BUILDING ENGLISH FLUENCY IN THE ELL BRAIN
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THE BILINGUAL BRAIN

DeHaene, 2009

THE HUMAN BRAIN IS AN EXPERIENCE-DEPENDENT ORGAN

• But exactly how does experience drive neuroplasticity?
Much of the change in brain structure occurs early in life. But...

THE HCP TOOLS AND SUPPORT HELP RESEARCHERS UNDERSTAND HOW INFORMATION IS CODED AND TRAVELS IN THE BRAIN

Microscale – edges and nodes

- Macroscale - connectome

NODES, EDGES AND MODULES CLOSE UP

- Nodes (orange dots) are connected by short and long-range edges (light blue lines) within modules (in green dotted circle).
- Connections between nodes, for example node a and node b, can have a short path length (solid yellow arrow) or a long length (dotted yellow arrow).
- Rich club nodes (red glowing dots) are connected across modules with strong (solid dark blue lines) and weak (dotted dark blue lines) long-range edges.

SECOND LANGUAGE LEARNING

- Affects the way the brain is organized for language
- Differs depending upon when the second language is learned
- After the critical period, requires the same developmental criteria as the first language
Brain Wired for Language

- Learning language is an early “test” of our brain’s learning system
- At birth, we have equal potential to learn any language
- By 6 months, we begin to build the phonemes specific to our native language based on experience

In infancy, we record and map the speech sounds of our first language in the auditory cortex of the left hemisphere.

Newborn babies have inbuilt ability to pick out words

Neuroscience News January 29, 2019

Using a painless technique called Near-Infrared Spectroscopy, which shines light into the brain, they were able to measure how much was absorbed, telling them which parts of the brain were active. NeuroscienceNews.com image is in the public domain.

Organization of cortical responses to spoken language in 3 month old infants

Dehaene-Lambert et. al. 2006
Researchers can see the actual map using electrodes placed on the temporal lobe.

The map continues to refine itself through early childhood based on language experience.

N. Mesgarani et al. Science 2014;343:1006-1010

Think of these neural clusters as keys on a piano.

- Each language has its unique keyboard.
- A child raised with English records a keyboard of the 44 speech sounds or phonemes of English.
- A child raised with Spanish records a keyboard of the 26 phonemes of Spanish.
- Learning a second language required the brain to build new "keys" — clusters or sets of neurons — to access the new language accurately and quickly.

Re-tuning the keyboard.

- Using the principles of brain plasticity, Fast ForWord® exercises build and tune the inner keyboard for English.
- Perceiving and sounding out English words becomes easy and automatic.
- The exercises that build the English keyboards for ELL students also correct mushy keyboards in the brains of struggling readers.
IMPORTANCE OF SPEECH SOUND PERCEPTUAL EXPOSURE IN LEARNING A NEW LANGUAGE

• Authors - Jari L. O. Kurkela, Jari L. O., Jarmo A. Hämäläinen, Paavo H. T. Leppänen, Hua Shu, and Pia Astikainen

HIGHLIGHTS (KURLEA ET AL, 1018)

• Passive exposure to speech sounds induces plastic changes in the mature human brain.
• Plasticity was indexed by electrophysiological measures (the MMN, P3a and P3b of event-related potentials).
• The effect of passive exposure transfers to some extent to non-speech sounds.
• Results encourage applying passive exposure to real-life learning situations.

RAPID INCREASE IN STUDENTS FROM POVERTY

THERE IS ALSO AXONAL PLASTICITY –REMAPPING “SPECTACULAR EXAMPLE” (SAPOLSKY, 2017)

• When a blind person, adept at Braille reads, there’s the same activation of the tactile cortex as anyone else
• However, there is also activation of the visual cortex
• Neurons abhor a vacuum – ergo diaschisis

"Neurons that normally send axons to the fingertip-processing part of the cortex instead have gone ‘miles’ off course, growing..."
Language Experiences by Group

SOCIAL COMPETENCIES (CASEL, 2013)

Collaborative for Academic, Social, and Emotional Learning (CASEL)

Attributes of a "seen" object

- Shape: sphere
- Color: yellow
- Dimensionality: 3D
- Solidity: yes
- Pattern: none
- Movement: no
- Transparency: no
- Texture: fuzzy

Slide, courtesy of Nina Kraus, brainvolts.northwestern.edu

Attributes of sound

- Pitch: high
- Intensity: loud
- Consistency: dissonant
- Consonance: dissonant
- Location: straight ahead
- Movement: left to right

Slide, courtesy of Nina Kraus, brainvolts.northwestern.edu
THE HUMAN AUDITORY SYSTEM

Slide, courtesy of Nina Kraus, brainvolts.northwestern.edu

Making sense of sound

Outside
Inside
Soundwaves
Air pressure
Electricity

SIGNALS
the head

AUDITORY VS. VISUAL PROCESSING SPEED

Slide, courtesy of Nina Kraus, brainvolts.northwestern.edu

3/12/2019
AUDITORY VS. VISUAL PROCESSING SPEED

Cochlea

Sound

Action potential every 1 ms!

40 ms for photons striking retina to trigger action potential

Retina

Light

AUDITORY PROCESSING SPEED

Left Ear

Auditory Brain

Right Ear

Slide, courtesy of Nina Kraus, brainvolts.northwestern.edu
3/12/2019

**SOUNDWAVE**

**BRAINWAVE**

da high

das?

dobie

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34. **THERE IS ALSO AXONAL PLASTICITY – REMAPPING “SPECTACULAR EXAMPLE” (SAPOLSKY, 2017)**

- When a blind person, adept at Braille reads, there’s the same activation of the tactile cortex as anyone else.
- However, there is also activation of the visual cortex.
- Neurons abhor a vacuum – ergo diaschesis.

“Neurons that normally send axons to the fingertip-processing part of the cortex instead have gone ‘miles’ off course, growing projections to the visual cortex.” page 144

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**Figure 1 | Influence of a single neuron on the surrounding network.** Chettih and Harvey describe a model of network computation. They found that experimental stimulation of a single neuron (yellow) predominantly caused widespread inhibition (red) of the activity of neighboring neurons. Stimulation also had an excitatory effect (blue) at short distances (25–70 μm), which affected a small proportion of neighboring neurons, and almost no effect (grey) on neurons at long distances (more than 300 μm).


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**ADDITIONAL FACTORS THAT AFFECT ELL**

- Under 40%
- 40% +
- Percentage of Low Income Students
- Percentage of Low Income Students in U.S. Public Schools
- Current National Average 51%
BILINGUAL BRAIN ADVANTAGES

- Researchers now believe that when people learn another language, they develop cognitive advantages that improve their attention, self-control and ability to deal with conflicting information.

BILINGUALS – BETTER WITH MENTAL COMPETITION

- Judith Kroll, an expert on bilingualism is director of the Center for Language Science at Penn State.
- Bilinguals are “apparently able to keep languages separate while keeping them both available and active in their minds at the same time.”
NEW BILINGUAL RESEARCH

• Anderson et al (2018) Language and Cognitive Control Networks in Bilinguals and Monolinguals Neuropsychologia · June 2018 DOI: 10.1016/j.neuropsychologia.2018.06.023

THE BILINGUAL BRAIN ADVANTAGE

• https://www.bing.com/videos/search?q=the+bilingual+advantage+ted+talk&&view=detail&mid=DA13DD0211A03BC50978DA13DD0211A03BC50978&rvsmid=6BFD4ABB75D5A9E7BAB86BFD4AB B75D5A9E7BAB8&FORM=VDMCNR

BLANCO-ELORRIETA AND LIINA PYLKKÄNEN (2018)

• Commanding more than one language is the norm for the majority of the world’s population, and
• multilingualism has been notably increasing in recent years.
  – A remarkable feature of multilingual individuals is their ability to quickly and accurately switch back and forth between their different languages.
  – Thus, multilingual individuals not only command each of their languages independently, but they are additionally able to alternate and coordinate the rules that govern each language.

THE BILINGUAL BRAIN ADVANTAGE

• A growing body of research reports domain-general changes in nonverbal cognitive control for bilinguals that are frequently associated with enhanced performance on some types of executive function tasks (reference 5)
• When other socio-demographic variables are considered, these effects of bilingualism persist into older age as protective factors; for example, bilinguals have been shown to display symptoms of dementia at a significantly older age than monolinguals. (reference 6)
THE BILINGUAL BRAIN ADVANTAGE (CONTINUED)

- Furthermore, recent research has identified a set of structural and functional brain differences between monolinguals and bilinguals that may reveal the neural substrate of the mechanism reflected in the behavioral effects.

A DECADE LATER (2008)

Figure 1. (A) LIFC activation in bilinguals > monolinguals contrast for English language (BA 45; x = -48, y = 38, z = 4, t = 4.35, p < .001, uncorrected; cluster size k > 10 voxels). Hot/red colors refer to activation unique to bilinguals, spring/green colors refer to the shared activation between bilinguals and monolinguals on the syntactic task in English. (B and C) ROI analysis of LIFC activation for SO and OS sentences in monolinguals in English and bilinguals in English and Spanish (BA 44; x = -46, y = 16, z = 24, t = 6.18; Tukey HSD, p < .05). Color scale represents t-value.

SWITCH COSTS

- Research has led to the conclusion that language switching is behaviorally effortful [i.e., there are switch costs]
  - Switch cost: the slower behavioral responses (and associated neural effects) elicited by switching languages for a given item, as compared to not switching.

Language Switching prompted by a cue elicits Executive Control Regions

Neurobiological investigations using these paradigms have additionally found that language switching as prompted by a cue elicits engagement of executive control regions, mainly the prefrontal cortex, the pre-supplementary motor area/anterior cingulate cortex, and the left caudate nucleus.

ANDERSON, ET AL (2018) LANGUAGE AND COGNITIVE CONTROL NETWORKS IN BILINGUALS AND MONOLINGUALS

In summary, we showed that while bilinguals and monolinguals have similar brain responses to increasing task difficulty across trial types, and similarly distinguish between verbal and nonverbal task, the interaction of the two reveals unique network recruitment.

Bilinguals recruit overlapping sets of regions for language and executive functions.

Bilingual experience with switching in everyday life appears to have furnished them with a superior and more efficient mechanism that extends beyond language and into switching between tasks.

DOI: 10.1016/j.neuropsychologia.2018.06.023
Second Language Learning is very good for the brain

At the Institute for Learning and Brain Sciences at the University of Washington, 9-month-olds listen to Mandarin Chinese in play sessions with native speakers of Mandarin. On this week’s podcast, we’ll hear how some psychologists say being bilingual may actually be good for children’s cognitive development.

http://www.npr.org/player/112/mediaPlayer.html?action=1&d=135106090-135043787

IMPLICATIONS FOR EDUCATORS: FOUR CONSIDERATIONS

1. Native Language competence
   - The better the language skills of a student’s native language — the better the second language will be learned
     • The research does support determining the second language learner’s native language competence before determining the best approach for second language learning
   - Immersion may frustrate a student whose native language skills are impaired
     • If there is a Specific Language Impairment

2. Evidence suggests that older second language learners require and benefit from direct instruction that:
   - Includes auditory training on perceptual differences
   - Includes direct teaching of grammar

IMPLICATIONS FOR EDUCATORS: FOUR CONSIDERATIONS

3. Evidence that students should be encouraged to use both languages
   - Language switching builds frontal lobe structures important for attention, self-control, delayed gratification, goal orientation
   - Language switching may also facilitate right and left hemisphere language related skills
USING EXAGGERATED PHONEMES, FAST FORWARD EXERCISES
TEACH THE BRAIN TO DISTINGUISH AND LAY DOWN NEW KEYS.

RAPID AND ACCURATE LANGUAGE PROCESSING
MAKES ALL LEARNING EASIER

• Spelling, reading, and writing progress more quickly.
• Teachers can move on to what they can do best.

THE ROLE OF NEUROSCIENCE TECHNOLOGY

• Well designed neuroscience-based technology builds the underlying capacities that are reduced in some children of poverty or with learning issues.

SOCIAL COMPETENCIES (CASEL, 2013)

Collaborative for Academic, Social, and Emotional Learning (CASEL)
COGNITIVE CONTROL IS TRAINABLE

- Fast ForWord as an Executive Training Program
- Research indicates that two of the best methods for building SR are:
  - Exercising and enhancing working memory
  - Exercising and increasing Selective and Sustained Attention

MORGAN ET AL PENN STATE

- Executive function deficits in kindergarten predict repeated academic difficulties across elementary school
- *Early Childhood Research Quarterly*
- Volume 46, 1st Quarter 2019, Pages 20-32
- [https://doi.org/10.1016/j.ecresq.2018.06.009](https://doi.org/10.1016/j.ecresq.2018.06.009)
The study compares working memory, cognitive flexibility and inhibitory control deficits to different STEM coursework starting in kindergarten. Morgan said the strongest correlation in his data set comes between math and working memory. Study results also show that kindergarten children with working memory deficits were more than twice as likely to display difficulties with science coursework through 3rd grade. 


Typically reading children         Reading Impaired Children

before remediation

after remediation

Critical Changes After FFWD L (Now Foundations I)
LANGUAGE AND READING AREAS ARE ACTIVATED AFTER SIX WEEKS

Typically reading children         Reading Impaired Children

before remediation

after remediation


BUILD ENGLISH FAST™.

Fast ForWord®
The Top Ranked English Language Development Intervention on What Works Clearinghouse.

reading assistant®
The easy program that helps to and corrects English language learners as they read and speak aloud.

OTHER REFERENCES