

Functional Neuroscience for the Clinical Music Therapist

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Objectives

- To understand basic neuroanatomy
- To learn basic neurodevelopment
- To define Network Theory and it's impact on the therapeutic process
- To learn how music affects the brain (and why that matters to you)
- To make it clinically functional and approachable

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The Building Blocks

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Two Nervous Systems

CNS = Central Nervous System

- Spinal Cord and Brain
- Function: Coordinates our activity and behaviors

PNS = Peripheral Nervous System

- Somatic and Autonomic NS
- Sensory neurons and motor neurons
- Function: To connect the CNS to the limbs and internal organs

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Basic Components of the CNS

- Neurons = Brain cells
- Synapses = Neuronal connections (e.g. communications)
- Networks = Group of neurons that cooperate
- Systems = Group of networks



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Neurons are the building blocks



- Cell Body: Keeps the neuron functioning
- Dendrites: Collects information
- Axons: Carries the information (myelin)

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The Colors of the CNS

Grey matter

- Masses of cell bodies & dendrites
- Superficial and deep parts of the cortex & cerebellum, Deep parts of the spinal cord

White matter

- Bundles of myelinated axons
- Deep parts of the cortex & cerebellum (Fasciculi), Superficial parts of the spinal cord (Nerves)

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Cell Communication

Electrical Synapses

- Pass a current from one cell to another
- Conduct impulses more quickly (simple, synchronized actions)
- Bidirectional

Chemical Synapses

- Carry a neurotransmitter (messenger chemicals)
- Most common
- More complex and can vary in strength

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Other Important Parts

Blood Supply

- Two pairs of arteries that feed the brain

Meninges (Dura Mater, Arachnoid, Pia Mater)

- 3 membranes that protect the CNS

Ventricular System

- Contains cerebrospinal fluid (CSF)
- Bathes and cushions the brain and spinal cord

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Neuroanatomy

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Spinal Cord: A Pathway

- Functions: 1) Transmits Sensory & Motor information; 2) Reflex center
- 31 Spinal nerves ("mixed")
- Ascending and Descending Spinal Tracts (white)
- Crossing Over
- Clinical: Plegia



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The Brain Stem allows us to live

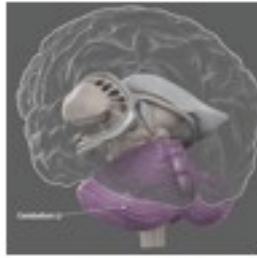
- Medulla, Pons, & Midbrain
- 12 Cranial Nerves (motor and sensory)
- Respiration, Cardiac Fx, Consciousness, Sleep, Regulation
- Clinical: Coma, Vertigo, Sleep apnea



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Cerebellum is for timing

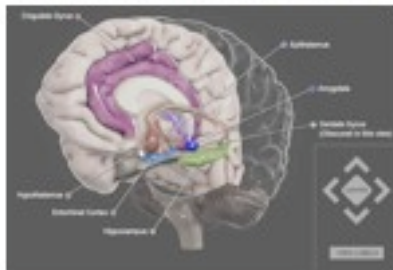
- **Functions:** Coordinates voluntary motor movements
- Motor learning
- Balance & Posture
- Timing & Sequence learning
- **Clinical:** Loss of coordination, tremors, slurring



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Limbic System

Emotions, Memory, Drive, Motivation



- **Clinical:** Depression, Uncontrolled Emotions, Memory Probs

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Cortex

"Thinking," Language, Processing, Sensory, Motor



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Frontal Lobe

- Largest lobe in humans
- Orbitofrontal Cx, Prefrontal Cx, Broca's area, Motor Cx
- Attention, Thought, Voluntary movmnt, Language, Decision-making
- **Clinical:** Aphasia, Mood changes, Atypical social & personality traits, Poor social interactions, Paralysis



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Parietal Lobe

- Somatosensory Cx
- Integrates sensory information to help us make sense of the world (visual, spatial, somatosensory)
- Clinical: Inability to locate & recognize objects, Disorientation, Diff. discriminating sensory info



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Temporal Lobe

- Recognition (face, object), Perception, Understanding language, Learning & Memory, Emotional reactions
- Primary Auditory Cx & Wernicke's area
- Clinical: Agnosias (recognition), Aphasia, Schizophrenia, Autism, Memory loss, Aggression



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Occipital Lobe

- Primary visual area
- Clinical: Hallucinations, Blindness, Synesthesia, Inability to see color/motion/orientation



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Neuroplasticity

- Neurons respond, change, and re-organize based on experiences
- Learning by adding connections, removing connections, adding cells
- More network activation = Stronger information is learned (internalized)
- Clinical: Allows for therapeutic change!!!

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What is a Network?

- Brain processes in networks, not in places
- Distributed regions cooperate with each other (chemically or functionally connected)
- Networks linked by fasciculi
- "Neurons that fire together wire together" (Hebbian 1945)

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Song Break

The 3 Neurotransmitters

Primary Concepts:

- Neuroplasticity occurs because of the action of neurotransmitters (neuromodulators) = the "how" of therapy
- Norepinephrine is involved in getting our attention. Novelty works well.
- Acetylcholine is involved with getting and keeping our attention. Make tasks motivating and interesting.
- Dopamine is like a "save" button, using reward and motivation to reinforce learned information.

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Neurodevelopment

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A Four-Step Process

- Neuron Formation (in utero)
- Neuronal Migration (2nd trimester)
- Dendritic & Synaptic Development (3rd trimester through life)
- Myelination (lifetime)
- Clinical: Trauma / LD (prob with migration #2), DD (not enough neurons #1)

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A Period of Rapid Growth

- Most rapid development occurs from fetal to age 3/4
- Genes drive formation & migration
- Born with an overproduction of neurons which are pruned
- Period of development for our "Superhighways" Fasciculi (architecture)
- Use-Dependent development: Experiences shape our brain

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Critical Developmental Opportunities

- Infant's brain is 1/3 size of adult brain
- Adult brain size = 2/3 based on connections (synapses)
- By age of 3, 90% of brain developed
- Critical Periods: Developmental windows of opportunity
- THUS...most critical developmental opportunities

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Development is predictable & hierarchical

- "Right-to-Left"
 - Right hemisphere (Gestalt, holistic, gross, intuitive, whole)
 - Left hemisphere (expert, discrete, fine, specialization, details)
- "Back-to-Front" -- Primitive structures (caudal) to Complex structures (rostral)
- Primary --> Association --> Integration
- Success at one stage is dependent on previous success

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Song Break

The Neurodevelopment Song

Primary Concepts:

- Neurodevelopment is predictable and hierarchical.
- Our brain grows in a use-dependent fashion and is influenced by both genes and our environment.
- At birth, some structures fully developed & others are not.
- Define Critical Periods.
- Describe pruning neurons and the growth of connections (fasciculi)

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Neuroscience and Therapy

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Therapy involves making new connections.

- Therapy involves recruiting neurons from other areas to repair the network.
- Forcing a person to do what they can't do forces their brain to recover (Constraint-Induced Therapy 1970s)
- Practice --> More Myelin --> Efficiency
- Therapy only works if a client does it right. Limit rewards to progressive change towards the positive.

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Therapy is a 2-step process

- Stimulate the brain to make new connections (recruit new neurons, come up with strategies)
- Practice for increased myelination (homework, machines, CDs)
- Other factors: diet, exercise, sleep, lifestyle

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Two types of processing to use

- Top-Down Processing (Visualization, Seeing, Experience and Knowledge) --> Adults
- Bottom-Up Processing (Experiencing, Doing, Environment and Memory) --> Children

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Impact of Emotions

- Amygdala “supercharges” the hippocampus
- Highly emotional memories are easier to store and recall
- *Therapy that taps into our emotions is more effective*

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Song Break

Watch and Learn: The Mirror Neuron Song

Primary Concepts:

- Brain can organize itself (learn) by watching others
- Brain can't tell the difference between seeing something and doing something
- Network: Inferior Frontal Gyrus (Broca's) – Parietal Lobe – Posterior Superior Temporal Sulcus
- Clinical: Empathy, Learning, Emotional Connectedness, “Broken” system may be implicated in some dx (autism)

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Summary of the Therapeutic Process

- Do it (Mirror Neurons, Developing strategies)
- Make it Relevant (Functional, Emotional)
- Repetition & Practice (Myelination for increased efficiency)

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Music and the Brain

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Listening starts a cascade of events...

- Subcortical structures → initial auditory processing
- Auditory Cx = Initial processing
- Frontal Cx = Processing structure and expectations
- Limbic system = Arousal & pleasure
- Cerebellum/Basal Ganglia = Processing rhythm and meter
- Wernicke's area = Processing lyrics
- PLUS...all the connections between these structures

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Performing music involves...

- Motor Cx (Frontal) = motor execution
- Sensory Cx (Parietal) = sensory feedback
- Frontal lobe = planning, decision-making
- Limbic system = make it emotional
- Broca's area = Singing lyrics

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References

- Basso (2009), "Linking Neuroscience to Clinical Practice" (training at PVHS)
- Levitin (2006), *This is Your Brain on Music*
- Thaut (2005), *Rhythm, Music, and the Brain*
- Goldberg (1979-2003), *Clinical Neuroanatomy Made Ridiculously Simple*
- Genes to Cognition Online: <http://www.g2online.org>
- PBS's NOVA Science Now: <http://www.pbs.org/nova/sciencenow/>

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