

CSEN | CONGRÈS INTERNATIONAL
LES SCIENCES COGNITIVES
DANS LA SALLE DE CLASSE

SCNE | INTERNATIONAL CONGRESS
COGNITIVE SCIENCE IN THE CLASSROOM

POUR L'ÉCOLE
DE LA CONFIANCE

FONDAMENTAUX
DES SCIENCES
DE L'APPRENTISSAGE
LES PÉRIODES CRITIQUES
DE L'APPRENTISSAGE DU LANGAGE

THE FUNDAMENTALS
OF LEARNING
THE CRITICAL PERIODS IN LANGUAGE
LEARNING

PATRICIA K. KUHL

Université de Washington, États-Unis | Washington University, USA



UNESCO



SCIENCES HUMAINES

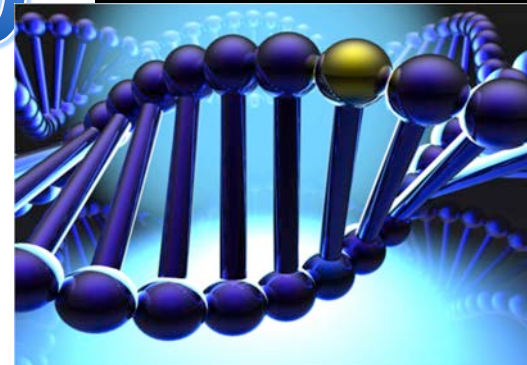
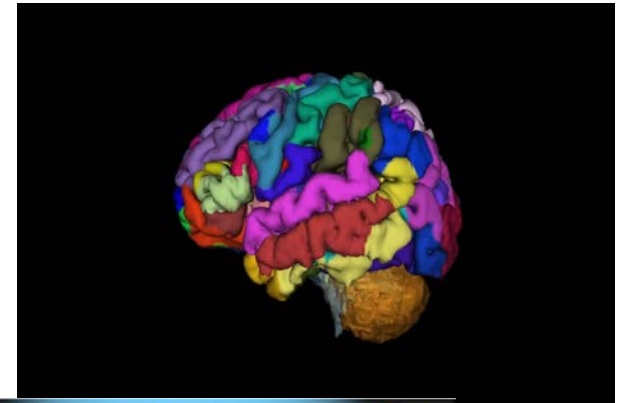
futuribles





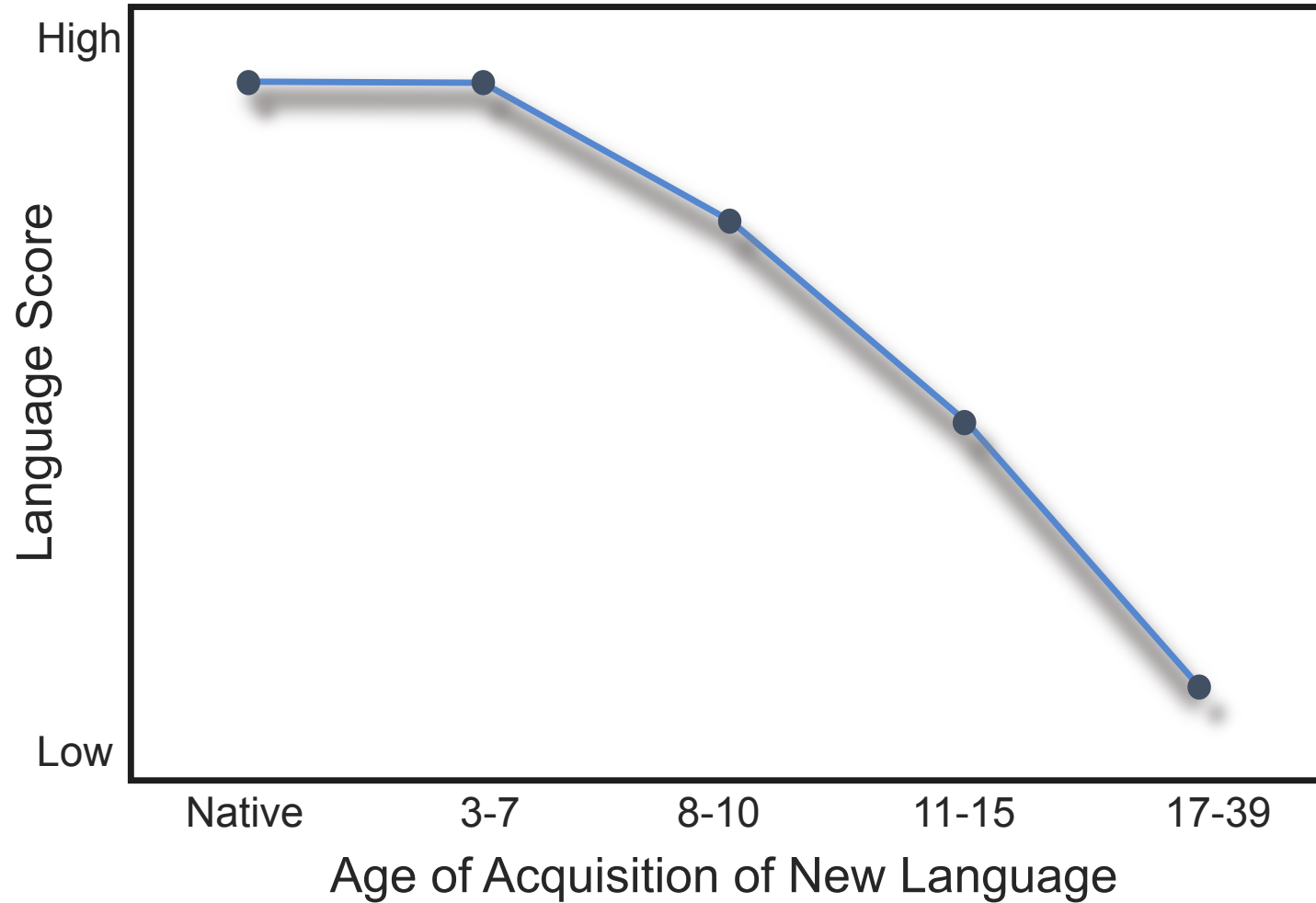
Brain Function

Brain Structure



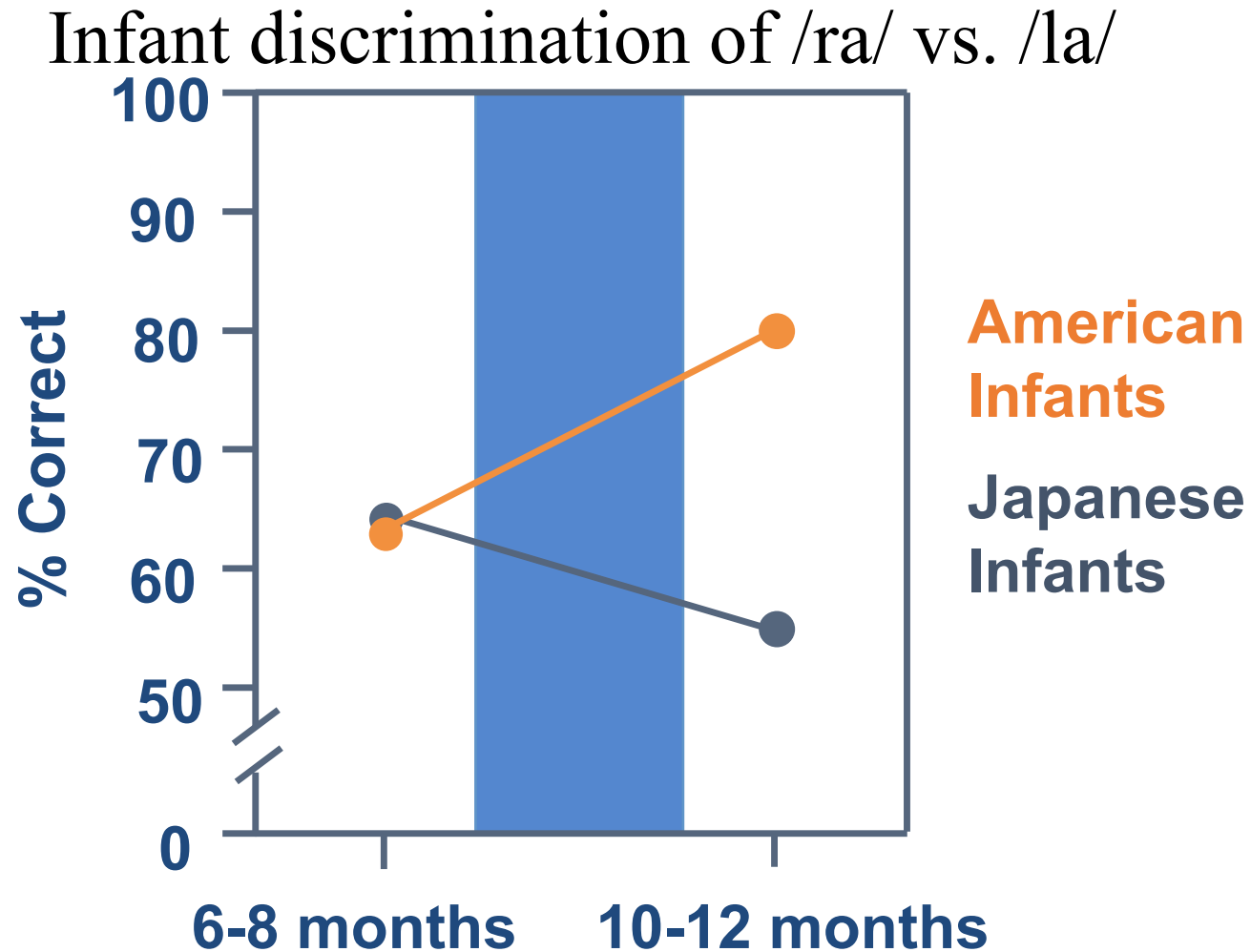
Genes

The 'Critical Period' for Language



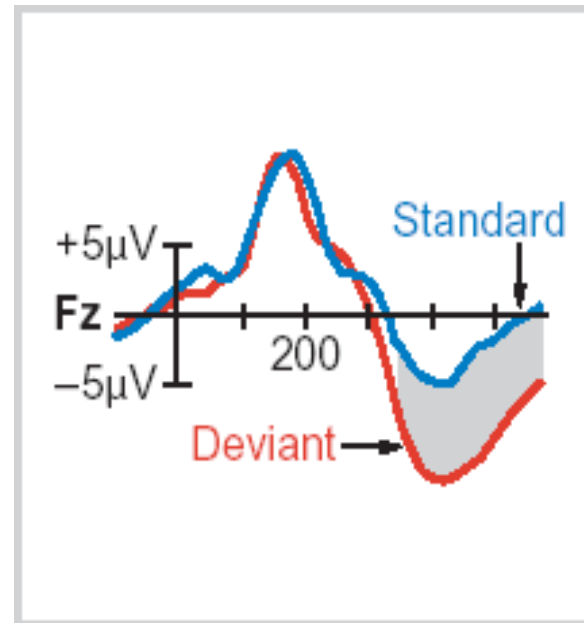


A 'Sensitive Period' for Speech Learning



Neural Signatures of Speech Learning

Event-related Potential (ERP): Mismatch Negativity (MMN)



Mismatch Negativity (MMN)

Powerful Learning Mechanisms

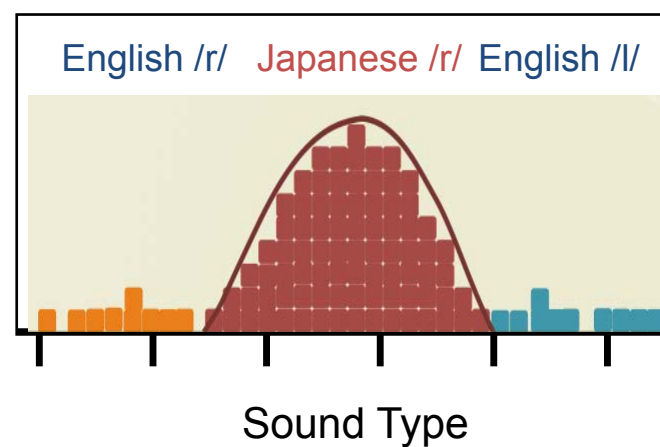
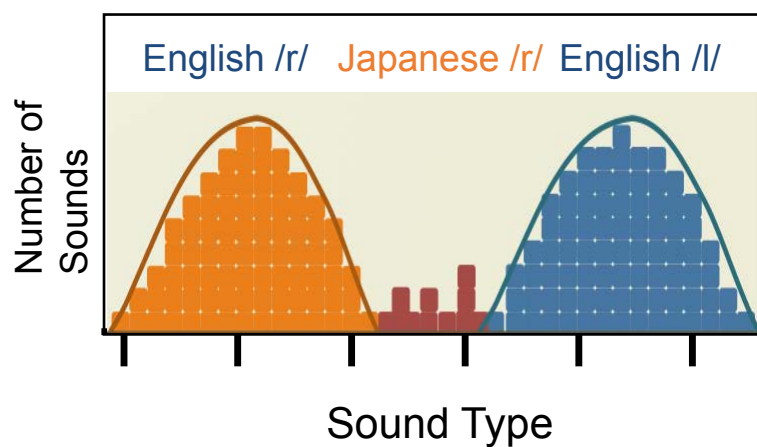
Statistical Learning + Social Context

Infants Take Statistics

English Speaker

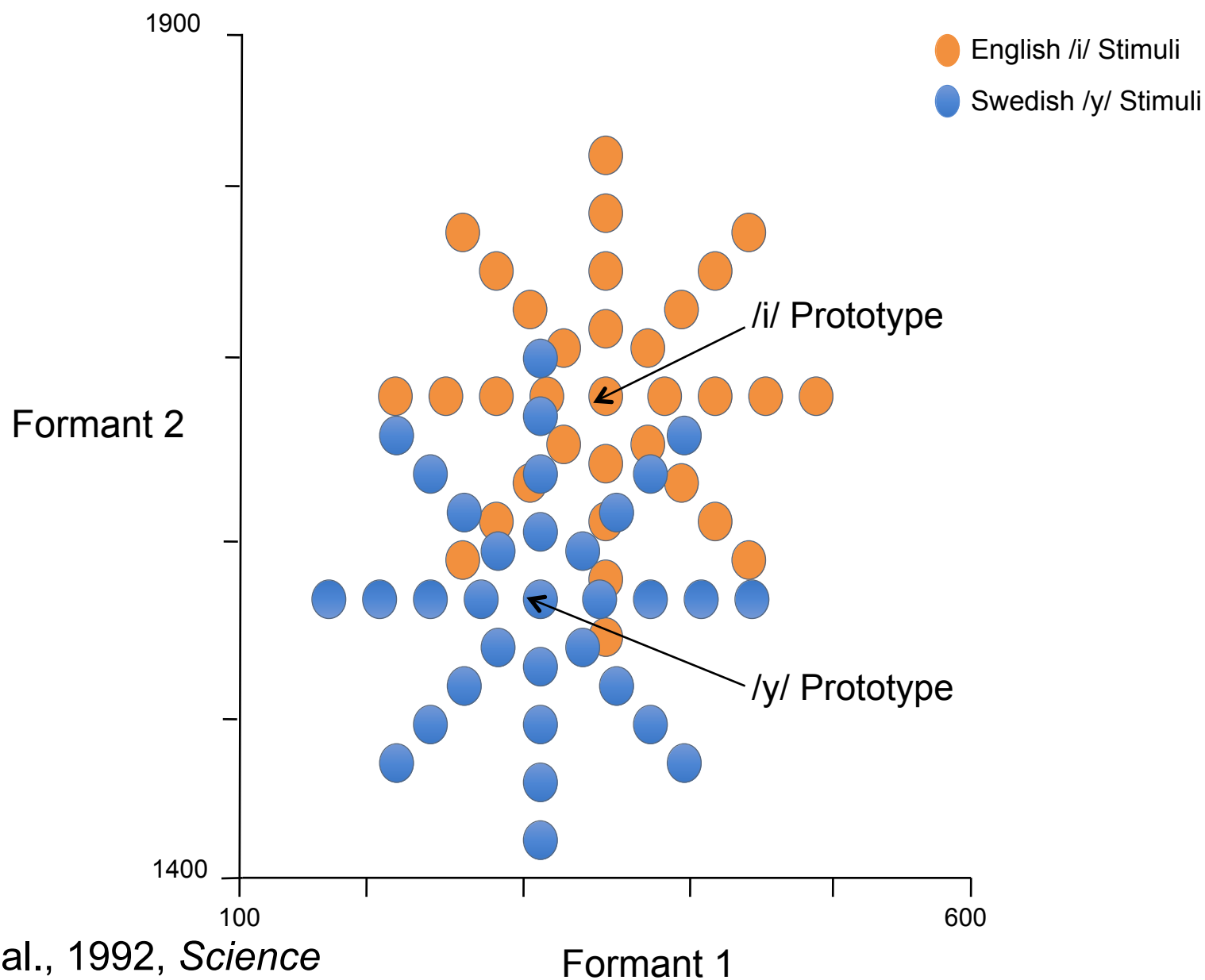


Japanese Speaker



Kuhl et al., *Science*, 1992; TED.com, 2011

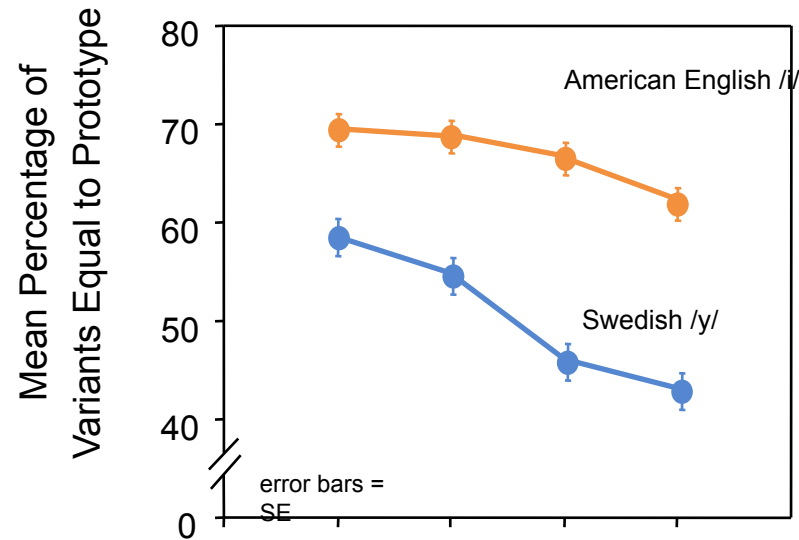
Infants' Sensitivity to Statistical Cues



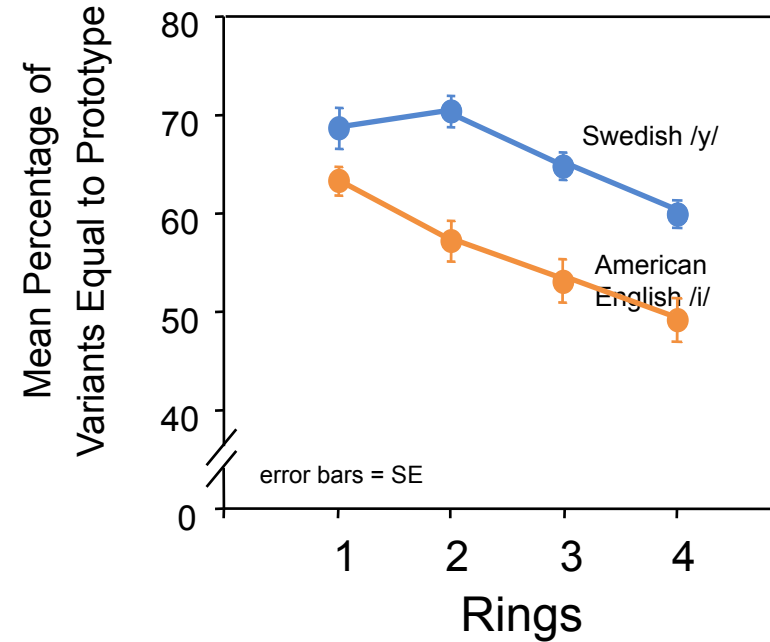
Kuhl et al., 1992, *Science*

Infants' Categorization

**American
Infants**



**Swedish
Infants**

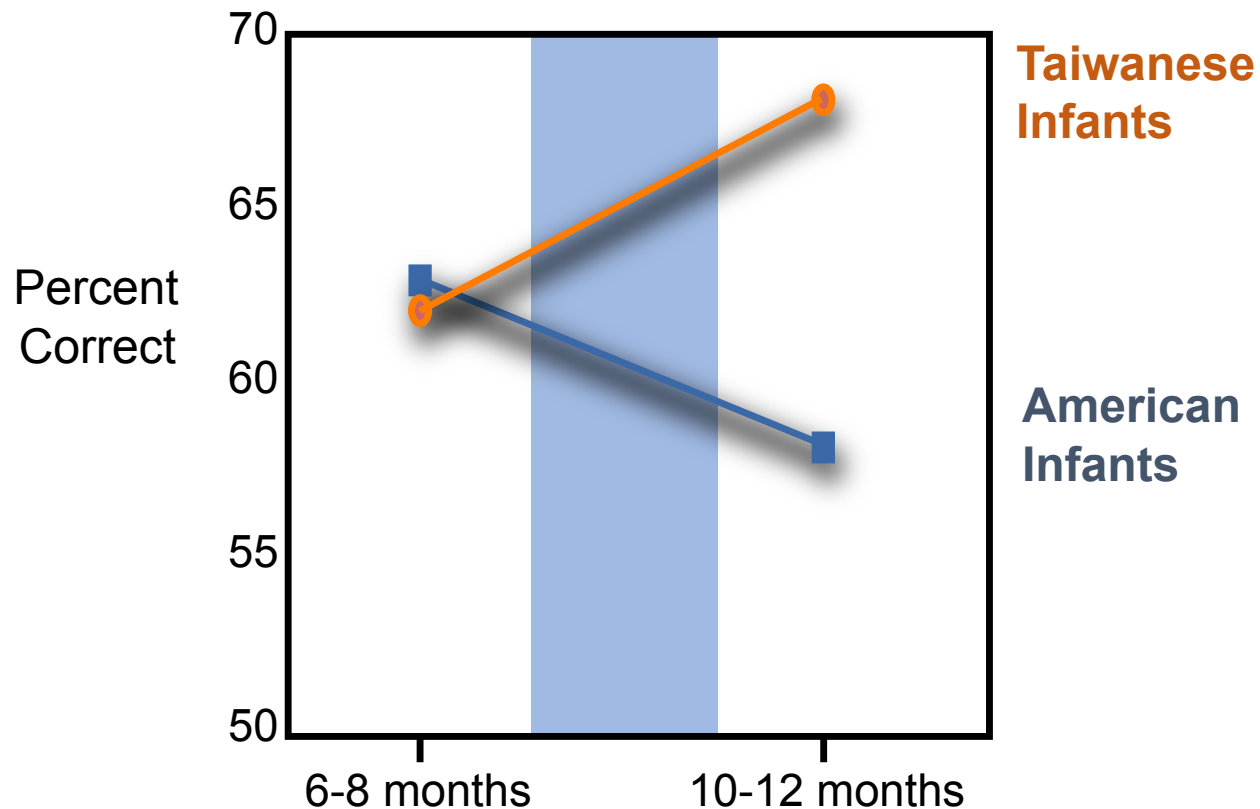


New Question:

Can infants 'take statistics' on a new language during the sensitive period?

Perception of Mandarin Chinese Sounds

**Intervention: 12 sessions, 25 minutes each,
4 different talkers (mean # of syllables = 33,000)**



Kuhl, Tsao & Liu, *Proceedings of the National Academy of Sciences*, 2003

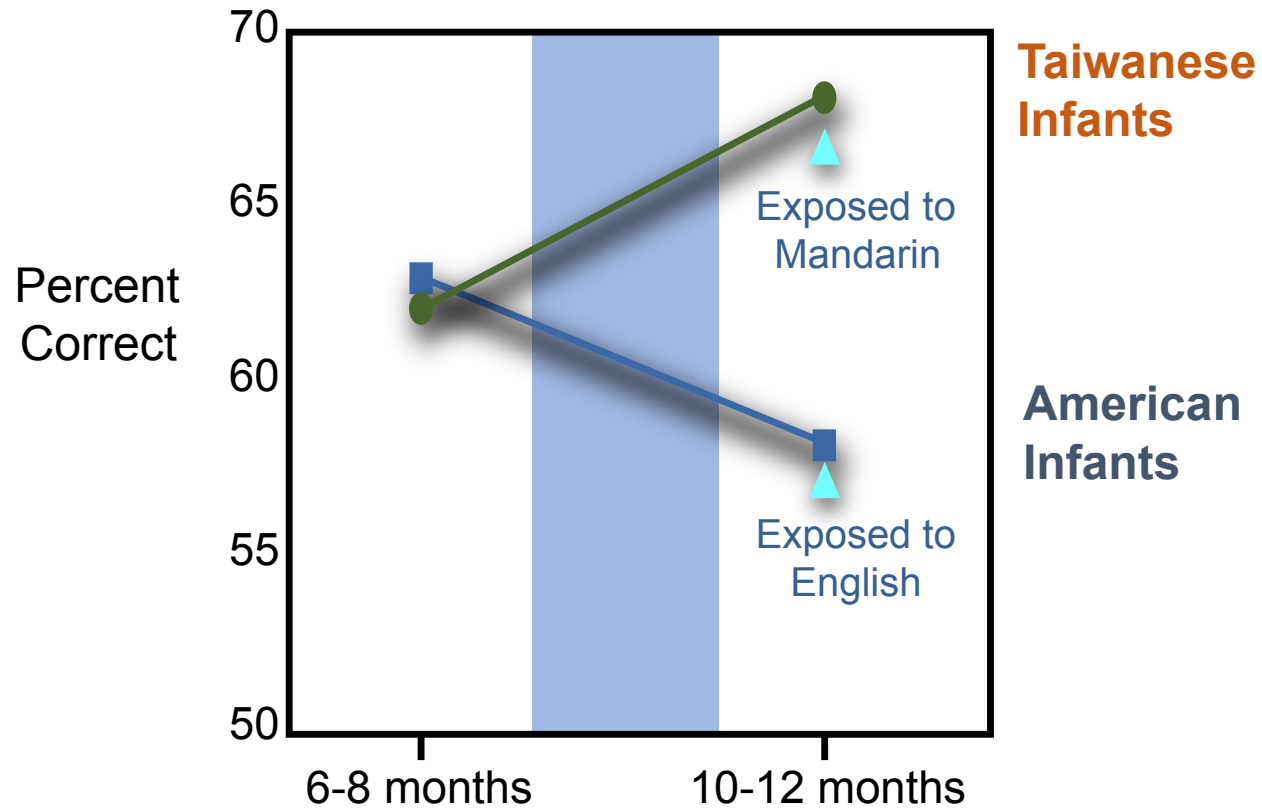
Mandarin Chinese Exposure

12 sessions between 9 and 10.5 months of age



Kuhl, Tsao & Liu, *Proceedings of the National Academy of Sciences*, 2003

Did Infants Learn?



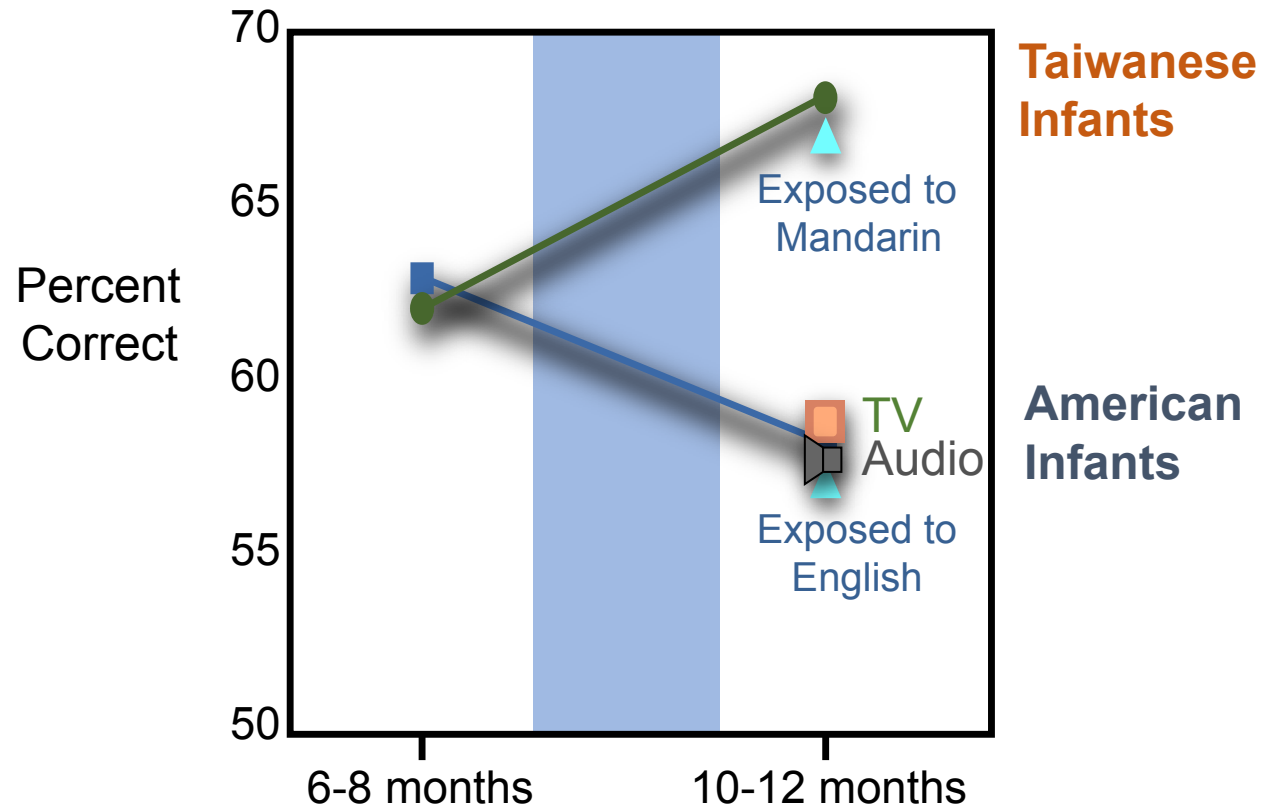
Kuhl, Tsao & Liu, *Proceedings of the National Academy of Sciences*, 2003

Do Infants Learn From a Machine?



Kuhl, Tsao & Liu, *Proceedings of the National Academy of Sciences*, 2003

Do Infants Learn Language From Video?



Kuhl, Tsao & Liu, *Proceedings of the National Academy of Sciences*, 2003

Magnetoencephalography (MEG)

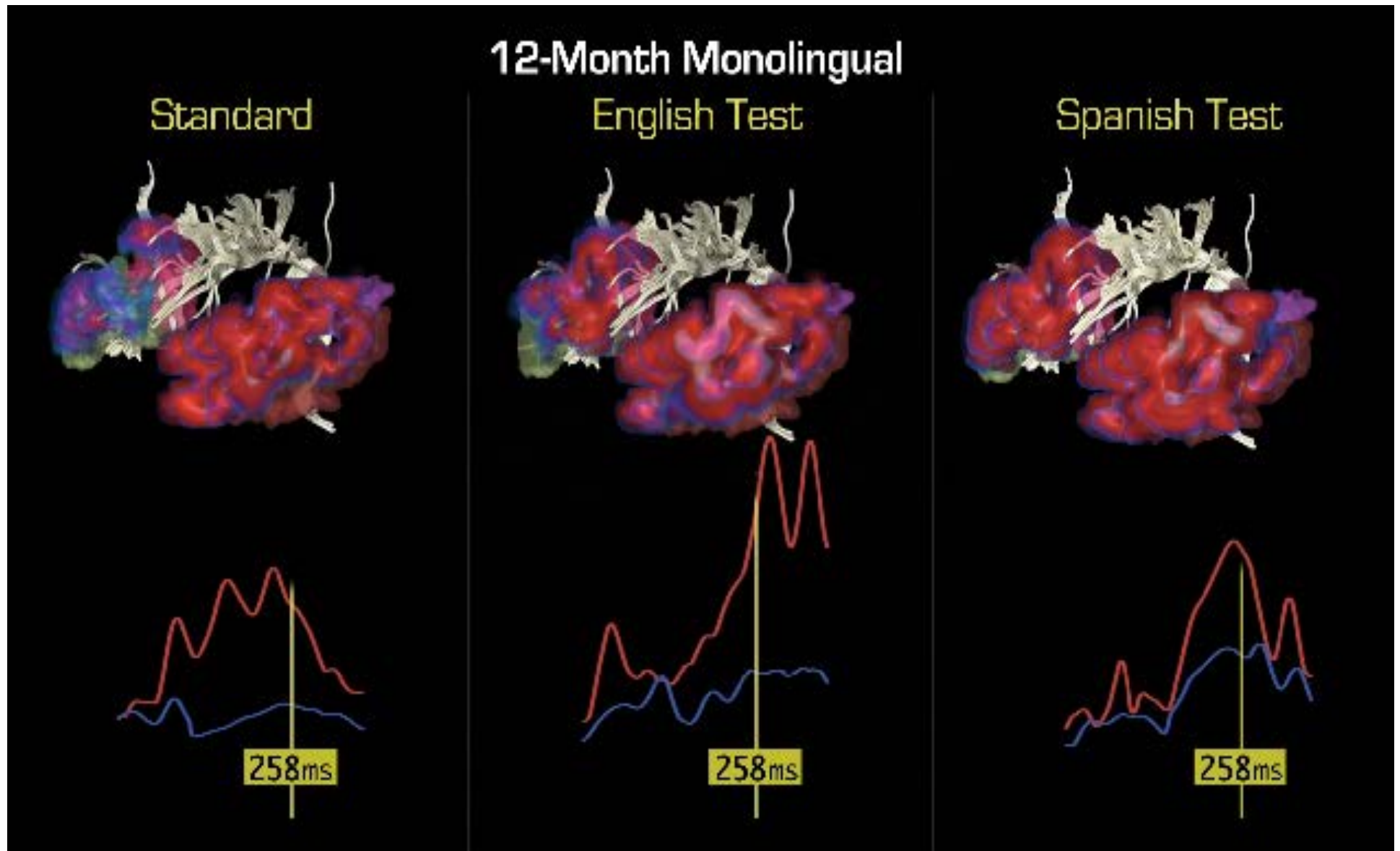


Baby MEG



Imada, et al., *NeuroReport*, 2006; Kuhl, et al., *PNAS*, 2014

Baby Brain ‘Rehearses’ a Response to Speech



Kuhl et al., *Proceedings of the National Academy of Sciences*, 2014

Bilingual Baby Intervention in Madrid, Spain

The Bilingual Brain

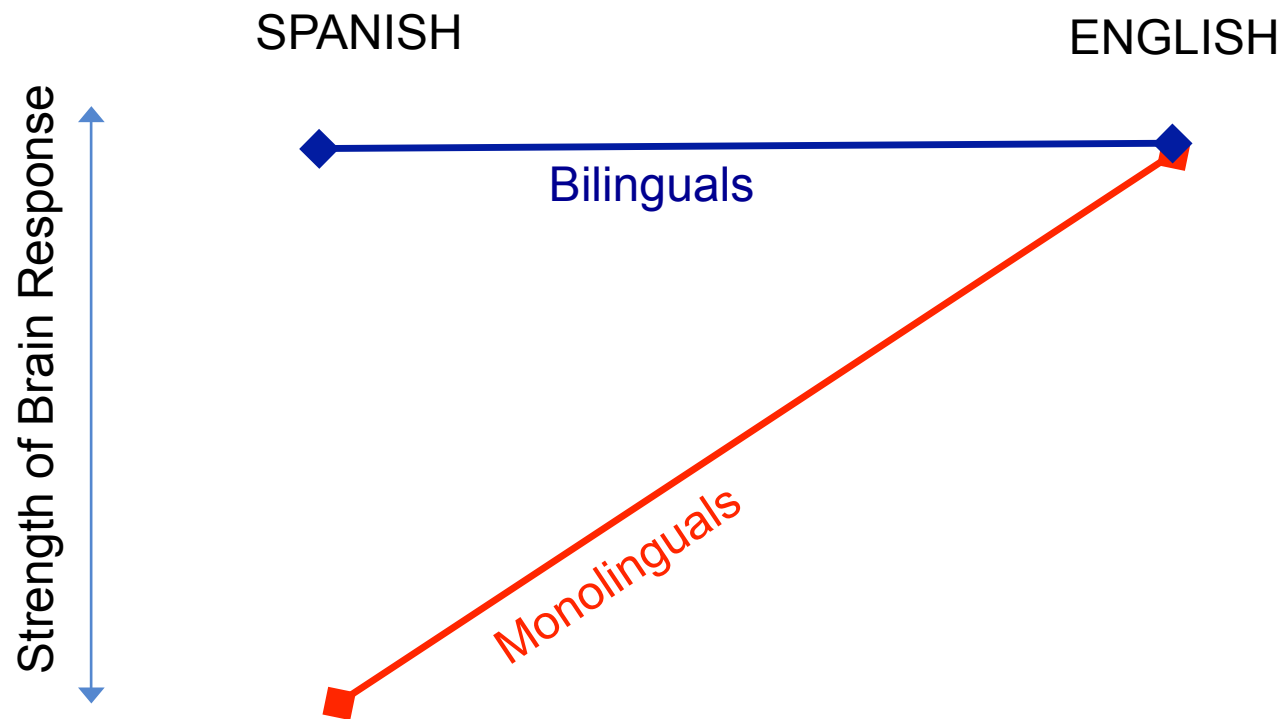


11-month-old Bilingual and Monolingual infants listen to English and Spanish

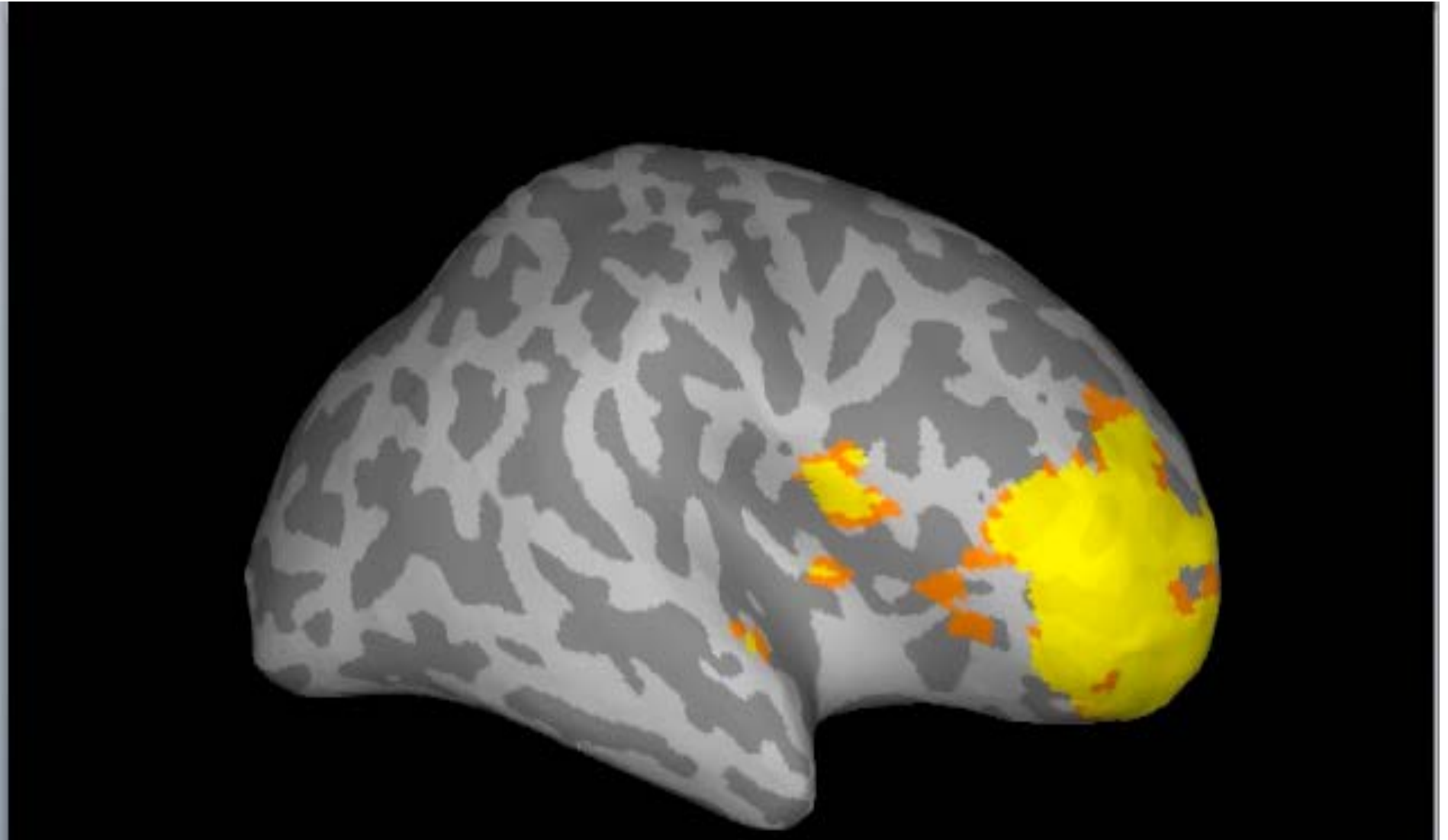


Ferjan-Ramirez, Ramirez, Taulu, Clark & Kuhl, *Developmental Science*, 2017

MEG Results on Monolingual and Bilingual 11-month-old Infants



Bilingual Babies Show Greater Prefrontal Activation: Cognitive Flexibility



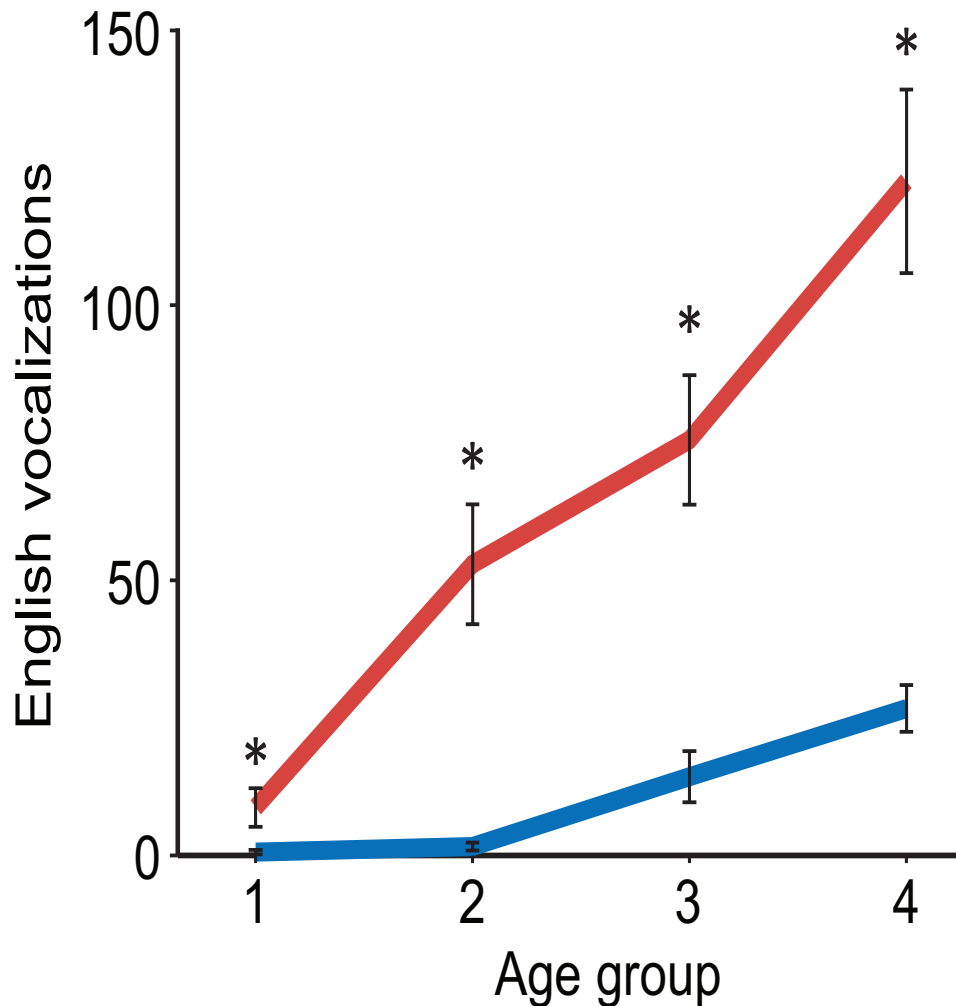
Ferjan-Ramirez, Ramirez, Taulu, Clarke, & Kuhl, *Developmental Science*, 2017

Bilingual Babies: Madrid!



Naja Ferjan-Ramirez & Kuhl, *Mind, Brain, and Education*, 2017

I-LABS bilingual learning in school: 18 weeks, 1hr/day



— Intervention	Age Group
— CPC	1 - 7-14 months
	2 - 14-20.5 months
	3 - 20.5-27 months
	4 - 27-33.5 months

Children who experienced I-LABS Bilingual Baby method and curriculum show extraordinary gains compared to children who experienced current bilingual teaching methods in use in Madrid.

Ferjan-Ramirez & Kuhl, *Mind, Brain, and Education*, 2017

■

CPC

1 - 7-14 months

Bilingual Graduates



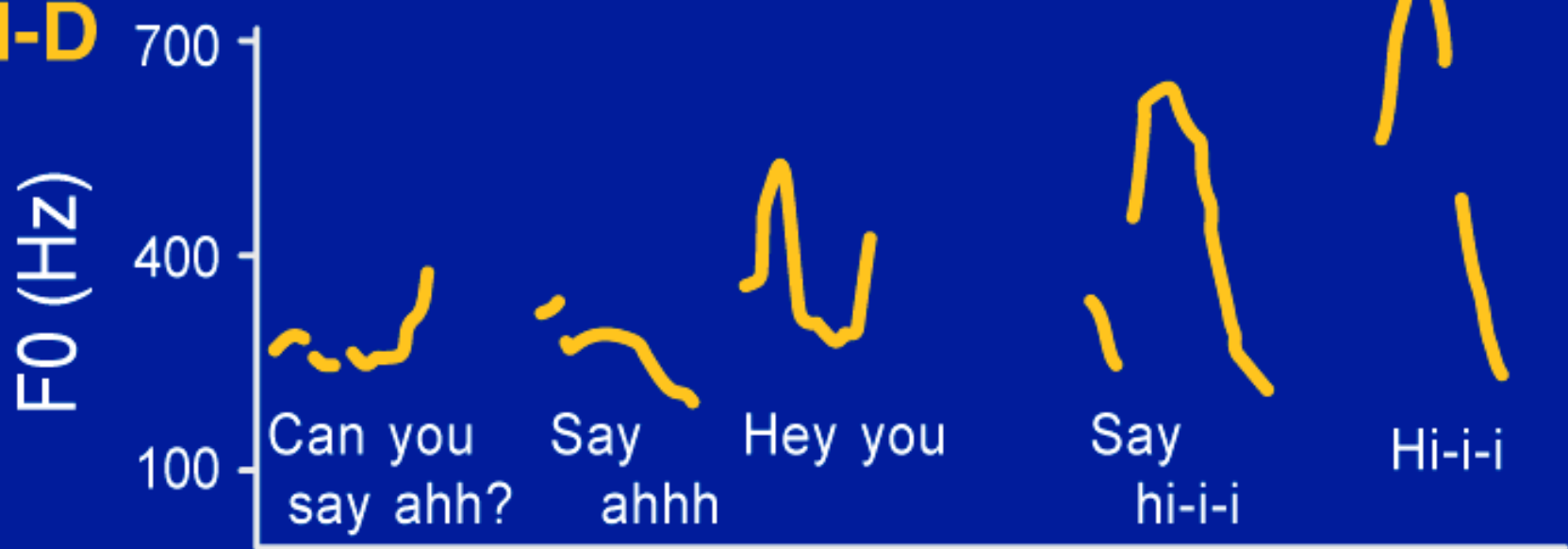
Ferjan-Ramirez & Kuhl, 2017, *Mind, Brain & Education*

Language Skills are Malleable

A-D

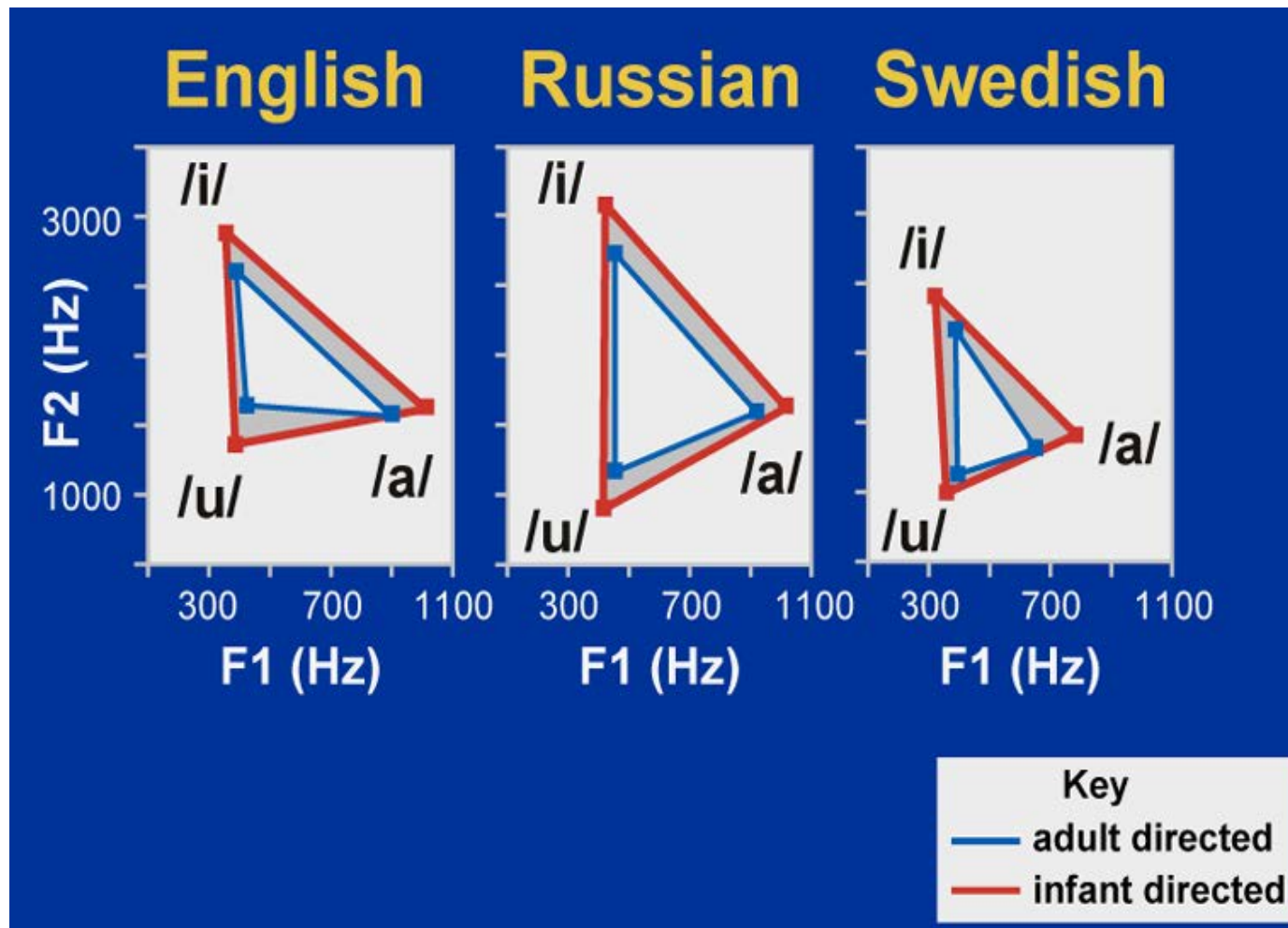


I-D



Time →

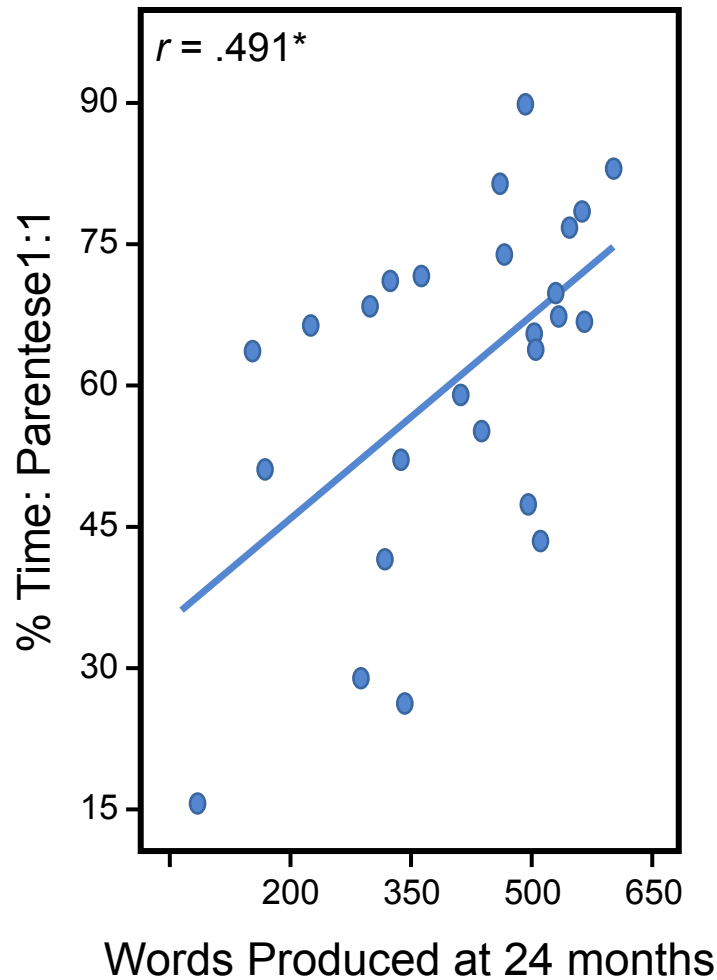
'Parentese' Exaggerates Acoustic Differences Between Phonetic Units



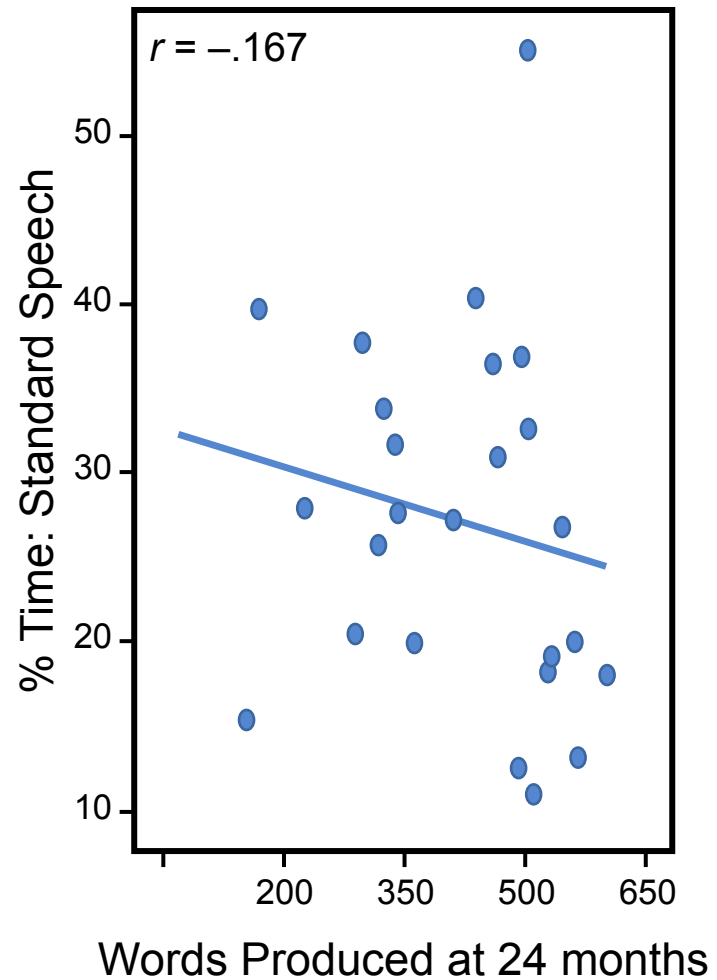
Kuhl et al., *Science*, 1997

'Parentese' One-to-One Associated with Advanced Later Language Skills, regardless of SES

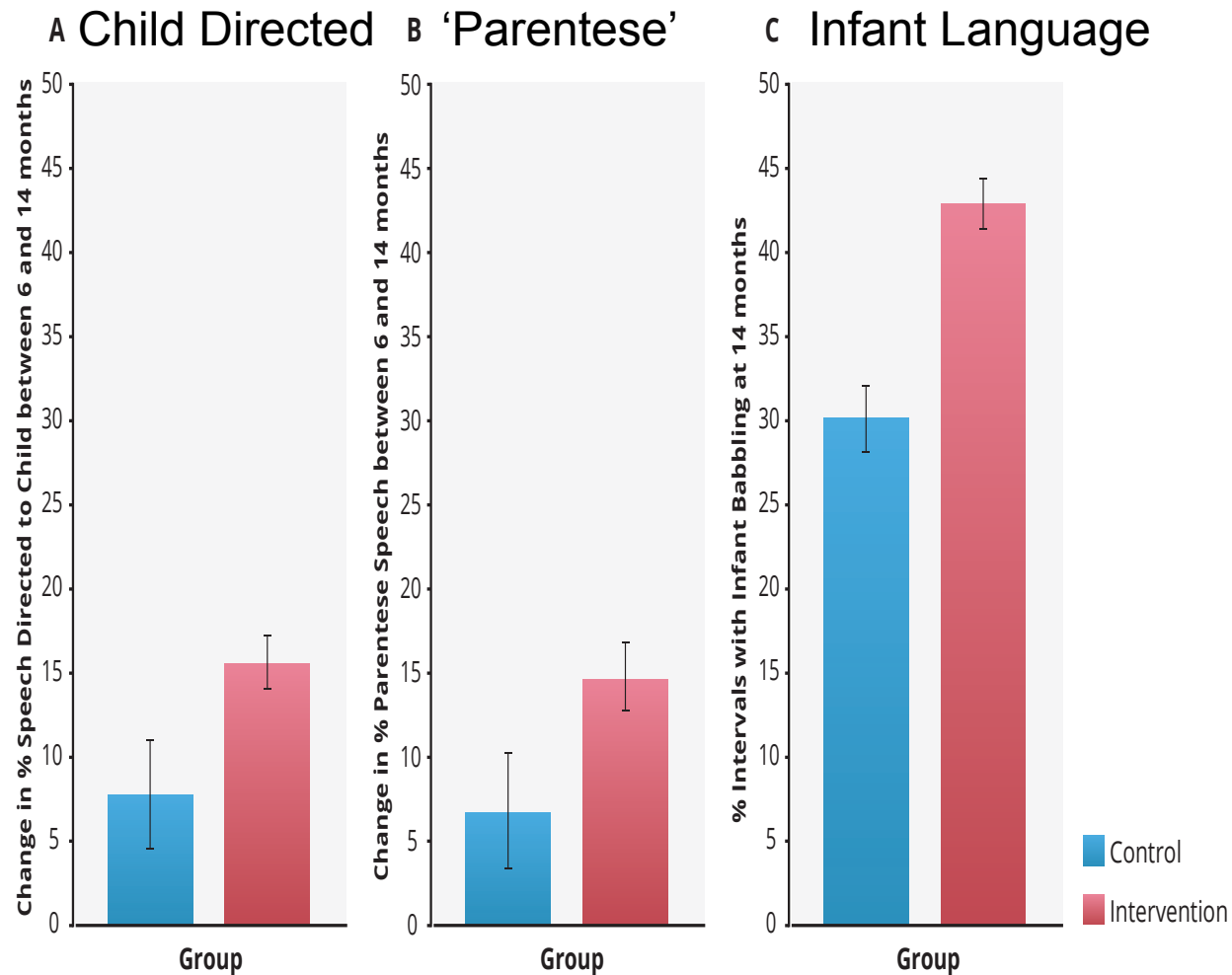
Parentese Speech



Standard Speech



Parent 'Coaching' at 6 and 10 Months Enhances Infant Language at 14, 18, and 24 Months



Ferjan-Ramirez, Lytle, Fish & Kuhl, *Developmental Science*, 2018

Does Music Intervention Affect the Brain?



- The “waltz”
- Social environment
- 12 sessions over one month’s time
- Brain tests after exposure
- Track language development until 30 month of age

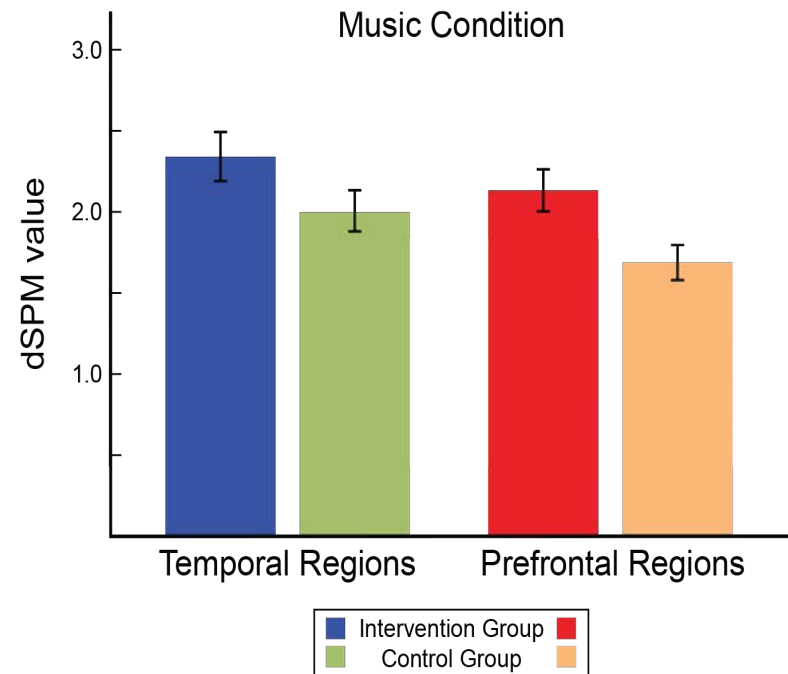
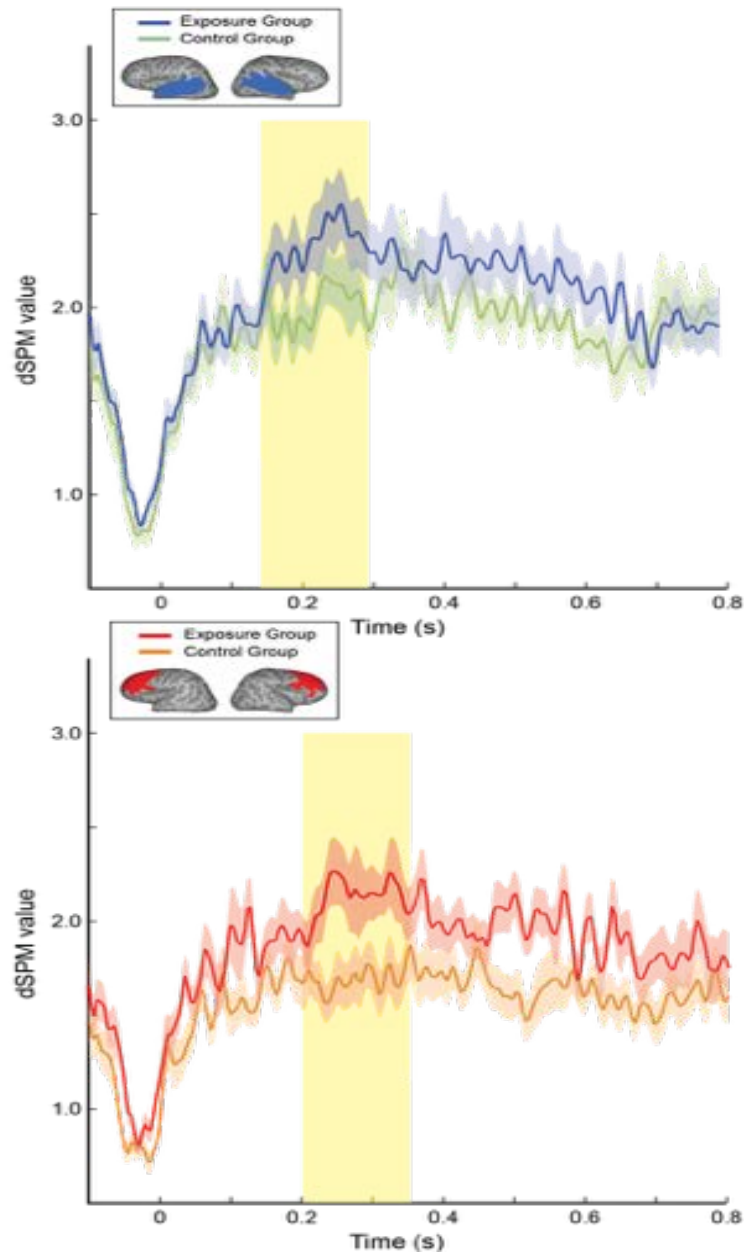
Zhao & Kuhl, *Proceedings of the National Academy of Sciences*, 2016

MEG Tests of Temporal Processing for Music and Speech



Zhao & Kuhl, *Proceedings of the National Academy of Sciences*, 2016

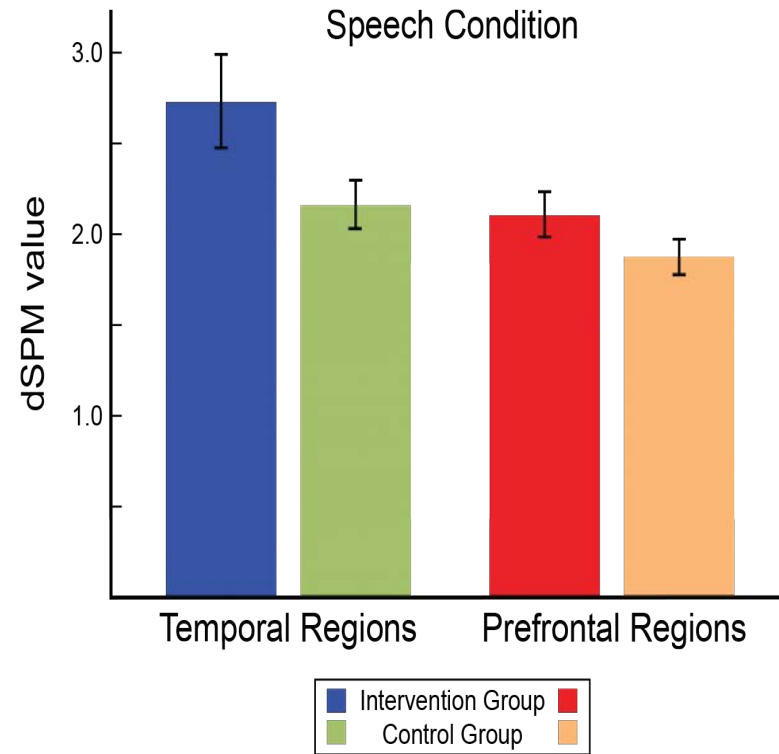
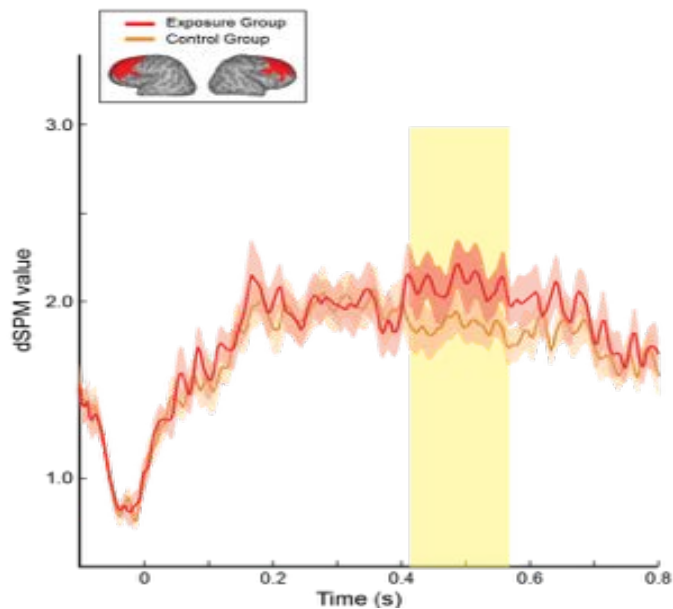
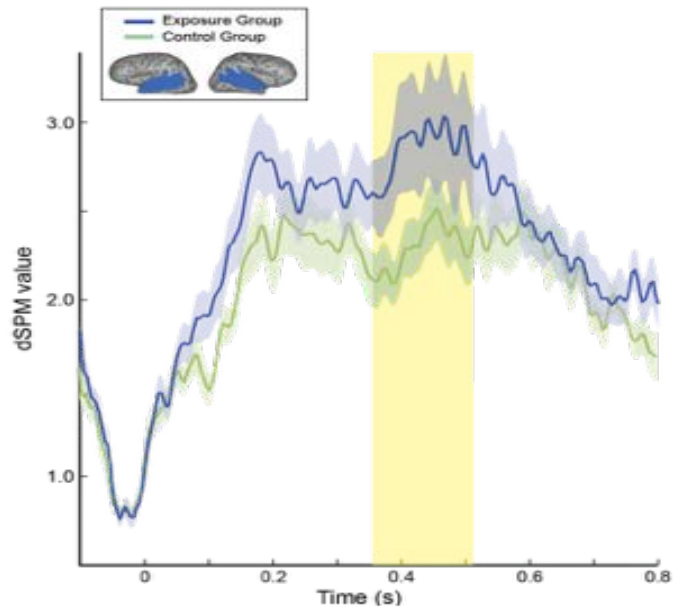
MEG Results for Music Test



Significant differences in both Auditory and Prefrontal Cortex for detection of violations in musical rhythm, with the Intervention group showing stronger responses.

Zhao & Kuhl, *PNAS*, 2016

MEG Results for Speech Test



Significant differences in both Auditory and Prefrontal Cortex for detection of violations in speech rhythm, with the Intervention group showing stronger responses.

Zhao & Kuhl, *PNAS*, 2016

The Future: Science of Learning



The image features a collage. On the left is the cover of the July 17, 2009 issue of *Science*, showing two brain scans with highlighted regions and a chalkboard with the alphabet and numbers. On the right is a diagram with a central yellow circle labeled "NEW SCIENCE OF LEARNING". Four white arrows point towards this center from four surrounding images: a woman with a child (Psychology), a brain scan (Neuroscience), a baby (Machine Learning), and children at a table (Education).

Foundations for a New Science of Learning

Andrew N. Meltzoff,^{1,2,3*} Patricia K. Kuhl,^{1,3,4} Javier Movellan,^{5,6} Terrence J. Sejnowski^{5,6,7,8}

Human learning is distinguished by the range and complexity of skills that can be learned and the degree of abstraction that can be achieved compared with those of other species. *Homo sapiens* is also the only species that has developed formal ways to enhance learning: teachers, schools, and curricula. Human infants have an intense interest in people and their behavior and possess powerful implicit learning mechanisms that are affected by social interaction. Neuroscientists are beginning to understand the brain mechanisms underlying learning and how shared brain systems for perception and action support social learning. Machine learning algorithms are being developed that allow robots and computers to learn autonomously. New insights from many different fields are converging to create a new science of learning that may transform educational practices.

Meltzoff, Kuhl, Movellan, & Sejnowski, *Science* (2009)

Thank You!

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