

Lecture 12: Language and Lateralization

- Review: **Crossover** of perceptual and motor pathways; Plays a role in some dominance patterns
 - VISION: Right Visual Cortex receives from Left Visual Field (from Right Retinas of both eyes) & vice versa
 - SOMATOSENSORY: Right somatosensory cortex from Left half of body (& vice versa); Face more shared
 - MOTOR: Right hemisphere controls Left half of body (& vice versa); Both control face altho opposite dominant

Lateralization = Dominance of one hemisphere of cerebral cortex over the other for particular functions

- Determined in part by Wada Test = Anesthetize 1 hemisphere by injecting Sodium Amytal in L or R carotid artery
 - Right hemisphere is usually dominant for visio-spatial tasks and socio-emotional processes (see more below)
 - Left hemisphere is usually dominant for language & other sequential and analytic processes
 - Includes manual control: ~90% humans are right-handed, even prehistorically (per early tools, artwork, etc.)
 - **Planum Temporale** - area in Temporal Cortex (includes Wernicke's Area) - **larger in Left Hemisphere**
 - In Nonhuman Primates: Equal or only slightly larger in left, also involved in vocal communication
- **Interference** can be observed in simultaneous tasks controlled by same hemisphere, or in competition between hemispheres
 - e.g. While talking (Left hemi dom), will tap more slowly w/Right hand (Left hemi dom), than w/Left hand (Right hemi dom)
 - e.g. **Stuttering** (most often in left-handers) may involve hemispheric competition for control of speech
- **Corpus Callosum** = Bundle of axons connecting 2 cortical hemispheres integrate sensory/motor info from 2 sides
 - Thicker in Left Handers (who also tend to be more ambidextrous than right-handers)
 - Thicker in Women, who are thus less lateralized (e.g. after damage to one hemi, other more able to take over function)
- **Split-Brain Patients** have Corpus Callosum connections severed - e.g. As treatment for epilepsy
 - Word or image flashed in Right Visual Field (=> Left hemi) can be ID'd by touch only by Right hand but not by Left hand
 - Image flashed in Right Visual Field (=> Left hemisphere) easily named, but not if in Left Visual Field
 - Image (e.g. **5**) flashed in Left Visual Field (=> Right hemisphere) and experimenter ask yes/no question
 - e.g. Exp: Is this a letter? Subject: Yes (response produced by ignorant Left hemisphere)
 - If incorrect, knowledgeable Right hemisphere => frown, Left detects frown & changes response!
 - Sometimes patient's hands operate independently - e.g. One buttons shirt while other unbuttons it
 - Overall, however, behavior fairly normal, subject learns to cope by shifting eyes, hands, talking to self, etc.
- **Anterior Commissure** - connects anterior parts of cerebral cortex, especially the Temporal Lobes
 - Larger in Females and Homosexual Males

Specializations of the LEFT Hemisphere

Broca's Area

- Left Frontal Lobe, just rostral to the base of the Primary Motor Cortex which controls face and mouth movements
- Damage to this and surrounding Cortical area, including underlying Basal Ganglia => **Broca's Aphasia**
 - AKA "Nonfluent" or "Productive Aphasia" = deficits in producing (& comprehending) grammatical speech
 - Subjects are aware of and highly frustrated by deficits
- Symptoms vary, but can include Articulation Difficulties, Agrammatism, and Anomia
 - **Articulation Difficulties**: Speech is slow, halting, laborious (loss of prosody), words often mispronounced (e.g. phonemes switched, such as "lipstick" => "lickstip")
 - However, words generally used correctly and speech is at least somewhat comprehensible
 - **Anomia** = Cannot "find" word, esp Closed Class terms
 - Although speech fairly meaningful tend to omit Closed Class (grammatical) terms such as Prepositions (of, by, for) Articles (the, a) Conjunctions (and but), Tense & # markers (-ed -es) etc.
 - That is, speech consists mainly of nouns, verbs and adjectives ("Content Terms")
 - Cannot even repeat or read Closed Class terms
 - e.g. Can repeat COWS EAT GRASS but cannot repeat NO IFS, ANDS, OR BUTS
 - e.g. Can read TWO BEE OAR KNOT TWO BEE, but cannot read TO BE OR NOT TO BE
 - **Agrammatism**: Difficulty in producing and understanding grammatical forms
 - e.g. Given "The boy that the girl is chasing is tall", cannot say who is tall
 - e.g. Cannot follow sequential commands - "Put red block on green block"
 - e.g. Given "Boy chases Man" can't choose correct drawing (boy chase man vs. man chase boy)
 - Unless can use meaning to figure out probable order - e.g. can choose "Man swats mosquito"
 - So in general comprehension is better than production
- Also produces deficits in Sign Language production

Wernicke's Area

- Left Temporal Lobe, on Superior Temporal Gyrus just caudal to Primary Auditory Cortex
- Damage to this & surrounds (including adjacent Parietal) => **Wernicke's Aphasia** AKA "Fluent" or "Receptive Aphasia"
 - = Deficits in the comprehension (and production) of meaningful speech
 - Subjects often seem unaware of deficits, although do detect reaction (confusion, frustration) of others
- Symptoms include Fluent Articulation, Anomia, Nonsensical Speech, and Incomprehension
 - **Fluency**: Speech is unlabored, prosody maintained, sounds like it *should* make sense (but doesn't)
 - Still take turns in conversation, recognize questions and readily answer, respond to intonation, etc.
 - Speech is grammatical, although sometimes switch agent/object (e.g. "The Astros listened to the radio")
 - **Nonsensical Speech**: Very glib, but use wrong words or nonsense words
 - **Anomia**: Mainly for Content Terms (nouns, verbs adjectives etc.) May substitute vague phrases, wrong word
 - Depending on location of damage, can get specific deficits:
 - e.g. Words for animate vs. inanimate objects, parts of the body, spatial relations etc.
 - **Incomprehension**: Cannot follow simple directions, cannot pick named object, etc.
 - Some can read, write words and even read lips, but cannot understand spoken = "**Pure Word Deafness**"
- Does **NOT** typically produce deficits in Sign Language Comprehension
 - Instead, STS and Parietal Lobe damage implicated in deficits of Sign Language comprehension

Arcuate Fasciculus

- Bundle of axons (White Matter) forming reciprocal connections between Broca's and Wernicke's Areas
- Damage to these axons => **Conduction Aphasia**
 - Ability to **Repeat impaired** – esp of unfamiliar or nonsense words
 - So Arcuate Fasciculus in part for "Rehearsal" of just-heard and/or about-to-be-spoken words (talk to self)
 - i.e. Aspect of a particular form of Working Memory called the "Phonological Loop"
 - May produce **Phonemic Paraphasia** = substitute wrong phoneme into word
 - Instead of "happy" say "hippy" (substitute another word); instead of "party" say "partoo" (nonsense)
- Damage to other white matter connections between Temporal and Frontal lobes...
 - May permit meaningful, fluent speech, fairly good comprehension, but show problems in conversation
 - May impair Lip Reading, processing Facial Expression (esp when **Right STS** involved)

IMPORTANT to recognize that **both hemispheres** and **multiple cortical areas** participate in language!

- e.g. Right hemisphere also active – e.g. Occipital (visual) & Parietal (spatial) lobes usually involved
- e.g. Orbito-frontal Cortex important for evaluating appropriateness of response
- Understanding and generating language is a complex process involving **non-cortical** areas as well
 - e.g. Cerebellum plays a role in articulation (for rapid, skilled movements)
 - e.g. Limbic System important for comprehending & producing emotional content, and recall
 - e.g. Basal Ganglia for pragmatic goals, turn-taking Etc etc etc!

Specializations of the RIGHT Hemisphere

- **Global** pattern-recognition versus local (detailed) analysis
 - e.g. Magnocellular (low spatial frequency) visual pathway dominates over Parvocellular (high spatial frequency)
- Right hemisphere plays dominant role in organizing narrative - selecting and assembling elements
 - i.e. "Gets the gist" versus keeps particular details straight; Getting a joke
- **Music** (esp Melodic) perception and appreciation
 - Probably related to global pattern-recognition abilities, organization, and interpreting ffective tonal qualities
- **Spatial** abilities, related to above.
 - Split-brain patients can complete picture puzzle better with left hand
 - Damage (esp in **Parietal Lobe**) results in...
 - => Deficits in map reading, and in generation/use of own "cognitive map" (resort to landmarks to get around)
 - => Deficits in perceiving or discussing spatial relations (over/under, left of/right of)
 - => Some indication that mathematics (geometry, but also other types) impacted
- **Socio-Emotional** expression and perception. Damage (esp in **Frontal Lobe**) results in...
 - => Reduced emotional expression both in face and in speech (i.e. speak in monotone, little inflection)
 - => Reduced ability to recognize, correctly categorize emotional expression/speech in others
 - Includes failure to recognize sarcasm, humor (probably also related to global/gist processing)

Again IMPORTANT to recognize that in normal people, both hemispheres participate in, contribute to all of above