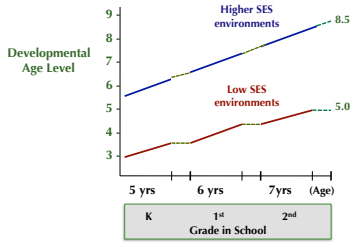
How & why early experience is so crucial in learning language

Anne Fernald
Adriana Weisleder
Stanford University

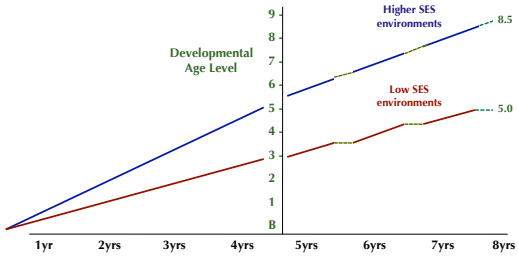
LENA
4/18/11

Ramey & Ramey (2004): Early environmental differences correlate strongly with later outcomes



]

Ramey & Ramey: The Prequel



Cognitive disparities between higher- and lower-SES infants at 9 and 24 months

The New York Times
October 21, 2009

Hispanic Immigrants' Children Fall Behind Peers Early, Study Finds

By JAMES C. McKINLEY Jr.

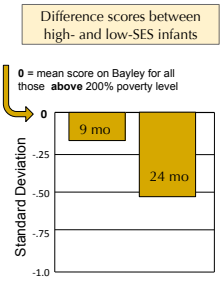
HOUSTON — The children of Hispanic immigrants tend to be born healthy and start life on an intellectual par with other American children, but by the age of 2 they begin to lag in linguistic and cognitive skills, a new study by researchers at the University of California, Berkeley, shows.

The study highlights a paradox that has bedeviled educators and Hispanic families for some time. By and large, mothers from Latin American countries take care of their health during their pregnancies and give birth to robust children, but those children fall behind their peers in mental development by the time they reach grade school, and the gap tends to widen as they get older.

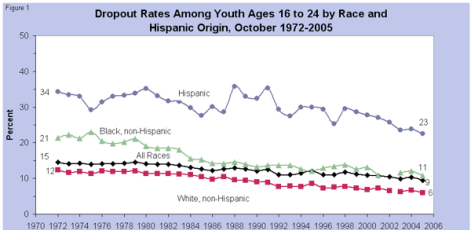
The new Berkeley study suggests the shortfall may start even before the children enter preschool, supporting calls in Washington to spend more on programs that coach parents to stimulate their children with books, drills and games earlier in their lives.

"Our results show a very significant gap even at age 3," said Bruce Fuller, one of the study's authors and a professor of education at Berkeley. "If we don't attack this disparity early on, these kids are headed quickly for a pretty dismal future in elementary school."

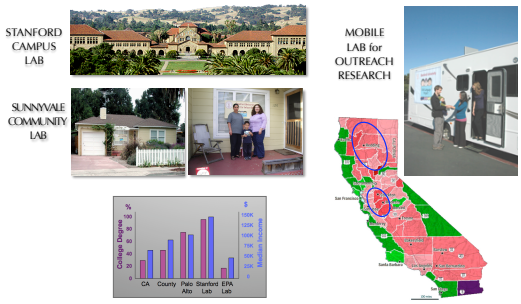
Professor Fuller said blacks and poor whites also lagged behind the curve, suggesting that poverty remained a factor in predicting how well a young mind develops. But the drop-off in the cognitive scores of Hispanic toddlers, especially those from Mexican backgrounds, was steeper than for other groups and could not be explained by economic status alone, he said.



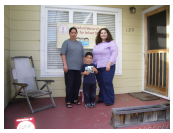
Future school success can be predicted from cognitive differences evident at 3 years of age



Our research includes children diverse in language experience and socioeconomic status







At our community lab in Sunnyvale, we conduct longitudinal studies with monolingual and bilingual children growing up in Spanish-speaking families

Our mobile research lab in Northern CA








What is fluency in understanding?

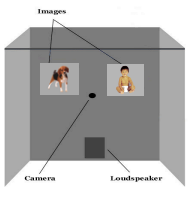
Adults listen *predictively*, anticipating how speech will continue by integrating linguistic and contextual information on multiple levels:

- LEXICAL kan-ga -> roo
- SEMANTIC let's read a -> book
- MORPHOSYNTACTIC that's a big -> [noun]

Four questions

- **How do we study the development of receptive fluency in very young children?**
- How do infants build proficiency in this crucial aspect of language use?
- To what exent does early fluency VARY among children, and are these differences *consequential?*
- Where do such differences come from - both *within* groups and *between* groups?

Looking-while-Listening procedure



Fernald, et al. 1998; 2008

Coding gaze patterns using *Eyecoder* software

Sample coding record for two 4-s trials

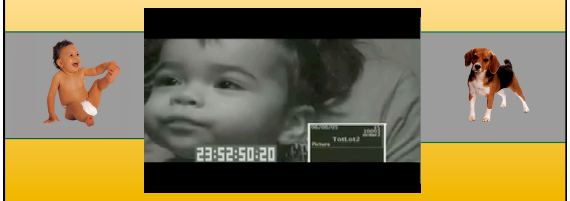
Each line indicates time when coder judged a change occurred:

- in the **stimuli:**
  - pictures on/off
  - sound on/off
- in the **position of the child's fixation:**
  - left, off, right, away

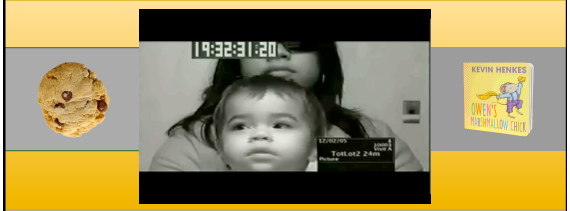
Time Line of an Experimental Trial

Trial	Pictures	Sound	Fixation	Onset
2	on	on	right	20:32:23.02
2	on	on	off	20:32:23.05
2	on	on	left	20:32:23.10
2	on	on	off	20:32:24.17
2	on	on	right	20:32:24.22
2	on	off	right	20:32:25.20
2	off	off	right	20:32:26.21
3	on	on	left	20:32:30.10
3	on	on	off	20:32:32.09
3	on	on	right	20:32:32.13
3	on	on	off	20:32:32.28
3	on	on	left	20:32:33.04
3	on	off	left	20:32:33.28
3	on	off	off	20:32:34.02
3	on	off	right	20:32:34.06
3	on	off	off	20:32:34.23
3	on	off	left	20:32:34.28

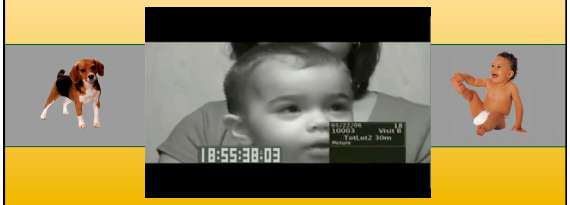
18 months: Distracter-to-Target shift



24 months: Distracter-to-Target shift

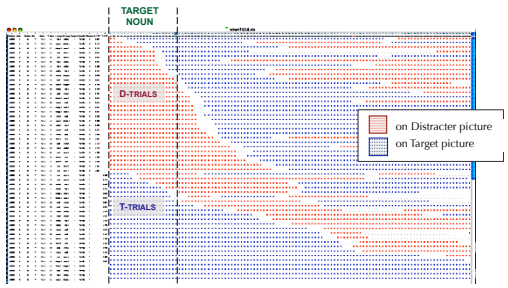


30 months: Distracter-to-Target shift

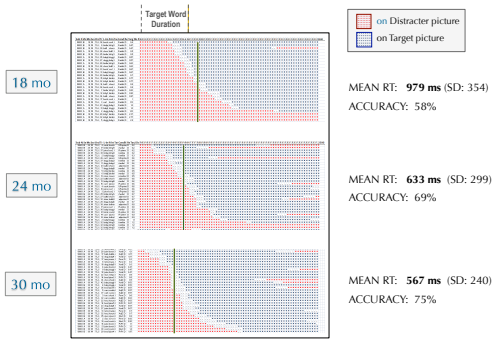


18 months: Target-initial trial

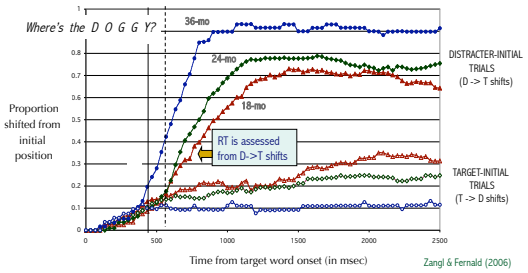
Data from one 18-month-old infant showing shift patterns on 60 DISTRACTER-INITIAL and TARGET-INITIAL trials



Shifts to target picture from one child at 18, 24, & 30 months



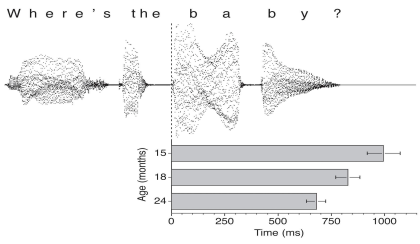
Two ways to respond correctly: on **target-initial** trials *(stay put)* and on **distracter-initial** trials *(get moving)*



Four questions

- How do we study the development of receptive fluency in very young children?
- **How do infants build proficiency in this crucial aspect of language use?**
- To what exent does early fluency VARY among children, and are these differences *consequential?*
- Where do such differences come from - both *within* groups and *between* groups?

Developmental gains in the speed of spoken word recognition over the 2nd year: Cross-sectional data



Incremental processing of spoken language

Adults listen *predictively*, integrating linguistic information with contextual cues on multiple levels:

- LEXICAL
- SEMANTIC
- MORPHOSYNTACTIC

And so do very young children!

Processing speech from moment to moment

- In this **English** sentence, you have to wait til you hear the noun to know what to look at:

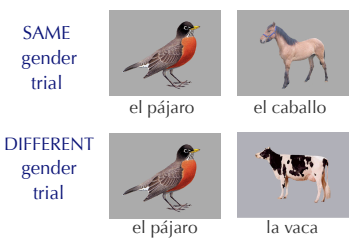
  Find the ball!

- But in **Spanish**, the word for "the" (*la* or *el*) may let you make up your mind sooner:

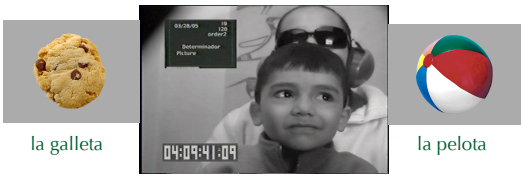
  Encuentra la pelota!

Incremental processing at a ***morphosyntactic level***: Spanish-learning children use gender-marked articles to identify the referent more quickly

¿Dónde está el pájaro?



Same-gender condition



"Encuentra la pelota"

Mean RT: 935 msec

Lew-Williams & Fernald (2007)

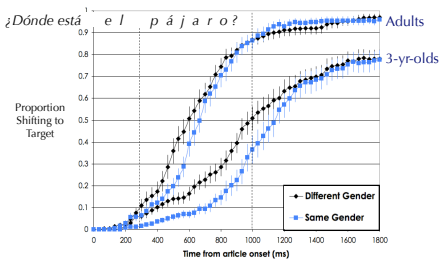
Different-gender condition

"Encuentra la pelota"

Mean RT: 842 msec

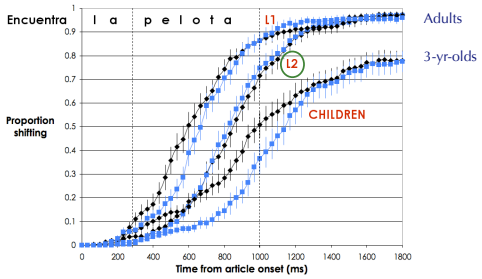
Lew-Williams & Fernald (2007)

3-yr-old Spanish-learning children make rapid use of grammatical gender to identify the correct referent



Lew-Williams & Fernald (2007)

Adult L2 Spanish-speakers do ***not*** make use of the gender-marked article in real-time processing



Lew-Williams & Fernald, JML, 2010

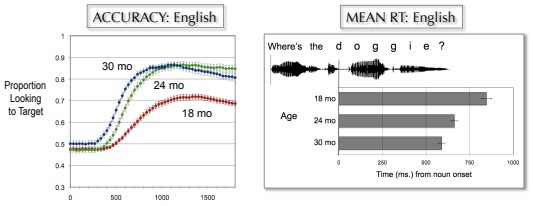
Four questions

- How do we study the development of receptive fluency in very young children?
- How do infants build proficiency in this crucial aspect of language use?
- **To what exent does early fluency VARY among children, and are these differences *consequential?***
- Where do such differences come from - both *within* groups and *between* groups?

Exploring how fluency in understanding develops with age and experience

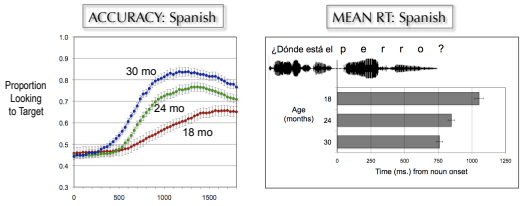
- Three ongoing *prospective longitudinal studies*
  1. Monolingual English-learning children (n = 76)
  2. Monolingual Spanish-learning children (n = 50)
  3. Bilingual Spanish/English-learning children (n = 52)
- Tested at 18, 24, 30, 40 months on age-appropriate *real-time language-processing challenges* (+ CDI)
  - Familiar word recognition
  - Novel word learning
  - Semantic integration
  - Morphosyntactic integration
- Language & cognitive outcome measures at 5 years:
  - PLS-4
  - PPVT/TVIP
  - CELF-4
  - Leiter IQ
  - Working memory
  - Executive Function

ENGLISH longitudinal study: Changes in processing efficiency and vocabulary size from 18 to 30 months



VOCABULARY English (CDI)	18 Mo	24 Mo	30 Mo
	100	236	562

SPANISH longitudinal study: Changes in processing efficiency and vocabulary size from 18 to 30 months



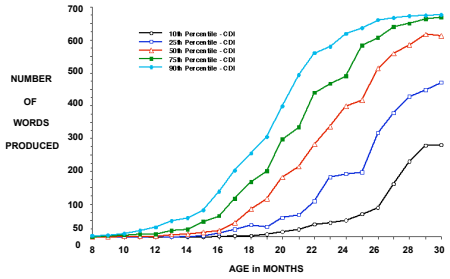
VOCABULARY Spanish (CDI)	18 Mo	24 Mo	30 Mo
	60	230	411

Similar results – why bother?!

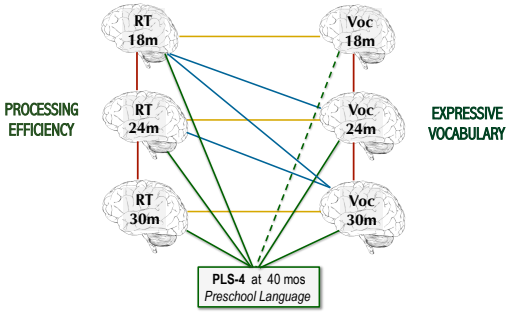
- At the *group level*, our longitudinal results replicate our cross-sectional results in both English and Spanish
- *So why spend 5 years collecting data that just tell us again what we already know?*
- Because longitudinal data can give us a fundamentally different perspective . . .

Variability in vocabulary growth from 8 to 30 months:

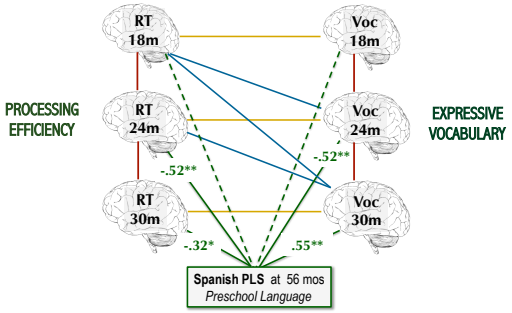
Number of words spoken (as reported on the MacArthur CDI)



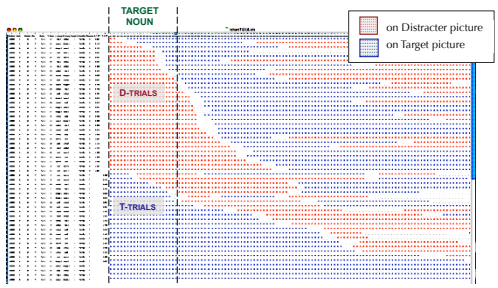
ENGLISH: Intercorrelations among processing & vocabulary from 18-30 mos, predicting to **PLS-4** at 40 months



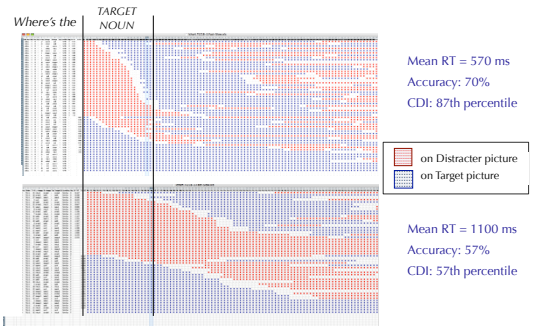
Spanish-learning children: Comparable stability and predictive validity



These data are from the 'modal child' at 18 months



These data are from two other 18-month-olds in the same population. Note the variability…



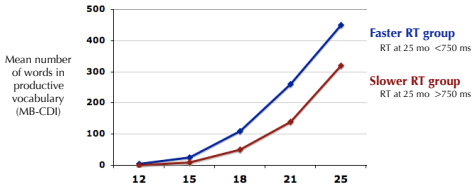
Do these early differences in processing efficiency really matter?

Looking back at an earlier longitudinal study of processing efficiency & lexical growth across the 2nd year:

- 60 INFANTS followed from 12 to 25 months
  - monolingual English-learners, typically-developing
- LOOKING-WHILE-LISTENING TASK at 15, 18, 21, 25 mos
- MACARTHUR-BATES CDI at 12, 15, 18, 21, 25 mos
- PEABODY PICTURE VOCABULARY TEST (PPVT) at 25 mo
- VISUAL REACTION TIME (non-language RT task) at 15, 18, 21 mos

Fernald, Perfors, & Marchman, (2006)

Growth curve modeling showed strong relations between differences in speech processing efficiency and trajectories of vocabulary growth



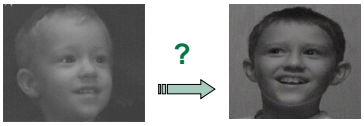
***Retrospective prediction**: Children with **faster mean RT at 25 mo** had shown **more accelerated growth in vocabulary** across the 2nd year*

Fernald, Perfors, & Marchman, (2006)

A follow-up study 5 years later...

Half the children from our longitudinal sample were tested on standardized assessments (KABC and CELF-4) at 8 years of age

Would their efficiency in interpreting simple sentences at 15 and 25 months predict their later language development?



Marchman & Fernald (2008)

Substantial correlations between processing efficiency in infancy and later cognitive skills

Vocabulary size @25 months was correlated with later cognitive and language skills, but ***knowing mean RT in addition to CDI doubled the predictive power***, accounting for 58% of the variance in working memory at 8 years.

Marchman & Fernald (2008)

Scores on **working memory subscale** at **8 yrs** in relation to **RT** and **vocabulary** at **25 mo**

Vocabulary: 25 mo

Response Speed: 25 mo	LOW CDI	HIGH CDI
SLOW RT	**104**	118
FAST RT	118	**127**

Marchman & Fernald (2008)

Summary: Robust links between processing efficiency and vocabulary at 18, 24, & 30 mos and later language outcomes

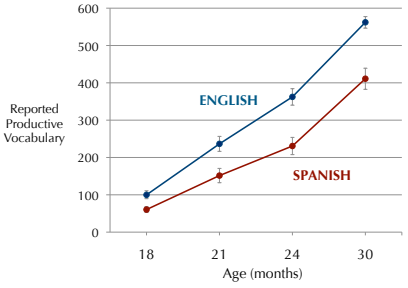
In both Spanish & English longitudinal studies, mean RT at 24 months, together with 24-mo vocabulary, predicted language and cognitive skills in preschool.

In several analyses it was *processing efficiency*, but not vocabulary, that accounted for unique variance in later language proficiency.

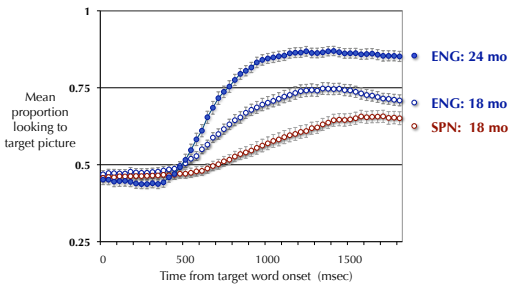
Summary of cross-sectional and longitudinal findings so far…

- Age-related increases in processing efficiency from 18 to 30 months
- Early differences in fluency among children within each group relate meaningfully to cognitive and language outcomes at 5 years
- Similar results in English- and Spanish-learning children from diverse populations
- **Is processing efficiency related to *between-group differences* as well as within-group differences?**

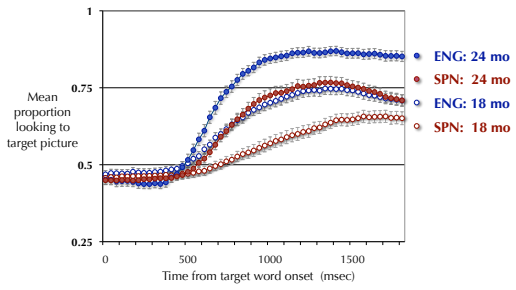
Vocabulary growth by English- and Spanish-learning children



Online processing of familiar words by *High-SES* English-learning & *Low-SES* Spanish-learning children



Online processing of familiar words by *High-SES* English-learning & *Low-SES* Spanish-learning children



Four questions

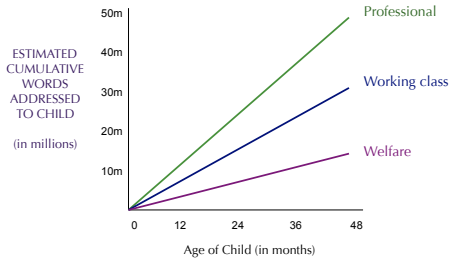
- How do we study the development of receptive fluency in very young children?
- How do infants build proficiency in this crucial aspect of language use?
- To what exent does early fluency VARY among children, and are these differences *consequential?*
- **Where do such differences come from - both *within* groups and *between* groups?**

How does early experience contribute to variability in language processing efficiency?

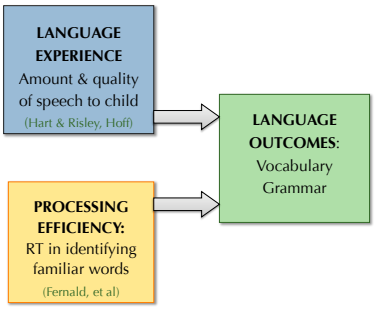
- **Amount and diversity of caregiver talk** in infancy are related lexical and grammatical development
- Links between **SES** and early language outcomes are mediated by **differences in linguistic experience**
- **Conclusion**: **variation in maternal input** is robustly related to **differences in vocabulary growth**

(Huttenlocher; Hart & Risley; Hoff; Snow; Pan; Rowe; Goldin-Meadow)

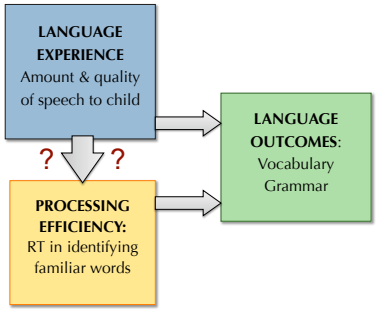
Hart & Risley (1995) *Meaningful Differences in the Everyday Experience of Young American Children*



We know that language experience and processing efficiency both influence later language outcomes…



But does early language experience also influence *the development of processing efficiency*?



Question: does early input affect *processing efficiency* as well as vocabulary growth?

- 27 mother-child dyads observed when child was 18 mo
- Children tested on familiar object names in looking-while-listening task at 18 and 24 months (plus CDI)
- All monolingual Spanish-speakers; low SES
- Measures of caregiver talk:
  - Total amount of talk to child in 12-min session
  - Lexical diversity
  - Grammatical complexity

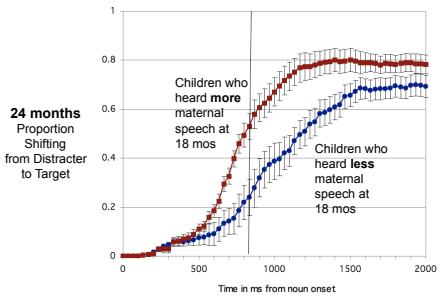
(Hurtado, Marchman, & Fernald, 2008)

Question: does early input affect *processing efficiency* as well as vocabulary growth?

- Children of mothers who talked with them more heard:
  - 7 times more words
  - 3 times more different words
  - Sentences twice as long
- Children of mothers who talked more at 18 mo had **larger vocabularies at 24 mo** AND ***they increased more in processing speed***
  [controlling for differences in CDI & RT at 18 mo]

Hurtado, Marchman, & Fernald (2008)

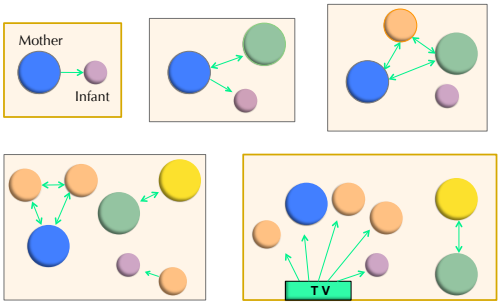
Results: Early language input affects later skill in language uptake!



Hurtado, Marchman, & Fernald (2008)

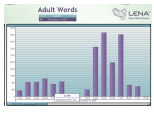
Most earlier studies of child-directed speech focused on this idealized situation: One-to-one interaction between mother and child

But in family life at home the child is exposed to many "streams of talk". Which ones matter?



Using **LENA** (Language ENvironment Analysis) technology

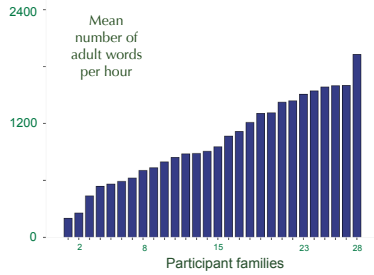
- Digital recorder & software analysis system
- Unintrusive data collection
- Up to 16 hrs of continuous recording
- Automated analysis of:
  - Number of "clear" adult words (tokens)
  - Distant speech
  - TV and other media



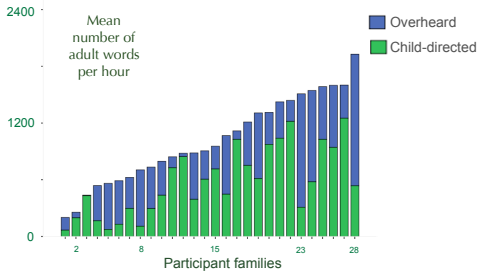
What kinds of speech in the home environment predict increases in vocabulary & processing skill?

- 28 Latino families with infants observed at 18 & 24 months
- Low-SES sample
  - Maternal education: *M* = 10.2 yrs.
  - Median annual income < $25,000
  - 3-11 people living in the same home
- Measures
  - Online comprehension (LWL)
  - Vocabulary (CDI)
  - 12-hr recordings of home language environment

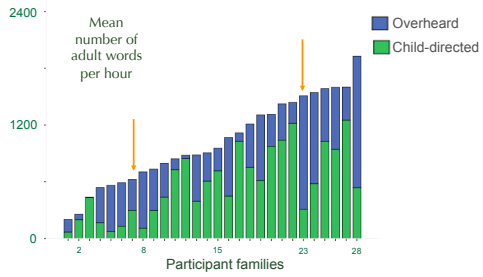
Striking variability in the numbers of **adult words** infants hear over the course of a typical day



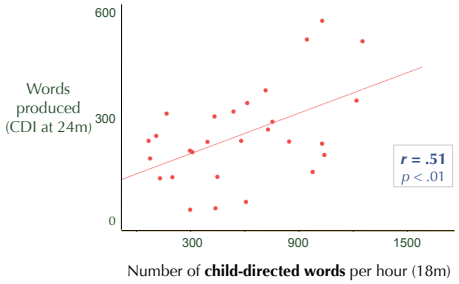
Differences in amounts and proportions of **child-directed** and **overheard** speech



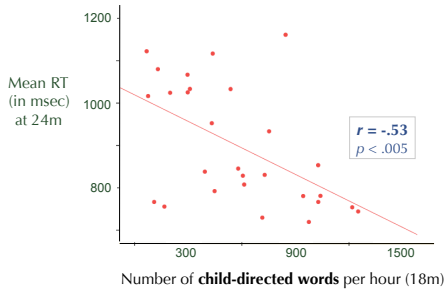
Differences in amounts and proportions of **child-directed** and **overheard** speech



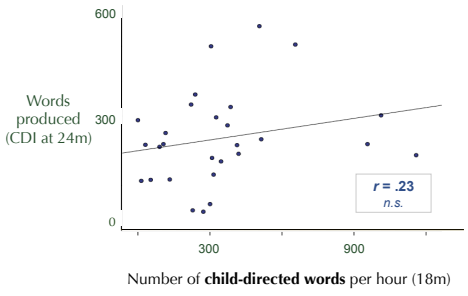
Infants who hear **more child-directed speech** have **larger productive vocabularies** at 24-mos



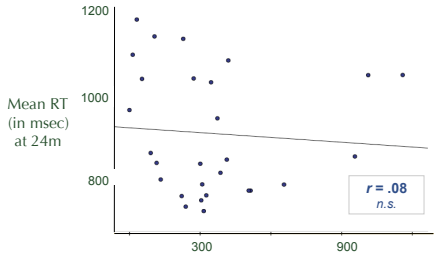
Infants who hear **more child-directed speech** are **faster to interpret familiar words** at 24-mos



But **overheard speech** is **not correlated** with expressive vocabulary at 24-mos

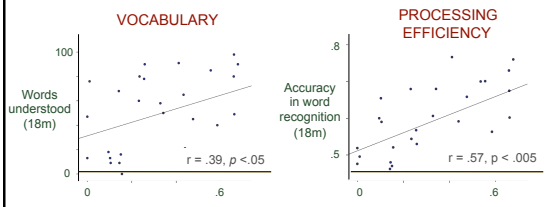


… or with processing efficiency at 24 months



Number of **child-directed words** per hour (18m)

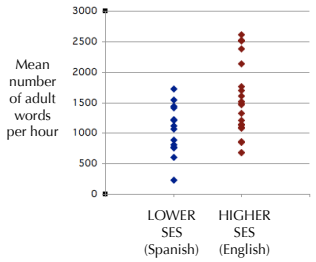
Infants who hear a higher **proportion of CDS** in **child-engaging contexts** are more advanced in vocabulary and processing efficiency



Proportion of **CDS in child-engaging contexts***

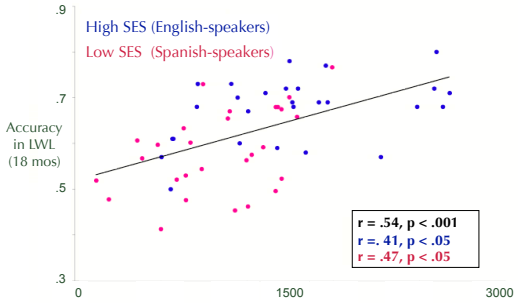
(* CDS in context of **book-sharing & play** vs. meals and routines)

Automated analysis of 12-hr home recordings of speech to 18-mo-olds in lower and higher SES families



(Weisleder & Fernald, in prep)

Across Low- & High-SES groups, infants who hear more speech are **more accurate in real-time language processing**



Number of adult words per hour (18 mos)

Verbal engagement with young children can vary in different families for many different reasons

Summary

- Caregiver talk not only **guides the end-products** of vocabulary learning, but also **sharpens the processing skills** used in real-time language comprehension.
- These results show the potential **benefits** of early processing efficiency for vocabulary growth
- They also reveal the **potential cost** to children with less efficient processing skills, in terms of **missed opportunities for learning**

The Main Point and the Big Question

- Rich and varied engagement with language, starting early in infancy, are critical for optimal language development
- How can we frame these discoveries as a *public health message*? The goal: to help parents understand that they play a crucial role in providing their infant with early **linguistic nourishment** and opportunities for **language exercise**.

For many contributions over the years, thanks to:

Virginia Marchman
Nereyda Hurtado
Casey Lew-Williams
Adriana Weisleder
Renate Zangl
Amy Perfors
Ricardo Bion
Grace Budde
Ana Luz Portillo
Dan Swingley

Chris Potter
Poornima Bhat
Lucia Rodriguez
Narges Afshordi
Theres Gruter
Amber MacMillan
Arielle Borovsky
Kirsten Thorpe
Jerry McRoberts

and to NICHD and NIDCD for their generous support of this research