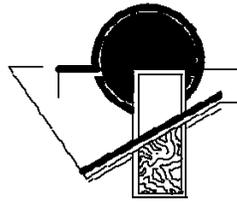




Mild TBI **Impact on Language**



Arlene Kasprisin, PhD

Chief, Audiology/Speech Pathology Service
VA Palo Alto Health Care System

Objectives

- **Define** communication/language & brain-language relationships
- **Differentiate** left & right hemisphere language processes
- **Discuss** pathophysiology of mTBI
- **Describe** mechanism of connections between language centers of the brain & the impact of mTBI on those connections
- **Outline** language/communication consequences of mTBI
- **Discuss** language/communication consequences of mTBI in two patients
- **Outline** a language/cognitive syndrome secondary to mTBI injury

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Outline

- **General Persp/Definitions**
 - Commun/Lang/Speech
 - Hist Persp – Prop/Affec Lang
 - Aphasia/Aprosodia
 - Communication – Whole Brain
- **Pathphysiology of TBI/DAI**
 - DAI - Imaging
 - DAI – Blasts
 - DAI – Language
- **Brain-Lang Relationships**
 - Fleshig/Functional Zones
 - LH – Types of aphasia & Wernicke's Model of Language & the Brain
 - RH – Affective Lang & Aprosodias
 - Other Language Related Problems
- **Case Study – mTBI/Blast**
 - Conduction Aphasia
 - Conduction Aprosodia
 - Other Lang/Cog Dysfunction
 - Tractography
 - Treatment/Tractography
 - Implications re: Neurobiologic Recovery Patterns
- **mTBI Lang/Cog Syndrome**
- **Case Study – mTBI/MVA**
 - Visual Percep/Rela to Conduc Apha & Aprosodia
 - Constr Apraxia/Rel to Dyslexia & Dysgraphia
 - Rel to Other Cog Functions

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Definitions

- Communication**
- **Transfer** of an idea, feeling or information from one person to another. Can also be from inanimate objects, animals or the environment.
- Language**
- A **"symbol system"** where a word, sound, or written symbol stands for something else. Language symbols are **arbitrary** and agreed on by a general language community (e.g. "dog" is "perro" is Spanish)
- Speech**
- The **oral-verbal** representation of language or "talking"

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Language & Communication

1865 - 1879

- 1865 *Broca* • *Language/speech* mediated by LH, focal lesions result in specific problems, described syndrome of aphasia associated w frontal lesion
- 1875 *Wernicke* • Described syndrome of aphasia associated with temporal lesion & proposed a *model* of language organization in the brain
- 1879 *H. Jackson* • *Affective* lang/speech mediated by R Hemis - pt lost propositional speech but could express emotion/sing; and possibly *figurative* language mediated by R Hemis

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Language & Communication

1865 - 1879

Propositional



Affective

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Concrete Language - Cool

Left Brain



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Figurative Language - COOL

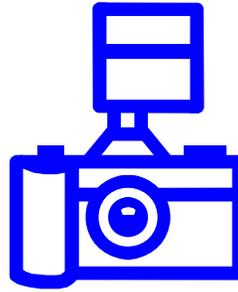


Right Brain

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Concrete Language - Flash

Left Brain



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Figurative Language - Flash



Right Brain

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Definitions

Aphasia

- A non-functional impairment in the reception, manipulation and/or expression of **symbolic** material (or **language**). Results from organic damage to relatively central brain structures. Can occur in reception or expression of auditory, visual (graphic) or gestural modalities.

Aprosodia

- A disturbance in the processing of **ffective** or emotional components of language. Can include problems in recognition or production of emotional tone of voice, facial expression, gesturing or matching one area to another (e.g. tone of voice with facial expression).

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Communication - Whole Brain

Left Brain



Right Brain

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Communication - Whole Brain

*Left Brain/
Right Brain*

- **Focal Lesions** – can evaluate specific syndromes relative to specific hemisphere/lobe; for 100 yrs after Broca emphasis on lang/LH focal lesion relationships; 1970's expansion of affective lang/RH relationships

Whole Brain

- **TBI** – often more than one lesion site requiring evaluation of multiple areas of brain function (left & right, cortical & subcortical, anterior & posterior in same hemisphere) to identify consequences.

Particularly Important in mTBI since signs are subtle & can be confused or co-exist with problems producing similar symptoms

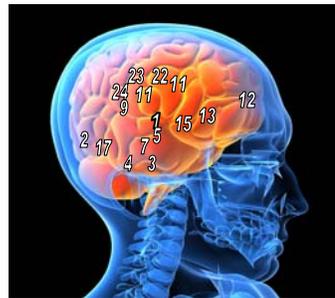
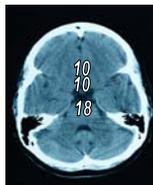
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Communication & the Brain



- 1-Hearing
- 2-Vision
- 3-Concepts
- 4-Memory
- 5-Aud Recognition
- 6-Prop Underst
- 7-Affect Underst
- 8-Naming-Prop
- 9-Naming-Figur
- 10-Inter Hem Trans
- 11-Intra Hem Trans

- 12-Motor Initiation
- 13-Motor Planning
- 14-Motor Prop Speech
- 15-Motor Affect & Singing
- 16-Aud Component Reading
- 17-Vis Component Reading



- 18-Rt-L Info Transfer
- 19-A-V Integ Reading
- 20-Grapheme Transfer
- 21-Writing
- 22-Pragmatics/Non-Verbal Rules
- 23-Higher Lang-Presup/Infer, Rel/Irrel
- 24- Fig Lang-Metaph,Idiom,Proverb

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Other Functions Subserving/Supporting Language

- Finger Recognition* ➤ *LH*
- Spatial Orientation* ➤ *RH*
- Motor Coord/Tone* ➤ *Cerebellum/Basal Gang*
- Visual Perception* ➤ *Both Hemispheres*
- Memory/Atten/Conc* ➤ *Both , Brain Stem*
- Sensory Integration* ➤ *Thalamus*

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Pathophysiology of TBI

- **Rotational forces & skull fractures**
- **Subdural Hematomas**
- **Contusions**
- **Diffuse Axonal Injury - mTBI**

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Diffuse Axonal Injury

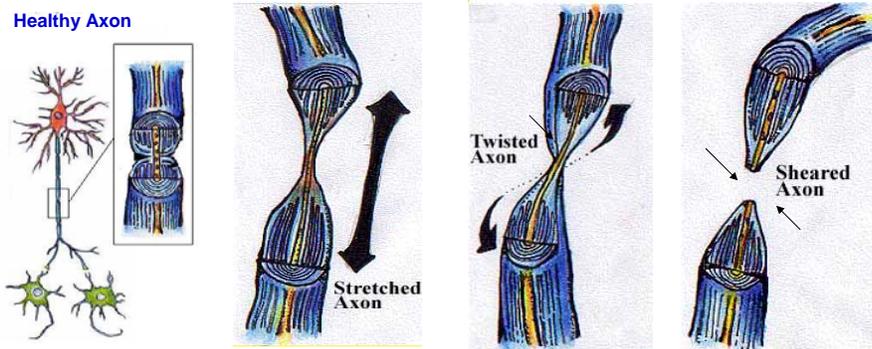
- Axon can be detached
- Axon can be stretched
- Increased permeability
- Calcium influx
- Damage to cytoskeleton
- Impaired axoplasmic transport
- Axonal swelling
- Detachment

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Diffuse Axonal Injury



Do **NOT** see this with common imaging

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Imaging Studies

- Fewer than **10%** mTBI pts have acute intracranial lesions identified on imaging
 - CT
 - MRI
 - SPECT Scan
- **Blast & mTBI** – no difference

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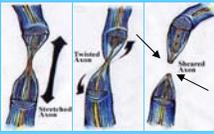
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DAI & Blasts

- *Overpressure wave* of 1,600 ft/sec strikes *twice* – initial wave followed by "*secondary wind*" or air flooding back into the vacuum under high pressure
- Sudden & extreme pressure changes are *1,000x greater* than atmospheric pressure - helmets nor armor protect the body from being set into motion
- Nerve cells & axons – contain different concentrations of fluid & fat so when set into motion they move at *different speeds*
- *Potential Impact* – blasts set nerve cells & axons into motion at different speeds resulting in a shearing effect

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Impact of mTBI On Language

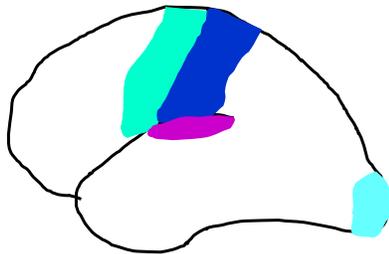
Understanding mTBI impact on language requires understanding:

- **Cortical zones mediating lang components & functions subserving those components**
(e.g. spatial perception & reading)
- **How those zones connect with each other**

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Fleshig's Primary Zones



Primary Zones - myelinate first in each lobe. Have a "primary" motor or sensory function (receive sensory-motor information only).

- No other part of the brain can assume their function
- Cannot assume function of any other part of the brain.

• **Frontal Lobe** - motor

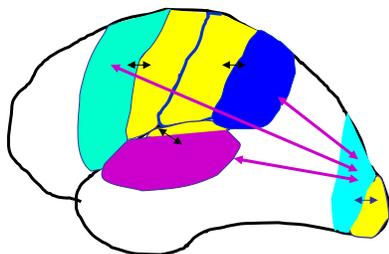
• **Parietal Lobe** - somatosensory

• **Temporal Lobe** - auditory

• **Occipital Lobe** - visual

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Fleshig's Secondary (Association) Zones



Association Zones -

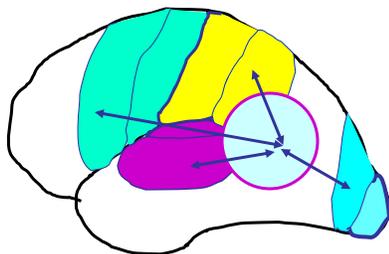
myelinate second in each lobe. Surround & process information of primary zones.

- *Frontal Lobe* - secondary motor
- *Parietal Lobe* - second somatosens
- *Temporal Lobe* - secondary auditory
- *Occipital Lobe* - secondary visual

- Called association because are the only areas that communicate with responding primary zones
- Communicate with each other

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Fleshig's Tertiary Zones

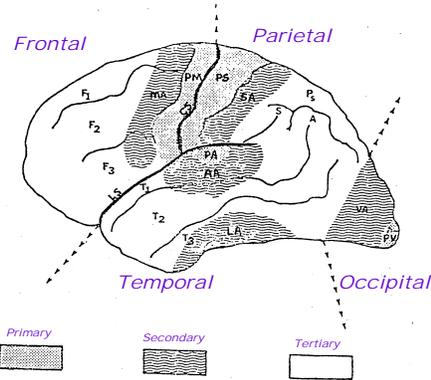


Tertiary Zones - myelinate last in each lobe. Have "integrative" higher cognitive functions.

- *Frontal Lobe* - "prefrontal" tertiary deals with personality, motivation, initiation.
- *Temporal Lobe* - temporal tertiary mediates "interpretive" responses, "concepts" etc.
- *Parietal Lobe* - infraparietal lobule (supramarginal & angular gyri) is the "association zone of association zones."

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Fleshig's Zones

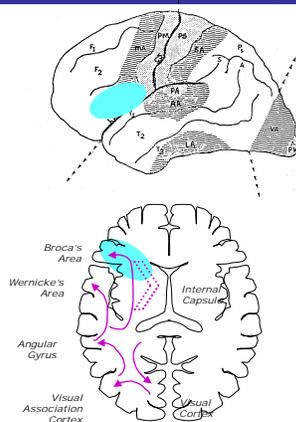


- **F1, F2, F3** - first, second, third frontal gyri
- **T1, T2, T3** - first, second, third temporal gyri
- **CS, LS** - central sulcus (Rolando), lateral sulcus (Sylvius)
- **PM, PS, PA, PV** - primary motor, somasthetic, auditory visual cortex
- **MA, SA, AA, VA, LA** - motor, somesthetic, auditory, visual, limbic association areas
- **S, A** - supramarginal gyrus, angular gyrus

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Description of Problems Broca's Aphasia 1865

(+ = No Problem, *- = Problem)



Lesion - Post Portion of 3rd frontal convolution, adjacent subcortical white matter

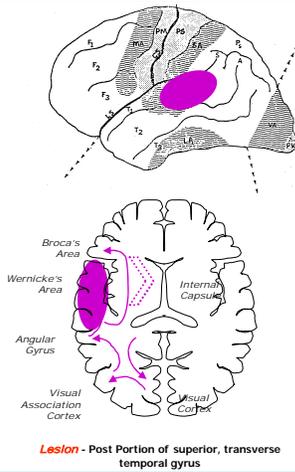
- **Physical** -
- **Auditory Comp** +
- **Fluency** -
 - Speech Rate -
 - Ease of Production -
 - Articulatory Agility -
 - Motor Initiation -
 - Phrase Length -
 - Melody -
 - Syllable Transitions -
 - Rhythm -
- **Grammar** -
- **Naming** +/-
 - Content +/-
 - Paraphasias +
- **Reading** -
- **Writing** -
- **Singing/Autom Speech** +
- **Repetition** -

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Description of Problems

Wernicke's Aphasia 1875

(+ = No Problem, "-" = Problem)



Lesion - Post Portion of superior, transverse temporal gyrus

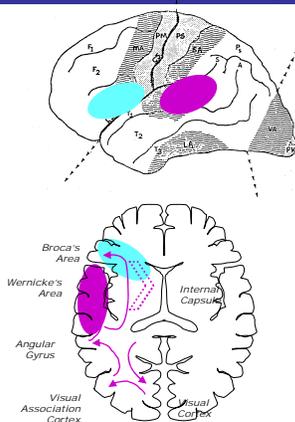
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• Physical	+
• Auditory Comp	- - -
• Fluency	+ + +
• Speech Rate	+
• Ease of Production	+
• Articulatory Agility	+
• Motor Initiation	+
• Phrase Length	+
• Melody	+
• Syllable Transitions	+
• Rhythm	+
• Grammar	+
• Naming	- - -
• Content	- - -
• Paraphasias	- - -
• Reading	-
• Writing	-
• Singing/Autom Speech	+
• Repetition	-

Comparison of Problems

Broca's & Wernicke's

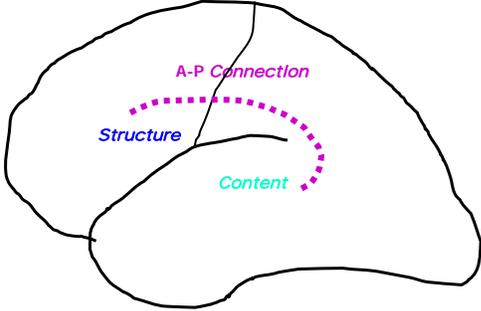
(+ = No Problem, "-" = Problem)



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	Broca	Wernicke
• Physical	-	+
• Auditory Comp	+	- - -
• Fluency	-	+ + +
• Speech Rate	-	+
• Ease of Production	-	+
• Articulatory Agility	-	+
• Motor Initiation	-	+
• Phrase Length	-	+
• Melody	-	+
• Syllable Transitions	-	+
• Rhythm	-	+
• Grammar	-	+
• Naming	+/-	- - -
• Content	+/-	- - -
• Paraphasias	+	- - -
• Reading	-	-
• Writing	-	-
• Singing/Autom Speech	+	+
• Repetition	-	-

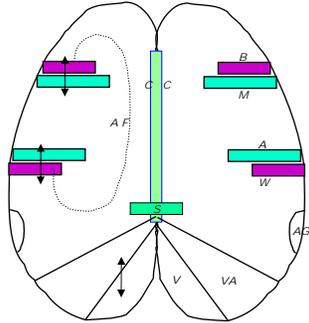
Wernicke's Model of Language/Brain



- Structure
- Content
- Anterior-Posterior Connection

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Wernicke's Model Intrahemispheric Connections

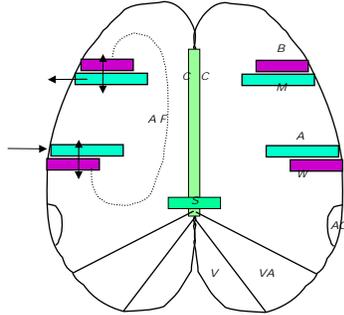


- B - Broca's Area (Motor Association)
- M - Motor Cortex
- A - Auditory Cortex
- W - Wernicke's Area (Auditory Association)
- AG - Angular Gyrus
- VA - Visual Association
- V - Primary Visual Cortex
- CC - Corpus Callosum
- S - Splenium
- AF - Arcuate Fasciculus

Route
 A - W Primary Auditory to/from Secondary Auditory (Wernicke's area)
 M - B Primary Motor to/from Secondary Motor (Broca's area)
 W - AF - B Secondary Auditory thru Arcuate Fasciculus to/from Secondary Motor

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Wernicke's Model Route for Repetition



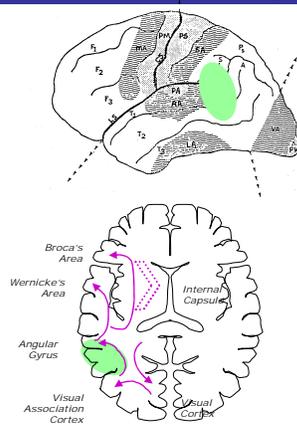
- Ear
- Dominant Hemisphere
- A - Primary Auditory
- W - Secondary Auditory
- AF - Arcuate Fasciculus (A-P Connection)
- B - Secondary Motor
- M - Primary Motor
- Speech Musculature

Code
 B - Broca's Area (Secon Motor) VA - Visual Association
 M - Primary Motor Cortex V - Primary Visual Cortex
 A - Primary Auditory Cortex CC - Corpus Callosum
 W - Wernicke's Area (Secon Audit) S - Splenium
 AG - Angular Gyrus AF - Arcuate Fasciculus

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Description of Problems Anomic Aphasia 1900

(+ = No Problem, *- = Problem)



Lesion - Infraparietal lobule or angular/supramarginal gyri

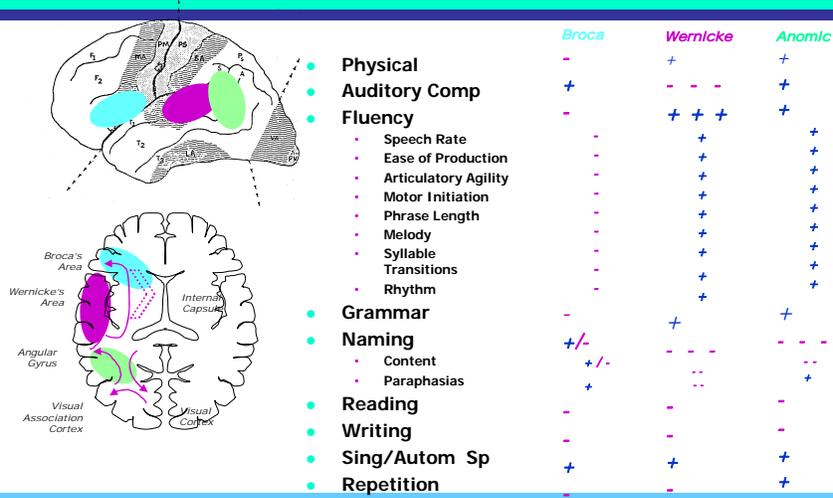
- Physical +
- Auditory Comp +
- Fluency +
 - Speech Rate +
 - Ease of Production +
 - Articulatory Agility +
 - Motor Initiation +
 - Phrase Length +
 - Melody +
 - Syllable Transitions +
 - Rhythm +
- Grammar +
- Naming --
 - Content --
 - Paraphasias +
- Reading -
- Writing -
- Singing/Autom Speech +
- Repetition +

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Comparison of Problems

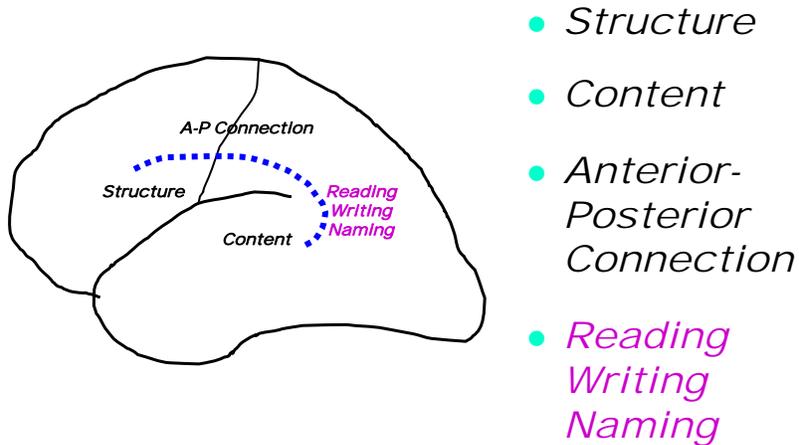
Broca's -Wernicke's-Anomic

(+ = No Problem, "-" = Problem)



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Extension to Wernicke's Model

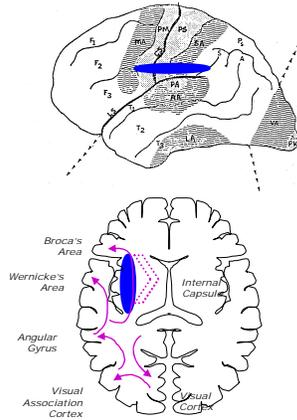


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Description of Problems

Conduction Aphasia 1965

(+ = No Problem, *- = Problem)



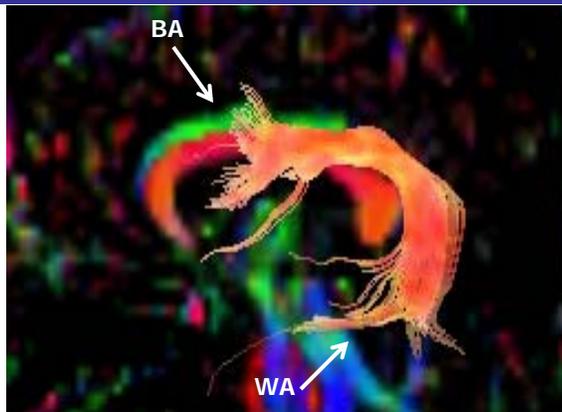
Lesion - Arcuate fasciculus, a lesion deep to supramarginal gyrus or insula

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- Physical +
- Auditory Comp +
- Fluency +
 - Speech Rate +
 - Ease of Production +
 - Articulatory Agility +
 - Motor Initiation +
 - Phrase Length +
 - Melody +
 - Syllable Transitions +
 - Rhythm +
- Grammar +
- Naming -
 - Content - -
 - Paraphasias - -
- Reading +
- Writing -
- Singing/Autom Speech +
- Repetition - -

Tractography/Left Hemisphere

Arcuate Fasciculus Normal 25y/o



Corpus Callosum – deep orange

Arcuate Fasciculus – light orange

BA - Broca's Area Insertions

WA - Wernicke's area Insertions

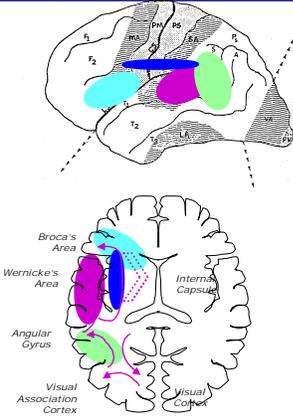
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Comparison of Problems

Broca's-Wernicke's-Anomic-Conduction

+ = No Problem, "-" = Problem)



	Broca	Wernicke	Anomic	Conduction
• Physical	-	+	+	+
• Auditory Comp	+	- - -	+	+
• Fluency	-	+ + +	+	+
• Speech Rate	-	+	+	+
• Ease of Production	-	+	+	+
• Articulatory Agility	-	+	+	+
• Motor Initiation	-	+	+	+
• Phrase Length	-	+	+	+
• Melody	-	+	+	+
• Syllable Transitions	-	+	+	+
• Rhythm	-	+	+	+
• Grammar	-	+	+	+
• Naming	+/-	- - -	- - -	- - -
• Content	+/-	- - -	- - -	- - -
• Paraphasias	+	- - -	+	- - -
• Reading	-	-	-	+
• Writing	-	-	-	-
• Sing/Autom Sp	+	+	+	+
• Repetition	-	-	+	- - -

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Right Hemisphere Language

Historical Perspective

- 1879 - *H. Jackson*
 - **Affective** speech mediated by R Hemis (pt lost propositional speech but could express emotion)
- 1950 - *Denny-Brown*
 - Described alterations in **expression** of emotion in pts with R Hemis lesions
- 1977 - *Heilman et al*
 - **Emotion** mediated by R Hemis - pts can't recognize &/or produce happy, sad, angry, indifferent
- 1978 - *Larsen*
 - R hemis **blood flow** patterns for automatic speech similar to L hemis patters for propositional speech
- 1979 - *Ross & Mesulam*
 - R hemis mediates "prosody" & emotional gestures - proposed **functional anatomic relationship**

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Right Hemisphere Language Historical Perspective

1981 - *Ross*

- Tested Pts - supported anatomic relationship/R hemis affective lang is organized in analogous fashion to L hemis propositional lang/termed **APROSODIA**

1983 - *Hughes et al*

- Showed R hemis lesioned Chinese (**tonal lang**) pts had problems with affect but not propositional lang

1984 - *Brownell et al*

- R hemis pts reduced in "**connotative**" processing & L hemis pts in "denotative" processing of same words

1984 - *Weintraub &
Mesulam*

- Described "**developmental R Hemis problems**" (like develop dyslexia in L hemis) - consisted of chronic emotional difficulty, (partic in expression) & disturb of interpersonal skills

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Aprosodia

Classification

- The functional-anatomic organization of affective lang in R hemis mirrors L hemis organization for propositional lang. So, aprosodias are classified in a fashion **analogous to aphasia** (e.g. motor aprosodia is analogous to Broca's)

Lesions

- Aprosodia lesion sites are **analogous to L hemisphere** lesion sites causing aphasia

*Patients - Functional
Appearance*

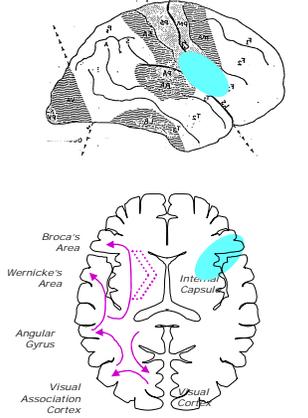
- **Expressive**
 - May appear depressed (doesn't initiate interaction)
 - May appear uninterested (doesn't look at speaker)
 - May display no emotion on face or incongruous signals (smile when describing sad situation)
- **Receptive**
 - May misperceive jokes or miss "in-jokes" with family & friends
 - May appear confused &/or respond "concretely" to specific words instead of message carried by tone of voice("you look awful" used teasingly to express compliment)

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Description of Problems

Motor Aprosodia

(+ = No Problem, *- = Problem)



Lesion - Post Portion of 3rd frontal convolution, adjacent subcortical white matter

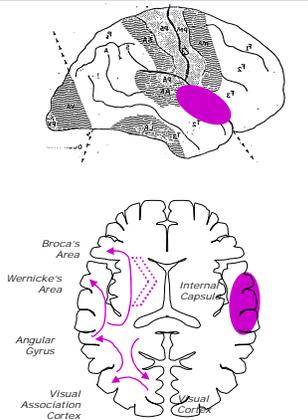
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- Physical -
- Comp of Emot Tone +
- Comp of Emot Gest +
- Prod of Prosody in Lang -
- Match Affect Tone to Semantic Output -
- Repetition -
- Prod of Affect Facial Exp & Gestures -
- Match Facial Express/ Gest to tone of voice -
- Match Facial Exp/Gest to Semantic Content -
- Appearance
 - Flat Affect/Depressed -
 - Confused/Inappropriate +
 - Labile -
- Other Problems
 - Hemianopsia/Neglect +
 - Slurred speech -
 - Disoriented +

Description of Problems

Sensory Aprosodia

(+ = No Problem, *- = Problem)



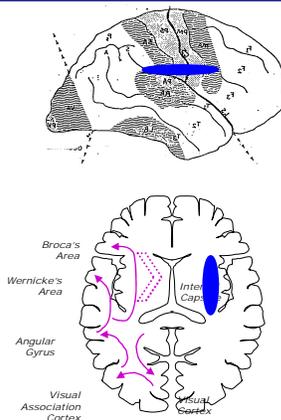
Lesion - Post Portion of superior, transverse, adjacent subcortical white matter

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- Physical +
- Comp of Emot Tone -
- Comp of Emot Gest -
- Prod of Prosody in Lang +
- Match Affect Tone to Semantic Output -
- Repetition -
- Prod of Affect Facial Exp & Gestures +
- Match Facial Express/Gest to tone of voice +
- Match Facial Exp/Gest to Semantic Content -
- Appearance
 - Flat Affect/Depressed +
 - Confused/Inappropriate -
 - Labile +
- Other Problems
 - Hemianopsia/Neglect -
 - Slurred speech +
 - Disoriented -

Description of Problems Conduction Aprosodia

(+ = No Problem, +/- = Problem)



Lesion - Arcuate fasciculus, a lesion deep to supramarginal gyrus or insula

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- Physical +
- Comp of Emot Tone +
- Comp of Emot Gest +
- Prod of Prosody in Lang +
- Match Affect Tone to Semantic Output -
- Repetition - - -
- Prod of Affect Facial Exp & Gestures - - -
- Match Facial Express Gest to tone of voice - -
- Match Facial Exp/Gest to Semantic Content -
- Appearance +/-
 - Flat Affect/Depressed -
 - Confused/Inappropriate +
 - Labile +
- Other Problems
 - Hemianopsia/Neglect -
 - Slurred speech +
 - Disoriented -

Aprosodia Functional Problems

- Family reports "personality" change & pt is "*not the same person*"
- Family/friends/staff report pt is purposefully being "*difficult*"
- Pts often end up in **divorces** due to changes in relationships
- Pts may **insult others** by attempting inappropriate "in-jokes" or using inappropriate tone of voice
- Pts appear "**concrete**" because they react to the linguistic components of messages vs emotional components
- Pts feel "*disconnected*" because they cannot produce or understand non-verbal messages (carry up to 90% of meaning)
- Pts appear "**uninterested**" due to lack of eye contact or facial expression - can result in reduced stimulation or cessation of interaction
- Audience becomes "**suspicious**" because pt sends confusing messages (e.g. sad story with smile on face)
- Pts appear & can become *depressed* &/or be diagnosed as having primary psychiatric problems because of the above

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Case of A.L.

- Iraq 3/03 to 6/04 – exposed to 2 roadside bomb blasts
- First - 10 ft from blast, no reported consequences
- Second – April 2004, 5 feet from blast
 - No obvious physical injuries
 - LOC – unknown amt of time, estimated a “few minutes”
 - Reported “slow” vision; hearing problems; impaired memory; stuttering; mumbling
 - No obvious “physical” injuries – was “looked over” w no other med tx

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Case of A.L.

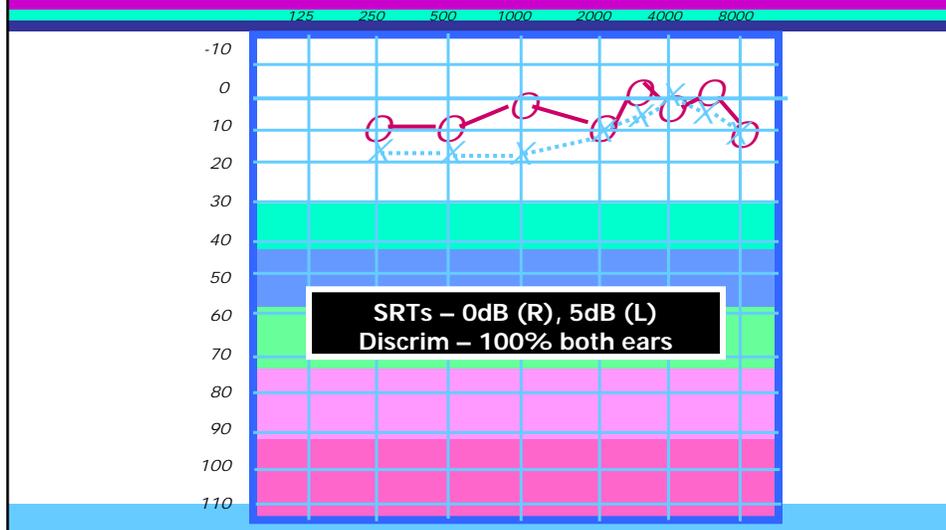
- 2 ½ Yrs Later Sept 2006 – seen in Palo Alto PNS clinic; reported continuing problems with above issues, reduced hearing, tinnitus, concentration problems, reduced family interactions, social withdrawal, headaches
- Tests
 - Speech Pathology – positive on screen, referred for indepth speech & language evaluation
 - Neuropsych – WNL cognitive; PTSD, referred to Mental Health
 - Audiology – normal peripheral hearing (see audiogram); no CAP testing conducted

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Audiogram of Pt A.L.

9-29-06



Case of A.L.

- **In-depth Speech-Language Eval** – revealed multiple problems suggesting bilateral, sub-cortical etiologies
 - Mild *conduction aphasia* (LH arcuate fasciculus)
 - Mild *neurogenic stuttering* 2dary to conduction aphasia
 - Moderate *conduction aprosodia* (RH arcuate fasciculus)
 - Moderate attention deficits (sustained)
 - Reduced speed of cognitive processing
 - Reduced *visual-perceptual* functioning
 - Constructional apraxia
 - Reduced spatial orientation
- Other – **reduced pragmatics, flat affect**

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Case of A.L.

- **Auditory Processing Findings** – areas of the speech-language exam suggested auditory processing problems
 - Auditory comprehension – 100th percentile except for complex ideational material (80th) suggesting auditory concentration or memory component
 - Test of Everyday Attention – worst scores on
 - 20th percentile - Elevator Counting with Distraction
 - 1-3rd percentile - Visual Elevator (also suggests attention prob)
 - 1-3rd percentile - Sustained Auditory Lottery (listening for targeted numbers presented in combination with letters & other numbers in various sequences)
 - Results – reduced speed of processing auditory information, concentration, memory, & *sustaining auditory attention* indicate auditory processing problems

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Case of A.L.

- **Treatment** – enrolled in therapy; early in tx complained of sleep problems & referred to Mental Health
- **Serendipity** – reviewed by Dr. Ashford (psychiatrist) and Dr. Rosen MD (neuropsychologist); read our report implicating arcuate fasciculus lesion; aware UCSF obtained new tractography technology; referred; A.L. one of first pts
- **Tractography MR** – new technology which permits identification of a magnetic resonance image of specific nerve tracts

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**Radiologist – Normal limits?
Neurologist – Interpretation**

Lateral View – arcuate fasciculus light orange

Anterior termination at Broca's area – the pt's is stumped without dispersion of its terminals

Middle tract of AF – pt's is clearly smaller & seems to be thinned with individual fibers apparent, suggesting loss of fibers in between

Posterior termination at Wernicke's area – again the pt's termination does not have dispersion of terminals & elongation appears to be abnormal growth of some fibers looking for a place to terminate

Anterior Posterior

**Radiologist – Normal limits?
Neurologist – Interpretation Below**

Anterior Posterior View – arcuate fasciculus light orange

A-P View – left hemisphere appears on right of slide

Anterior/Middle/Posterior – as on prior slide

AP View – features shown on lateral view also apparent on A-P view particularly the branching at Broca's area/control subject has profuse branching, pt's appears sheared

Right Hemis Left Hemis

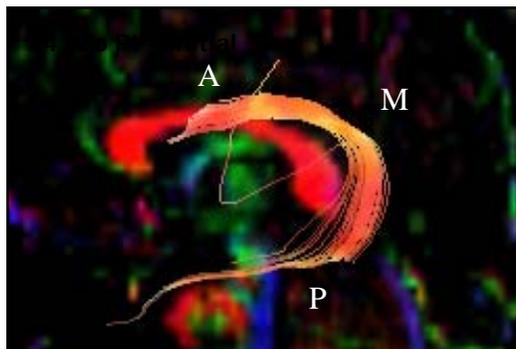
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Case of A.L.

- **Treatment** – emphasis on conduction aphasia, neurogenic stuttering, aprosodia & auditory attention
- **Repeat Tractography** – referred for 2nd tractography evaluation 4-6 mo after the first
- **Repeat Testing**
 - **Speech Path** – **significant improvement** in all tx areas
 - Distraction Subtest – 1-3rd to **30-43rd** percentile
 - Sustained Auditory – 1-3rd to **30-43rd** percentile
 - Aprosodia/Emotional Production – 25% to **87%**
 - Aprosodia/Repetition – 0% to **80%**
 - Audiology Peripheral Hearing – stable
 - Audiology Central Testing – SSW, SCAN-A

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Anterior

Posterior



Radiologist – No change?

Observation – Interp Below

Anterior termination at Broca's area – no longer a "stumped" appearance/new terminal growth

Middle tract of AF – appears to have new branching

Posterior termination at Wernicke's area – appears denser with more branching

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Right Hemis Left Hemis

Anterior Posterior View – arcuate fasciculus light orange

A-P View – left hemisphere appears on right of slide

Anterior termination at Broca's area – no longer a "stumped" appearance/new terminal growth

Middle tract of AF – appears denser

Posterior termination at Wernicke's area – appears denser & larger with more branching

no FU

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Therapy - Tractography

- **Tractography** – although there are no “normative” data yet, appears to be potentially powerful tool
- **Images** – pt seen 2½ yrs post blast, initial imaging showed what looked like “shearing” effect, 2nd imaging clearly shows changes after 9mo that look like **new terminal growth**
- **Therapy** – image changes 9mo into tx suggests tx works & functional changes correlate with brain structure changes

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Stages of Neurobiologic Recovery

Rapid Physiologic Changes

- **1-7 Days After Injury**
 - **Reduction of edema** - results in decreased intracranial pressure & in
 - **Improved oxygenation** - of cells around injury & analogous contralateral regions of brain (Benson & Geschwind)
 - **Passage of diaschisis** - or neural shock (Finger & Stein)

Intrahemispheric Reorganization

- **1-6 Months After Injury**
 - **Reconnection** - of damaged pathways/new synaptic connections to intact systems denervated by lesion (Jacobson, Bach-y-Rita)
 - **Transfer of Function** - reorganization or "unmasking" of intact pathways that were underutilized (Canter & Henri)
 - **Reduction of Disinhibition** - release of influence of damaged areas resulting in maladaptive behaviors such as perseveration, lability, distractibility (Wil & Echlaner)

Interhemispheric Reorganization

- **Months to Years After Injury**
 - **Reconnection** - transfer of function to analogous contralateral regions (Smith - recovered aphasics became aphasic again after R hemis lesion)
 - **Alternate Strategies** - use of processing strategies of intact functions to aid damaged areas (phonic vs sight reading)

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Stages of Neurobiologic Recovery??????

A.L Injuries

- **2 ½ yrs before eval**

Intrahemispheric Reorganization

- **???** Tractography suggested the normal A-P pathway was compromised; ??? if spontaneous reconnections occurred; limited if they did

Therapy

- **Changes suggested after 6 mo of treatment**

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Summary - mTBI Lang/Cogn Syndrome

- Conduction Aphasia
- Conduction expressive Aprosodia
- Neurogenic Stuttering 2ndary to conduction aphasia
- Visual-spatial Perceptual Problems/constr apraxia re: reductions in reading speed, writing/spelling
- Pragmatics reductions related to aprosodia
- Reduced speed cognitive processing
- Reduced attention w distractions

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Case of M.S.

- **Background** – 56 yr old SP 2 mTBIs; very bright, 2 degrees, 8yrs Air Force (4 active/4 reserve); pilot/worked in intelligence in AF/plotted bombing targets in Vietnam
- **History** – head hit windshield in MVA; immediate nausea & vomiting w “reduced speed of thinking” which did not last. Sustained 2nd MVA 7 yrs later.
 - Hit from behind while stopped w head turned, rt side of head hit windshield hit windshield
 - Immediate bloody taste in mouth, electric-like shocks down legs, nausea, vomiting, incontinent
 - Persistent nausea & headache for 7 days
- **Evaluation** – received no eval because there was no LOC
 - 3 yrs later - sought eval for persistent symptoms particularly w memory/concentration. Neuropsych findings included reduced processing speed but “emotional functioning was most likely cause of perception of reduced intellectual efficiency” & referred to Mental Health.
 - 3 yrs after that – again sought eval; neuropsych reported “w exception of processing speed no sig impairment in any domain of cognitive functioning.
- **Sp/Lang** – referred during routine audiology eval be: complaints of continuing attention problems

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Case of M.S.

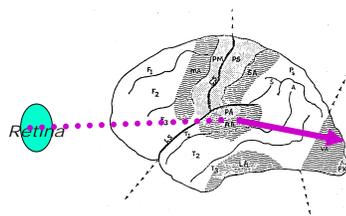
- **Sp/Lang Eval Presentation** – seen 8 yrs after second MVA (reported much stress about the lack of recog of her problems by professionals_
 - Reported changes in social interactions & history of “stuttering, stumbling, difficulty saying words”
 - No obvious prob w lang production or reception
 - Rapid, loud speech w no variation in volume
 - Reduced non-verbal repres of subtle emotional changes including reduced gestures
 - Verbose, consistently elaborated details (irrelevant), tangential, difficult to interrupt
 - Facial expression & other non-verbal posturing did not always match emotion expressed propositionally (often smiled & laughed while describing situations that brought her to tears
 - Displayed behaviors suggestive of functional memory, attention or organizational problems (papers filled w notes, constantly making notes)

- **Findings** – hx of conduction aphasia & mild neurogenic stuttering (by report), conduction aprosodia, visual-spatial processing problems, reduced communication pragmatics, reduced cognitive processing speed, reduced selective & sustained attention

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Visual Pathways - General

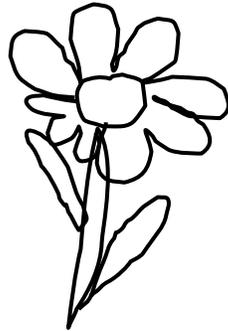


- **Cranial Nerves**
 - **II** - Optic
 - **III** - Oculomotor
 - **IV** - Trochlear
 - **VI** - Abducens

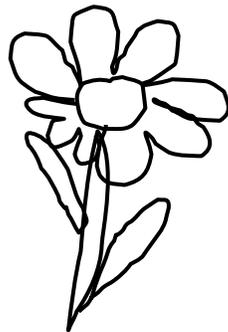
- **Optic Nerve** - not a specific nucleus but a fiber tract
 - First Order Neurons - rods & cones
 - Second Order - Bipolar cells in retina
 - Third Order -Ganglion cells in retina
 - Fourth Order - Fibers from LGB/Thalamus

- **General Pathway**
 - Retina
 - Lateral Geniculate Body in Thalamus (& superior colliculus in midbrain to connect to other cranial nerves)
 - Through Cortical Zones
 - Primary Visual Cortex

M. S. - Where's the Lesion



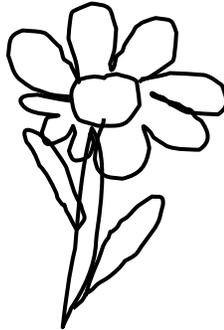
M. S. - Where's the Lesion



NOTE

Center first
Abnormal Pattern - LR quadrant next
Resumes Normal Pattern - UL
then circling to right
DELAY - LL quadrant petals delayed
and then LL design quadrant delayed
DISTORTION - LL quadrant leaves
are equal in number but show
significant size distortion

M. S. - Where's the Lesion



Hemisphere
Lobe
Cortical/Subcortical
Severity
Etiology
Complaints

Right
Parietal
Subcortical
Mild
TBI
Memory, organization, "slowed thinking"

Behavioral Correlates

Attention WNL on WMS but 30 points below General Memory
Distractibility 6th percentile on elevator counting with distract
Visual Memory 13 point diff between Visual & Auditory memory on WMS
TVPS 99th percentile on vis seq vs 50 on vis mem,
Speed Sig red on TVPS 3 hrs vs 20 min & 0% on cog flex on TEA (time on visual elevator)
Conduction aprosodia – match emot with propositional lang
Pragmatics Tangential, press of speech, turn-taking
Higher Lang Relev/irrelev, infer & presupposition
Spatial Map orient, construc on PLB lowest or <1st Quartile
Gen Cog Q strategies, Rel/Irre, Analy of attributes <30% on Ross & mild impairment on Hooper VOT (isolate responses)
Impact Funct problems with deductive reasoning, problem solving

Constructional Apraxia & Visually Based Dyslexia/Dysgraphia

Reading/Writing

Orients Visually to Strong Side

Reads R-L instead of L-R
 Example - "dog" for "god"

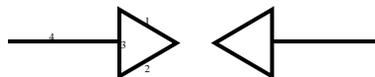
Moves to Strong Side

Writes to R-L toward strong side
 Example - "bop" for "dog"

Confuses Directions/Order

Reads "MOM" as "WOW"
 Spelling Errors – writes "boht" for "both"

Constructional Apraxia Errors



Summary

- **Pt Complaints** – carefully document complaints; problem presentation can change (e.g. some areas can improve) but hx of problems helps define patterns
- **mTBI Impact** – almost always bilaterally; in-depth language/communication/cognitive eval can identify subtle (but significant) consequences!
- **Imaging/Cortical/Subcortical** – pathophysiology of mTBI (DAI) is not obvious w routine imaging techniques, generally does NOT result in cortical syndromes (makes it difficult for Neuropsych & SLPs to diagnose since most tests sensitive to cortical dysfunction) but in mild subcortical problems that are varied be: of bilateral involvement & functionally can look just like problems seen in PTSD, depression, etc.
- **Repetition Testing** – critical for evaluation both of propositional & affective language; often missed because of administration errors (either giving sentences in phrases or crediting as correct pt responses that in phrases or single words)
- **Qualitative Evaluation** – extremely important; can see “within normal limits” results in context of subtest spread (e.g. pt M.S. 99th percentile on vis seq vs 50th on vis mem); WNL results coupled with unusual responses (e.g. pt M.Q. scored WNL on Boston Naming test but showed errors suggestive of conduction aphasia including “abstract” for abacus and “scripture” for scroll – non-aphasic pts either would give an “in-class” substitution or be self-cued phonemically when producing the first syllable)

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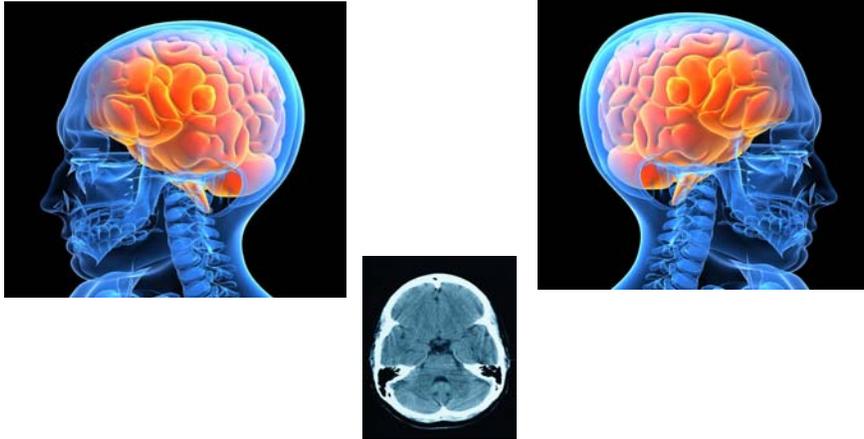
Summary

- **Whole Brain** – even though propositional “language” is mediated by the LH, communication is mediated by virtually the whole brain
- **mTBI** – re: in DAI with SOL difficult to predict & potentially multiple sites
- **Pt Complaints** – virtually all complain of initial “stuttering” or mumbling, “hearing” problems even in the context of normal tested hearing, “slowed” thinking, difficulty thinking of or saying words, memory or concentration problems, changed social relationships
- **DO NOT COMPLAIN** – of difficulty understanding or producing emotions, visual perceptual problems because they are unaware
- **mTBI Communication Syndrome** – VERY DIFFICULT TO DIAGNOSE bc symptoms can be mild in formal testing and complaints are consistent with other problems (PTSD), but careful analysis reveals a syndrome consistent with multiple subcortical dysfunction sites including *Conduction Aphasia, Conduction or Expressive Aprosodia, mild neurogenic stuttering, visual-spatial perceptual problems, pragmatics reductions*
- **Tractography** – potentially powerful tool for laboratory confirmation of clinical findings & response to tx
- **Treatment** – both functional outcome (repeat testing, vocational) & potentially tractography suggest tx is effective even YEARS after injury

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All of These Areas Connect With Each Other



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Case of A.L.

- *SSW* – one word substitution error, no reversals, no response bias
- *SCAN-A*
 - *Filtered Words & Auditory Figure-Ground* – test perception of distorted speech/relate to functional listening (speech in noise, speaking rate)
 - *Competing Words & Competing Sentences* – dichotic tests reflecting hemispheric maturation & specialization
 - *Results* – wnl on all except **borderline** normal on Filtered Words
- *Possible Correlations* – improved performance on auditory attention tasks & pt report of improved function

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