



Classroom Implications for Medina's Brain Rules

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ABSTRACT: This paper summarizes the main concepts covered in Brain Rules by John Medina. It also overviews current brain and learning research done since the original publication of the book that supports Medina's 12 brain rules. Thereafter, recommendations are presented for how teachers can make classroom modifications to take advantage of current brain science.

KEYWORDS – Brain rules, classroom instruction, brain science, psychology of learning.

1. INTRODUCTION

This paper will begin by overviewing the popular book by John Medina, Brain Rules. While the book was originally published in 2008 and contains evidence from numerous research studies, since its publication additional research has been conducted that aligns with each of Medina's twelve assertions. Thus, after summarizing each of the main points, relevant research will be presented in support. Finally, suggestions for applying the principles covered in Brain Rules will be given, as applicable to a classroom setting.

2. MEDINA'S 12 BRAIN RULES

In this section, each of Medina's twelve brain rules will be explicated. Thereafter, relevant recent research for each rule will be covered, with particular attention given to research published after 2008, the year that Medina's book was published.

Rule 1: Want your brain to work better? Then exercise.

The first of Medina's rules is that if you want your brain to work better, then you cannot ignore the fact that the brain functions better when the body is also moving well (2008). Medina purports that if you want your brain to run well, you also need to give attention to exercise, which helps the oxygen flow well and makes the synapses in your neurons keep activating. Medina also adds that aerobic exercise has been shown to lower the chance of dementia by 50% by engaging in it as little as twice a week (2008).

Hillman et al. (2008) reviewed research on the positive effects of physical activity and exercise on brain function and found results that are in line with Medina's assertions. They noted that a higher level of physical activity was correlated with reduced risk of both physical and mental health problems. Similarly, Ardoy et al. (2014) did a study on adolescents in Spain and concluded that school programs with physical activity components have a positive effect on cognition and academic performance. Additionally, Norris et al. (2020) performed a meta-analysis of the effects of physical activity on health, cognition, and learning. They noted that having lessons that included physical activity had a positive outcome on both physical health and learning.

Rule 2: The brain is no stranger to evolution. It has gone through change.

With this rule, Medina posits that the reason humans are still thriving is because we have been shown to be adaptable, and that adaptability applies to our brains as well (2008). He goes further to say that we once had a "lizard brain," that, over time, evolved to the advanced brains we know today as the human brain. The reason, he states, that we now are able to have such a complex brain, is because we no longer have to devote so much energy to simply surviving in the wild. This has liberated us to a place where we now have evolved to use symbolic reasoning, a trait not possessed by any other animal (Medina, 2008).

Recent findings support Medina's claim. For example, Barton and Venditti (2014) report that the brain has tripled in size over the past 2.5 million years, allowing humans to evolve superior cognitive abilities. In fact, the change in brain size is evidenced by an increase in size and expansion of the cerebral cortex along with changes to skull architecture as a result (Schoenemann, 2009). One such area of the cerebral cortex that has expanded is the prefrontal cortex, the area in charge of cognitive behaviors, decision-making, and regulating social behavior. Teffer and Semendeferi (2012) suggest this may have given an evolutionary advantage to early humans in increasingly complex social situations.

Rule 3: Humans are unique, and so are brains.

With his third rule, Medina suggests that our life experiences change or “rewire” our brains (2008). Thus, people with different life experiences and backgrounds will have differently wired brains. Accordingly, different people will store information in their brains in various ways and will process information differently as well. This is supported by research by Kolb and Muhammad (2014) that suggests life experiences may lead not only to functional changes but also to structural modifications to the brain across the lifespan.

Newberg et al. (2010) also had interesting findings related to brain function as it relates to meditation. They had 12 participants who were meditators and 14 who were not and measured cerebral blood flow of both groups at rest and found structural brain changes related to long-term meditation as well as in areas that control emotional function. More recently, Kozasa et al. (2018) also conducted research to look at brain changes caused by meditation. Their study compared regular meditators with non-meditators, both of whom attended an intense 7-day meditation retreat. Using brain scans, they found that the non-meditators showed reduced activation in brain regions related to attention and cognitive control, similar to the experienced meditators. This finding suggests that neural efficiency can be gained in just a week of intense training.

Rule 4: We focus on what is interesting.

For Medina’s fourth brain rule, he puts forth the idea that humans are not able to multitask, and we only focus on things we find interesting (2008). He says that while we may not be great at remembering details reliably, we are quite keen at noticing patterns and assigning meaning to things that happen. Additionally, emotion can aid in remembering. Furthermore, Medina asserts that in classes, most students have lost attention after 15 minutes, and he goes further to state that students report that they lose interest after about 10 minutes (2008).

Although it is not always safe to assume that physical signs of inattention are valid (Wilson & Korn, 2007), some research suggest certain physical markers can be good indicators of inattention. For example, Smilek et al. (2010) found that during a reading task, blinking was often a sign of impending inattention. It is important to reduce mind wandering in classes because as Lindquist and McLean (2011) found, there is a negative correlation between mind wandering and retention of information weeks later.

Rule 5: Want to remember something in the short term? Repetition is key.

Memory is not a simple process; in fact, it involves the four processes of encoding, storing, retrieving, and forgetting (Medina, 2008). Each of these, forgetting included, is vital to the functioning of memory. If we want to remember something, we need to encode it in a more intricate way. This means, for example, making connections to old information when we learn something new. Additionally, when considering the role of repetition and its effect on memory, the environment also has an effect. For example, recall of information increases if the conditions under which recall occurs are the same as when the information was learned or studied (Medina, 2008).

The role of forgetting in learning is also supported by research findings. While the goal is not to completely forget material, some forgetting increases the ability to reconstruct knowledge. For example, moderate levels of forgetting are an indication that abstract knowledge has been retained while specifics have been let go (Kornell et al., 2009). Finn and Roedinger (2013) also found that forgetting is beneficial for reconstruction elaboration, promoting encoding variability, which in turns supports retention.

Rule 6: Want to remember something in the long term? Again, repetition is the key.

As humans, we are exposed to a huge amount of information every day, and most of that disappears from our memories very quickly (Medina, 2008). The way to commit something to long-term memory is to add the new information little by little and at specific intervals. The process of consolidating information from short to long-term memory happens in days or years. The way to make this happen is not only through repetition but by also increasing the spacing between the repetitions. Additionally, to increase the likelihood of information being committed to long-term memory, it can help to associate the learned information with a greater range of contexts.

Repeated exposure to material improves learning, and research shows that spaced repetition also leads to better retention in the long term (Appleton-Knapp et al., 2005). In comparison with massed repetition, which is repeated practice without breaks between sessions, spaced repetition, which has longer lags between repetitions, aids long-term memory more (Cepeda et al., 2006). Roediger and Karpicke (2006) also confirm that using testing as a form of retrieval practice also improves retention more than simply restudying material.

Rule 7: Don't underestimate the power of sleep.

As sleep is necessary for a well-functioning body, so is it necessary for the brain (Medina, 2008). While there is some variation in how much sleep individuals need, most people need around eight hours of sleep per night, and if there is a deficit, there will be a noticeable loss in attention, reasoning, and working memory. Additionally, it is during sleep that the brain processes what has been learned during the day. Rather than the brain resting during sleep, what is actually happening is that the brain is quite active. Adding to this complexity is the fact that not all humans have the same circadian rhythms, meaning that some people really are “night owls,” mentally functioning much better in the late-night hours, whereas others are at peak brain performance early in the morning (Medina, 2008).

Recently, Simon et al. (2020) published new findings and updated theories on sleep and its consolidation effects on memory. They presented evidence suggesting that sleep helps reactivate memories faster than wakefulness, owing to slow wave sleep and sleep spindles in consolidation. Klinzing et al. (2016) also have conducted research showing sleep's effect on memory consolidation. In particular, they found that slow-wave sleep facilitates the stabilization and preservation of memories through hippocampal replay.

Rule 8: Stress is no friend to your brain.

In his eighth rule for the brain, Medina (2008) explains that a brain that is stressed does not learn in the same way as a brain under normal conditions. This is because, when stressed, the body releases cortisol to help put the body in fight or flight mode – as a call to act, not to cogitate. Additionally, he notes that emotional stress hampers students' ability to learn. Moreover, Medina mentions the associated benefit of organizations prioritizing growth mindsets (2008).

The negative cognitive effects of elevated stress have been shown by Joëls et al. (2006), who found deleterious effects of stress on memory, attention, and decision making, factors that are vital for learning. Chaby et al. (2015) also reported that stress lowers dopamine activity, consequently reducing motivation and the ability to form stimulus-reward associations, which are likewise vital for learning. Moreover, Schwabe and Wolf (2010) found that stress impairs declarative, special, and working memory processes.

Rule 9: To remember better, engage more senses.

Medina's ninth brain rule is that we should remember that we glean new information through our senses, and when that happens, the way it happens – the way it is perceived – depends on our past experiences (2008). Thus, when two people are exposed to the same new information in the same way, they may receive and process that information in different ways based on their backgrounds. Additionally, the more senses that are engaged, the greater the chance of remembering. This means that instead of focusing on one modality, such as the auditory sense, we can increase memory by adding other senses at the same time. For example, smelling something can bring back a memory, as can taste. Accordingly, associating memories with more than one sense will help encode the memory more deeply in the brain (Medina, 2008).

Research supports Medina's ninth rule as well. For example, research has shown that multisensory learning can lead to greater memory and understanding as compared to traditional, single-sensory teaching methods (Shams & Seitz, 2008). Furthermore, studies show that combining images and narration, for example, as opposed to narration alone, leads to measurable gains in learner outcomes across various domains (Butcher, 2014).

Rule 10: Vision is king.

While the ninth rule purports that we should engage more senses, in his tenth rule, Medina asserts that our most dominant sense is vision, taking up 50% of the brain's capacity (2008). Additionally, the way humans learn most effectively is through visuals rather than through words, whether written or spoken. Interestingly, other senses can heighten visual memory as well. For example, if smell or taste is activated, that can increase a visual memory. Another key point related to vision is the way we process information received visually. For example, information that is presented in a simple way trumps information that creates visual overload, such as in a slideshow presentation with too much text on the screen (Medina, 2008).

Across a variety of domains, visuals have been shown to enhance retention and transfer of knowledge by helping students create meaningful mental models of complex information (Heiser & Tversky, 2006). The reason that visuals increase learning may be related to reducing cognitive load through the dual coding of verbal and visual working memory (Sweller, 2022). PowerPoint is the tool often used to present visuals to students, likely because students deem instructors who use it to be more credible (Ledbetter & Finn, 2018). However, Hill et al. (2012) reported that students have noted that instructors who use PowerPoint teach at a faster pace. This finding supported research by Sugahara and Boland (2006), who reported that students said instruction with PowerPoint requires faster note-taking,

thus sometimes making PowerPoint a distraction.

Rule 11: The brains of men and women are not the same.

Looking at humans from a biological point of view, Medina states that there are noticeable differences in the brain (2008). For example, the amygdala in men is larger than in women; however, women are adept at remembering details related to emotions when stressed, a function of activating the left hemisphere of the amygdala. In contrast, men favor the right side and focus on the main idea.

Burman et al. (2008) used MRI to check brain connectivity in their study and confirmed that women use more areas of the brain for learning verbal material. This also resulted in girls performing better on standardized language tests. Additionally, Wang et al. (2007) reported that the way males and females respond differently to stress can have an outcome on their learning processes.

Rule 12: It is in our nature to continually learn.

Whereas we often think of children as having a greater capacity for learning, in reality, the adult brain is still very capable of learning new things (Medina, 2008). Our ability to continue learning does not stop just because we get older. Additionally, we learn by testing things out in our environment and then coming to conclusions. We are innately curious and have a desire to figure things out. Moreover, learning occurs through a discovery process, particularly when the learning is personally meaningful (Medina, 2008).

Research demonstrates that the adult brain maintains its ability to change and learn new information, even into old age (Goh & Park, 2009). While it was previously believed that neural connections plateaued after the critical learning period in childhood, current research shows that the brain continues forming new connections and adapting to new experiences throughout life (Lövdén et al., 2010). For example, in an MRI study conducted by Draganski et al. (2006) on adults ranging in age from 25 to 80, they found ongoing neural reorganization, indicating that older adults can continue to learn new skills.

3. TEACHING RECOMMENDATIONS

In the previous section, Medina's 12 brain rules were overviewed along with relevant research in support of each. In this section, practical recommendations for each of the 12 rules will be given for classroom implementation.

Rule 1: Want your brain to work better? Then exercise.

As for making classroom changes pertaining to this first rule, there are a few different perspectives from which to view it. First, there is the obvious need for students to get physical exercise during the day time. It is not natural for children to sit at a desk for eight hours, so at the very minimum, schools should have a period of the school day devoted to physical education, which has not only health benefits for the body but also for the mind. Additionally, teachers can implement little changes in their own classrooms with this rule in mind. For example, teachers should incorporate a variety of activities, some of which require physical movement. While many experts nowadays eschew the idea of learning styles, one of which is kinesthetic, this does not mean that kinesthetic activities are not of use. To the contrary, teachers should incorporate kinesthetic activities not because of students' preferences for them but because of their cognitive effects. In cases where it does not seem obvious to the teacher as to how to incorporate kinesthetic activities related to the content, then the teacher can still take advantage of movement by simply taking a one-minute break and instructing the students to stand and stretch, for example. Alternatively, teachers might find it useful to learn a few standing yoga poses to use in the class for short breaks. Additionally, teachers could invite students to take turns leading the class in brief in-class exercises breaks.

Rule 2: The brain is no stranger to evolution. It has gone through change.

In consideration of this rule, teachers should be reminded that students are indeed capable of learning and changing. Even though at times some students may seem to have stagnated in their learning, teachers should realize that learning is indeed possible and not give up on those students. This is true whether the students are children or older adults.

Rule 3: Humans are unique, and so are brains.

While learning styles have been recently disproven, this does not mean that everyone has the same preferences. Keeping this in mind, teachers should seek to do a thorough needs analysis of learners, which includes finding out what students know, want to know, and are interested in. Knowing more about students' backgrounds and past experiences can go far in explaining how they learn and their capacity for handling new information. Thus, while it can sometimes seem that certain students simply have a knack for learning, teachers should remember that those students simply are building on a greater wealth of background knowledge; and the more teachers increase all students' knowledge base, the greater their capacity for learning will be.

Additionally, considering that physical activity including exercise and meditation can literally rewire brains, it would behoove teachers to consider rule 3 in concert with rule 1. The in-class mini exercise routines suggested in line with rule 1 are also applicable here. Furthermore, in line with meditation research findings, teachers should consider that implementing meditation exercises in class can increase learners' cognitive control.

Rule 4: We focus on what is interesting.

To take advantage of what is known about learning with this rule, of course the main takeaway is that teachers should endeavor to make learning interesting for students. However, it goes beyond that. Not only should teachers consider what is interesting for the learners, but they should also aim to break up classes into smaller chunks of time, aiming for a maximum of 10 to 15 minutes. This means, for example, that a 50-minute class should ideally have 5 separate activities or segments; otherwise, students' attention may be diverted.

Additionally, the interest in a lesson can be enhanced if the teacher uses engaging storytelling techniques or weaves emotional aspects into the lesson. Moreover, during a class, teachers need to be on high alert for signs that students may be zoning out. This could include obvious signs such as heads nodding off to subtler signs, such as increased blinking. When teachers notice such signs, that could be a good time to switch gears or even to go back to rule 1 and have students take a short movement break.

Rule 5: Want to remember something in the short term? Repetition is key.

The recommendations related to this rule are quite straightforward and yet often not implemented. Repetition is the key to long-term learning. This means not only having a quick review at the start of a lesson to review the previous day's material but also planning in recycling of content into future lessons. Moreover, teachers need to make sure to connect new information to learners' prior knowledge because the more connections made, the greater the likelihood that information will be retained.

Retrieval practice is a key part of repetition in learning, and this can involve low-stakes quizzes or even brief written exercises that test what students remember from a previously covered concept in the middle of class. Students will initially feel frustrated because they will experience the weariness that stems from realizing they have forgotten information, but it is important for teachers to explain to students that forgetting is a necessary part of learning.

Additionally, learners should be taught about the importance of repetition as well as the importance of repetition in certain environments. It is helpful for students to study in the same environment as they will be in when they have to retain the information. For example, if they are learning information that will be useful to retrieve when in a loud and busy shopping mall, then it is actually best to mimic those surroundings when studying.

Rule 6: Want to remember something in the long term? Again, repetition is the key.

As mentioned above, not only is repetition important, but spread out the repetitions is also necessary. While many teachers make a habit of having a quick review of the previous day's material at the beginning of the lessons, what is less common but likely more crucial is planning and including recycling of material at well-spaced out intervals. For example, the information from lesson one should not only be reviewed in lesson two, but for example, again in lesson 10 and then again later in lesson 25. While the research on the optimum spacing intervals is still ongoing, teachers can still implement this strategy by ensuring recycling of material more than once in a course, and optimally several times. While this can be a time-consuming exercise for teachers, the increase in long-term learning outcomes cannot be denied.

Rule 7: Don't underestimate the power of sleep.

Students' sleeping habits are typically beyond the teachers' control. That being said, teachers could have an impact on students by teaching them of the importance of sleep so that students will make better decisions about when to go to bed and when to rise. To try to have a greater impact, teachers could also have students keep a sleeping log for a certain period of time. This could be part of a class project or even be a contest in which the student with the most consistently good sleep habits wins a benefit – beyond the obvious benefit of better cognitive function.

Another thing for teachers to consider is that if students are falling asleep in an early morning class, it might not be that those students did not get enough sleep; rather, it is possible those students are simply more alert later in the day or even late at night. Bearing this in mind, teachers may need to be understanding of students' natural waking and sleeping tendencies and make allowances accordingly.

Rule 8: Stress is no friend to your brain.

While it is normal to feel some stress in a learning environment with high expectations and requirements, teachers

need to be careful to have the right balance. It is important to challenge students to meet their full potential and to stretch themselves mentally, but at the same time it is incumbent on teachers to be cognizant of when students are receiving too much stress, such that it can hinder their learning. Through careful observation, teachers can monitor students for signs of excess stress and help to resolve those situations; if teachers do not do this, learners' progress can be impaired.

Rule 9: To remember better, engage more senses.

For teachers, this rule is the one that may require the most creativity, but it is also the one that can add an element of fun to teaching. The senses most often engaged in a class are sight and sound, so focusing on the other senses, including smell, taste, and touch, can provide new ways for students to encounter and experience information. Additionally, it helps students make additional connections to material, which is also well aligned with rule 5. Thus, teachers should seek out content areas in their lesson planning for multisensory learning opportunities.

Rule 10: Vision is king.

With the majority of classrooms these days being multimedia equipped, it is rare to find a teacher who does not regularly make use of PowerPoint or some other slideshow program. This can undoubtedly be a useful way to present information to students, as the visual mode is, according to Media, the most common way humans take in information. However, teachers also need to be judicious when implementing such technologies so that students do not become overwhelmed with information. Also, rule 4 should be considered simultaneously, meaning that teachers should consider how to present information visually but also in an interesting way. When in doubt, opting for a simpler visual is a safer bet than choosing overwhelming or complicated visuals. Along the same line, teachers who rely on slideshows should closely monitor the speed through which they present material, as there is a tendency for presenters to go faster when presenting with slideshows. If this overly stresses students (see rule 8), then the positive effects of the visuals will be nullified.

Rule 11: The brains of men and women are not the same.

For this rule, teachers should first examine whether the way they teach corresponds with an advantage for students of the same gender. After this first step, teachers can then make modifications to ensure learning opportunities for both genders. For example, some teachers will realize they have been prioritizing details or standardized testing skills, which favor females. Other teachers may realize they have been prioritizing the ability of students to glean global concepts.

Rule 12: It is in our nature to continually learn.

With this last rule, teachers are urged to not lose faith in their students; to remember that all students are capable of learning and to not give up on any individual student. While young learners may have the advantage of being full of wonder and having a higher tolerance for ambiguity, older learners have the advantage of more background knowledge upon which they can grow new knowledge. Thus, all students have the capacity for learning and can add value to a class.

4. CONCLUSION

Although Brain Rules written by Medina was published in 2008, his twelve rules hold up 15 years later. Each has been confirmed through additional empirical research in the years since the book was published, and it is clear to see how the twelve rules work together. As such, recommendations for how the rules can be generally applied in a classroom setting have been presented.

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