Transdisciplinary Assessment and Treatment of Language-based Learning Disabilities:

The Theoretical Importance of Sensory Processing



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## Neurons - How the Brain Works

- How many neurons In the brain?
  - □ ~ 100 Billion
- How many connections exist in the neural networks formed in the brain?
  - □ ~ 100 Trillion
- How many "connections" from one neuron?

□ ~ 40,000

- The brain is specifically designed for learning and behaviors. It is ready and willing to create neural networks.
- Learning to drive?
- Driving to Ft. Lauderdale.....

#### pIFG/dPM (left) articulatory-based speech codes

#### Area Spt (left) auditory-motor interface

STG (bilateral) acoustic-phonetic speech codes

**<u>STS</u>** phoneme representations

pMTG (left) sound-meaning interface

Hickok & Poeppel (2000), Trends in Cognitive Sciences Hickok & Poeppel (2004), Cognition

### UNIQUE <u>AND</u> OVERLAPPING NETWORKS SENTENCE/SYNTACTIC, SEMANTIC, PHONOLOGICAL



How does the brain develop these distributed networks of sensory and cognitive abilities?

### **UNIVERSAL SPEECH PERCEPTION: 0-6 MONTHS**

#### SENSORY LEARNING



### **UNIVERSAL SPEECH PRODUCTION: 0-6 MONTHS**

(Kuhl, 2004)

### **UNIVERSAL SPEECH PERCEPTION: 6-12 MONTHS**

#### **Sensory Learning**





Language Specific Speech Production

(Kuhl, 2004)

# Multisensory = any senses?

 To promote language development, does it matter what sensory systems or how the sensory systems are engaged/experienced?

# Sensory Systems & Speech Perception



(Kuhl et al., 2003)

# Sensory Systems & Language

- Why did live / invivo experience with a parent improve 2<sup>nd</sup> language discrimination when TV and Headphone experience didn't?
- What sensory systems are engaged by live experience and NOT by recorded experiences?
- What do you do when you teach a baby a new word and he/she has trouble saying all the word's sounds, e.g. "ba" versus ball?



# Early Language Development

- Brain is tuned to parents' language
- What systems do newborn's integrate for speech?
  - Oral-facial movements visual
  - Speech sounds phonology
  - Speech/babble oral motor tactile kinesthetic
  - Social-emotional (non verbal tones & gestures) pragmatics

 Newborns speech perception is affected by multisensory experiences during language development.

## Sensory Systems & Language Development

Is an adult's well-developed speech perception affected by multisensory experiences?

<u>http://www.youtube.com/watch?v=eQoYKuNcCpU&f</u> <u>eature=fvwrel</u>

Spell pseudo words

How does the brain develop these distributed networks of sensory and cognitive abilities?

Sensory and motor systems that fire together wire together to form functional neural networks in a typically developing brain.

Which sensory systems are firing during development of speech perception?



# Typical LANGUAGE Networks



## Typical <u>READING</u> Areas



# "CHANGES IN SYNAPSES?"

At what chronological age do neurons lose the ability to make new connections (synapses) or networks?

Can neural networks make new connections even after documented brain injury?

Following a stroke, can partially damaged brain areas be reactivated by neurorehabilitation?

YES! New activity and improved behaviors occur in some patients.

(*Chang, et al. 2006*)



### Post-Treatment



Botton

# Principles Of Neural Plasticity

- Neurons that fire together wire together
  - Multiple, salient sensorimotor inputs that wire together can strengthen neural networks
- Optimal arousal and attention
- Consistent input/learning experiences
- Learning experiences drive neural plasticity:
  - 1. SALIENCE specificity of instruction/experience
  - 2. FREQUENCY hour(s) per day
  - 3. INTENSITY days per week
    - practice, practice, practice

(Heilman and Alexander, 2003; Kleim and Jones, 2008)

# Variability in Neural Plasticity?

- Why don't neural networks all form the same for each person's brain?
- Why do some brains work "differently" than others?

# Visual, auditory & oral sensory systems – Are they integrated well in dyslexia?

Articulation Accessing scores of subjs in sample 2



Montgomery, 1981

## WHAT DYSLEXIA IS NOT

## DYSLEXIA...

►.. is NOT A VISUAL PROBLEM

►.. is NOT A LACK OF INTELLIGENCE

 $\succ$ .. is NOT due to lack of effort

►.. is NOT A DEVELOPMENTAL LAG

 .. is NOT UNCOMMON: 5–17.5 % OF POPULATION
.. is NOT RESPONSIVE TO STANDARD READING INSTRUCTION

# DYS = trouble **LEXIA** = words <u>Dyslexia is...</u>

- Neurologic in origin genetic
- Lifelong but environment may alter course
- Reading comprehension > word reading skills
- Dyslexia may include accompanying challenges
  - > ADHD 50-70%
  - Behavioral problems
  - Sensory motor difficulty
  - = More challenging to remediate

### THE PICTURE OF DYSLEXIA (ALL STENGTHS <u>DO NOT</u> OCCUR FOR EVERYONE)

(Alexander & Conway, 2007)



## LEADERSHIP SKILLS

## THINKING "OUT OF THE BOX"



PATTON

## JFK POLITICAL & MILITARY



THOMAS EDISON EDISON SCIENTISTS & INVENTORS





#### **NEUROSURGERY**

MOHAMMAD ALI NOLAN RYAN



## THE PICTURE OF DYSLEXIA (ALL SYMPTOMS <u>DO NOT</u> OCCUR WITH EVERYONE)

(Alexander & Conway, 2006)



## THE PICTURE OF DYSLEXIA (ALL SYMPTOMS <u>DO NOT</u> OCCUR WITH EVERYONE)

(Alexander & Conway, 2006)

### **ACCOMPANYING SENSORIMOTOR CHALLENGES**





## THE PICTURE OF DYSLEXIA (ALL SYMPTOMS <u>DO NOT</u> OCCUR WITH EVERYONE)

(Alexander & Conway, 2006)

### **ACCOMPANYING CHALLENGES (BEHAVIORAL)**





#### **Parents with similar challenges**

# Dyslexia - really, what is it?



# If Phonology Is So Important, Then When Does It Begin Developing?

At what age do children begin to learn the sounds of their native language?

## **Developmental Building Blocks for Language**



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## "OUT OF LINE NEURONS" (ECTOPIAS)



FRONT

BACK

### Typical <u>READING</u> Areas



### NEURONAL MIGRATION

#### Neuronal migration goes awry in developmental dyslexia?

www.thebrain.mcgill.ca



### **NEURONAL MIGRATION**



### Neuronal Ectopia



(Ramus, 2004)



#### What effects on brain function might ectopias have? Functional MRI (fMRI)

- same machine as clinical MRI
- additional measure of blood oxygenation levels in brain
- shows brain's active areas when doing some behavior/task



### **BRAIN ACTIVITY DURING READING**



Simos, et al 2002

### TREATMENT CHANGES the BRAIN'S ACTIVITY







(Alexander, 2006)

#### **READING** (PERCEPTION/PRODUCTION)

**DYSLEXIA** 



## Theory

Developmental Dyslexia: A Motor-articulatory Feedback Hypothesis (Heilman, Voeller, Alexander, 1996)

"The inability to associate the position of their articulators with speech sounds may impair the development of phonological awareness and the ability to convert graphemes to phonemes. Unawareness of their articulators may be related to programming or feedback deficits."

### Transdisciplinary Team for Assessment & Treatment

#### Disciplines:

- Neuropsychology
- Psychiatry
- Nursing/Nurse Practitioner
- Clinical Psychology
- Occupational Therapy
- Speech-Language Pathology
- Education

# Multidisciplinary vs Transdisciplinary

- Multidisciplinary more than one discipline individually evaluates and treats
  - Each discipline retains its methodologies and assumptions, without change or development from other disciplines
  - Cooperation may be mutual and cumulative, but is not interactive
- Transdisciplinary several disciplines evaluate and treat together
  - Each discipline is trained in some tenets of the other disciplines
  - Shared theoretical models that integrate perspectives from several disciplines
  - Blends the practices and assumptions of each discipline involved

## Case Study

- High school student
- History of dyslexia since elementary school
- Parent is a school teacher
- Years of school-based academic intervention and specialized tutoring at franchised centers...
- Starting athlete with scholarship potential, but he has body function and academic deficits in...

## Case Study - Assessment Findings

### Deficits in: • Att

- <u>Attention</u>
  - ADHD-Inattentive
- Language
  - Phonological
  - Reading
  - Writing
  - Spelling
  - Written comprehension
  - Expression

- <u>Sensory Processing Disorder</u>
  - Visual vigilance
  - Visual tracking
  - Vestibular
  - Visual perceptual
  - "Low Registration" on Sensory Profile
  - Poor balance with eyes closed
  - Poor supine flexion

### Case Study: Transdisciplinary Treatments

#### <u>Psychology</u>:

- Individual therapy
- Therapy with mother

#### Speech-Language:

- Phonological Awareness (LiPS Program<sup>®</sup>)
- Mental Imagery
   (Visualizing & Verbalizing<sup>®</sup>)
- Written Composition
   (Visual-Kinesthetic Sentence Structure)

#### <u>OT w/ SI focus</u>

- Sensory modulation & processing - esp. vestibular
- Oculomotor skills
- Joint stability
- Visual perceptual skills
- Balance
- Movement perception
- Sequencing

#### Case Study: Transdisciplinary Treatment of Dyslexia

Treatment Schedule:

- Daily
- 4-6 hours treatment per day
  - ~1 hour of OT-SI
  - ~3-5 hours language
- 5 days per week
- ~12 weeks

**Treatment Hours:** 

- Phonological/Cognitive: ~150 (neurodevelopmental LiPS®)
- Semantic/Memory (V/V<sup>®</sup>): ~50
- Syntax/Cognitive (VKSS): ~50
- Physical Medicine (OT-SI): ~45.

## Sensory Processing Disorder (SPD)

 "...difficulty taking in and interpreting sensory information so that an appropriate response can be generated." (Bialer & Miller, 2011, pg 20)

### Treatment of SPD

 "So, to be able to design and implement helpful treatment activities for kids with sensory challenges, it is important on a behavioral level to have some understanding about how sensory input either supports or challenges a child." (Bialer & Miller, 2011, pg.20)

### Body Functions: Visual-Motor Integration (VMI)



### Body Functions: Test of Visual Processing Skills-3



#### Body Functions:

Comprehensive Test of Phonological Processing (CTOPP)



### Improved Body Functions

Sensory Processing – "Low registration" was improved with OT-SI, medication and arousal strategies for use at home and school.

Processing/ Modulation of Vestibular Information - R & L LE balance without vision = 4 and 7 secs, improved to 21 and 18 secs; impaired supine flexion improved to 90 seconds while counting (without holding shoulders); depressed post rotary nystagmus was improved

Oculomotor Skills - losing his place during reading and poor visual endurance (blinked excessively during visual tasks/testing), both visual tracking and endurance were improved and excessive blinking was markedly decreased

- Visual Perception -TVPS=83 SS (below average) to TVPS=110 (high average)
- Graphomotor Skills VMI Motor Coordination = 75 SS improved to 89
- > Oral Motor Skills trouble with his oral-motor "feeling" was improved

#### Academic Functions: WECHSLER INDIVIDUAL ACHIEVEMENT TEST (WIAT-II)



### Conclusions and Future Directions

Participant01 Demonstrated:

- > Improved Body Functions,
- > Improved Academic Functions
- > Improved School Performance
  - > passed high school proficiency tests (including written exam)
  - > earned a standard high school diploma
- > Follow-up report: He has completed his first year of college

## Future Directions:

- More "Single-Subject Research Design" and RCT studies need to be published to document the specific impact of OT-SI treatment on body functions and academic functions for children with LD's.
- OT is an essential part of an Transdisciplinary assessment and treatment for children and young adults with LD's, but more empirical data is needed.

### Future Perspectives: TransdisciplinaryTreatment

- Complimentary Interventions (adapted from Doreit & Miller, 2011)
  - Language
  - Sensory processing/integration
  - Interpersonal relationships
  - Social engagement
  - Auditory processing
  - Cognitive behavioral strategies
  - Regulating mood/affect
  - Executive functioning
  - Academic performance
  - Parent & client education/training

# Thank You Questions & Comments

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## Human Sensory Systems

- Visual
- Gustatory
- Olfactory
- Auditory
- Tactile

Also:

- Vestibular movement of the head in relation to gravity
- Proprioception pressure in the muscles and joints
- Interoception awareness of body organs, hunger, thirst...


