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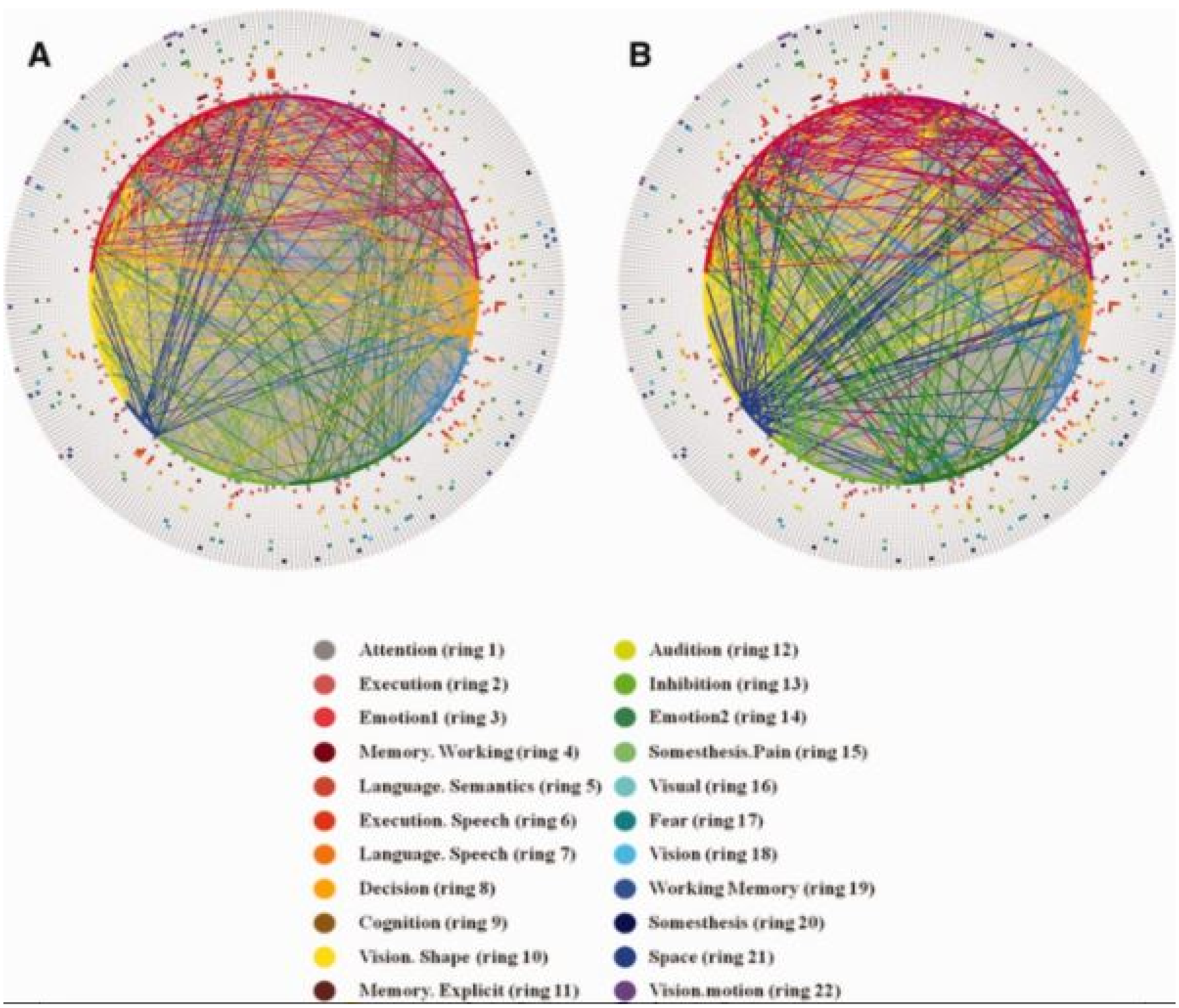
Psych 450 Neural Network models of
Social and Cognitive Processes

April 23rd, 2018

Examining working memory deficits in learning disabled populus using Emergent Neural Network Model



ABSTRACT:

Working memory is a central cornerstone to components of cognition. It entails keeping relevant information disposable for a task for approximately 10-15 seconds so long as persistent neural activity is available, then jetisons the information away. Furthermore, Working memory is the greatest predictor of later cognitive ability and academic achievement. Students high in indices of working memory while young are more likely to be academic elite; such as PHd's. Often, capacity of working memory is determined by a law -- Miller's law -- which states 7 ± 2 items is the maximum a person can use during an extended period of time. However, approximately 10-15% of the academic student population[1] suffer from learning disabilities. In the vast majority of cases, this means lowered working memory capacity or ability. Considering the high correlation between working memory and academic terminal education, a model for understanding the plight of LD individuals is necessary. Using Emergent Software, tasks will be recorded for efficiency when performed with decreasing units of working memory.

Final Emergent Project:

Working memory components for individuals with Learning Disabilities

Working memory is a concept first envisioned in 1956 by the Prolific Professor George Armitage Miller and his colleagues. Initially, the distinct between short term and long term memory was difficult to discern, therefore, numerous arduous testing procedures were performed also involving executive function to assess the average number of component items. Eventually, a greater distinction was drawn, showing that short-term memory that is concerned with the immediate processing of perceptual and linguistic information. Longer term declarative memory -- necessary for recognition or recall quizzes -- is stored in the medial temporal lobe or the hippocampus. “Seven Plus or Minus Two” is the opus work which Miller published. *Chunk* is another characteristic that Miller noted of working memory; a limit is applied to how much information can be within a single variable (item). Working memory is often misconstrued as being a powerhouse indiscriminate of needing to put forth effort. WM is higher in certain individuals, yet, attention -- or executive function -- needs to be applied at all times or else relevant items of information cannot be gained or manipulated. Lastly, the life of working memory follows a parabolic curve; increasing in childhood and eventually reaching the peak when neuroplasticity begins to decline (25-30) age range. During elder years, the working memory capacity declines, yet recall is still intact.

Conceptual recognition is important to understand the multi-modal pathway working memory. Baddeley and Hitch's (1974) representation of working memory is relatively simple: the Central executive powerhouse is linked to three modules: a phonological loop, visuospatial scratchpad and episodic buffer. Within the phonological loop are the articulatory loop and the acoustic storage space. Each one of the these pathways must communicate with each other, justy, bidirectionality applies. **Phonological Store** (inner ear) – Linked to speech perception. Holds information in a speech-based form for 1-2 seconds. **Articulatory control process** (inner voice) – Linked to speech production. Articulatory control process is the equivalent of Cerebellar matching of initial command to a feedback loop. Besides these two working memory entities, there are two other phenomena called **spatial working memory & verbal working memory**; used to work on complex mathematical equations and manipulate prior information. Spatial working memory focuses on mental rotation of objects while verbal WM is primarily ability to manipulate words through the articulatory loop. A learning disability could inhibit anyone of these auditory or visual pathways or the ability to integrate information (Like dyscalculia) because of motor deficiencies. My project will symbolize the interference that comes with WM impairments.

“Learning disability” is an extraordinarily broad category; Dyslexia, Dyscalculia and Autistic Spectrum Disorders (ASD), ADHD are often difficult to categorize. I’m primarily focusing on Non-Verbal Learning Disability, or NVLD. NVLD is a learning disability afflicting ~3.5 million Americans in the United States (1 in 100). Physicians do not definitively know what causes the disorder, but have narrowed it down to two possible phenomena: low quantities of white matter in the cerebral cortex or a missing portion of the corpus callosum which allows cross-over of information; also why it’s dubbed the Right-Hemisphere disorder, because the left (verbal) portion of the brain is still highly functioning. As expected, it is an impairment of short-term working memory and spatial reasoning intelligence. My purpose is not to localize & understand the neurophysiological/neurobiological components of NVLD, just to mirror the working memory components as simulated by blocks of information. Considering *Miller’s Law* principles, the peak capacity of a human’s working memory is 7 ± 2. Obviously there are differences between individuals; however, for experimination in my Emerent Final Project, seven items fits perfectly within the constructed size parameters. Disciplines of science that are highly analytical: mathematics, physics & computer science are top-heavy in components of working memory and challenging for a person with low WM. Understanding, in a visual representation, how the mind struggles to juggle information when inhibited is unique, providing opportunities for further research if allowed to release the project open source. Exclusion of spatial reasoning and intelligence will be independent from this project and excised completely.

When creating this model, the *conceptual representations were most important to me*, which is why I use the AB_AC interference model. Additionally, I wanted to *try something different* with an analytical approach instead. In order to create an Input layer (DLPFC), Output layer (HIPP) and Hidden layer (encoding). The input layer is named DLPFC -- or Dorsal Lateral Pre-Frontal Cortex. The Hidden layer in between is titled, “encoding” because there is a period where information must be captured to be viable. During that period the Medial Temporal lobe captures information if it is stored for minutes, rather than seconds. However, the Hippocampus is the final main arbiter and resting stop for declarative memory. Hippocampus, an organ critical to the consolidation of memory from short-term to long-term, will serve as the output layer. Biological plausibility is always an essential question to address. As mentioned above, my primary focus is not on biological plausibility, especially due to the the impossible task of differentiating auditory and visual-spatial working memory (made easier by into two different pathways which involve 5 or more structures of the brain. For example, ventral streams to recognize objects and temporal regions for localizing objects. A full biologically plausible model would be months of diligent work.

Methodologies:

- **Parameters:**

Learning rate: *xcal_l_lrn* default learning rate of 0.0005

Lrate: 0.04

-This is based upon the Miller’s Law number of 7 ± 2. Thus, we don’t truly need 1, because with each iteration, we will notice an **n-1** decrease. Also, like Miller, here I decide to take an aggregate of the working memory magical number.

-layers that will be connected similar to how we attempted the AX tutorial. Using the basis of AB_AC model in order to comprehend the results.

-Start with 9 items or components (Theoretical max) which will be represented in many units. Eventually, we will lesion progressively (add interference) to see how it affects performance on the task. Hopefully, there will be a more drastic decrease in performance. We are looking for a N/A dropoff/ exponential increase as represented by no hidden (encoding) units.

-**Each iteration** will yield a another lesion (by an increment of gi_inhib) Hidden_lay_inhib_gi 0.3. Every component of the memory will follow suit. The number of cycles will be measured in EPOCH AVG.

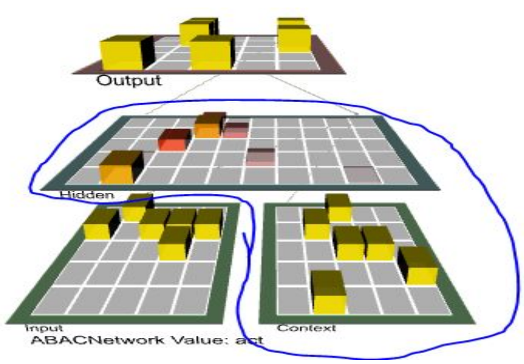
-**Batch RUN** to get 5 iterations of each were acquisitioned to ensure a proper statistical aggregate.

-**Contextual layer & hidden layer** are the two most important layers to observe. Every iteration and trial will be using *act* option for viewing.

-Pathway outline of pathway (simplistic):

DLPFC (input) → (**Hidden (encoding)** ← → **Context**) → HIPP (output)

Final highlighted diagram of how the layers will work:



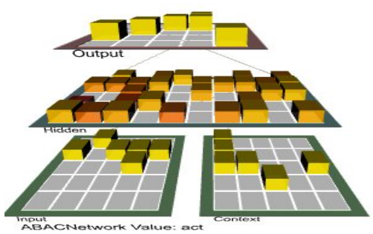
*Blue highlighted portion is the totality of the encoding layer. This picture taken on 2.1 g_inhib, thus, the hidden layer in the middle is experiencing some of the interference.

Results:

Using **AB_AC interference** not only made sense because it was simplistically fitting the loading of data, yet it also pertains to tasks of persistent neural activity and therefore working memory itself. My methodology in a conceptual project is to find an increment where I ramp up the interference. The increase of interference will act as lesioning.

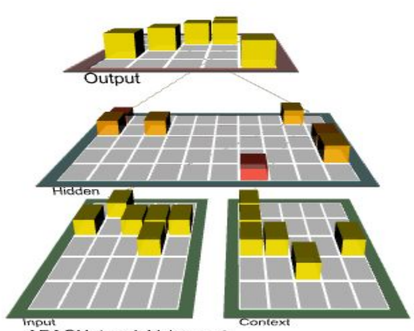
Working memory rep #:	9	8	7	6	5	4	3	2	1
Hidden_lay_inhib_gi:	1.0	1.3	1.6	1.9	2.2	2.5	2.1	2.4	2.7
EPOCHs required(avg):	27	30.6	35.4	41.8	65.8	***N/A**	***N/A**	***N/A**	***N/A**

Figure 1. 1.0 inhibition



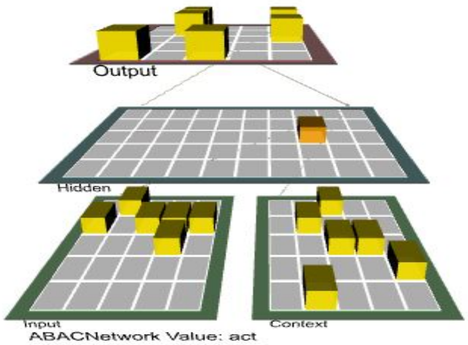
Note: hidden_lay_inhib_gi is set to 1.0 to start. AVG EPOCHS: 27. Absolutely infallible (though theoretically possible working memory capabilities).

Figure 2. Increasing inhibition to baseline (1.9) ~default



Rapid diminishment of Hidden encoding layers

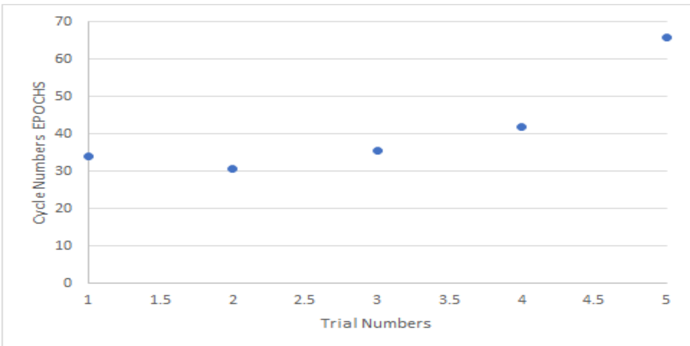
Figure 3. One unit left on inhib layer (2.5)



*This is what we are looking for. Additionally, **less output >input units.** Demonstration of transfer loss of working memory components could be symbolic of executive function inhibition.

Analysis of data/ discussion of results:

Plotted in excel are the notable diminishments of working memory through numerous trials:



**My Excel graph confirms exactly what I was looking for! Showing a proverbial collapse of ability to cycle through data once there in not proper communication between the hidden layer and contextual layer! Hidden layer units diminish to the point of collapse on the *act* viewing matrix. We witnessed the largest gaps between the unit jumps of 1.6 → 1.9, 1.9 → 2.2, 2.2 → 2.5 then, began the breakdown and a N/A availability of data section.

This result shows increasing inhibition which, in periphery, symbolizes low working memory/ anxiety within the student populus inhibits the ability to learn while performing a task.

Increasing g_inhib acts as decreasing the executive function, justly the capacity of working memory.

Second model (more ambitious):

Stroop modeling is more ambitious, considering the definitive amounts of units for lesioning.

Pathway:

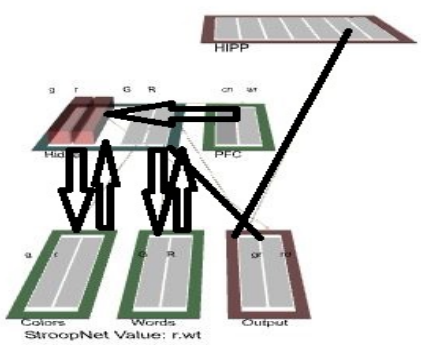
DLPFC (input) → Hidden (Encoding) ←→ **Colors (r,g)** → Output (MTL) (rg, RG) → HIPP

←→ **Words (R, G)**

- Load data in Excel to my my project in CSV file. Attempt to load weights from 9-1.

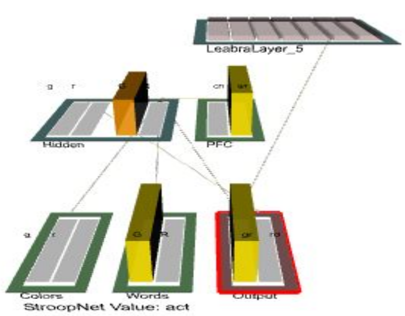
-Add more pathways (colors/ words), an attempt was made unsuccessfully. Model has partial performance on a simple task. The other output could be a plausible Medial Temporal Lobe.

Figure 1. Initial setup



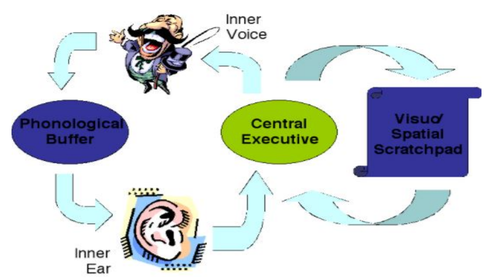
Pictorial representation of pathway.

Figure 2 small amounts of experimentation:



Output was initially set to target which was perfect for experimentation, however, I ran into a problem clearly evident from first glance. If the Lebra layer (HIPP) was to be viable in a working scenario, another buffer layer and expansion of all other tasks would be required. Words, Colors must all equal each other in unit geometry and be composed of seven bidirectional units. Currently, there is an aggregate of the below output unit's layer spread all over the HIPP above. Thus, the solution is to code 5 additional tasks on the WORDS/ COLORS layer and upload weights while selectively lesioning units. Stroop proved to be too ambitious, I understand the methodology how a neural network of this magnitude may be implemented, however, more time would a viable way to implement multiple colors and words with bidirectionality pathways while also integrated layers above and below.

How to improve the model(s):



After careful analysis of browsing each one of the models as a template, I've noticed several that are viable candidates to possible "improve" the model. BG would provide greater biological plausibility because the many hidden layer portions could be renamed into items that better fit the pathway such as: ventral, Temporal pathway, left/right crossover of Pre-Frontal Cortex. Furthermore, the Attn_simple task, I was fascinated about the potential of turning the two sides spat_1/ spat_2 symbolically as either the phonological loop or the visual spatial pathway, as lesioning these two could distinguish between these two paths. *ACTpriming* is the among the other simplistic viable options I saw, it would be a simplistic model of potentially lesioning units in an opportune manner. Chapter 4 *model and task*, chapter 6 *objectrec*; also honorable mentions in feasibility adaptability to a neural network model to working memory performance tasks.

A wide variety of models found in every chapter could be creatively adapted.

Lastly, in order to have the greatest value, we should implement the goal (task) towards something societally relevant. Open Cognition lab has a test of working memory; it focuses on pictorial representations, available to stored into a file for the Emergent software V1 program. A task on pictorial representation accuracy could be presented by training a network on hundreds of images for an extensive time period. During that time layer representation units, which follow the Miller’s law of 7 ± 2 items, will encode the images depicted. In order to begin the lesioning process, units should be selectively dissected from the right to left. Lesioning units on either sides prevents extraordinary outlining drops in performance. Progress should be tracked using percentages and then measured in excel. I would assure this methodology would yield a journal article if adapted to the right complexity.

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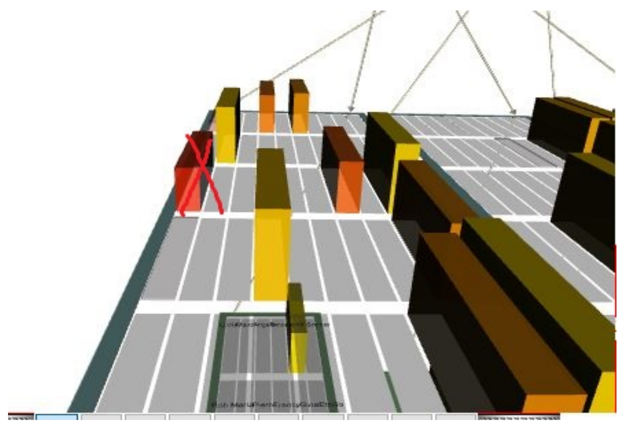
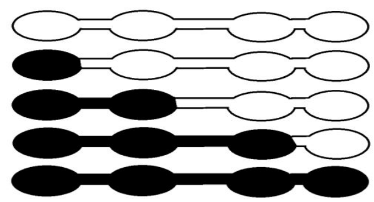
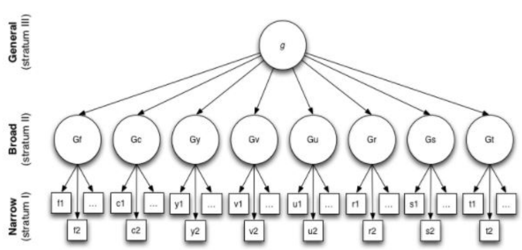


Why this was important:

Learning disabled individuals are often cast to the wayside in our education system. Inhibition of IQ occurs when a learning disability is present, which if also highly tied to income with a 0.4 correlation. Meanwhile, a lack of clarity and funding plague the system -- new, under-prepared special education teachers outnumber those who are fully prepared 2:1.[2]" Companies will not invest themselves into a venture that yields no profit. Learning Disability students do not simply shed the disorder in adulthood; as life becomes increasingly complex, learning disability adults are at far greater risk of commiting suicide, "Adults with learning disabilities had a 46 percent higher odds of attempted suicide than their peers without learning disabilities.[3]"

Additionally, I intend to use the information constructed in this model for my journal article titled, *Intuitive Cognitive Models for Individuals with Non-Verbal Learning Disabilities*. Using cognitive models constructed by myself -- essentially guides to help chunk information better -- I plan to ease the testing material workload by alleviating stress and heavy areas of working memory for students with dysfunctional working memory. For example, Color coding physics problems, increasing space and simplicity of word problems, finally, providing bubble markers for individuals unaware on how many steps are required to sufficiently complete a problem. During this scenario, I look to the John Carroll Model (1993) in order to understand the debilitating effects of learning disabilities. Areas such as Gf (fluid intelligence) is impaired the most, which is a critical component relevant to a world burgeoning with data.





Works cited:

[1] University College London. “Learning Disabilities Affect up to 10 Percent of Children.”*ScienceDaily*, ScienceDaily, 18 Apr. 2013.

[2] Freedberg, Louis, and Theresa Harrington. “Special Education in ‘Deep Trouble’ and Still Needs Reform, Says California Ed Board President.” *EdSource*, EdSource, 17 Oct. 2017.

[3] Frye, Devon. “Study: People with Learning Disabilities More Likely to Attempt Suicide.”*ADDitude*, ADDitude, 14 Aug. 2017.

Little Note/ Fun Fact: I was diagnosed with this condition -- Non-Verbal Learning Disability -- just a year ago. Designing the model and performing in the class was very difficult for me, I just thought I would let you know.