Brain Activity in those with Dyslexia Pre and Post Treatment: A Review

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Outline of Presentation

• 1. Introduction about dyslexia
• 2. Underlying differences in brain activity between dyslexics and nondyslexics
• 3. The effects of treatment on the brain
• 4. Clinical Implications
• 5. Review
• 6. Questions??
Goals of Seminar

• Name and identify different brain areas that are important for reading and phonological awareness.

• Explain brain differences that exist between those with dyslexia and normal readers.

• Explain the neural signature of dyslexia.

• Understand how the brain changes after intensive treatment.
What is Dyslexia?

- A significant difficulty in reading which continues throughout an individual's life course.

- Possess normal intelligence, motivation, and receive schooling considered necessary to develop accurate reading ability, BUT

- They still exhibit marked deficits in reading skills.

(Shaywitz, 1998)
Difficulties Associated with Dyslexia

- Oral language acquisition
- Spelling and writing
- Phonological awareness
- Visual processing disturbances—transposing letters, blurry and moving letters
What is Phonological Awareness?

• Core deficit in dyslexia

• Awareness of the sound structure of a language

• Ability to distinguish units of speech

• Involves segmentation, blending, and manipulation of phonemes and syllables

• Strong link between phonological awareness and development of accurate decoding skills and reading fluency.
Difficulties Acquiring Phonological Awareness

- English has a less consistent orthography, and low predictability of phoneme-grapheme mapping.
- Same alphabet symbol can represent more than one sound
- Different alphabetic symbols can represent the same sound
- Different words can be pronounced in the same way
- The same spelled word can be pronounced differently.
Brain Differences!
Theories of Causes of Dyslexia

• Visual deficit

• Phonological deficit
Phonological or Visual Deficit?

• Research suggests dyslexia’s core deficit is phonological in nature.

• Does not explain visual problems.

• Neural imaging has allowed us to see that there are multiple brain areas affected in dyslexics.

• Can account for the array of symptoms experienced in the population.
Magnocellular Theory
(Stein and Walsh 1997)

- Symptoms emerge from abnormalities in the magnocellular layers of lateral geniculate nucleus (LGN) and posterior parietal and occipital cortex.


http://www.benbest.com/science/anatmind/FigV7.gif
http://instruct.uwo.ca/anatomy/530/vistopo.gif
Magnocellular Theory

- Dyslexics exhibit low light levels and unusual motion in brains which are not found in normal readers (Corelisson et al. 1995; Lovegrove et al. 1980).

- In 5 post mortem brains, disordered magnocells were 20% smaller than control brains (Galaburda et al. 1985).

- When presented with moving stimuli, dyslexic males failed to produce the same results on a visual moving task (Eden et al. 1996).

- Lower activation in magnocellular system (Eden et al. 1996).
Conclusions of Magnocellular Theory

• Disconnection from magnocellular layers of LNG to posterior parietal cortex causing reading problems.

• Have behaviors consistent with magnocellular deficits—poor temporal judgment and visual instability. (Eden et al., 1996)

• Stein and Walsh (1997) emphasize visual impact, but believe dyslexics suffer from more than one neural abnormality.
Research Suggesting Phonological Deficit

- Differences noticed in posterior brain areas.

- Hypoactivation in posterior regions—Wernicke’s area, angular gyrus, and striate cortex (Shaywitz 1998).

- Hyperactivation in inferior frontal gyrus.

http://thebrain.mcgill.ca/flash/a/a_10/a_10_cr/a_10_cr_lan/a_10_cr_lan_1b.jpg
Brain Areas and Relation to Reading

- Inferior frontal gyrus - articulation and word analysis
- Parieto-temporal - word analysis (components of phonology and morphology)
- Occipito-temporal - word form area (influences fluent reading)

Phonological Deficit

• Strong link in cerebral blood flow between left angular gyrus and occipital/temporal lobes in normal male subjects during single word reading.

• Disconnection between angular gyrus and temporal and occipital regions in dyslexics (Horwitz et al. 1998; Pugh et al. 2000).
Activation During Real and Non Word Tasks

• Reduced activation in left posterior temporal gyrus (Wernicke’s), angular, and supramarginal gyri during real and non word reading tasks (Simos et al. 2000a and 2000b).

• Hyperactivation in homologous right regions.
Left and Right Hemisphere Differences

http://keys-to-learning.com/Reading_Writing_Spelling/Nichd_brain_img049.gif
Activation During Real and Non Word Tasks

• Authors suggested a heightened reliance on inferior frontal gryus and right posterior to compensate for those disrupted in left.

• Pugh 2000, suggests increased reliance in right temporo-parietal because this pathway develops before occipito-temporal in the left.
Neural Signature of Dyslexia

- Under activation of left parieto-temporal area and occipito-temporal
- Over activation of left anterior region - inferior frontal gyrus
Differences Between Older and Younger Readers

• Activation in left and right inferior frontal gyri greater in older children.

• In non word rhyming task- older readers engaged left and right inferior frontal gyri.

• During semantic category task- older dyslexic readers engaged right inferior frontal gyrus, non-impaired readers engaged the left.

• As the children get older they compensate by switching to ancillary systems such as inferior frontal gyrus.
LOT Area and Reading

- Heightened popularity over recent years for *left occipital temporal area* (LOT).

- Word form area

- Neurons in region rapidly exchange information for decoding words.

- Within 250 ms of being viewed- letter strings integrated and processed as words.

- Allows rapid recognition of sight words.
Shaywitz and LOT

- Shaywitz et al. (2003) longitudinal study following men and women from 5 to 18.
- Three groups: non-impaired, accuracy improved, and persistently poor readers
- Found typical disruption in accuracy improved and dyslexics during phonological task.
- Groups diverged in semantic category task.
- Persistently poor readers were similar to non-impaired even though reading scores were significantly lower.
Shaywitz and LOT

• Connectivity analysis revealed:
  – Correlation in nonimpaired between the LOT and left inferior frontal gyrus.
  – Persistently poor demonstrated connectivity between LOT and right prefrontal regions.
  – Area associated with memory- suggesting that LOT may function as a memory system rather than a phonological system in those with dyslexia.

Shaywitz and LOT

• Oral reading task showed persistently poor identified fewer low and high frequency words than accuracy improved and non-impaired.

• Suggested that brain systems for phonological analysis and reading have not developed, therefore they rely on memory based strategies
Same Reading Level Group Differences

• Hoeft et al. (2006) compared dyslexics (5\textsuperscript{th} graders) to same reading level matched groups (3\textsuperscript{rd} graders).

• Reduced activation in bilateral parieto-temporal cortex, right superior frontal gyrus, left inferior parietal lobe, and right posterior-temporal gyrus (occipital temporal area).

• Research shows that brain differences cannot be accounted by reading level.
Summary of Brain Differences

- Differences involving the Magnocellular layers of the LGN.
- Reduced activation in left temporal, occipital, frontal, superior parietal regions.
- Increased activity in right hemisphere homologues.
- Increased activity in right may be due to the abnormalities in neural systems in left.
Brain Activation
Post Treatment
Changes in Brain Activation Following Remediation

• With appropriate teaching conditions and well designed intervention programs research is finding that:
  
  • Reading and phonological skills are improving significantly over time

  • Brain activation changes are representing a pattern that is closer to normal readers.
Phonological Interventions and Brain Activation

- Lindamood Phonemic Sequencing Program and PhonoGraphix was used on dyslexic subjects for a total of 80 hours (Simos et al. 2002).
  - Programs focus on sound awareness, decoding, segmenting, and phoneme manipulation.
- Post intervention dyslexic children showed significant improvement in reading and increased activity in superior temporal gyrus across all individuals.
- Suggests abnormal brain organization can transcend in as little as two months.
Phonological Interventions and Brain Activation Continued

- Fast ForWord Language (computerized phonological intervention program) (Temple et al. 2003).
  - Program based on 7 levels

- After treatment reading test scores were within normal limits.

- Increased activity in left temporo-parietal cortex and inferior frontal gyrus which was similar to normal controls.

- Increased activity in left temporo-parietal linked to improvement in oral language ability.
Phonological Interventions and Brain Activation continued...

• Experimental phonological based reading intervention and school intervention have been investigated (Shaywitz et al. 2004).

• Students received experimental treatment or school treatment for one year.

• Both groups made gains but the experimental group reached statistical significance.

• Brain activation increases were found in left inferior frontal gyrus and middle temporal gyrus.
Phonological Interventions and Brain Activation continued…

- Imaging one year post.

- Children were found to be activating bilateral inferior frontal gyri, parietal temporal regions and occipital-temporal regions.

- This represented a pattern that was typical of a normal reader.

http://keys-to-learning.com/Reading_Writing_Spelling/Nichd_brain_img049.gif
Conclusions

• Evidenced based programs facilitate development of various reading skills and also reorganize neural abnormalities in those with dyslexia.

• Changes in brain activation can occur within as little as one to two months with intensive therapy.

• There is hope for those living with dyslexia to be successful academically and vocationally.

• It is possible that professionals can now facilitate reading skills to levels of their normal peers.
Clinical Implications/Discussion questions

- Previous research has been focused on evidenced based programs in experimental settings.

- Question remains as to if these programs would produce similar results within school settings and in how much time?

- What types of intervention programs are being used throughout schools?

- How do these programs impact performance on state wide standardized assessments?
Clinical Implications/Discussion questions

- What are the professional boundaries in relation to SLPs working on phonological awareness and reading in the schools?
  - SLPs have specific training in underlying sounds structure of language.
  - SLPs focusing on initial set up of reading: phonological awareness, segmenting, phoneme manipulation.
  - Rather, reading specialist focus on reading fluency, decoding skills, and reading comprehension.
In summary

• If we understand brain differences….

  – it may help professionals define more appropriate treatment goals.

  – it will deter professionals from making inaccurate assumptions.

  – research findings might support a change in policy.
Questions ???