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Neuroplasticity Phenomena in the Remediation of Learning Disabilities

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Abstract: Learning Disabilities Is A Neurological Disorder. It Is A Developmental Disorder Related To Brain Damage, So Learning Disabled Children Might Have Problems In The Areas Of Attention, Memory, Perception, Motor Functioning, Processing Speed, Planning And Problem Solving Skills.Learning Disabilities Usually Are Indicative Of Some Disorder In The Central Nervous System That Prevents The Child From Acquiring Skills Like Normal Children. This Article Focused On The Neurological Phenomena Behind The Remediation Or Management Of Learning Disabilities And Also Tries To Find Out How Neuroplasticity Phenomena Work In The Remediation Of Learning Disabilities.

Keywords: Learning Disabilities, Dyslexia, Neuroplasticity, Remediation.

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I. INTRODUCTION

Learning Disability Is A Term Currently Used To Describe A Group Of Neurological Conditions That Interfere With A Person's Learning. Under The Umbrella Term Ld, There Are Disorders Related To Listening, Speaking, Reading, Reasoning, And Mathematical Calculation. Individuals With Ld Have Intelligence In The Near Average, Average, Or Above Average Range. Because These Individuals Do Not Appear To Be Different, Difficulties Are Not Expected. The Impact Of The Conditions May Range From Mild To Severe Based On The Neurological Deficits Or Damage. According To National Joint Committee For Learning Disabilities (Njcld, Usa, 1997) "Learning Disabilities Is A General Term That Refers To The Heterogeneous Group Of Disorders Manifested By Significant Difficulties In The Acquisition And Use Of Listening, Speaking, Reading, Writing, Reasoning, Or Mathematical Abilities. These Disorders Are Intrinsic To The Individual, Presumed To Be Due To Central Nervous Dysfunction, And May Occur Across The Life Span". The Learning Disabled Children Might Have Problems In The Areas Of Attention, Memory, Perception, Motor Functioning, Processing Speed, Planning And Problem Solving Skills. These Deficits Are Due To Developmental Brain Damages So Remedial Training (Enhancement Of Attention, Memory, Working Memory, Processing Speed) Plays An Important Role In The Management Of Learning Disabilities. According To Kolb (1995), Neuroplasticity Is Considered To Be The Brain's Capacity To Change Either At The Microlevel (I.E., Cellular/Network Level), Known As Neural-Plasticity, Or At The Macro Level (I.E., Behavioural/System Level), Known As Behavioural Plasticity, Allowing The Brain To Respond Environmental Changes Or Changes In The Organism Itself. Neuroplasticity Refers To Structural And Functional Changes In The Brain That Are Brought About By Training And Experience. In The Case Of Learning Disabilities Training, Various Training Programmes For The Enahancement Of Cognitive Skills Such As Attention, Memory, Processing Speed And Problem Solving Skills Play An Important Role In The Structural And Functional Change In The Brain. This Change Is Known As The Phenomena Of Neuroplasticity.

Learning Disabilities Remediation And Neuroplasticity

The Investigation Of Neuroplasticity Has Added New Insight Into Our Understanding Of Change Through Remedial Training. In The Case Of Learning Disabilities Remedial Training Means Cognitive, Academic And Social Skills Training. As We Currently Know, Growth And Differentiation Of The Brain Are Not Only Determined Genetically, But Also By Its Continuous Interaction With The Environment. This Epigenetic Formation Of The Brain Does Not End In Early Childhood: There Is A Life-Long Re-Mapping Of Cortical Networks According To The Individuals Experience, Including The De-Novo Generation Of Neurons In The Adult Hippocampus, As Proven Recently. Neuroplasticity Is A Prerequisite For Any Enduring Change In

Behavior, Cognition, And Emotion, Which Is The Focus Of Ld Remediation. In Order To Produce Lasting Effects, Ld Remediation Should Arrive At Restructuring Neural Networks, Particularly In The Subcortical-Limbic System Which Is Responsible For Unconscious Emotional Motivations And Dispositions. 'Insight' Or 'Appeal' Reach Only Corticohippocampalstructures, Which Correspond To Conscious Memory And Cognition, But Have Only Very Limited Effects On The Motivational System.

Neurobiological Effects Of Learning Dissability Remediation

With Increasing Influence Of Neurobiological Paradigms On Ld Remediation, The Question Arises Whether Ld Remediation Effects May Also Be Demonstrated On The Neurobiological Level. Procedural Relearning In Remediation Should Be Expected To Influence The Structure And Functions Of The Brain By Altering Synaptic Plasticity And Gene Expression. There Is Growing Evidence For A Modification Of Gene Expression By Emotional Experiences; For Example, Tender Touch Activates The Expression Of An 'Immediate Early Gene' Which Promotes Cellular Processes Of Growth And Maturation. Of Course, Ld Remediation Effects Will Be More Dependent On Long-Term Changes In Pathophysiological Patterns Of The Brain Which May, For Example, Be Shown By Neuroimaging Studies.

Neural Plasticity Is Multiple And Includes Biochemical, Physiologic, And Structural Changes. The Consequences Of These Changes, Which Express Themselves In Behavioral Plasticity, Are Likewise Multiple. Micro Level Plasticity Allows The Brain To Learn New Behaviors And Skills. By The Same Token, The Behavior Itself Can Alter The Brain, Which In Turn Reinforces That Behavior. Thus, Plasticity Both Results From And Induces Behavioral Changes. Brain Damage Results In Neurophysiological Changes In The Brain That Modify Behaviors, And These Behaviors, In Turn, Produce Further Changes In The Brain. In A More Empirical And Functional Approach To Plasticity, Which Focuses At The Macro Systemic Level, Frackowiack (1997) Argues That, Plasticity Should Be Viewed As The Changes Of Neural Function Over Time, Or, More Specifically, The Changes Effected By Repeated Behavior Following An Injury. Thus, Plasticity Represents The Changes In Brain Activity Associated With The Tasks Performed (E.G., Action, Perception, Cognition) In An Attempt To Compensate For The Impaired Functions.

Plasticity And Remediation

It Has Long Been Thought That Hebbian Learning Primarily Occurs During Early Critical Periods Of Development When Sensory Neural *Maps* Are Established For A Lifetime. However, Single Cell Physiological Studies Demonstrating That These Maps Can Be Substantially Altered At The Cortical Level, By Intensive Behavioral Training In Adult Animals, Has Significantly Challenged That Perspective.

In The Early 1990s, My Colleagues Michael Merzenich, Steve Miller, Bill Jenkins, And I Began Discussing Whether The Results Of The Neuroplasticity-Based Behavioral Training Studies In Animals That He Had Been Conducting In His Laboratory, Particularly Those Pertaining To Enhancing The Capacity To Segment Rapidly Successive Auditory Events, Might Be Applied To Children With Language Learning Impairments And Rapid Auditory Processing Problems. These Discussions Led To A Series Of Laboratory Studies, And Subsequently To The Development Of A Novel, Computerized Training Approach Called Fast Forword. Fast Forword Incorporates Two Simultaneous Approaches To Intervention. In One Approach, Sub-jects Indicate The Temporal Order Of Sweep Tones That Are Either Rising Or Falling In Pitch. These Stimuli Were Specifically Designed To Cover The Range Of Frequencies And Speeds That Typify The Acoustic Frequency Changes That Occur In Formant Transitions In Consonants. The Exercise Begins At An Easy Level With Longer Duration Stimuli Presented Relatively Slowly (With Long Isis). The Computer Program Adaptively Changes (Increases Or Decreases) Theduration Of Stimulus Presentation Based On Each Subject's Trial-By-Trial Performance. The Goal Of The Exercise Is To Increase The Ability To Process More Rapidly Changing Acoustic Stimuli To Obtain Levels Typicallyfound In The Acoustic Changes That Characterizephonemes Within Syllables And Words. In The Second Approach, We Use A Computer Algorithm To Acoustically Modify (Temporarily Extend And Emphasize) The Rapidly Successive Acoustic Changes That Occur With Ongoing Speech. This Acoustically Modified Speech Algorithm Is Used In A Series Of Exercises Designed To Train Individual Components Of Language And Reading At All Levels, From The Phoneme To The Whole Sentence. Within All Of These Exercises, As Linguistic Performance Improves, The Amount Of Acoustic Modification Adaptively Decreases So That The Stimuli Becoming Increasingly More Natural. The Goal Of The Entire Series Of Fast Forword Exercises, As Linguistic Performance Improves, The Amount Of Acoustic Modification Adaptively Decreases So That The Stimuli Becoming Increasingly More Natural. The Goal Of Entire Series Of Fast Forword Exercise Is To Improve Multiple Aspects Of Oral And Written Language Comprehension And Fluency.

In The Original Laboratory Studies, Two Matched Groups Of Children With Significant Language Learning Impairments Participated In Daily Training For Approximately Three Hours Per Day For Four Weeks. Only The Fast Forword Language Exercises Were Evaluated In This Study. The Experimental Group Was

Trained With The Two Approaches Described Above. The Treatment Control Group Received The Same Language Intervention, But With Speech That Was Not Modified, And Instead Of The Auditory Tone Sequencing Exercise, The Control Group Played Non-Temporally Adapted Visual Computergames.After Training, The Experimental Groupshowed Significantly Greater Improvement Than The Controlgroup On The Rateof Acoustic Processing, Speech Discrimination, And Performance On Standardizedlanguage Tests. The Languagegainsmade By The Experimental Groupwere Dramatic, Bringing Many,But Not All, Of These Children Into The Normal Range (Merzenich*et Al*., 1996; Tallal Et Al., 1996).

These Results Have Significant Theoretical As Well As Practical Implications. They Provided Strong Empirical Support For The Hypothesis That Basic Acoustic Spectrotemporal Processing Constraints Play A Significant Role In Language Learning Impairment By Demonstratingthat When The Precision Of Spectrotemporalprocessing Issignificantly Enhanced Phonological Processing, As Well As Higher Level Aspects Of Linguistic Processing, Significantly Improves. Furthermore, Results Showed A Strikingly High Correlation Between The Degree Of Improvement In Rapidspectrotemporal Acoustic Analysis And The Degree Of Improvement In Language Comprehension.

These Results Were First Replicated And Extended To The Treatment Of Dyslexia In An Independent Study With French Childrenusing A Similar Acoustic Modification Algorithm To Train Phonological Awareness Abilities (Habibet Al, 2002). More Recently, Additional Fast Forwordintervention Programs Have Been Designed To Move Children From Language To Reading, And Then Through Multiple Levels Of Reading Skills, Further Extending This Intervention Approach To Struggling Readers. Thus, In Addition To The Theoretical Implications, These Laboratory Studies Have Had Considerable Practical Implications. They Led To The Development Of A Series Of Commercially Available Neuroplasticity-Based Computer Intervention Programs For Treating A Wide Variety Of Language And Reading Problems That Have Been Extensively Field Tested In Schools And Clinics. To Date, These Intervention Procedures Have Been Applied To Over 375,000 Children In Over 2,000 Schools And Clinics In English Speaking Countries.

As Is The Case With Any Intervention, Not All Children Improved To The Same Extent,And Some Not At All. Furthermore, Many Children In The Control Group Who Received The Same Intensive Language Intervention, But Without The Benefit Of The Acoustically Modified Speech Or Rap Training, Also Improved, Leading To Questions About The Specificity Of The Results To The Temporal Manipulations Per Se. Aspects Of This Intervention Share Some Features In Common With Many Other Successful Treatment Approaches, Specifically The Intensity And Consistency Of Treatment As Well As Explicit Training Of One Or More Components Of Language Or Reading (Ehri Et Al., 2001; Gillam& Van Kleek, 1996; Torgesen, 2000; Wise, Ring, &Oslon, 1999). However, These Factors Were Explicitly Addressed In Randomized Treatment Control Laboratory Studies. While Both Groups Showed Significant Gains Over Baseline Performance On Language Measures, The Experimental Group Receiving Language Training With Acoustically Modified Speech, Coupled With Rap Training, Showed A Statistically Significant Advantage Over The Treatment Control Group (Tallal Et Al., 1996). Thus, These Results Cannot Simply Be Attributed To More General Factors Such As Novelty Of Computer Intervention, Intensity Of Intervention, Or Amount Of Reinforcement As These Variables Were Controlled Across Groups.

Despite Good Overall Success With These First-Generation Neuroplasticity-Based Computerized Training Approaches, There Remains A Percentage Of Children Who Improve Only Slightly, Or Not At All. And, As Is The Case With All Intervention Strategies, Specifically Those Applied In Multiple Types Of Classroom Settings, Compliance To Protocol And The Percent Of Program Completion Will Significantly Alter Outcomes And Efficacy. Long-Term Follow Up Studies Of Trained Children Are Needed, Together With A Better Understanding Of Individual Difference In Outcomes That May Be Influenced By The Clinical Profile And Learning Environment Of Each Child. Studies Focusing On More Effective Ways To Translate Laboratory Research Into Clinical And Education Practice Are Also Sorely Needed. Finally Additional Research Is Needed To Better Understand Which Specific Components Of This And Other Intervention Programs Drive Which Specific Outcomes, And For Which Specific Children.

The Langauge To Literacy Link

The Laboratory And Field Trials Described Above Demonstrated That A Novel Form Of Neural Plasticity-Based Training Can Be Highly Successful In Increasing The Oral Language Skills Of Children With A Variety Of Language-Based Learning Disorders. Other Investigators Have Hypothesized That Phoneme Awareness Deficits, That Are Widely Accepted To Be The Core Deficit Of Dyslexia, Derived From "Fuzzy" Neural Representations For Distinct Phonemes. The Fastforword Training Programs, That Explicitly Focuses On Sharpening Neural Representations For Distinct Phonemes, Would Sharpen Neural Representation In The Auditory System, Leading To Enhanced Ability To Segment Words Into Component Sounds, Thus Improving Decoding And Other Reading Skills. However, Until Recently, This Hypothesis Had Not Been Put To An Empirical Test In A Controlled Laboratory Study.

Recently, A Group At Stanford University (Temple Et Al., 2000, 2003) Used Behavioral As Well As Functional Magnetic Resonance Imaging (Fmri) To Evaluate The Effectiveness Of Fast Forword Language Training In Remediating Reading Abilities In A Group Of Adult Dyslexic Subjects As Well As Children With Dyslexia. Previous Studies By A Number Of Researchers Using Fmri Have Demonstrated Consistently That Both Adults And Children With Dyslexia Have Aberrant Metabolic Activity During Phonological Processing Tasks In Language Areas In The Temporal-Parietal Region Of The Left Hemisphere (For Review, See Temple, 2002). The Goal Of The Stanford Studies Was To Determine Whether The Aberrant Metabolic Activity In Temporoparietal Cortex, Observed In Individuals With Dyslexia While Performing Phonological Awareness Tasks, Would Be Ameliorated After Neuroplasticity-Based Training (Temple Et Al., 2000, 2003). In The Latter Study, 20 Children Who Met Clinical Criteria For Developmental Dyslexia And 12 Typical Readers Matched For Age, Socioeconomic Status, And Intelligence, Received Two Fmri Scans At Approximately Eight Weeks Apart While Performing A Letter Rhyming Task. Between Scans, The Dyslexic Children Completed The Fast Forword Language Training Program. Recall That This Version Of Fast Forwordfocuses On Increasing The Rate Of Auditory Processing As Well As Improving Attention, Memory, And Oral Language Skills. After Training, Performance On All Measures Of Oral Language (Receptive And Expressive) As Well As All Measures Of Reading (Word Identification, Word Attack, Passive Comprehension) Showed Significant Improvement In The Group Of Subjects With Dyslexia. Of Particular Importance, Word Attack Skills (Representing The Core Deficit Of Phonological Awareness) Moved From One Standard Deviation Below The Mean (Below Average) Before Fast Forword Language Training To Well Within The Normal Range After Approximately Eight Weeks Of Fast Forword Training. The Control Group Who Received The Same Battery Of Language And Reading Standardized Tests Approximately Eight Weeks Apart Showed No Significant Change, Demonstrating That These Post-Training Results Cannot Be Attributed To Regression To The Mean, Normal Maturation, Or Test- Retest Practice Affects.

In Addition To Significant Changes In Reading Observed With Standardized Behavioral Measures, Fmri Results Demonstrated That After Training, The Dyslexia Readers Also Showed Increased Metabolic Activity During The Letter Rhyming Task In Left Hemisphere Temporo-Prietal Language Regions, Bringing The Brain Activation In These Regions Closer To That Seen In Children With Normal Reading Skills. This Result Is Consistent With Other Recent Studies Similarly Demonstrating "Normalization" Of Brain Function After Extensive Acousic/Phonological Training (Shaywitz Et Al., 2004; Tremblay & Kraus, 2002). Interestingly, The Magnitude Of Increased Activation In The Left Temporoparietal Cortex Was Significantly Correlated With The Magnitude Of Improvement In Language Skills. Other Areas Of The Brain Also Showed Significant Changes In Metabolie-Activity After Training, Specifically Homologous Areas In The Right Hemisphere (Temple Et Al., 2003). These Findings Are Being Further Investigated In A Current Study Incorporating A Randomized Control Group Of Dyslexic Subjects Receiving A Different Form Of Intervention.

The Significant Improvements In Reading Following Fast Forword Language Training Provide Strong Support For The Theoretical Premise Initially Driving The Hypothesis Linking Rapid Auditory Processing, Language, And Reading. Recall That This Series Of Training Exercises Does Not Incorporate Any Letters At All, But Rather Was Designed To Improve The Rate Of Auditory Sequential Processing, Attention, Memory, Phonological Processing, And Grammatical Skills. The Finding Of Improved *Reading* Immediately Following This Training Demonstrates The Importance Of These Essential Building Blocks, Not Only For Language Development But Also For Reading Success.

The Role Of Rapid Auditory Processing In Developmental Language And Reading Impairments Has Become A Central Focus Of Research.

Several Significant Methodological Issues That Have Clouded This Area Of Research Are Increasingly Being Resolved, Leading To Increased Understanding Of The Etiology Of These Developmental Language-Based Learning Disabilities. Specifically, It Is Becoming Increasingly Clear That We Need To Better Understand The Long-Term Effects Of Early Individual Differences In Experience And Brain Maturation. Patterns That May Be Seen In Infants Or Very Young Children May Fail To Replicate In School-Age Children, College Students, Or Adults. Even Well After Early Patterns Of Deficit/Difference/ Maturation Of Sensory Information Processing May Have Resolved, Or Become Recalcitrant To Behavioral Assessment, They Are Likely To Leave A Lasting Legacy On The Way The Brain Has Organized Itself For Phonological Processing, Language, And Reading Throughout Life. With The Advent Of More Sophisticated Neuroimaging Procedures, Specifically Those That Can Track Real-Time Neural Processing In The Time Range Of Speech, Future Research May Be Better Able To Address Issues Pertaining To Similarities And Differences In The Way Speech And Nonspeech Acoustic Signals Are Processed In The Human Brain. Such Studies Should Lead To A Better Understanding Of The Types Of Stimuli, Ages Of Subjects, And Clinical Subgroups That May Be Most Effective In Addressing The Most Relevant Questions Pertaining To The Neurobiological Origins Of Language-Based Learning Disabilities. Finally, The Development Of Animal Models That Mimic Anatomical, Physiological, And Behavioral Features Associated With Language-Based Learning Disabilities Offer New

Avenues For Exploring The Complex Interaction Of Neurobiological, Genetic, And Environmental Factors That Contribute To These Impairments.

II. CONCLUSION

The Brain Is An Amazing Organ. In This Context, It Is Important To Understand The Plasticity Of The Brain. Neuroplasticity Refers To Structural And Functional Changes In The Brain That Are Brought About By Training And Experience. The Brain Is The Organ That Is Designed To Change In Response To Experience.
Most Of The Studies Strongly Support The Use Of Rehabilitative Training As A Tool To Improve Brain Reorganization And Functional Outcome.

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