Can We Reverse Aging? Using Cognitive Training in Rodents to Enhance Overall Cognitive Performance

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Aging, Cognitive Flexibility and Plasticity

- Amount of Cognitive Resources decline as we get older (Park, 2013)
- What happens in the brain as we age?
  - Fewer synapses
  - Decrease in brain volume
  - Decrease in dopamine and its receptors
  - Less myelin around the axons

- What is the difference between Cognitive Plasticity and Flexibility
  - Plasticity
    - The capacity for changes in cognitive flexibility (Lödén et al., 2010)
  - Flexibility
    - Refers to the capacity for changes in the possible range of cognitive performance (Lödén et al., 2010)

So how can we reverse Cognitive Decline during Aging?

Ways to Slow Cognitive Decline

Ones that Work!

- Contemporary Dance and Tai Chi increase performance in setting, suppressing, and switching attention tasks (Coubard et al. 2011)
- Creative behavioral action promotes flexible processing (De Dreu & Nijstad, 2010).
- Higher education (Vitelli, 2016)

Ones that have less support!

- Brain Training Apps or Cognitive Mobile Games
  - Peak
  - Elevate
  - Luminosity
  - BRAINLY
  - Brain HQ
- Brain training apps earn 1.9 billion dollars in 2018 (Weiss, 2019)
- Peak won “App of the Year” while any benefits would only be seen if the individual played for one hour a day for eight to ten weeks (Suszynski, 2021).

Brain Training Apps prey on vulnerable individuals and created a successful market that is mainly based on misinformation

Improving upon Brain Games

- Brain games have exercises targeting
  - Working memory
  - Speed
  - Attention
  - Flexibility
  - Problem solving
- Brain games have focused too broadly on improving whole systems

- Working memory capacity
  - Estimate for cognitive resources
  - Estimate of performance for memory systems (Castillo Escamilla, 2020)
  - High WMC is attributed with fewer mistakes in spatial memory tasks (Castillo Escamilla, 2020)
- WMC is dependent on dopamine
  - D2 receptors decline with age, and therefore WMC declines as a results (Volkow et al., 2015)

If Working Memory Capacity is linked to other types of memory and dopamine, could cognitive training that specifically targets WMC slow the rate of age-related decline?

ADHD and Aging

- Attention Deficit Hyperactivity Disorder is a disorder affecting inhibition and a dysregulation of dopamine (Levy & Swanson, 2001)
- Most Common mental disorder in the United States (NIHM)
- Little to no information about how ADHD individuals age
- ADHD individuals have decreased WMC
    - Therefore have a decreased cognitive resource capacity/ cognitive plasticity
    - Could show cognitive decline earlier, as cognitive resource capacity also decreases with age

The Current Study

- To assess the effectiveness of working memory training on later cognitive abilities
- I examined aged Sprague Dawley (control) and Spontaneous Hyperactive (ADHD-like) rats
- I constructed a Cognitive Flexibility Program to mimic the Working Memory Tasks that humans do in brain training apps
- I tested the rats on 2 versions of a learning task – one that assesses Working Memory and one that assesses Reference Memory

By using Cognitive Exercises that improve working memory, the overall rate of cognitive decline will lessen

Using this Cognitive Training Program that focuses on set-shifting and working memory could benefit the entire cognitive system as WMC is linked to numerous other memory systems

SHRs that participate in the program will do better than both SD groups, and SHRs that do not receive training

Cognitive Training Procedure

- Adapted from Birrell and Brown 2000
- Each day consisted of two rounds
- Rats had to get six correct to either move to the next level/ finish for the day
- There were three levels of training available depending on how well the rats were doing
  - **"Easy"**
    - Simple discrimination like the ones in habituation
  - **Standard**
    - All rats start here
  - **"Complex"**
    - Round one is the same, but round two switches all stimuli pairings instead

Table 1
Pairs of Odors and Medias

DAY	ODOR PAIR	MEDIA PAIR
1	**cumin**/tarragon	**string**/kitty litter
2	**lavender**/cinnamon	Shredded paper/ sand
3	**Rose geranium**/ cypress	grit/ course shavings
4	**grapefruit**/rosemary	Fine shavings/ cotton pads
5	Cedar wood/ ylang ylang	**Cigarette filters**/course cork
6	bergamot/tangerine	**Fine cork**/ beads
7	**peppermint**/vanilla	gravel/ sparkles
8	**ginger**/cucumber melon	yarn/ care fresh
9	turmeric/cloves	**Sheet moss**/ cut raffia
10	dill/ pumpkin spice	**Cut sponge**/ easter grass
11	**thyme**/sassafras	Coconut bedding/ puff balls

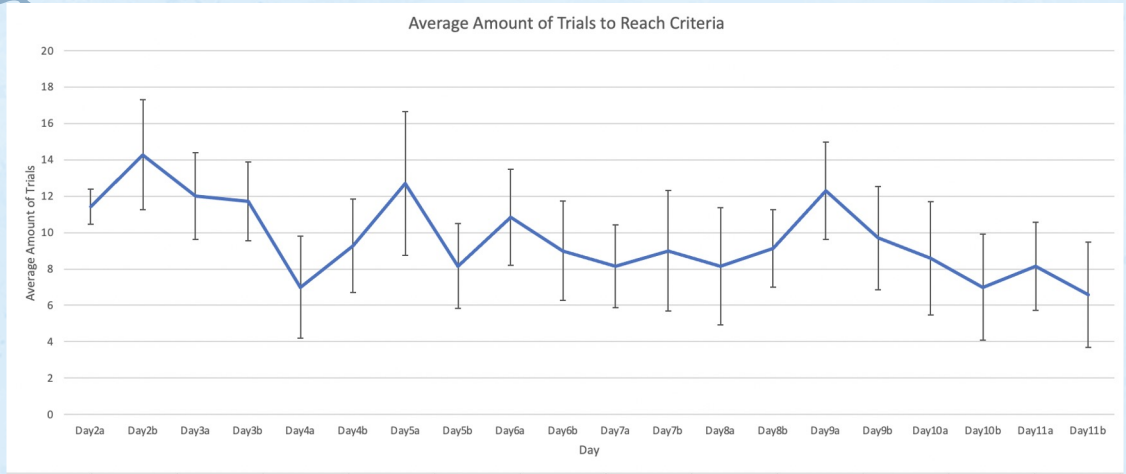
Table Description: Each bolded term is the relevant stimulus for that day. The first day both cumin and string are relevant as it is a habituation trial. After the first day only one stimuli is relevant.

Morris Water Maze

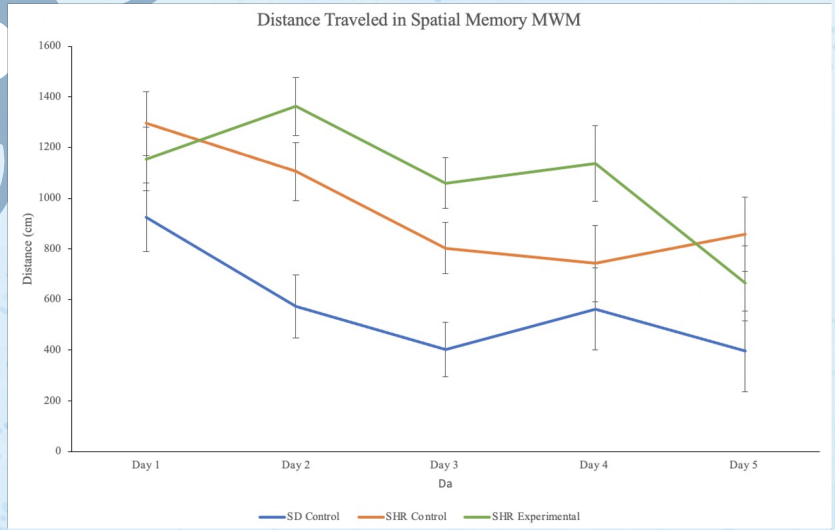
- Two different variations of the MWM
  - Reference Memory (5 days)
  - Working Memory (4 days)

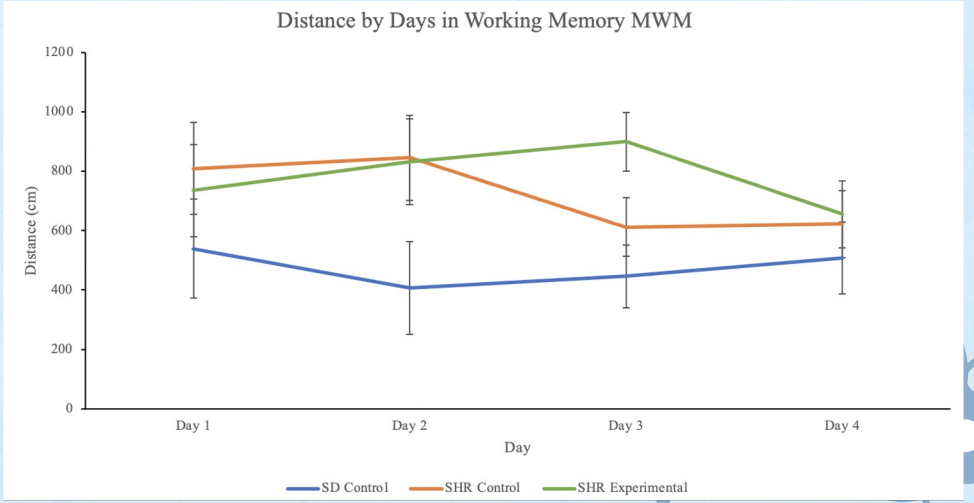
Augusta University
https://www.augusta.edu/research/core/sabc/test-spatial-learning-memory.php

Trials to Criterion in the Cognitive Training Task

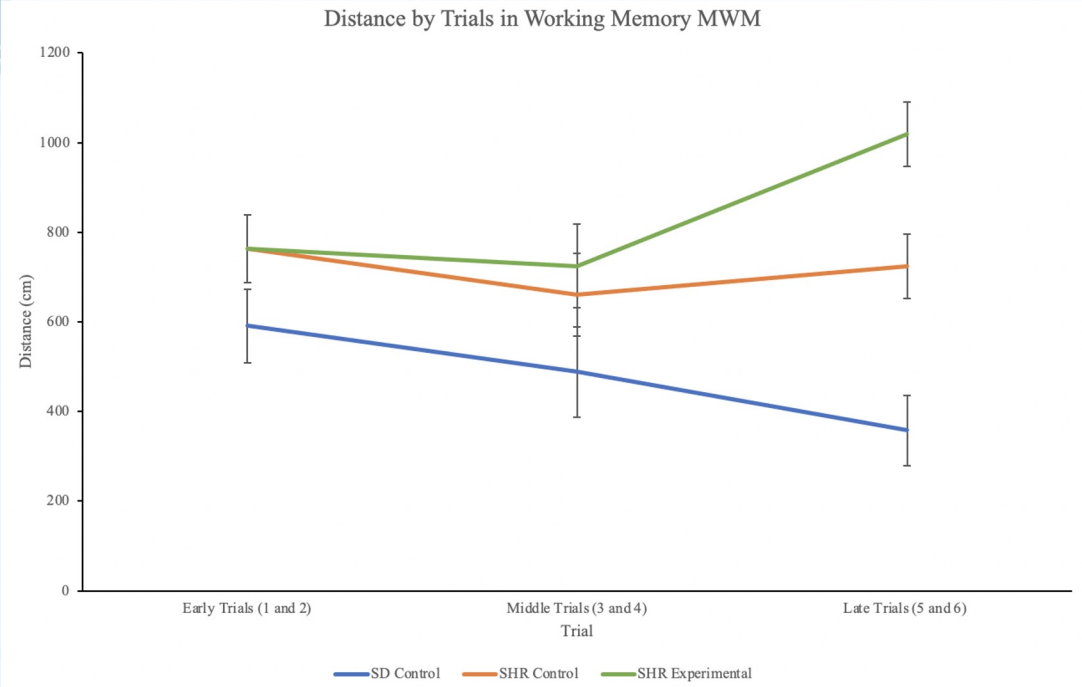


Distance Traveled in Spatial Memory and Working Memory MWM

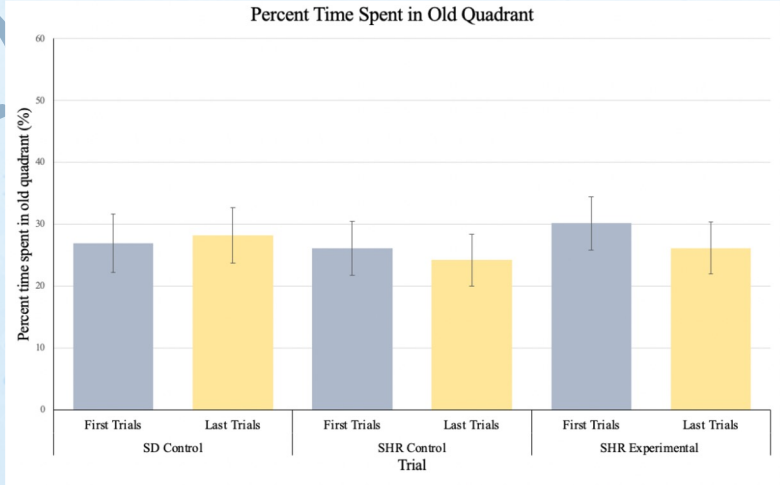


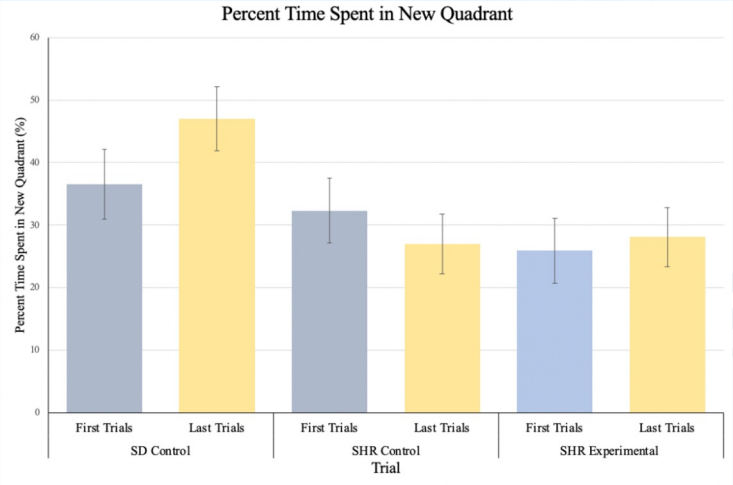


Distance by *Trials* in the Working Memory MWM



Percent time spent in the Previously Correct Quadrant (old) vs Currently Correct Quadrant (new)





Overall Conclusions and Suggestions

- SHRs that received Cognitive Training actually did worse than every group
  - Had a reverse learned curve
    - Swam farther in WM MWM trials
  - Could be because the program allowed them stimulation
  - SHRs seem to become more hyperactive as they age
- The rats ***did*** learn, but the cognitive flexibility training did not severely/improve affect spatial memory
- SHRs age differently than SDs!
  - Suggesting Neurotypical individuals age differently than Neurodivergent individuals
- Although the cognitive training was ***not effective,*** it may have changed the rats in some manner, and allowed the rats to display either a ***decrease*** in working memory or an ***increase*** in hyperactivity.

Thank you so much for attending!

Any Questions?