

### Promising “non-traditional” approaches to cognitive enhancement

I’d like to start off by saying that I was sorry to hear that your students fell short of state expectations and that I understand the depth of this fortunate opportunity provided the generous contributor. I find it interesting that the majority of students and parents give great reviews regarding the quality of education and the teachers in the school. I am convinced that the right route to solving this disconnect between the positive feedback and evidence within the test results is cognitive enhancement. I do not believe that there isn’t a lack of excellent teaching happening with the school and I know that students know when they aren’t being taught the material. I think we should target adjusting the way the students perceive the information, their attention and their memories.

Prior to making a final decision, I made sure to keep in mind the goal of increasing the students’ ability to learn as well as another aspect of this dilemma which is the attitudes of the students and parents. I can understand how frustrating it may be for the students to feel that they were on a higher level than they truly were. On top of that, the new approaches will be yet another mandatory task implemented into their days so the approaches should be helpful and pleasant. Certainly, the parents want a helpful and pleasant learning environment for their children. I have concluded that the best approaches to invest in would be creating an exercise program and creating a neurofeedback clinic for the students.

Achieving cognitive enhancement through exercise intervention, in various forms, has seen several positive results spanning across decades. Using the wording of Strobach and Karbach (2016), I refer to exercise as a subtype of physical activity that is planned, structured,

repetitive and purposive. This study claims that physical exercise can contribute to the development of cognitive health across a person's life span. Multiple studies, mainly focusing on aerobic exercise, have produced results that show that exercise has led to increased brain function and improvements in attentional control and executive functions (e.g., Singh, 2012; Kramer, 1999; Voss et al., 2011). Strength and resistance training is another form of exercise that has shown improvements in executive scores and increased brain activity in regions of the brain that are associated with response inhibition (Lui-Ambrose 2012). Response inhibition is a key skill for everyone to strengthen and maintain to help with keeping focus and processing information. Sharpening this skill would be beneficial for students in the classroom daily as well as during test taking.

A meta-analytic study by Columb and Kramer (2009) provides evidence that exercise has positive effects on cognitive enhancement. Although this study uses participants much older than our students, I view this study as more significant than some other exercise intervention studies because the participants were healthy adults. Other studies use older adults with health issues and have the goal of preventing or slowing cognitive decline. This study is still focused on cognitive enhancement and not cognitive decline. The findings of this study show that fitness training, using two active groups, enhanced cognitive performance. Interestingly, both the group doing cardiovascular fitness only and the group doing cardiovascular fitness and strength training had improvements in their performance. The group involved in cardiovascular fitness and strength training had a higher improvement in executive processes. The first group had about  $\frac{1}{8}$  standard deviation increase while the group with two activities combined had about  $\frac{1}{2}$  standard deviation increase. While a half of a standard deviation improvement may seem small, it is an

improvement. I would like to once again point out the ages of the participants. The participants were between fifty five and eighty years old. Even if they are healthy individuals, they also most likely have age-related cognitive decline, which is normal. I believe that the students could produce even larger improvements as a result of exercise intervention because they are not battling any cognitive decline issues.

Similarly to any other cognitive approach, exercise intervention is not a guaranteed technique and there are valid concerns involving the efficacy of the approach that I think we can prevent from becoming issues. Several studies stress how situational and uncertain utilizing exercise as a cognitive enhancement can be for researchers and people in reality. The duration and intensity of exercise as well as when the exercise will be completed have shown to be relevant factors in the success of cognitive enhancement. While one study says exercise sessions need to be more than twenty minutes to see immediate improvement, another study says thirty minutes isn't enough time to see immediate improvements. Based on those two observations, forty five minutes should be enough time for exercise to have an effect. Along with that point, a Chang et al. 2012 study emphasized that exercise appears to only improve cognitive performance when the cognitive tasks are completed after the exercise and the effect subsides fairly quickly afterwards. I believe that it would be more beneficial to focus on the students' improvements over time instead of single bout, immediate improvement. We aren't looking to see what will work the fastest, but what will impact and change the students' skills in a long lasting way. As I stated earlier, the intensity of the exercises are also a concern addressed in multiple studies (e.g., Ploughman, 2008; Tomporowski, 2002; Chang et al., 2012). Researchers have warned against participating in an exhaustive amount of exercise because it hasn't been shown to be beneficial to

cognition. Going a step further, it has actually shown to be detrimental to cognitive performance. No one wants the students to be overworked for any reason so I'm certain that the intensity of the exercises would be set at a moderate level so no students are put at harm.

Adding an exercise program should have very little practical or ethical dilemmas to be considered. Students would have to participate in the exercise program three times a week, every other day, leaving the other two days for the neurofeedback clinic. This is best so that the students aren't too exhausted and trying to have both techniques used each day, within forty five minutes, wouldn't be effective at all. Hopefully, three times a week isn't too miserable for the students who don't like exercising or participating in physical activities within groups since effort helps the effectiveness of cognitive enhancing approaches. There's nothing particularly harmful about aerobic exercise and there can be simple exceptions made for students with health problems. This technique is also inexpensive so it won't become a big concern for the school, the parents or the contributor.

Exercise does appear to have stronger effects in conjunction with other techniques targeting cognitive enhancement. A strong cognitive enhancement approach to combine with exercise is neurofeedback. I find neurofeedback to be appealing because it is a direct connection to brain functioning and it is self regulating which gives the students their own sense of independence. I imagine that this independence would be appreciated so that the students could understand firsthand why their test scores were lower than they had predicted. It would be interesting for them to see their results and progress in real time as they actively train. Neurofeedback training is currently being used in three different ways. It can be used as a therapeutic tool, used as an approach to peak-performance training and used in experimental

investigations. For our purposes, the students would use neurofeedback as a peak-performance training tool.

One study that explored neurofeedback training and had positive findings was a Zoefel, Huster and Herrmann study conducted in 2010. Their participants had five sessions where they played mental rotation games while the neurofeedback system targeted the amplitude of the upper alpha frequency band. By targeting and manipulating the upper alpha amplitude, the researchers wanted to see if the increase would be related to improved performance. Eleven of the fourteen participants then attended all five neurofeedback training sessions in the week significantly improved their cognitive performance in comparison to the control group. The Enriquez-Geppert et al., 2014 study is another study that found positive results from neurofeedback training. The researchers wanted to increase the fm-theta oscillations up-regulation within the midcingulate cortex(MCC). The MCC is known to be heavily involved with executive functioning. Neurofeedback would allow for self-up-regulation of fm theta which should enhance performance of executive functioning. The researchers found that the participants in the experimental group did have increased fm theta levels. These two studies demonstrate the process of neurofeedback and the effects it can have on cognitive functions.

A cognitive enhancing approach that I am opposed to is the use of nootropics. I am skeptical about the use of nootropics for multiple reasons, but two of my main concerns are the efficacy and the ingredients of the nootropics. It is extremely difficult for researchers and manufacturers to pinpoint which specific ingredients cause the effect seen in the consumers. Even if you are able to determine the effects of each isolated ingredient, it's still hard to determine if every ingredient contributes to the outcome of the drug or how much of each

ingredient is enough. There's the possibility that the effects could be heightened more by tweaking some or all of the measurements of the ingredients. Another possibility is that none or some of those ingredients wouldn't have had an effect, but the effect can be seen only in combination with each other. There's so many varying opportunities that researchers or manufacturers can test and often not have to disclose that one batch of supplements is different from another batch. I feel that with all the possibilities, making nootropics can quickly become throwing in a bunch of ingredients that may or may not be effective. Often, companies will either use basic studies testing their ingredients to connect themselves to existing research, without testing their own products or there's a conflict of interest where the company supplies the funds for the research. Some companies don't use any research at all and rely on testimonials of customers which is very wrong. Nootropics are too expensive, on an individual and larger level, for the efficacy to be so uncertain.

Additionally, nootropics seems to target people with cognitive deficiencies or older people facing and handling cognitive decline. For example, the medication that people with ADHD are prescribed is a nootropic option for cognitive enhancement because it improves the patients' attention and focus. A study by Elliot et al., 1996 tested the effects of methylphenidate on attention and focus as well as other cognitive functions in healthy young adults. The mean age of the participants was 21.25 years. The cognitive tests were completed ninety minutes after the participants ingested the tablet to get the maximum amount of methylphenidate in the blood plasma. The results found that there were no dose-dependent effects observed. There were no significant effects on non-spatial tests like verbal fluency and attentional set-shifting. The researchers also discovered that methylphenidate had a negative effect on the participants' blood

pressure and pulse rate. The drug raised their blood pressure and their pulse rates. Those side effects are significant enough to deter people from using the drug because those risks may outweigh the cognitive benefits.

Similarly to methylphenidate, potential side effects are concerning to me. Some of the students may not have ever taken medication before or only taken common medications like cold medicine. Side effects are already something that is uncomfortable for anyone, but it'll probably be even more alerting for students who are unfamiliar with medication to experience side effects. It wouldn't be worth it if the students are uncomfortable with their bodies as an effect of the supplements and then don't want to continue to take the supplements. The solution wouldn't be that simple if the side effect is much more severe than uncomfortability. Another potential issue could be drug tolerance. I wonder if the students would begin to develop a tolerance and need the supplements at a higher frequency or higher dose. Generally, I am very hesitant about giving minors supplements especially in a school setting. Introducing the students to these supplements that should be harmless may still normalize drugs to the students, especially supplements that could be accessed over the counter in stores. The students may begin taking the supplements on their own time in excess or begin experimenting with other supplements. I think the risks are too high.

### References

- Chang, Y. K., Labban, J. D., Gapin, J. I., & Etnier, J. L., (2012). The effects of acute exercise on cognitive performance: A meta-analysis. *Brain Research, 1453*, pp. 87-101.
- Erickson, K. I., Voss, M. V., Prakash, R. S., & Kramer, A. F., (2011). Exercise training increases size of hippocampus and improves memory. *PNAS, 108*(7), pp. 3017-3022.
- Lambourne, K., & Tomporowski, P. (2010). The effect of exercise-induced arousal on cognitive task performance: A meta-regression analysis. *Brain Research, 1341*, pp. 12-24.

- Ploughman, M., (2008). Exercise is brain food: The effects of physical activity on cognitive function. *Developmental Neurorehabilitation*, 11(3), pp. 236-240.
- Strobach, T., & Karbach, J. (Eds.). (2016). *Cognitive Training: An Overview of Features and Applications*. Springer Press.
- Stroth, S., Hille K., Spitzer, M., & Reinhardt, R. (2009). Aerobic endurance exercise benefits memory and affect in young adults. *Psychology Press*, 19(2), pp. 223-243.
- Tomporowski, P. D., (2002). Effects of acute bouts of exercise on cognition. *Acta Psychologica*, 112, pp. 297.
- Elliot, R., Sahakian, B.J., Matthews, K., Bannerjea, A., Rimmer, J., Robbins, T.W. (1996) Effects of methylphenidate on spatial working memory and planning in healthy young adults. *Psychopharmacology*, 131, 190-206.
- Zoefel, B., Huster, R. & Herrmann, C. (2010). Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. Elsevier, 1427- 1430.  
[www.elsevier.com/locate/ynimg](http://www.elsevier.com/locate/ynimg)
- Enriquez-Geppert, S., Huster, R., Figge, C. & Herrmann, C. (2014). Self-regulation of frontal-midline theta facilitates memory updating and mental set shifting. *Frontiers in Behavioral Neuroscience*, 1-13.doi: 10.3389/fnbeh.2014.00420