younger  
children doing better?  
Was there something  
wrong with 14-month-olds'  
ability to discriminate  
sounds?



# Stager & Werker 1997

14-month-olds

Experiment 3



'Lif'



'Lif'



'Neem'



*...lif...lif*

Habituation



*lif!*

Test

*neem!*



# Stager & Werker 1997

14-month-olds

Experiment 3



'Lif'



'Lif'



'Neem'



...lif...lif



Habituation



Expected

*lif!*



Test

Unexpected

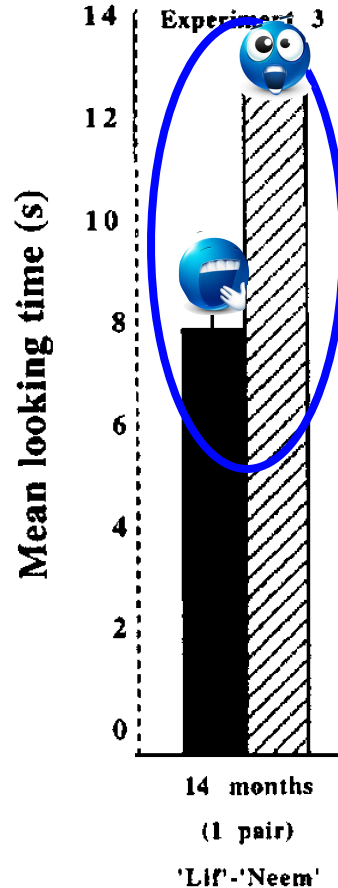
*neem!*



# Stager & Werker 1997

14-month-olds

Experiment 3

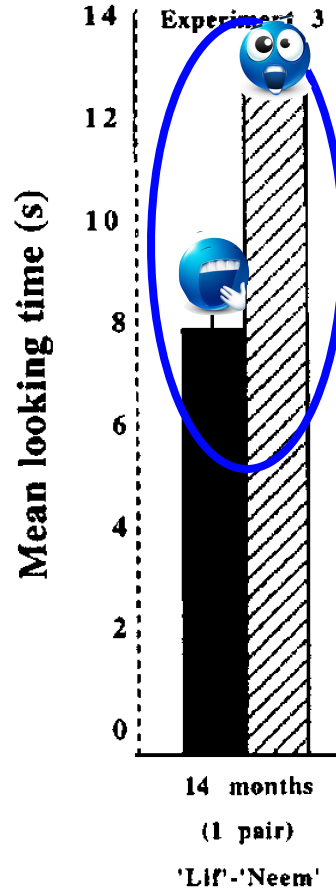


Here, the 14-month-olds look longer at the “lif” object when it’s labeled “neem”. They notice the difference.

# Stager & Werker 1997

14-month-olds

Experiment 3



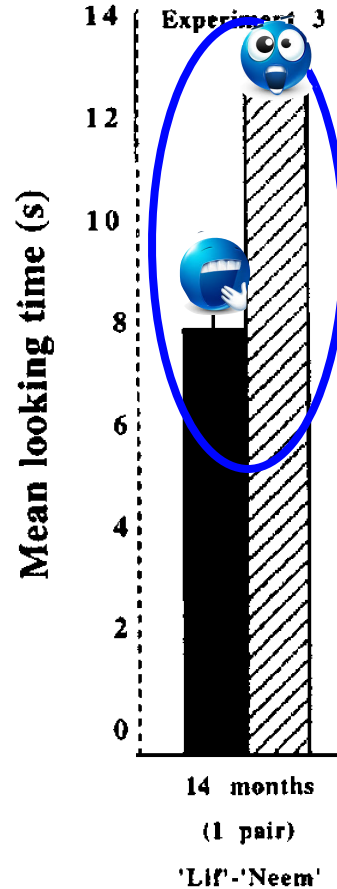
Okay, so 14-month-olds are capable of discriminating sounds in words when the words are really different. Why can't they do it when the words are very similar, especially when 8-month-olds can do that?



# Stager & Werker 1997

14-month-olds

Experiment 3

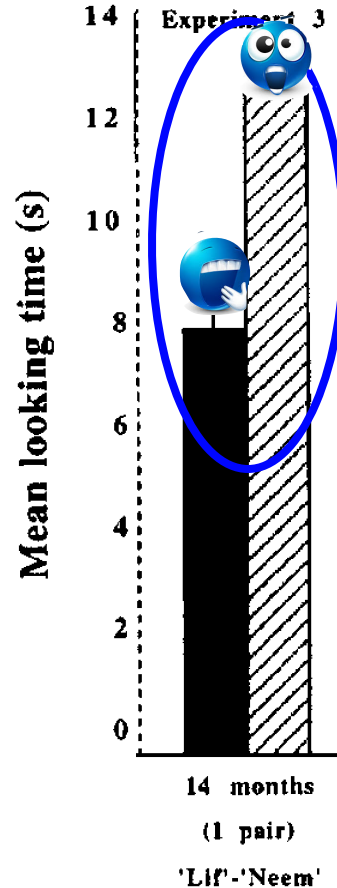


The key: 14-month-olds are capable of **discriminating sounds in words**

# Stager & Werker 1997

14-month-olds

Experiment 3



The key: 14-month-olds are capable of **discriminating sounds in words**

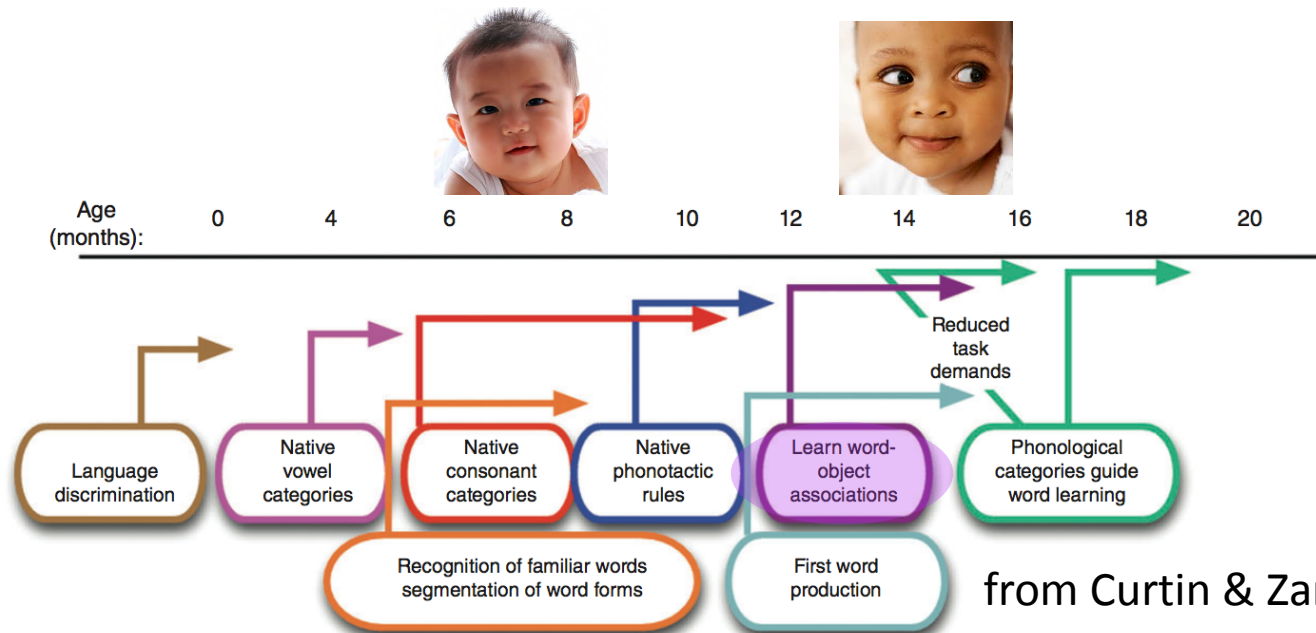
What else might be happening with words at 14 months that's not happening at 8 months?

# Stager & Werker 1997

The key: 14-month-olds are capable of **discriminating sounds in words**



What else might be happening with words at 14 months that's not happening at 8 months?



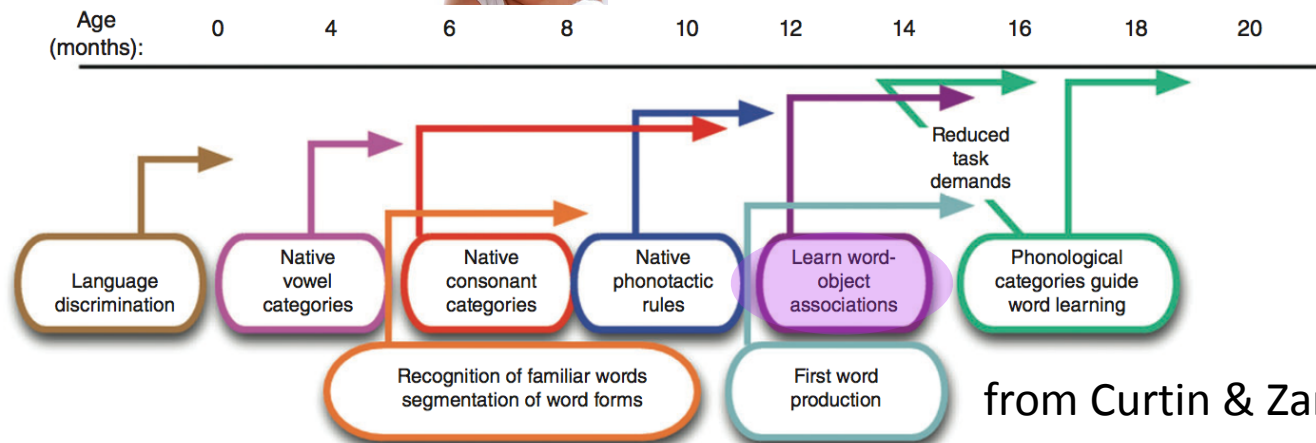
from Curtin & Zamuner 2014

# Stager & Werker 1997

The key: 14-month-olds are capable of **discriminating sounds in words**



Maybe 14-month-olds are trying to connect word forms with meanings at the same time during the experiment, and that affects their sound discrimination performance.



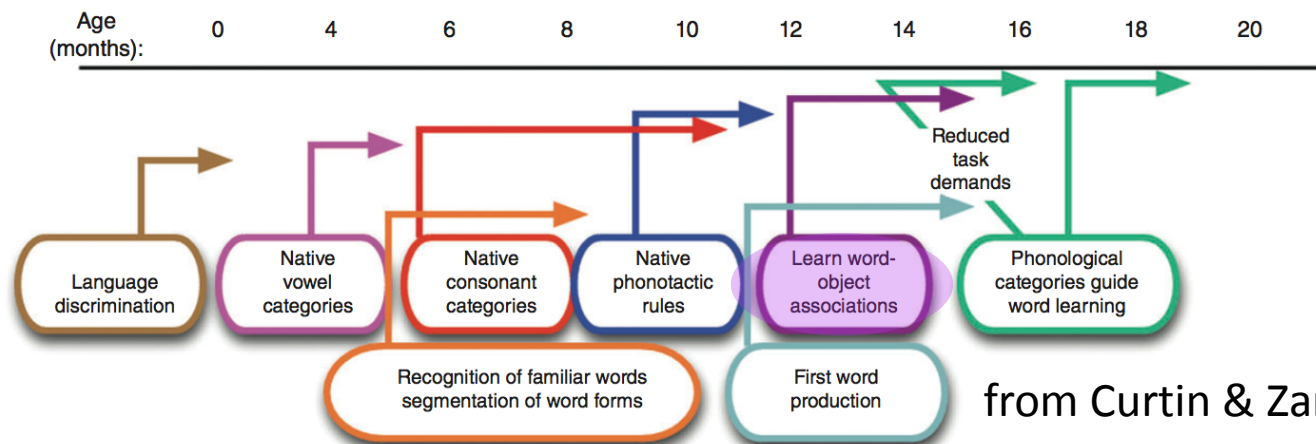
from Curtin & Zamuner 2014

# Stager & Werker 1997

The key: 14-month-olds are capable of **discriminating sounds in words**



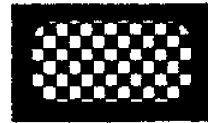
In contrast, 8-month-olds are just hearing the novel word forms, and not really connecting them to meaning.



from Curtin & Zamuner 2014

# Stager & Werker 1997

## Experiment 4 14-month-olds



'Bih'



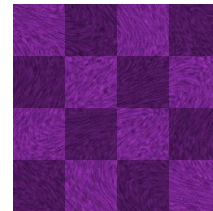
'Bih'



'Dih'

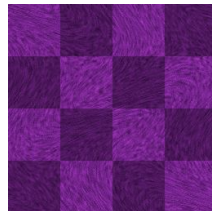
...bih...bih

Habituation



Expected

bih!

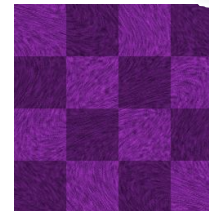


Unexpected

dih!



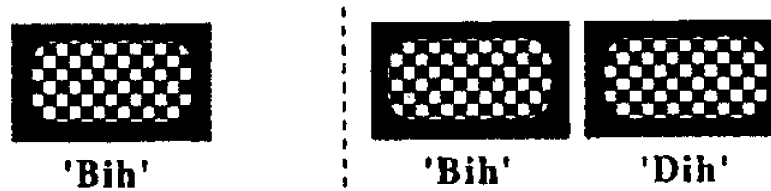
Test



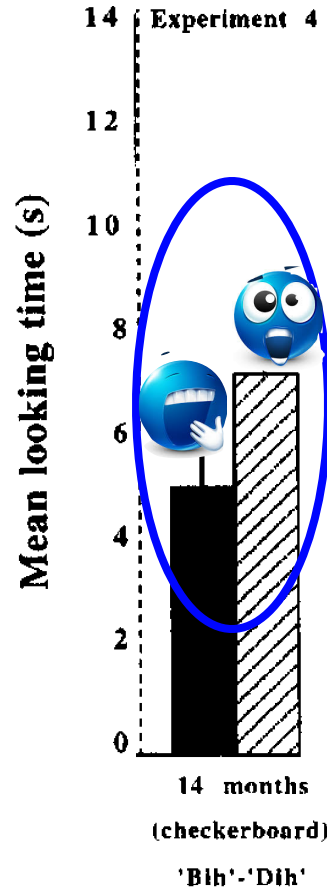
Infants unlikely to associate label with checkerboard pattern (that is, to treat it like a word that has a referent/meaning)

# Stager & Werker 1997

## Experiment 4 14-month-olds



14-month-olds



Here, the 14-month-olds look longer at the “bih” “object” when it’s labeled “dih”. They notice the difference.

# Stager & Werker 1997



Key: Experiment 2 vs 4

14-month-olds

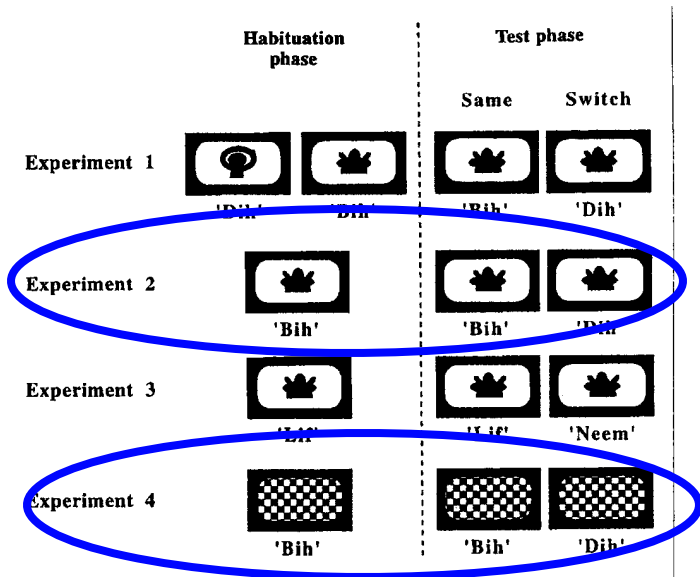


Figure 1 Diagrammatic representations of experiments 1-4.

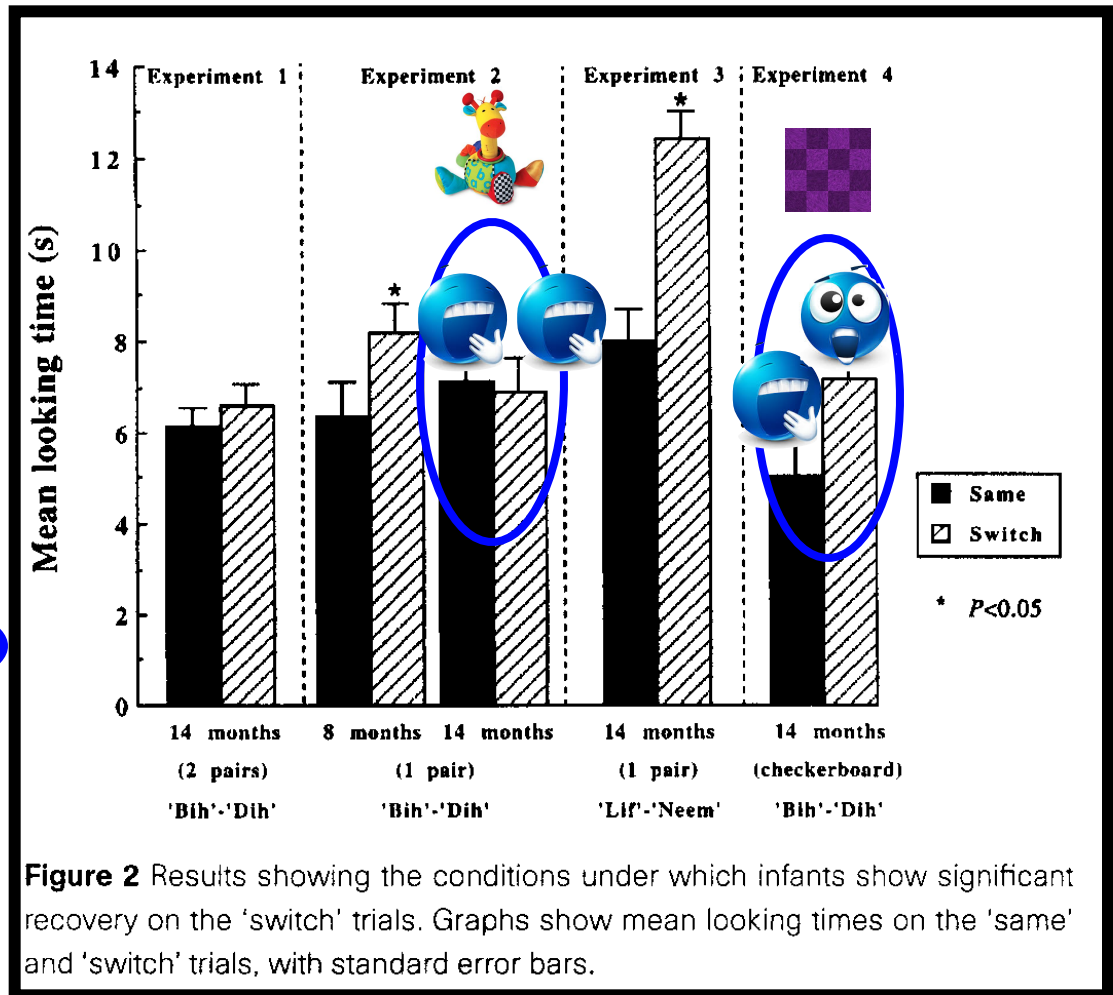


Figure 2 Results showing the conditions under which infants show significant recovery on the 'switch' trials. Graphs show mean looking times on the 'same' and 'switch' trials, with standard error bars.



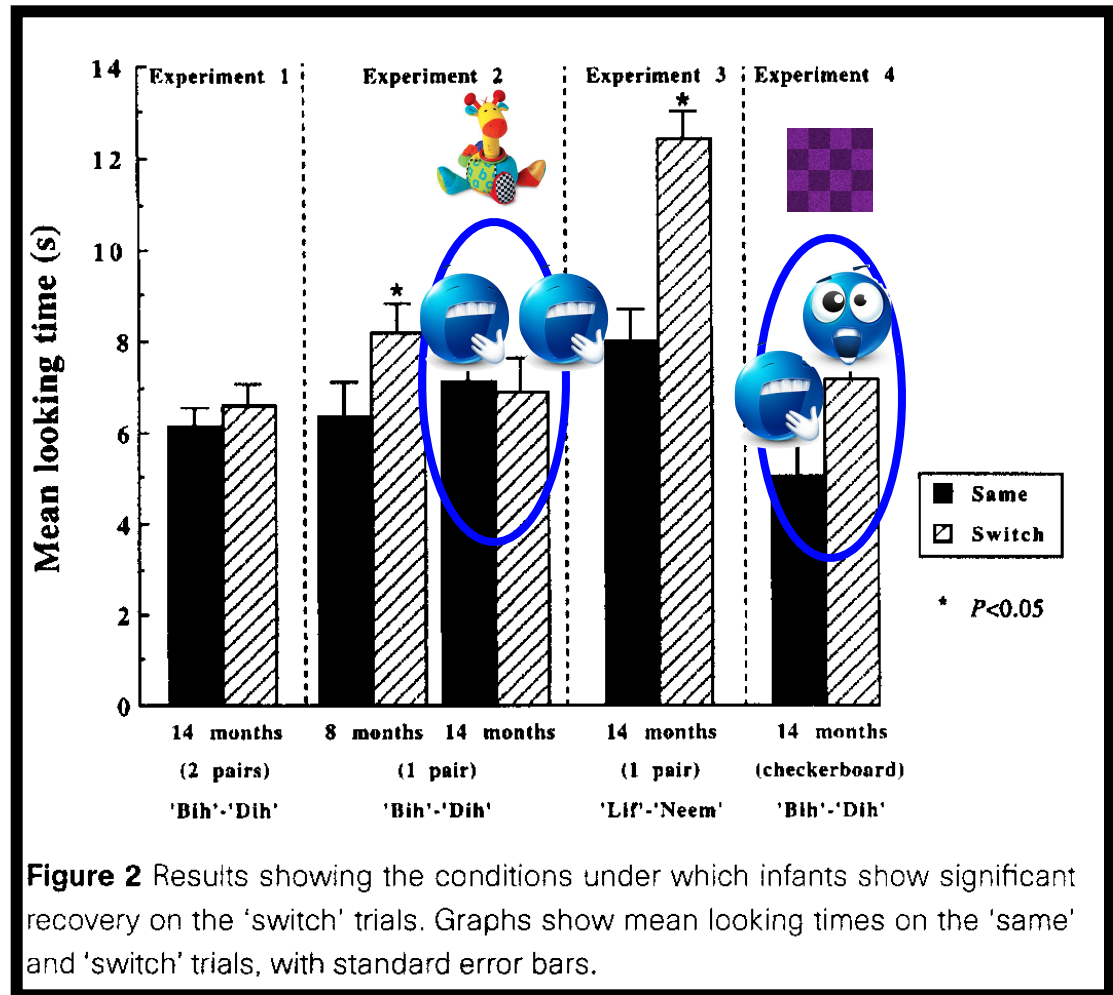
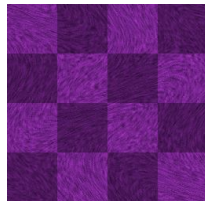
# Stager & Werker 1997



Key: Experiment 2 vs 4

14-month-olds

14-month-olds only seem to notice the finer details of which sounds are in a word when they're *not* trying to connect that word form to a meaning.



# Summary of key findings

14-month-olds can discriminate the minimally contrasting words (Expt. 4)

...but they fail to notice the minimal change in the sounds when they are paired with objects, i.e., *when they are words with associated meaning* (Expt. 2)

14-month-olds *can* perform the task, when the words are more distinct (Expt. 3)

Therefore, *14-month-olds use more detail to represent sounds than they do to represent words?*



# What's going on?

They fail specifically when the task requires word-learning.

They *do* know the sounds...but they fail to use the detail needed for minimal pairs to store words in memory.

What's going on?

- Is this true for all words?
- When do they learn to do this?
- What triggers the ability to do this?

# What children may be doing

One idea: Encode detail only if necessary

If children have small vocabularies, it may not take so much detail to distinguish one word from another.

*(baby, cookie, mommy, daddy...)*



# What children may be doing

One idea: Encode detail only if necessary

Neighborhood structure idea: When a child knows two words that differ only by a single phoneme (like “cat” and “bat”), more attention to detail is required to distinguish them.



# What children may be doing



One idea: Encode detail only if necessary

Some support for this idea:

Children with smaller vocabularies have more high neighborhood density words (Stokes 2010, Stokes et al. 2012a, Stokes et al. 2012b). This may help children keep the word forms separate.

Words from dense neighborhoods are produced more accurately and with less variability than words with sparse neighborhoods (Freedman & Barlow 2012, Sosa & Stoel-Gammon 2012).

# What children may be doing

One idea: Encode detail only if necessary



Prediction: The **content of children's vocabulary** drives their ability to notice the difference between words that differ minimally (ex: by a single phoneme)

# Going with the neighborhood idea, look again at Stager & Werker 1997

## Experiment 2



'Bih'



'Bih'



'Dih'

## Habituation

...bih...bih



bih!



Test

dih!



“bih” and “dih” are too close (they differ only by one phoneme). This hypothesis predicts 14-month-old kids don't know any words close enough to motivate attention to the “b”/“d” difference when word-learning (i.e., that differ only by those two specific sounds).

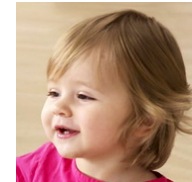
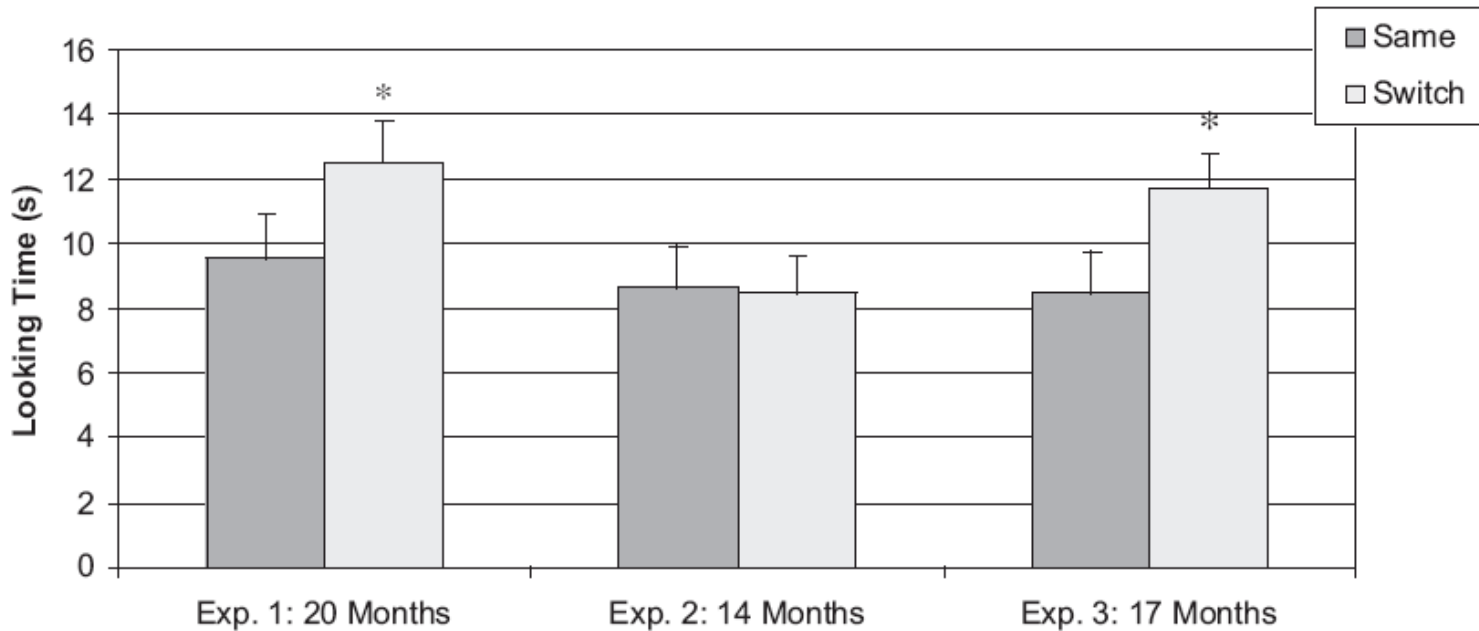


# Werker et al. 2002: Vocabulary size matters

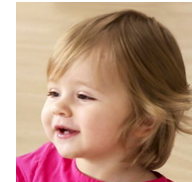
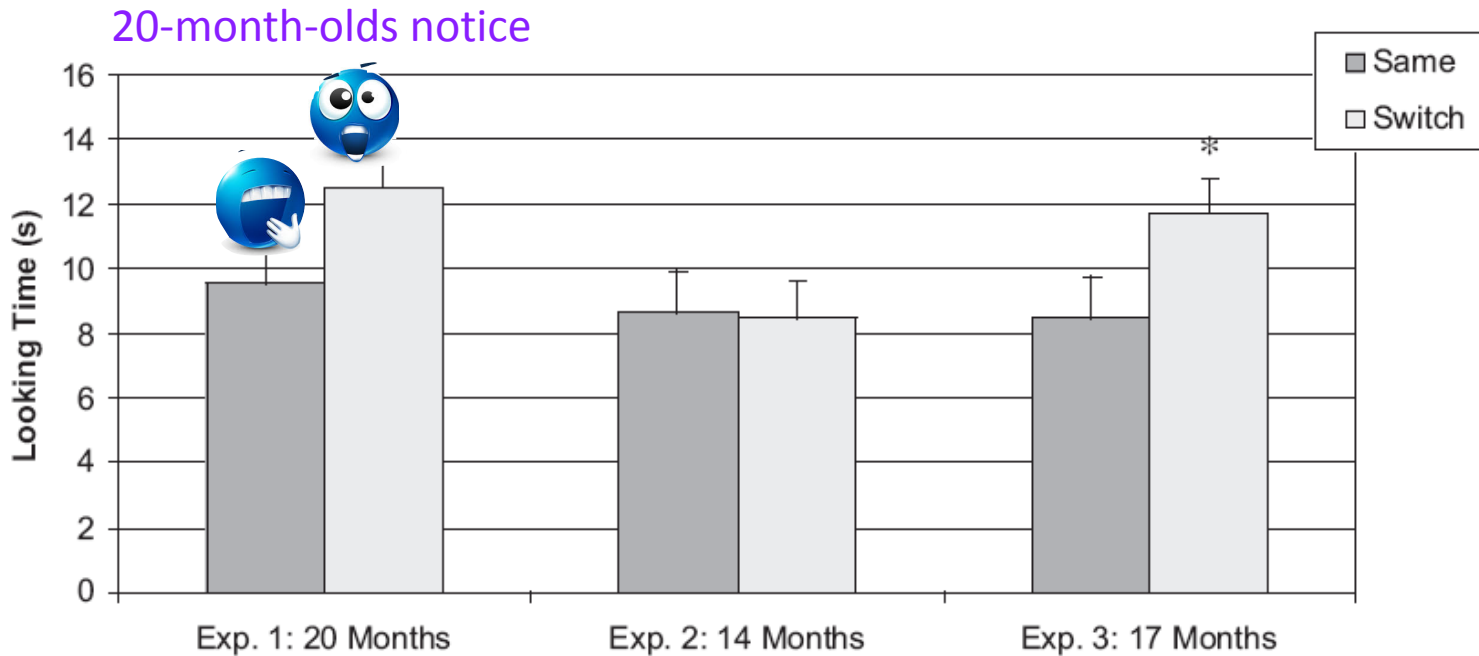
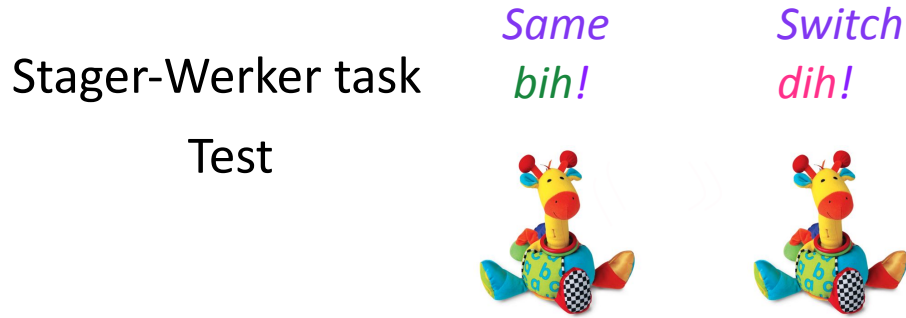
Stager-Werker task

Same *bih!*      Switch *dih!*

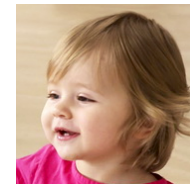
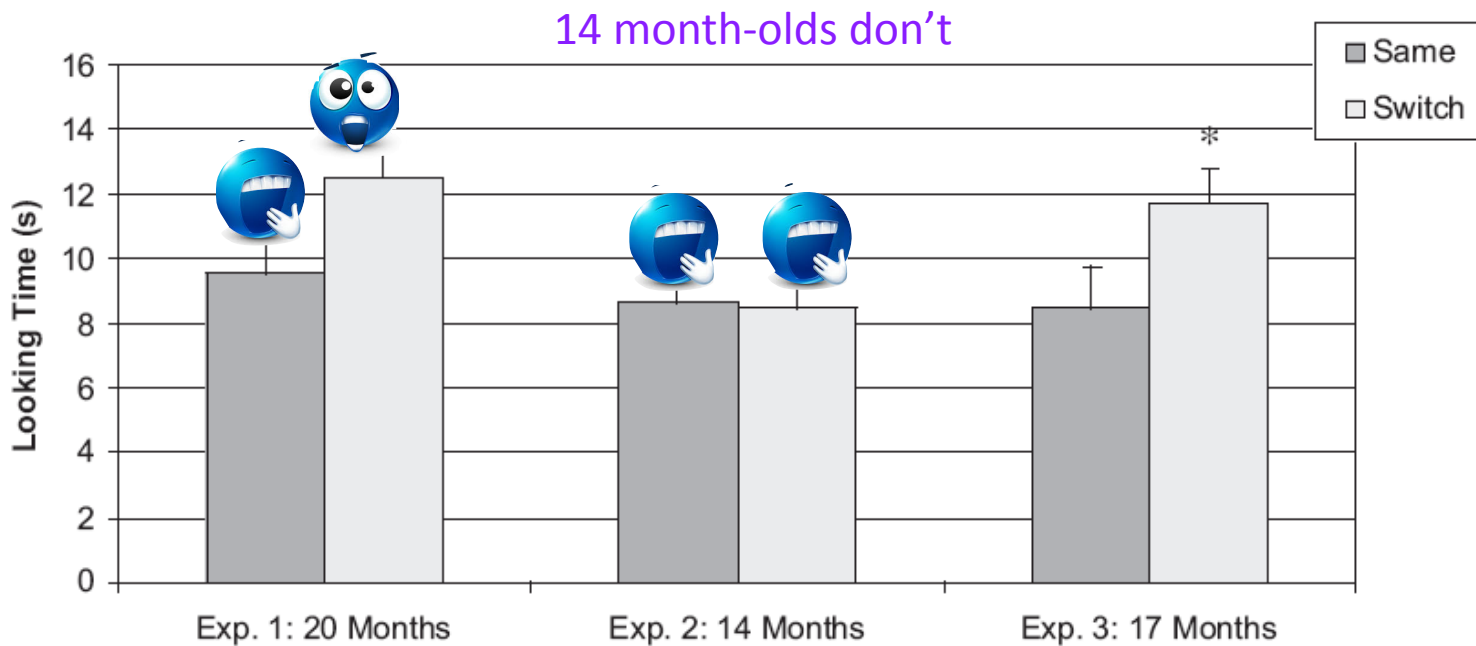
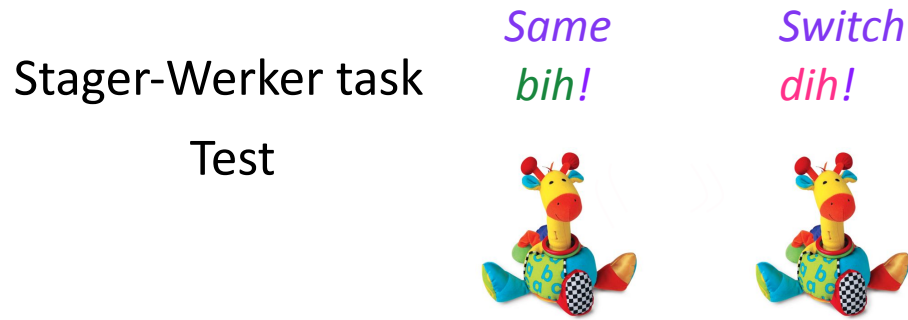
Test



# Werker et al. 2002: Vocabulary size matters



# Werker et al. 2002: Vocabulary size matters



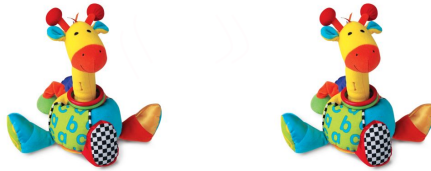
# Werker et al. 2002: Vocabulary size matters

Stager-Werker task

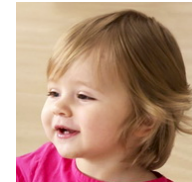
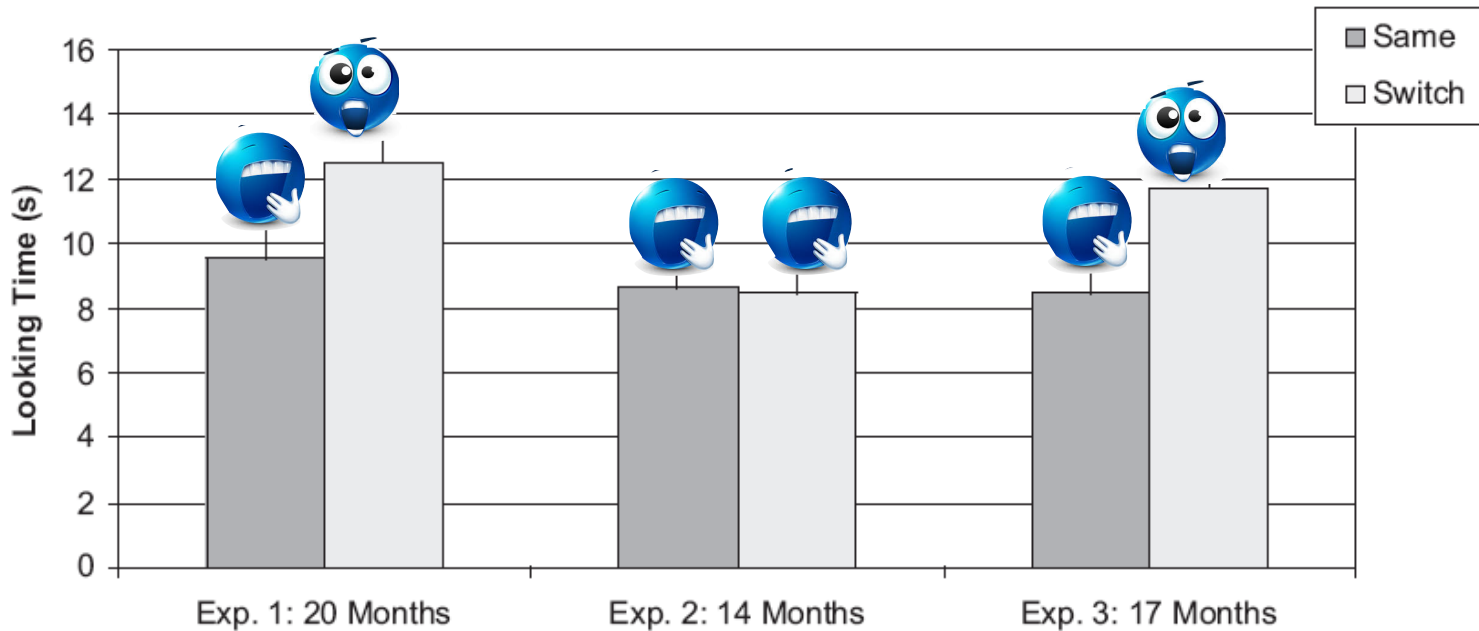
Test

Same *bih!*

Switch *dih!*



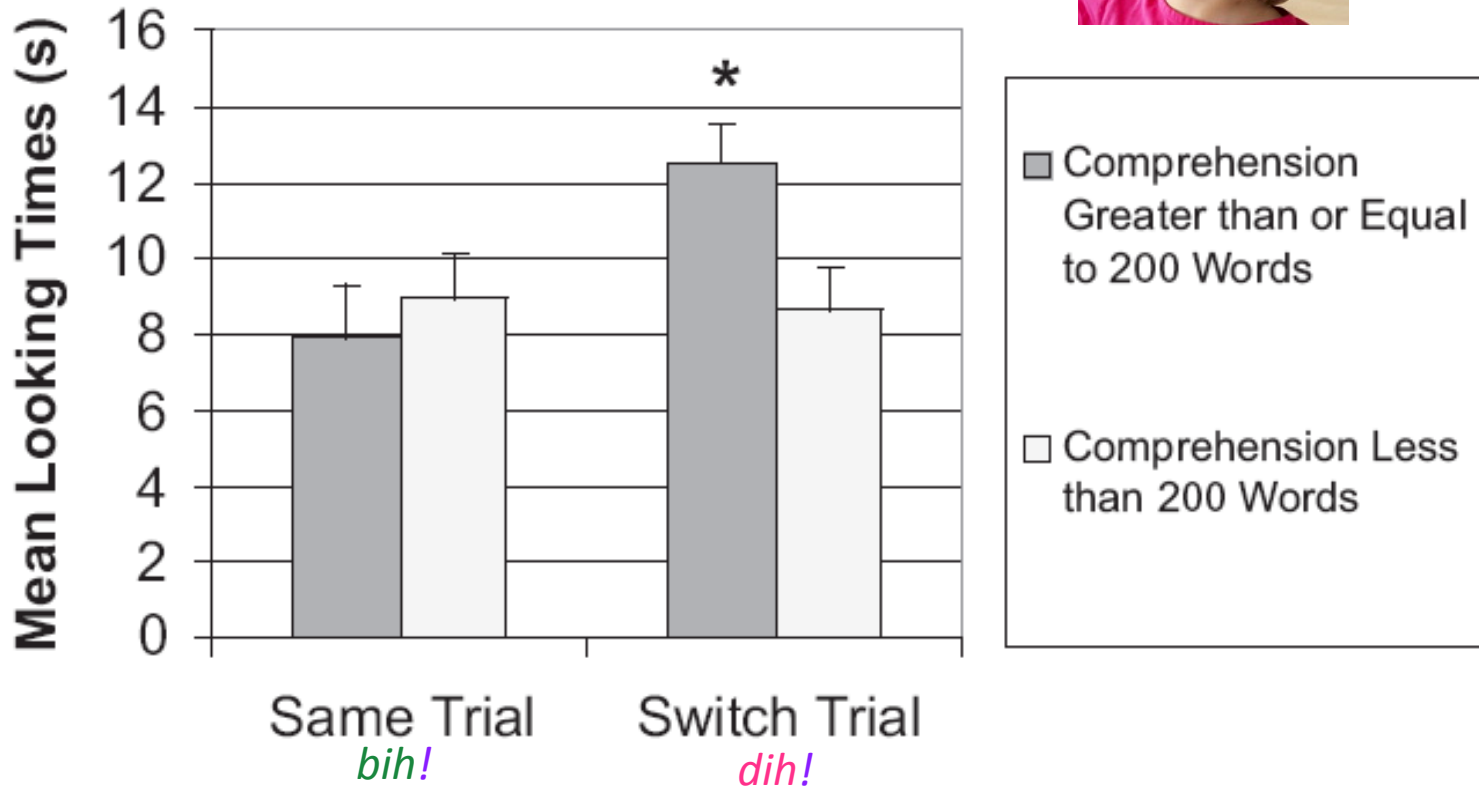
17-month-olds notice



# Werker et al. 2002: Vocabulary size matters



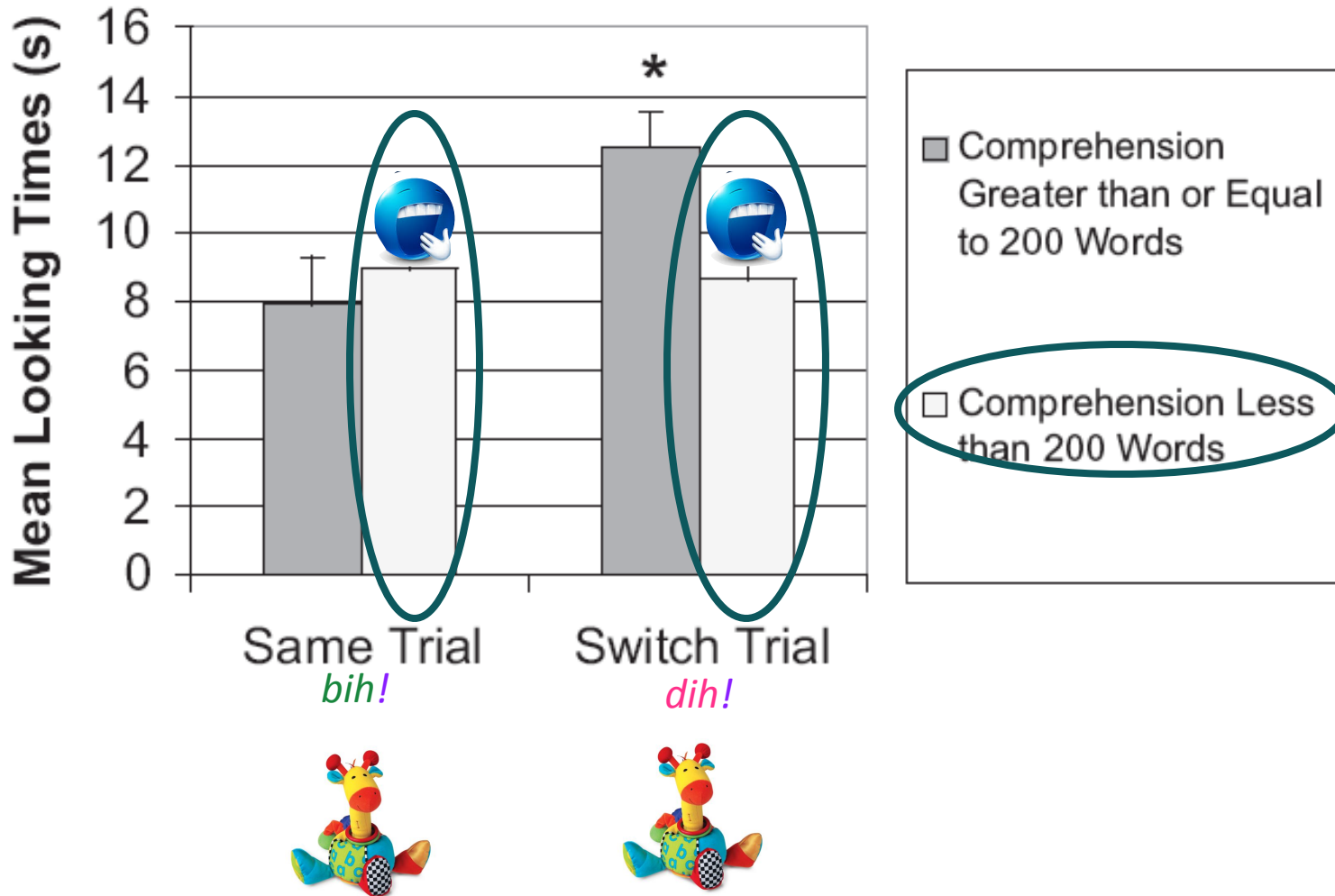
Zoom in on the 17-month-olds



# Werker et al. 2002: Vocabulary size matters

Those with a **small vocabulary look like 14-month-olds** - they can't tell the difference for a novel word they haven't heard much.

Zoom in on the 17-month-olds

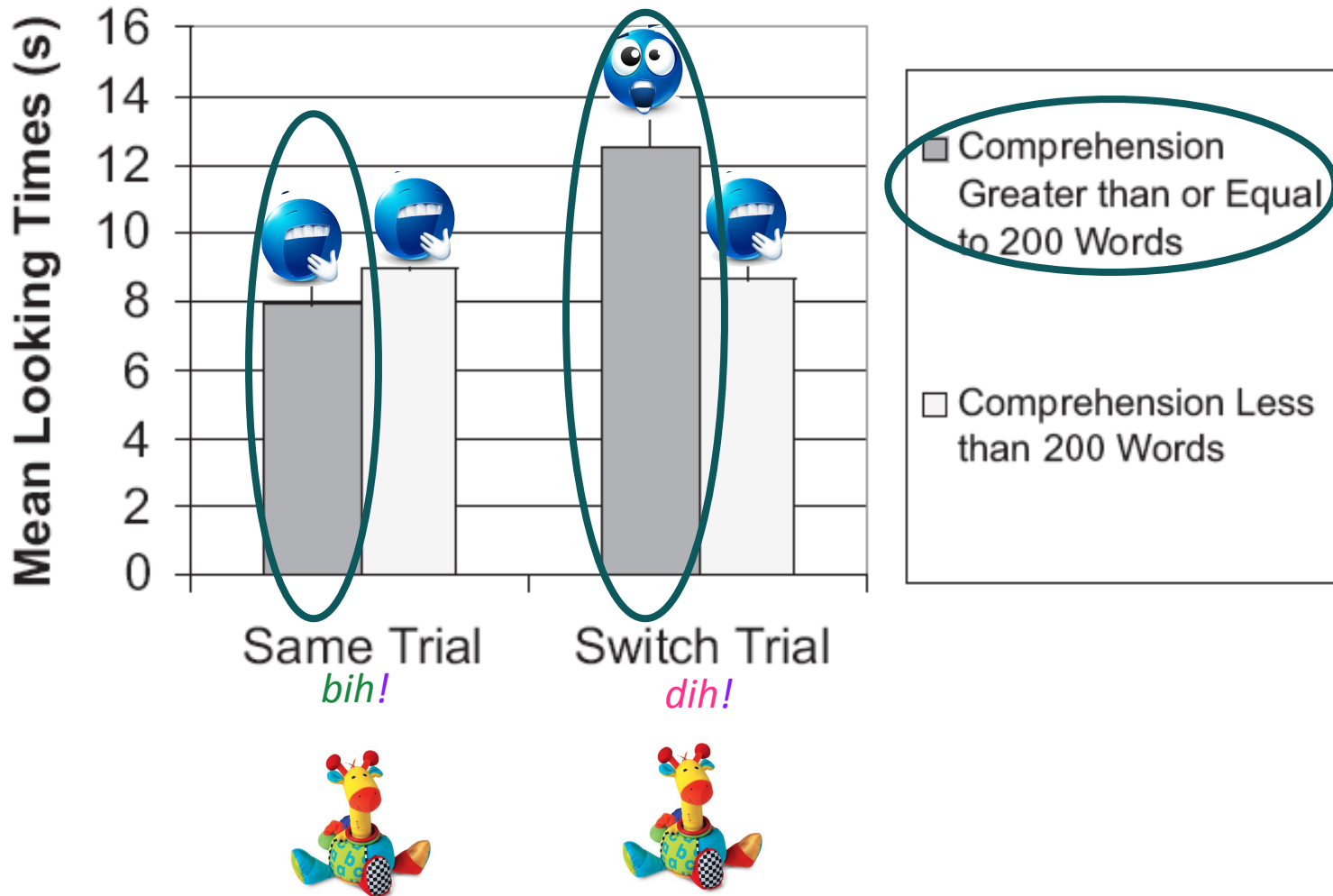


# Werker et al. 2002: Vocabulary size matters

Those with a **larger vocabulary look like 20-month-olds** - they *can* tell the difference for a novel word, even though they haven't heard it much.



Zoom in on the 17-month-olds

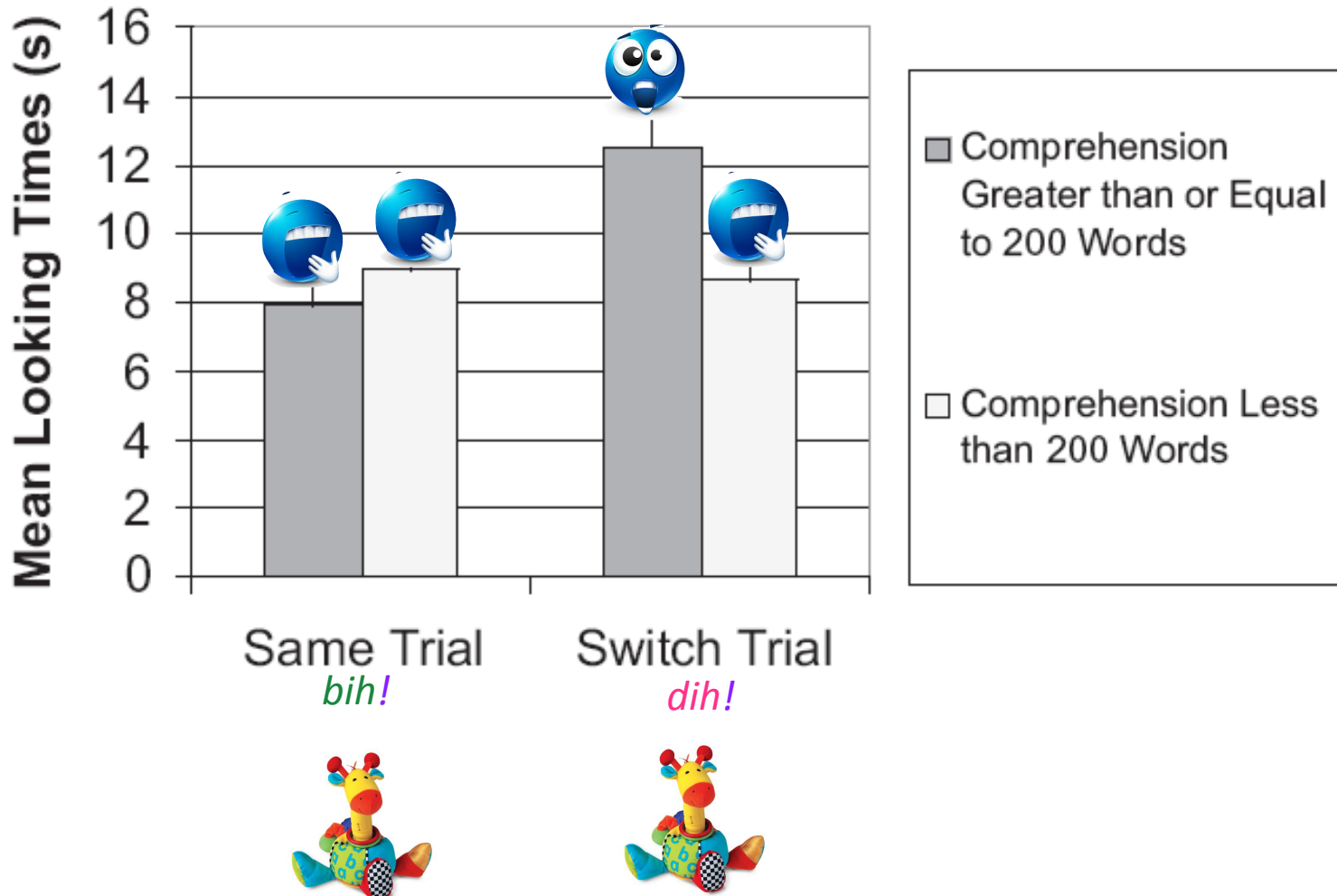


# Werker et al. 2002: Vocabulary size matters

Implication: Performance on Stager-Werker task with novel words *does* depend (somehow!) on how many words the child knows.



Zoom in on the 17-month-olds





# More vocabulary = more necessary distinctions?

Werker et al. 2002: Performance on Stager-Werker task with novel words depends on how many words the child knows.

Implication: The content of children's vocabulary drives their ability to notice the difference between words that differ minimally (ex: by a single phoneme)

Prediction: This should apply to familiar words too. Specifically, children with small vocabularies should have trouble noticing phonemic differences in familiar words.






# Swingley & Aslin 2002: Familiar word tests

But English 14-month-olds noticed the difference between correct pronunciations and mispronunciations when the words were familiar!



**Table 1.** *Correctly pronounced (CP) target words and their mispronounced (MP) versions*

CP 	MP-close 	MP-distant 
apple (/æpl/)	opple (/apɫ/)	opal (/opɫ/)
baby (/beɪbi/)	vaby (/veɪbi/)	raby (/ɹeɪbi/)
ball (/bɔɫ/)	gall (/gɔɫ/)	shawl (/ʃɔɫ/)
car (/kɑɪ/)	cur (/kɜɹ/)	kier (/kiɪ/)
dog (/dɔɡ/)	tog (/tɔɡ/)	mog (/mɔɡ/)
kitty (/kɪti/)	pity (/pɪti/)	yitty (/jɪti/)

Maybe these 14-month-olds just happen to have large vocabularies?

# Swingley 2005: Familiar words for younger children

(Dutch) 11-month-olds noticed the difference between correct pronunciations and mispronunciations **when the words were familiar** (Headturn Procedure: tests ability to hear sound differences)



Familiar	Nonword	Onset-MP
befn	baf	defn
bef	bøf	def
bæyk	bæyn	køeyk
efnt	efp	efnt
h nt	ha/k	x nt
haf	hefn	saf
hont	ho	font
ku	kus	xu
mont	mafnt	nont
nøf	nut	møf
paft	pøft	daft
pus	purt	tus
sxa/p	sxef	flap
tefn	to	pefn
v s	vafnt	v s
vut	vefnt	but



# Swingley 2005: Familiar words for younger children

(Dutch) 11-month-olds noticed the difference between correct pronunciations and mispronunciations when the words were familiar



But this is before they've likely learned many words...so it probably isn't just the number of words they know (and which words they know) that drives the detailed representations of the sounds in the words.

Point: Vocabulary can't be the only thing determining children's ability to distinguish the sounds of words. So what's the problem with the 14-month-olds in the Stager-Werker task?

# Was the task too hard for 14-month-olds?

Yoshida, Fennell, Swingley, & Werker (2009)



Maybe the problem with the 14-month-old infants was that the switch task was too hard - they have to be very confident that the close mispronunciation of the new word (*dih* for novel word *bih*) is not actually close enough

What would happen if we habituated 14-month-old children the usual way for the Switch procedure, but then tested them a different way that didn't require them to be as confident about the correct pronunciation of a word's form?

# The Visual Choice Task

## “Preferential looking”

Golinkoff, Hirsh-Pasek, Cauley & Gordon 1987

A two-alternative forced choice looking task that compares visual fixations to target and distractor objects



“Where’s the **dog**?”

# The Visual Choice Task

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“Where’s the **dog**?”

Familiar object is a better  
match for familiar word

# The Visual Choice Task

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“Where’s the **tog**?”

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“Where’s the **tog**?”

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## “Preferential looking”

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“Where’s the **tog**?”

Novel object is a better match for novel word form and importantly the familiar object is a poor match - the infant knows the familiar word.

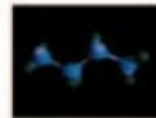
# Yoshida, Fennell, Swingley, & Werker 2009

**Novel labels**

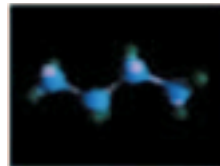
Habituation  
Trials  
(maximum 24)



“bin”



“din”



Test: 14-month-olds

“Where’s the bin?”

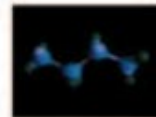
# Yoshida, Fennell, Swingley, & Werker 2009

## Novel labels

Habituation  
Trials  
(maximum 24)



“bin”



“din”



Test: 14-month-olds

“Where’s the bin?”

14-month-old infants  
look significantly more  
at the correct novel  
object - they do have  
detail for words!

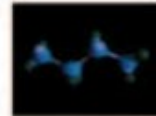
# Yoshida, Fennell, Swingley, & Werker 2009

## Novel labels

Habituation  
Trials  
(maximum 24)



“bin”



“din”



Test: 14-month-olds

“Where’s the bin?”



*Note how the test was a much more natural task, where you’re asking the infant to look for an object with a particular label, not just labeling an object and seeing how the infant reacts.*



# The problem with the Stager-Werker Task



Maybe the problem with the 14-month-olds in the Stager-Werker task was that they encoded the phonetic forms with **low confidence**. So, when tested on the original switch task, they didn't have enough confidence in their representation of the novel form to realize it was the wrong label for the novel object.

Yoshida et al. 2009: "Calling a *din* object by the word *bin* is not good pronunciation to the 14-month-old, but neither is it categorically incorrect."

# Another methodological check



Fennell & Waxman 2010: 14-month-olds can pass this switch task if the **communicative purpose** of the novel word label is made more salient.

Habituation

Stager & Werker 1997

*bih...bih...bih...bih...bih...*

Fennell & Waxman 2010

...I like the *bih*...look at the *bih*...

Issue: Is *bih* a label like “toy”? An exclamation like “wow”? Something else?



Non-issue: *bih* is definitely a label for the object.

Test

*dih!*

(This is fine if it means “wow”!)

Look at the *dih*...

(This is definitely strange, given the habituation.)

# Another methodological check



Fennell & Waxman 2010: 14-month-olds can pass this switch task if the **communicative purpose** of the novel word label is made more salient.

The communicative intent of the novel word can also be made clear by training items that show familiar objects and labels.

Fennell & Waxman 2010

Kitty!



Car!



Shoe!



Bih!



Non-issue again: *bih* is definitely a label for the object.

Look at the *dih*...



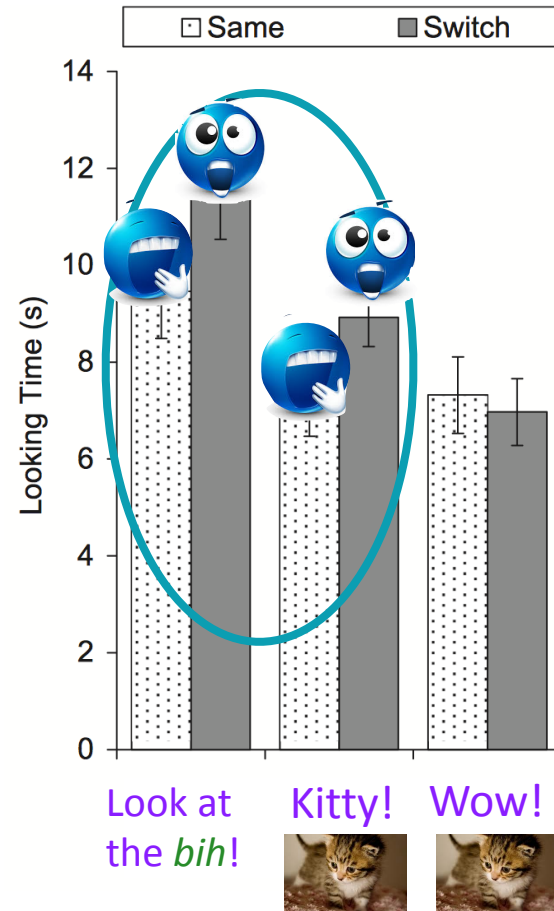
(This is definitely strange, given the habituation.)

# Another methodological check



Fennell & Waxman 2010: 14-month-olds can pass this switch task if the **communicative purpose** of the novel word label is made more salient.

When there's clear intent for the novel word to be a label, 14-month-olds can pass the Switch task just fine.

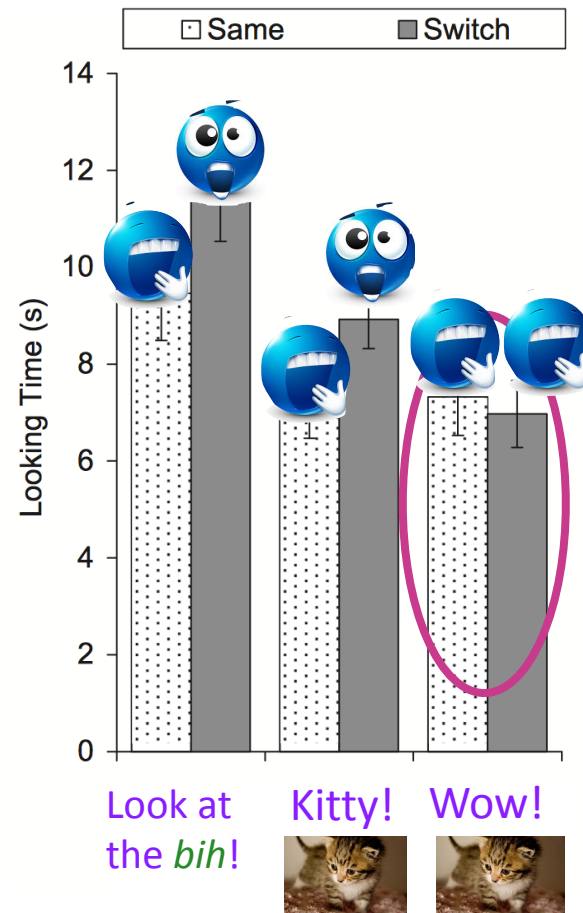


# Another methodological check



Fennell & Waxman 2010: 14-month-olds can pass this switch task if the **communicative purpose** of the novel word label is made more salient.

When it's not clear the novel word is intended as a label (in fact, it seems to be more of an exclamation like "wow"), 14-month-olds look just like they did in the Stager & Werker (1997) experiment.



# Why does having a familiar word help?

Idea: Children build up more confidence in the word form the more times they hear it.

$\{p/b/d/g\}\{a/o/u\}\{l/r\} = \text{“pall”, “dor”}$

...  $\text{“gull”, “ball”}$

$\{p/b\}\{a\}\{l/r\} = \text{“pall”, “ball”,}$

...  $\text{“bar”, “par”}$

$\{b\}\{a\}\{l\} = \text{“ball”}$



# Why does having a familiar word help?

Idea: Children build up more confidence in the word form the more times they hear it.

Some empirical support for this idea:

Word repetition to 7-month-olds is directly linked to vocabulary size as toddlers.

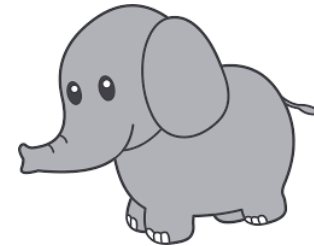


*Newman, Rowe, & Bernstein Ratner 2015*

<http://www.sciencedaily.com/releases/2015/09/150921103539.htm>

# Why does having a familiar word help?

Idea: Children build up more confidence in the word form the more times they hear it.



Also, not all positions in the word are created equal with respect to how well infants remember them. For words with more than one syllable, seven-month-olds (Benavides-Varela & Mehler 2014) and newborns (Ferry et al. 2015) remember the first and last syllables best.

**e**                      **le**                      **phant**

{ε/a/ɔ} {l/r/d/t}{ε/a/ɔ} {f/v/p/b}{æ/a/ə}{n/m}{t/p/k}

...

{ε/a}    {l/r/d/t}{ε/a/ɔ} {f/v}{æ/ə} {n/m}{t/k}

...

{ε}            {l/r/d}{ε/ɔ}                      {f}{ə}{n}{t}

<http://www.sciencedaily.com/releases/2014/09/140908083348.htm>

<http://www.sciencedaily.com/releases/2015/07/150721081725.htm>



# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

15-month-olds learned novel names for objects that began with either [t] or [d].

*dawbow* vs. *tawgoo*



This was meant to draw attention to the difference between these phonemes.

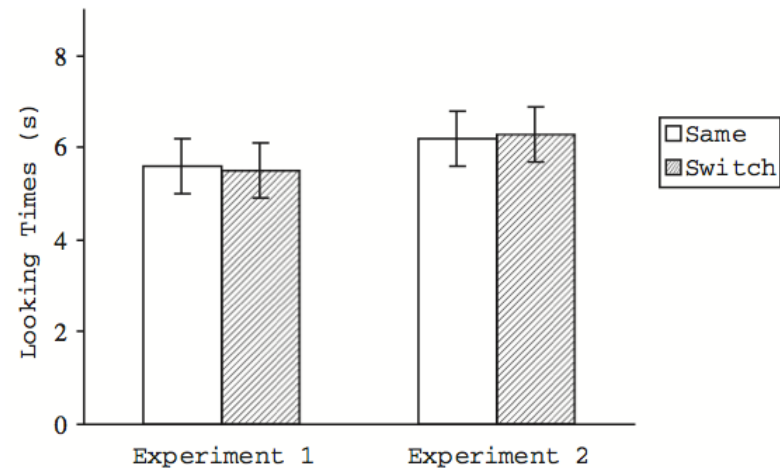


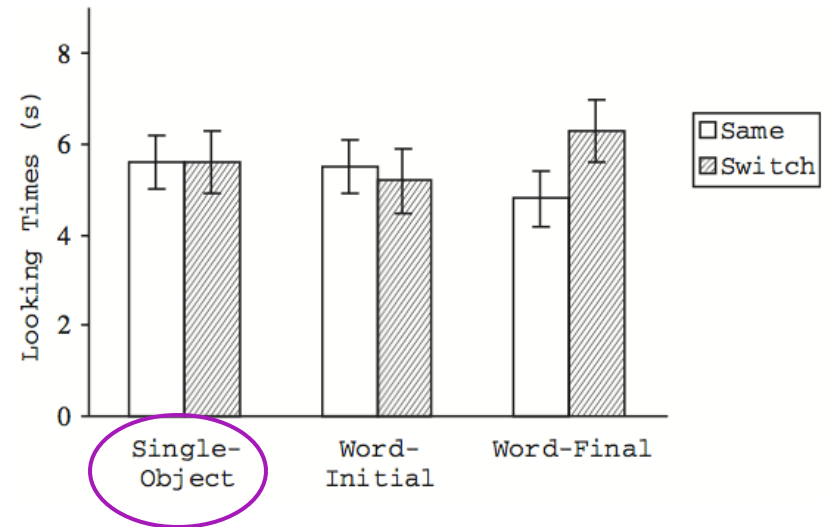
Figure 1. Children's looking time to same and switch trials after exposure to *Dawbow* and *Tawgoo*. In Experiment 1, same and switch trials are *yad* versus *yat*; in Experiment 2, they are *dee* versus *tee*. Error bars indicate  $\pm$  standard error.

# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

15-month-olds learned the name of a novel object, called

*yad*

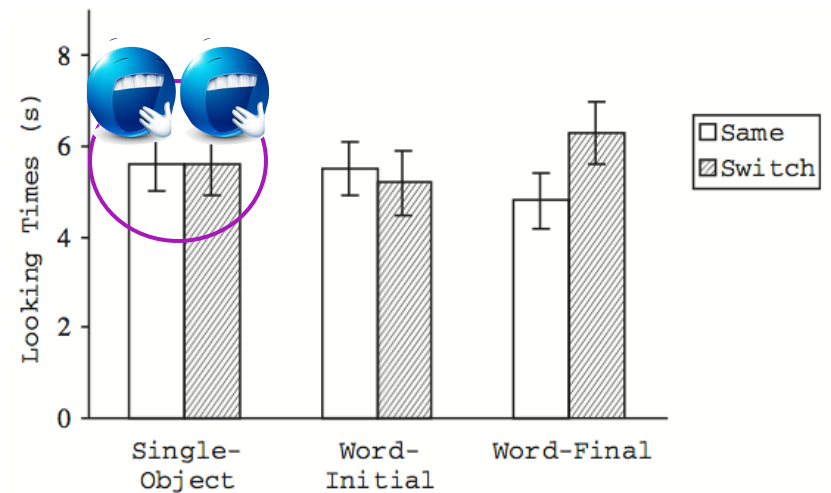


# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

Similar to the 14-month-olds in Stager & Werker 1997, when this name was switched to *yat*, they **didn't notice**.

*yat*

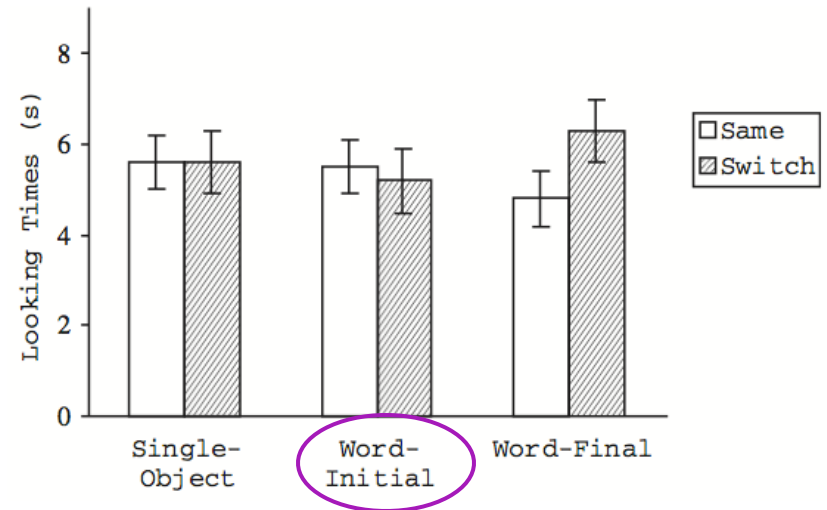


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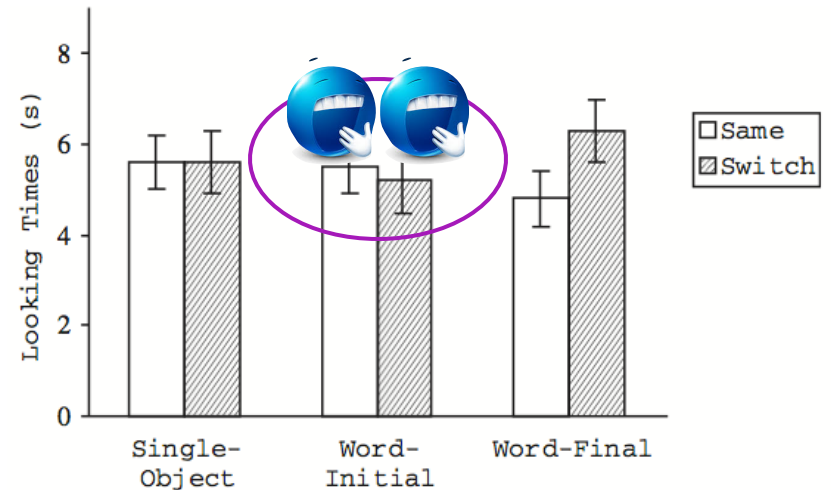


This was meant to draw attention to the difference between these phonemes.

# Building up an abstract representation from many samples

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If they were able to represent the [d] vs. [t] distinction abstractly, *dawbow* and *tawboo* should help remind them that [d] and [t] are distinct. So, if the other novel object's name is switched from *yad* to *yat*, they should notice.

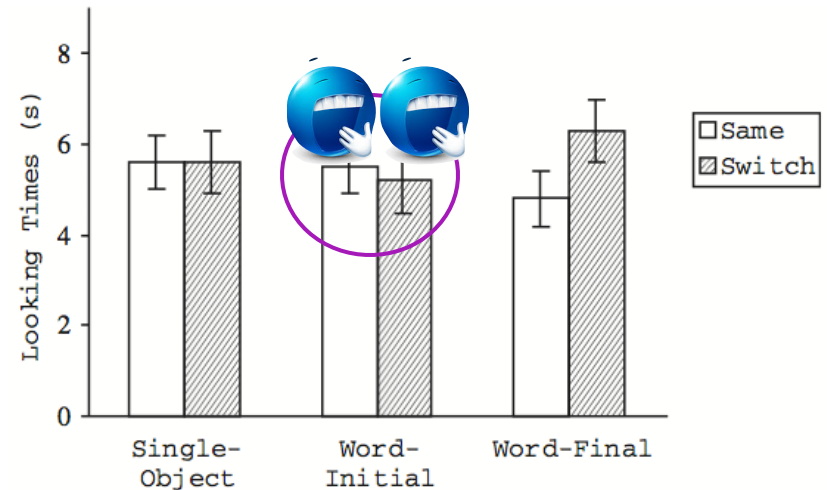


**But they didn't...** probably because this is a different acoustic context (word-initial vs. word-final).

# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

This suggests they're representing a lot of extra contextual and perceptual detail about the [d] and [t] examples they heard, which causes them not to recognize those sounds (and the important differences between them) when they're used in the third novel word.

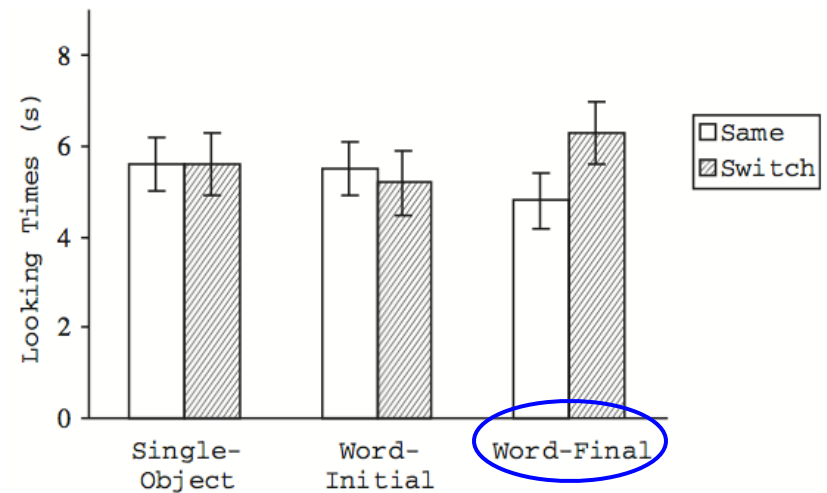


# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

Check: When they're habituated to novel words that use the same acoustic context as the test word...

*boeyad* vs. *gooyat*

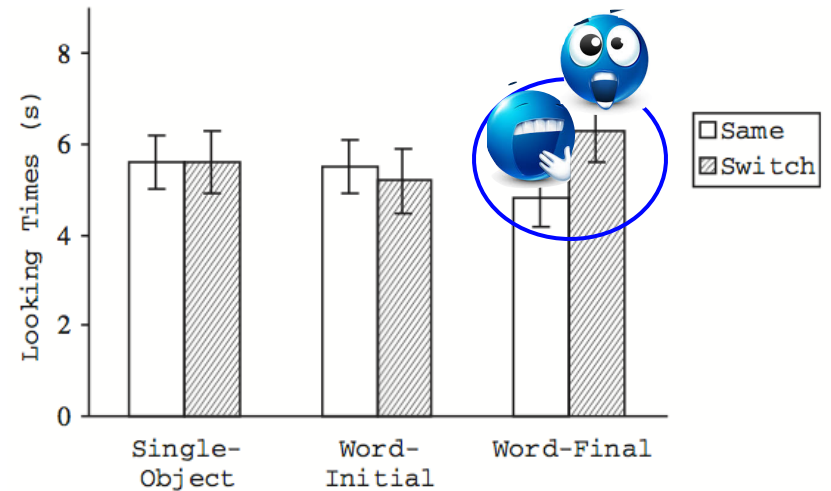


# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

Now they do better at telling that this contrast is relevant in the same context.

Same                      Switch  
*yad*                      vs.                      *yat*



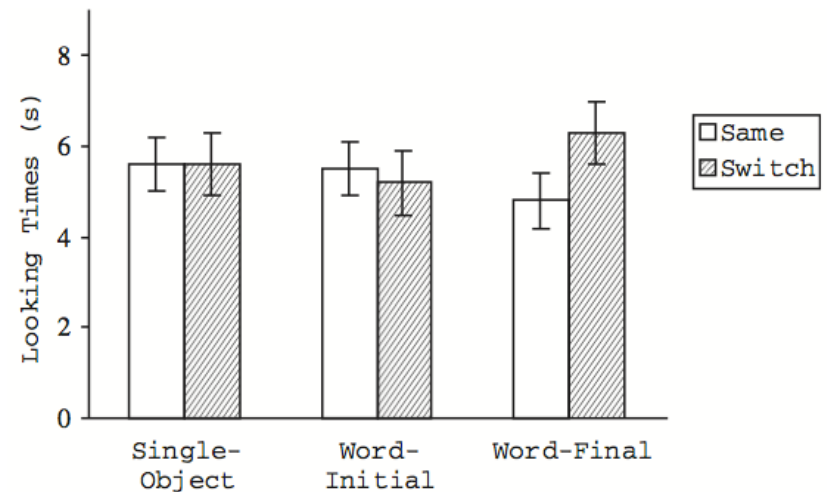


# Building up an abstract representation from many samples

Thiessen & Yee 2010: Early word form representations retain contextual and perceptual features associated with children's prior experience with words.

This suggests that they are detecting the difference between [d] and [t], but not at the abstract level that would allow them to recognize that difference in different acoustic contexts.

They haven't yet abstracted to the phonemic level adults use.



# Recap: Sounds, words, and detail

Word-learning is very hard for younger children, so detail seems to be initially missed when they first learn words.

When children are tested with a visual choice task, they show more knowledge of detailed word forms than when they are tested with a Switch procedure task.

They also do better when the communicative intent of the label in the Switch task is made clear.

Many exposures are needed to learn detailed word forms at the earliest stages of word-learning, so that the word forms are represented at the appropriate abstract level.

# Questions?



You should be able to do all the questions on HW2 and all the review questions for sounds & sounds of words.