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Describing the Neural Components for Cognitive-Skill Units within Each of the Multiple Intelligences - A Brief Summary

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ABSTRACT

The concept of intelligence has been debated since introduction of IQ tests in the early 1900s. Numerous alternatives to unitary intelligence have achieved limited acceptance and IQ remains the predominant theoretical basis for schooling. Multiple intelligences theory, despite criticism it lacks experimental validity, has had sustained interest by educators worldwide as a means of personalizing instruction and curriculum. The neuroscientific evidence for the intelligences has not been updated since 1983. This investigation reviewed 417 neuroscientific studies examining neural correlates for skill units within seven intelligences. Neural activation patterns demonstrate each skill unit has its own unique neural underpinnings as well as neural features shared with other skill units within its designated intelligence. These patterns of commonality and uniqueness provide richly detailed neural architectures in support of MI theory as a scientific model of human intelligence. This brief article provides an excerpt from the full dataset describing the neural features for cognitive-skill units for the linguistic intelligence. Full details for six other intelligences are available in the original full article and supporting Supplemental Materials.

Keywords: Frames of mind, Multiple intelligences, Occipitotemporal

CHRONIC PAIN AND ACUTE PAIN

This investigation examines the neuroscientific bases for the theory of multiple intelligences (MI) as described by Gardner [1] in his influential book Frames of Mind. Gardner [1] redefined intelligence as the ability to solve problems or create products of value in a culture or community. Using this broad, common-sense definition and criteria that cover a range of evidence (e.g. neuroscience, psychometric and evolutionary evidence and atypical populations); Gardner [1] described eight distinct forms of intelligence that are possessed by all people, but in varying degrees. The eight intelligences identified to date are linguistic, logical-mathematical, spatial, kinesthetic, musical, interpersonal, intrapersonal and naturalist **(Table 1**). Each intelligence represents a composite of related cognitive-skills that includes convergent problem-solving as well as divergent thinking and creativity.

Educators around the world responded to MI theory with enthusiasm by revising instruction, redesigning curriculum and re-envisioning entire schools in order to personalize the educational experience and maximize success for all students regardless of their cognitive profiles [2]. However, doubts about the scientific validity and efficacy of MI theory limit its acceptance and adoption by traditional educational institutions [3].

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Table 1. Multiple intelligences core cognitive units and dominant neural regions [4].

Intelligences (# of studies)	Core Cognitive Units	Primary Regions	Sub-regions
Interpersonal (61)	-Social Perception -Interpersonal Understanding -Social Effectiveness -Leadership	Frontal Temporal Cingulate Parietal	Medial-Temporal Amygdala Dorsolateral PFC Anterior Cingulate Superior Temporal Sulcus
Intrapersonal (101)	-Self-Awareness -Self-Regulation -Executive Functions -Self-Other Management	Frontal Cingulate Temporal Parietal Subcortical	Prefrontal-Cortex Anterior Cingulate Dorsomedial PFC Lateral Prefrontal Ventromedial
Logical-Mathematical (32)	-Mathematical Reasoning -Logical Reasoning	Frontal Parietal Temporal	Prefrontal Intraparietal Sulcus Inferior Parietal Lobule
Linguistic (37)	-Speech -Reading -Writing -Multimodal Communication of Meaning	Temporal Frontal Parietal	Superior Temporal Gyrus Inferior Frontal Gyrus Broca's Area Posterior Inferior Frontal Gyrus
Spatial (49)	-Spatial Cognition -Working with Objects -Visual Arts -Spatial Navigation	Frontal Parietal Temporal Occipital	Premotor Cortex Motor Cortex Medial Temporal Prefrontal
Musical (77)	-Music Perception -Music and Emotions -Music Production	Frontal Temporal Subcortical Cerebellum	Superior Temporal Gyrus Primary Auditory Cortex Premotor Cortex Basal Ganglia Supplementary Motor
Kinesthetic (60)	-Body Awareness/Control -Whole Body Movement -Dexterity -Symbolic Movement	Frontal Parietal Subcortical Cerebellum	Motor Cortex Primary Motor Cortex Premotor Cortex Basal Ganglia
Naturalist (0)	-Pattern Cognition -Understanding Living Entities -Understanding Animals -Understanding Plant Life -Science	Temporal Subcortical	Superior Temporal Sulcus Amygdala Brainstem Thalamus Midbrain Basal Ganglia

Note: *Eight forms of intelligence are described by Gardner with several core cognitive components per intelligence. Each intelligence (as well as constituent components) is aligned with specific patterns of neural activation in regions both large and small. Displayed above are the most frequently cited neural regions and not the full list of citations from the literature. Intelligence is a complex idea that is represented by the diversity of neural structures cited for each intelligence*

MI theory was one of the first contemporary models of intelligence based on neuroscience evidence gathered by Gardner in the early 1980s. This evidence has not been comprehensively reevaluated since 1983, until recently when over 500 neuroscience reports were systematically reviewed. Five investigations used a “wisdom of the field” approach to gather insights from a wealth of neuroscience evidence to determine if the eight intelligences possess neural coherence aligned with contemporary cognitive models of skill and ability [4,5]. These data models indicate that each of the intelligences have neural architectures that are equivalent with the most widely accepted neural descriptions of general intelligence (IQ).

The idea of multiple intelligences is still evolving from a framework presented in 1983 towards a fully realized scientific theory. Shearer and Karanian [4] demonstrated that each intelligence has general neural coherence but for a theory to have scientific validity more detailed neural modeling is required. The following review of 417 neuroscience reports organizes 30 years of neural data according to the core skill units within each of seven intelligences. Naturalist is not included due to a limited number of studies available for its skill units. The goal was to determine if the evidence describes meaningful neural differences and commonalities among three or four skill units within each intelligence as predicted by MI theory.

The minimum number of studies included in this analysis was 32 for logical-mathematical and a maximum of 101 for intrapersonal (mean=60) (**Table 1**, column 1). A complex data set was obtained where neural activation patterns from three levels (primary, sub-regions, multi-regions) were matched to the intelligences’ skill units. The eight primary neural regions were defined as frontal, temporal, parietal, occipital, cerebellum, subcortical, cingulate and insular. Numerous sub-regions within each primary region were systematically organized (i.e., prefrontal gyrus, anterior cingulate, etc.) in addition to multi-region activation patterns (i.e., limbic system, occipitotemporal cortex, etc.).

SUMMARY AND CONCLUSION

This paper is not intended as medical advice or to replace consultation with a physician or medical specialist. It is designed to provide a global overview of some of the issues regarding pain and pain management. Some suggestions are offered simply for consideration. In some cities and towns there may also be support groups available for pain management.

A detailed description of the entire neural data is beyond the scope of this discussion so the linguistic intelligence data will be presented to illustrate how the neural architectures for cognitive-skill units are related to each other and to their designated intelligence. Linguistic intelligence includes three cognitive-skill units: Reading, Writing and Speech.

LINGUISTIC

Linguistic intelligence is associated most strongly with the temporal (51 cites, 33%), frontal (44 cites, 28%) and parietal (24 cites, 15%) primary regions. Temporal sub-regions identified include inferior temporal, fusiform gyrus and visual word form area. Frontal sub-regions include inferior frontal gyrus, posterior inferior frontal gyrus and Brocas Area. Parietal sub-regions include inferior parietal lobule, angular gyrus and precuneus.

The reading skill unit has its highest primary regions nearly identical to those of the whole intelligence described above. Many of the same sub-regions are also included. Writing skill unit is dominated by the frontal (13 cites, 31%) and occipital (8 cites, 19%) regions. Sub-regions within the frontal cortex include prefrontal, motor cortex, dorsolateral PFC, Brocas Area and the orbitofrontal gyrus. Speech has the temporal cortex as its dominant (12 cites, 52%) with related sub-regions: superior temporal sulcus, Wernickes area and the visual word form area.

Overall, two skill units have temporal, frontal and parietal as their highest while it is in fourth place for the Writing unit. Writing is also different with occipital in second place and it is of much less importance to the other skill units. Each skill unit has its own unique sub-region pattern while having two sub-regions in common. Reading has four sub-regions unique to it while both writing and speech have five sub-regions that are not shared with either of the other two skill units **(Table 2 and Figure 1)**.

Table 2. Linguistic primary neural regions.

Linguistic: Skill Units		
Combined	**ct**	**%**
Temporal Cortex	51	33
Frontal Cortex	44	28
Parietal Cortex	24	15
Reading		
Temporal Cortex	13	34
Frontal Cortex	11	29
Parietal Cortex	8	21
Writing		
Frontal Cortex	13	31
Occipital Cortex	8	19
Speech		
Temporal Cortex	12	52
Frontal Cortex	5	22
Parietal Cortex	4	17

Note: *Primary regions with the highest number of citations (ct) per skill unit*

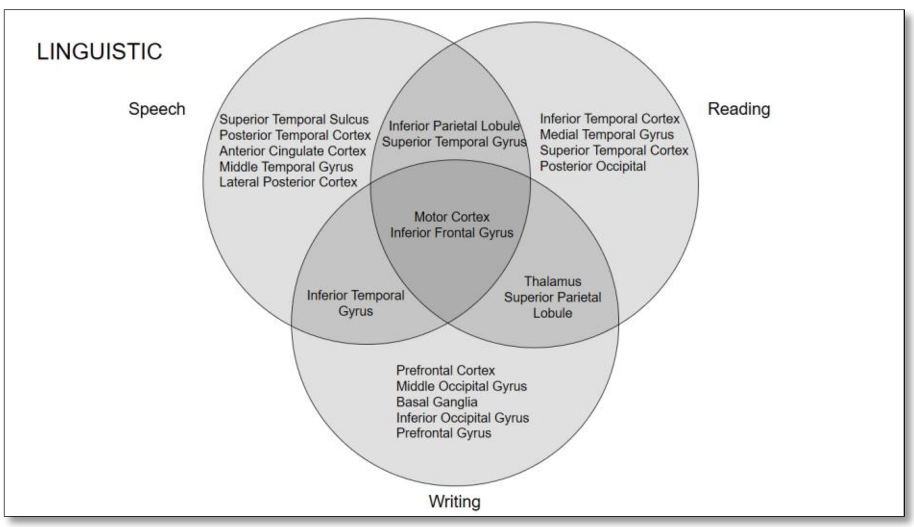

Figure 1. Linguistic: Sub-regions unique and common among skill units.

Note: *Three skill units are identified for linguistic intelligence. Each unit has several neural regions unique to it along with several neural regions in common with other skill units. Two sub-regions are common to all three skill units*

DISCUSSION AND CONCLUSION

This investigation uncovered neural evidence indicating that within each of the multiple intelligences is cognitive-skill units that have their own neural uniqueness and commonalities. These shared and unique neural activations are evident in large (primary) regions as well as smaller sub-regions and large-scale multi-region activation patterns.

There are three potential implications emanating from this investigation. First, the development of any new scientific theory rarely emerges fully realized in a single effort. Frames of Mind are a comprehensive description of MI theory with brief descriptions of several neural regions associated with each of the seven intelligences. Extensive accounts of many other kinds of data are provided in support of Gardner's contention that intelligence is best characterized as multiple rather than singular. The present analysis adds multiple layers of neural description to the frameworks underpinning each of the intelligences and their constituent skill units.

Neuroscientists study specific behaviors and then extrapolate from the data to infer broader abstract categories of behavior. The theory of multiple intelligences has been difficult to investigate directly due to the abstract nature of the designated intelligences as composites of skills and cognitive performances. The neural architectures presented here offer a detailed roadmap of specific behaviors amenable to experimental research not previously available. Thus, making further investigation of human intelligence in its many forms more amenable to scientific study.

Lastly, this work describes the neural features underlying specific cognitive-skills that are the target of instruction in schools and classrooms, e.g. reading, mathematical reasoning, musical performance and whole-body movement, etc. MI theory has inspired many educators to alter instruction, curriculum, and school design without this knowledge. However, due to scientific doubt and criticism by administrators, these efforts have been difficult to deploy widely and to sustain their integration into existing educational systems. The dichotomy between the science of brain research and the art of instruction has been described as a "bridge too far" by Bruer [6].

The emerging field of educational cognitive neuroscience strives to bridge these differences and apply its findings from the lab to the classroom in ways that can be systematic and replicable without over-simplification [7]. The detailed neural architectures described here represent a practical interface between instructional efforts and insights about how the brain functions during a variety of intellectual activities. This multiple intelligences-inspired interface provides a detailed neural foundation for the creation of educational systems that can personalize instruction and curriculum to maximize engagement, motivation and achievement of all students.

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