Center for Creative Leadership®

FUELING THE BRAIN: FROM EXHAUSTED TO ENERGIZED

Strategies for Recovery, Maintaining Focus and Boosting Brain Power

By Sharon McDowell-Larsen

Introduction

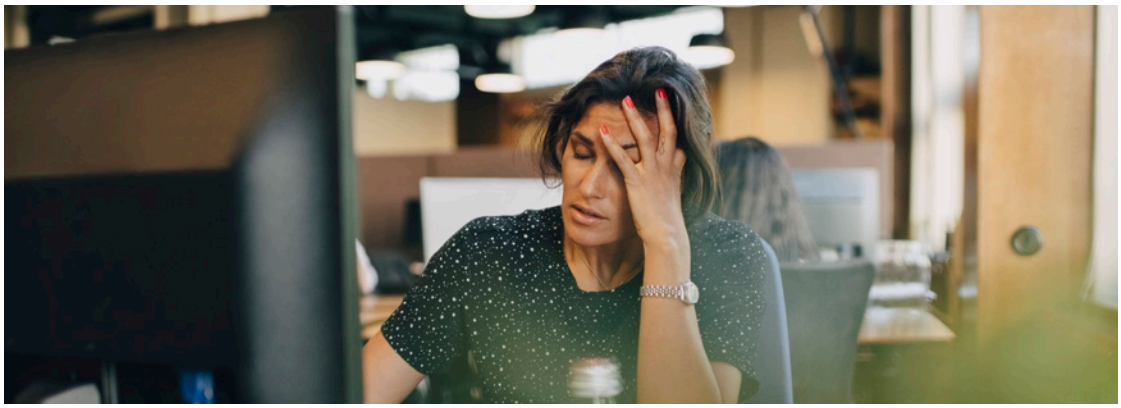
I don't think anybody could have predicted how quickly and dramatically one tiny virus could disrupt and upend our ways of living and working. Neither could we have predicted that this was going to be a marathon and not a two month blip on the radar. The currant reality has forced a different way of working for leaders and their teams for many months to come.

Gone are the informal chats around the coffee machine, the chance encounters in the hallway or popping into someone's office for a quick word. The restroom is now the next room over, a much shorter walk than when it was on the far side of the building. There is no need to go out to lunch or walk to a meeting in a room different than your office. For many, commuting to and from work, that built-in boundary between work and home life, is now gone. The chances to mentally recharge, switch gears or interface with other humans other than via a computer screen are less inherent in our work day. The mental energy to get through the day is now less varied and more intense and draining than ever before. This only serves to increase mental fatigue.

Just what is mental fatigue and how can one best recover from it?

Mental fatigue is the psychobiological state of tiredness that makes your brain foggy and slows you down. It is a state caused by prolonged periods of demanding cognitive activity. This can come on gradually and is cumulative. It is not always easy to know when you have it, but eventually its impact will be felt. There is a decreased ability to react to things, reduced confidence, feelings of 'tiredness', a 'lack of energy', and a decrease in mood and motivation. In other words, anything that requires effort, either mentally or physically, takes a hit. There is resistance against further effort and a decreased level of commitment to any task. Emotional management can also take a turn for the worse as can the ability to focus, plan and be creative. In short, mental fatigue hurts brain power and the ability to get work done. [1][2]

There are two factors that contribute to brain fatigue and loss of brain power. One is the build up of something called adenosine (and a resulting decline in dopamine), and the other is reduced blood flow to the brain.



Adenosine

Physiologically the experience of fatigue is due to a buildup of adenosine in the brain and a reduction in dopamine. Adenosine is a byproduct of the breakdown of ATP or adenosine tri-phosphate. ATP is the energy currency of our bodies. It is what provides the energy for muscular and cognitive work. Without its production, well, we would be dead. The more we burn through our ATP, the more we accumulate adenosine and the more fatigued we feel.

Adenosine accumulates within the brain during periods of wakefulness, of intense physical exercise and by doing effortful brain activities, such as the daily grind of an executive's workday. [1] Adenosine dissipates during sleep, thus sleep is a critical component of cognitive renewal as I will get into.

Adenosine binds to A1 receptors in the brain which in turn inhibits dopamine release. Dopamine, known as the pleasure hormone, plays a role in improving mood states and is an important modulator of learning and motivation. [3] Thus, declines in dopamine also contribute to cognitive fatigue.

Increases in adenosine occur over the course of a long day, but it can also go up in response to short intense bouts of cognitive effort. Strategically taking brain breaks during the day can help replenish substrates such as glucose, and reduce adenosine levels. Thus, recovery can occur throughout the day in addition the important longer recovery of a good night's sleep.

Of interest is that caffeine has a similar structure to adenosine. Binding of caffeine to the A1 receptors therefore inhibits some of the fatigue inducing effects of adenosine. Thus, caffeine can provide a bit of a mental boost. While judicious use of caffeine can help on occasion, indiscriminate use is not helpful. Many people get into a downward spiral of fatigue, followed by use of caffeine to offset the fatigue. Overuse of caffeine will never allow for full recovery, rather it just masks the symptoms. The other concern is that the half–life of caffeine is 5-8 hours (some people are slower metabolizers and others are faster). Thus, if you have a strong cup of coffee in the morning, 5-8 hours later you still have 50% of that caffeine in your system, 5-8 hours later, you have 25% still in your system. This can create chronic levels of caffeine, which in turn will interfere with sleep, even when you do not think it does. [4]

The term "wired and tired" has been used to describe this vicious cycle of poor sleep and caffeine stimulation. Of interest, if you want to accelerate the breakdown of caffeine in the liver, eat lots of broccoli (or other cruciferous vegetables); these are the detox foods of the plant kingdom.

Blood Flow

The brain is particularly demanding in its use of resources. It consumes 15% of our total cardiac output, 20% of our oxygen uptake and 25% of our total glucose. [5] When it is working hard, it demands more energy than fully working quadriceps. It burns through a lot of glucose, and indeed, factors such as hypoglycemia or low blood sugar, limited glucose intake and/or glucose depletion, will profoundly affect recovery and impede cognitive functions that require effort. [6] Thus, the brain is very reliant on getting adequate blood flow and nutrition. Improve blood flow to the brain and there is an uptick in performance; reduce blood flow, our brains slow and we lose mental sharpness.

Given all of this, what can one do to mitigate fatigue and renew cognitive function? Presented below are a number of strategies that will help. These will not prevent cognitive fatigue, as that is par for the course. However, these habits will help create greater cognitive resilience and allow for renewal of reserves. It will also serve to enhance certain types of cognitive function, such as creativity, executive function, and certain types of memory. These key strategies may be difficult to implement, at least initially. They require some changes in habit, creating positive rituals, and unlearning of other habits. Let's face it, the greater environment is not conducive to these practices. However, if implemented consistently over time, will be worth the time and effort. As Will Durant put it, "we are what we repeatedly do. Excellence, then, is not an act, but a habit."

Sleep

> "Early to bed, early to rise, makes a man healthy, wealthy and wise." –*Benjamin Franklin*

Of all the renewal strategies, this is probably the most important, but also one that many leaders find the most challenging. Our modern environment is toxic to good sleep. Rumination, or the inability to turn our brains off, work hours that now creep late into evening, or staring at screens when we should be dimming the lights, wreak havoc on the best attempts at good sleep.

Our bodies modulate sleep in two ways, a) our circadian rhythm and b) homeostatic system. The circadian rhythm (cira-around, dian-the day) is regulated by the superchiasmatic nucleus, a small group of nerve cells found in the hypothalamus. [7] This is known as our central clock. However, we have peripheral clocks as well, as our other organs also function on a circadian cycle. [8]

The circadian rhythm is characterized by increases in energy in the morning, then dipping in the afternoon. There is a 2nd increase following that afternoon dip, then another drop in the evening before bedtime. This is also affected by light and melatonin production. Melatonin production rises in the hours before midnight, (hence sleep before midnight is considered to be a more "productive" sleep) and then starts to decline. Light exposure in the morning helps to improve sleep. [9] Thus a good nights sleep starts with a healthy dose of daylight exposure in the morning. Exposure to daylight during the workday has also been reported to improve sleep compared to artificial light. [10] Lack of daylight exposure has also been shown to negatively impact vitality and mental health.

Cortisol has an opposite cycle to melatonin. It rises in the morning, helping to energize us and ready us for the day, then it should decline in the evening. Here again, too much light exposure, rumination, or eating the wrong foods will cause it to stay elevated when it should be going down.

The homeostatic system is the body's attempt to balance wakefulness with sleep and is driven in large part by adenosine levels. As awake time increases, so does the drive to sleep. Thus, the sleep drive is lowest early in the day when adenosine levels are low and increases as adenosine levels go up. Lack of sleep or disrupted sleep will result in a stronger sleep drive during the day, especially during times when our circadian rhythm takes a dip, such as early to midafternoon.

It is important that the circadian rhythm and the homeostatic systems are aligned. For example, you want adensosine levels to be high before you go to bed at the same time as your circadian rhythm is winding down. Misalignment of these two systems can create chronic sleepiness and/or chronic sleep disruptions.

Most people recognize that getting 7-8 hours of sleep per night is the sweet spot. True some people need more, and a small percentage of others can get by on less. Most leaders we surveyed fall short of this, as average sleep times are around 6.6 hours per night. [11]

However, consistently getting 7-8 hours a night can be challenging. Rather than stressing about this, a more practical approach may be to aim for a certain number of hours of sleep per week. If you are in the 50-60 hour range, than you are where you want to be. This can include naps and nights where you get more than 8 hours. Yes, ideally, you want to consistently aim for to 7-8 hours per night, but aiming to increase total sleep volume per week is also important if your nightly sleep hours are less than consistent.

What many people do not realize is that there is a strong connection between diet and sleep. Eating a nutrient dense plant-focused diet may help to improve sleep. Many plant foods such as walnuts, cherries, berries, and tropical fruits contain melatonin and have been shown to increase serum levels of melatonin. [12] [13] Studies show that tart cherry juice or kiwi fruit, for example, consumed prior to bedtime improve sleep. [14] [15]

Animal protein, on the other hand, has been shown to increase cortisol levels. One study found that a single meal high in animal protein can nearly double the level of this hormone in the blood 30-60 min after the meal. Eat a meal of crabmeat, tuna fish, cottage cheese, and cortisol levels shoot up. [16] Eat a meal of barley soup or a vegetable stir-fry on rice, and cortisol levels goes down after the meal.

Increased gut microbial diversity is also linked to better sleep and less stress and anxiety. A healthy gut produces 90% of our serotonin, 50% of our dopamine and over 30 other neurotransmitters. Insufficient fiber and starch intake, too much alcohol, consumption of processed foods and artificial sweeteners, high-fat processed foods, too much stress, lack of exercise and poor sleep all hurt gut health. This in turn hurts sleep and brain function. [17] The key to improving and maintaining gut health is to eat a wide variety of minimally processed plant foods rich in fiber and starches.

Exercise

> "You are only one workout away from a good mood." *–Unknown*

The brain benefits of exercise are clear. Exercise enhances memory and learning, improves executive function, counteracts age-related declines in mental function and protects against age-related atrophy in those brain areas that are crucial for higher cognitive processes. [18] It is also therapeutic in that it can help treat and prevent depression. Incidentally, depression is linked to cognitive decline, which by itself is a good reason exercise. [19]

The mechanisms behind these improvements are complex and beyond the scope of this paper. However, in short, exercise is anabolic to the brain. It increases our levels of brain-derived-neurotropic-factor (BDNF) and other growth factors like insulin-like growth factor and vascular endothelial derived growth factor (VEGF).

BDNF is like fertilizer for the brain in that it promotes production or proliferation of new neurons and promotes survival of these neurons. Studies show that BDNF does its best work when we sleep. Regular exercise in turn is associated with improved sleep. Here is a perfect example of the synergy that occurs between different health promoting behaviors. As you will see below, there are also synergies between exercise and food when it comes to enhancing brain function.

VEGF helps to increase both the size and number of blood vessels within the brain, which in turn improves blood flow. [18] As mentioned, given that the brain is such a blood hungry organ, increases in blood flow to the brain will serve to improve brain function and stave off cognitive decline as we age.

Exercise can also boost production of dopamine. Remember, dopamine levels go down as adenosine rises. Dopamine plays an important role in motivation and learning. Motivation "looks forward" to future reward serving to energize current behavior. Learning "looks backward" at states and actions in the recent past. Dopamine appears to prompt both at the same time. [20] Dopamine plays a key role in determining whether it is worth exerting effort towards something, including tasks that require cognitively demanding, decision-making strategies. It can also speed up the time it takes to make decisions and take action. Thus, increasing dopamine via exercise can come in handy in a fatigued state when motivation to do difficult tasks is low.

Exercise, however, is a double-edged sword. Exhaustive exercise can increase adenosine levels, increasing mental fatigue and decreasing motivation to do cognitively demanding tasks. By exhaustive, I mean long bouts of exercise that are quite intense. If you are training for a marathon, save that 20-mile run for the weekend and try not to

schedule demanding work afterwards. Doing more moderate exercise or shorter bouts of exercise with some intensity during the week is the way to go. Finding the right balance between exercise that is restorative and exercise that is exhausting is important and likely different for different people.

Cardiorespiratory exercise has been most studied with regard to its effects on brain function. Fortunately, it doesn't take much to experience benefit. Thirty minutes most days will do it, but doing frequent 5-10 min breaks will also serve to provide both a mental break and get the blood flowing.

One study found that even a single 20-minute session of moderate aerobic exercise (70% of age predicted max heart rate) was able to improve the brain's functional connectivity in young healthy adults. [21] Increased connectivity is good for cognitive performance and long-term brain health. Numerous studies support this finding and show that there are immediate benefits to the brain post-exercise, in addition to the long-term benefits. [22]

Executives are increasingly aware of the beneficial effects of exercise. When we compared executives attending the Leadership at the Peak program prior to 2006, to those attending more recently, we found that the percentage of those who exercised on a regular basis had increased in males from 46% to 53% and from 36% to 49% in females. This represents a major shift in the number of executives who exercise regularly. The amount of time spent exercising has also increased from an average of 3.8 hours per week to 5 hours per week on average.

To summarize, short bouts of movement and reduced sitting time will go a long way to improve and renew cognitive function. Taking short hourly movement breaks and/or a 10-30 min brisk walk outside at lunch, are relatively easy ways to incorporate daily exercise.

Food

> "Just like other organs in the body, the brain is acutely sensitive to what we eat or drink." *–A brain researcher*

Food and exercise also work synergistically to improve cognitive function. Similar to exercise, certain foods can increase and improve blood flow to the brain, especially in critical areas that are prone to hypoxia, or lack of blood flow.

However, before we go there, there are certain foods and constituents of foods that hurt blood flow to the brain. If you have ever experienced a "food coma", below is one of the reasons why that happens.

Foods that Hurt

When we eat high fat foods, like ice cream (sorry), burgers, deep fried foods, butter, cream, or pizza, we get something called "dietary fat-induced postprandial lipemia". [23] In other words, we get a lot of fat flowing in our blood stream post meal. The effects of this are not good for long-term health as it increases risk for atherosclerosis (or arterial plaque). [24] Carbohydrate rich foods on the other hand, reduce lipemia in a dose-dependant manner. [25] In particular, saturated fats have been shown to increase lipemia. [26] Another term for this postprandial increase in blood lipids is plasma lactescence. Lactescence is what happens when the plasma becomes milky and cloudy due to high levels of fat in the blood. [27]

From a brain performance perspective, this is not helpful. For starters, it impairs cognitive functions such as reaction time, attention and alertness. [28] It also results in something called red blood cell aggregation, where the red blood cells lose their ability to repel each other and they clump together. In fact, the red blood cells absorb some of the fat into their membranes. This has the effect of significantly slowing blood flow and reducing oxygen availability. [29] In one study where they fed subjects some cream, their blood flow was reduced by 20% at peak lactescence. [27] Incidentally, a cornstarch-based meal did not have the same effect. [23]

Fatty foods also negatively impact the endothelial cells, or the cells which line our arteries. Our arteries are not just rigid pipes; they are living, breathing organs that actively dilate or constrict, thinning or thickening the blood and releasing hormones. A single layer, the endothelium, comprised of endothelial cells, controls all of this. [30] Eat a fatty meal and endothelial dysfunction occurs. Arteries stiffen; inflammation and oxidative stress goes up. To quote one paper, "the Western diet has been advocated as a most tough villain against endothelial health because of the concept that repeated exposure to high-fat meals per se may damage the endothelial cells, hence promoting atherosclerosis. This issue, "post prandial endothelial dysfunction" has been a major topic in the field of clinical research for a decade." [31]

One way to study this is to measure something called flow-mediated dilation (FMD), or the ability of the arteries to vasodilate in response to increased blood flow. Eat a fatty meal and you will see a significant decline in the ability of the artery to dilate. [32] A study on young healthy adults found that a high fat meal reduced vascular compliance whereas a low-fat meal did not. [33] The fatty meal makes the arteries stiff and much less responsive or less vasoactive. [34] Fortunately, this effect is transient, lasting for only a few hours, but eat another high-fat meal in a few hours and the damage starts to accumulate. In fact a second high fat meal that comes on the heels of a previous high-fat meal hits arterial function even harder. [35] High carbohydrate foods on the other hand do not have this effect. In the above study, they tested a meal of corn flakes with similar calories, which did not negatively impact dilation.

One study found that when rats consumed a high-fat diet, there was an immediate and dramatic decline in cognitive function and working memory, regardless of whether they had exercised or not. [36] Additionally, physical performance declined by as much as 50% in men eating a high-fat diet. One reason is that using fat for energy is less efficient, i.e. it takes more oxygen to produce the same amount of energy when fat is used. The brain is also an obligate glucose user. Fatty acids, and in particular saturated fats, damage the blood brain barrier. [37] Studies have shown that diets high in saturated fat also reduce levels of BDNF. Reduced BDNF, in turn, hurts learning and memory processes. [38] [39]

Foods That Help

Fats that come packaged with fiber, antioxidants, and phytonutrients, however, such as walnuts or almonds, are good for the brain and improve endothelial function. [40]

Antioxidant rich foods also improve FMD. When Italian researchers switched subjects from a low antioxidant diet (but similar in macronutrients and calories) to a high antioxidant diet, FMD improved significantly on the antioxidant rich diet. [41] Antioxidant rich foods also come with fiber and carbohydrate. A high carbohydrate, high fiber meal (all-bran and whole grain bread) was also shown to improve FMD. [42]

More importantly, however, brain scans show that consumption of antioxidant rich foods such as blueberries improve blood flow or perfusion within the brain. One study compared chronic consumption of 30mL of blueberry concentrate to an isogenic placebo. Those on the blueberry juice had significant increases in brain perfusion as well as improved brain activity. There was evidence of improved memory as well. [43] Another study found that high flavanol intake from cocoa resulted in increased cerebral blood volume compared to a low flavanol group. [44] Dentate gyrus function (a region in the hippocampus whose function declines with aging) also improved in healthy older adults who consumed the flavanols.

Plant polyphenols enhance angiogenesis, or increased production of blood vessels in the brain, probably even more so than exercise. However, exercise serves to enhance this effect. [45] Of interest is that those who exercise show increased absorption of nutrients such as antioxidants, by as much as nine fold. Here again, we see a nice synergy between diet and exercise. [46] The sum of the whole is greater than the sum of the parts.

An important point to make, however, is that just adding some blueberries to your diet while a good thing is not going to completely do the job. What is most helpful is to eat across the spectrum of plant foods. Different plant foods provide different types of antioxidants and nutrients and there is a synergistic effect when we eat a variety of plant foods. One study, for example, found higher cognitive function when a variety of fruits and vegetables were consumed compared to increasing intake of a few fruits and vegetables. [47] Another study found a dose dependent relationship between cognitive function and increased fruit, vegetable, mushroom and whole grain consumption. [48] Thus, eating across the plant kingdom is a good idea.

Other foods also shown to improve blood flow to the brain are those high in nitrates. However, when people hear nitrate rich foods they think of processed meats like lunchmeat and bacon. Alas, the nitrates in these foods convert to nitrosamine, a class 1 carcinogen also found in cigarettes (it is the most cancer-promoting carcinogen found in cigarettes). The phytonutrients in plant foods (like vitamin C) prevent this conversion from taking place. Thus, eating more nitrate rich foods like leafy greens and beets, or in the case of a number of studies, beet juice, increases production of nitric oxide and improves blood flow and arterial health.

How Nitrate Rich Foods Help Improve Blood Flow

Nitrates from these foods are converted to nitrites by your friendly mouth bacteria. These in turn get absorbed from the intestine into the circulation, which become bioactive nitric oxide in tissues and blood. In addition to protecting the arteries from plaque deposition, nitric oxide is a potent vasodilator. It is also important for mitochondrial biogenesis (the creation of new mitochondria, the energy factories of the cell), glucose uptake and muscle contraction and relaxation. [52] An important point is that when you do eat these foods it is best to not use mouthwash as that hurts the mouth bacteria and the conversion to nitrites. Additionally, one study found that when athletes consumed a ketogenic, high-fat diet, this damaged the bacterial population in the mouth and thus hurt their ability to convert nitrates from food to nitric oxide. [53]

A single 450 ml dose of beetroot juice resulted in improved cerebral blood flow and cognitive performance compared to a nitrate free placebo in healthy adults. [49] A similar study where participants consumed a high nitrate versus a low nitrate meal also found increased perfusion to critical areas of the brain that were most prone to hypoxia. In particular, those areas associated with executive function were the most positively affected. [50]

In addition to beets and beet juice, foods highest in nitrates are leafy greens like arugula (or rocket lettuce), spinach, beet greens and Swiss chard. These have been shown to increase nitrate plasma concentrations. [51]

The final study I will share looked at the combination of aerobic exercise training and beetroot juice consumption. They found there was enhanced connectivity between parts of the brain with just the exercise, but there was an even greater effect in the exercise and beetroot- juice intervention group. To quote, “The exercise plus [beetroot juice] group developed brain networks that more closely resembled those of younger adults, showing the potential enhanced neuroplasticity conferred by combining exercise and [nitrate-rich vegetables].” [54] Thus, the combination of exercise and healthy eating are particularly powerful tools to keep our brains young and highly functioning.

Thus, food can profoundly affect brain performance, either for the positive or the negative. The effect of plant polyphenols on the ability to improve blood flow to the brain might even be superior to exercise. However, eating a plant-based, antioxidant and fiber rich diet that is naturally low in saturated fat and cholesterol, in combination with exercise could be even more powerful. [55]

Nature

> "Climb the mountains and get their good tidings. Nature's peace will flow into you as sunshine flows into trees. Let the winds blow their freshness into you and the storms their energy and cares will drop off like autumn leaves." *–John Muir*

Our environment plays a significant role in how we think and behave. The modern environment that most people experience living in urban areas is characterized by a dramatic decrease in exposure to nature and an increase in exposure to technology. The vast majority of people spend about 90% of their time inside with little to no exposure to natural settings. Urban living is also associated with increased stress and related diseases.

The ability of nature to improve creativity, mood and attention is so powerful that a number of companies are now creating biophilic environments. Biophilic design incorporates natural elements into the workspace. Studies indicate that exposure to nature reduces stress, rumination, and improves cognition, affect, creativity and productivity. [56] Companies such as LL Bean have created outdoor workspaces for their employees. Other companies such as Amazon have "The Spheres" which are packed with plant life into which they have incorporated workspaces. Apple headquarters have unabated views of the outside with a forest at the center of its "spaceship" ring.

However, can nature help reduce mental fatigue and aid in recovery? At the heart of the research on nature and the brain is an idea called ART or Attention Restoration Theory. ART is based on research showing that there are two types of attention.

The first is voluntary or directed attention where attention is directed by cognitive-control processes. In other words, this type of attention takes energy, requires focus and is what we use throughout the workday.

The other type of attention is involuntary where attention is captured by inherently intriguing or important stimuli. According to ART, interacting with environments rich with inherently fascinating stimuli such as looking at a sunset or mountain views, allows directed-attention to replenish. Thus, after spending time in nature we perform better on tasks that require focus and directed attention. [57] Being in nature is also mood elevating and can benefit health and reduce sick days.

Thus, being in nature is both restorative, and can be used as a vehicle to improve cognitive function. One study found a 50% increase in creativity after an extended time spent in nature. [58] Another study compared walking outside in nature to walking on a treadmill. Walking outside produced the most novel and highest quality on tests of creativity. [59] Interestingly, there was a residual effect on creativity after being outside, in that creativity received a boost once seated back inside. Walking outside in a natural environment has the double benefit of exercise and being in nature.

If there are no parks or tree-lined streets nearby bring nature into your office by adding potted plants and/or pictures of nature. Even staring at an image of natural scenery for 40 seconds is enough to trigger the brain into a more relaxed state. [56]

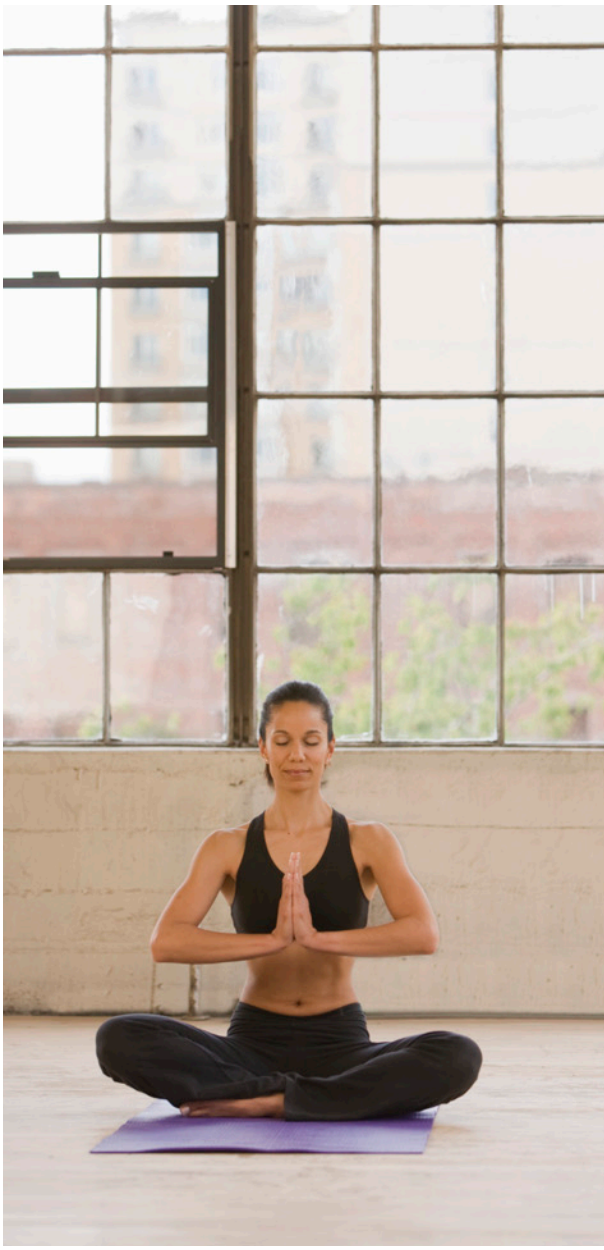
Meditation

> “Meditation is a vital way to purify and quiet the mind thus rejuvenation of the body.” –*Deepak Chopra*
>
> “I have lived with several zen masters – all of them cats.” –*Eckhurt Tolle*

The final strategy is to take some quiet time for the brain. One tried and true method to do this is to engage in activities that relax the brain such as nature and meditation. Meditation, however, seems a bit counterintuitive. How can something that requires such focus be restorative, especially if, like me, you are not very good at it. Nevertheless, the data are quite compelling.

Researchers from Harvard found that a calm or quiet brain with less neural activity could lead to a longer life while excitation of neuronal activity hurts cognition and reduces lifespan. Scientists have discovered a transcription factor (a protein that regulates gene expression) called REST that serves to maintain neural homeostasis and buffer against neural excitation. Boosting REST led to lower neural activity and longer lifespans while suppressing it did the opposite. [60] So does meditation boost REST? To my knowledge, that has not been studied, but meditation can help to slow brain activity leading to synaptic downscaling. Synaptic downscaling aims to renormalize synaptic loads (i.e. slow neural activity) after a waking period and helps to prepare the brain to receive new information during subsequent wakefulness. [61] In other words, taking a meditation break can do wonders for performing subsequent mentally challenging tasks.

Meditation refers to a variety of techniques that encourage mental self-regulation and the purposeful focusing of attention, with the goal of promoting relaxation and inducing a particular state of consciousness. [62] While it does require focus, it is a focus on the present in a non-judgmental way, relieving us of worrying about things that may happen in the future and anxiety about things that have happened in the past. Its practice may therefore serve to increase cognitive reserve, enhance cognitive function and alter neurological pathways. Indeed studies have found that the practice of mindfulness and meditation helps to improve one's focus, attention, and improve regional cerebral blood flow and white matter connectivity. It can also induce theta brain waves, which help to confer a state of relaxed wakefulness. Theta waves are increased in almost all relaxing activities, even if they involve complex actions like playing the piano or skiing. This is also referred to as being in the "flow" or "in the zone". [63]



One group of researchers employed a 16-week meditation program of 10-minutes of daily practice. They observed improved focus, attention and efficiency of cognitive processes. In other words it helped reduce energy for demanding mental tasks. [64] Another study by Harvard researchers found that meditation can change the expression of genes that regulate inflammation, apoptosis (or programmed cell death, a good thing) and oxidative stress in only a few weeks. They found a dose response, i.e. the more trained people became in meditation, the more it beneficially changed these genes and helped to reduce oxidative stress and inflammation. [65] Another thing that happens is that meditation can send inhibitory signals to your amygdala (the emotional part of the brain where fear and anger are triggered). Those who meditated for about thirty minutes a day increased the size of their hippocampus, but also decreased the size of their amygdala (resulting in less anger and fear). [66]

There are many ways to meditate, relax, and practice mindfulness and quietness. Doing yoga, using a meditation app, taking a mindfulness walk, can all be things to incorporate during these long days of work and virtual meetings.

In Conclusion

Getting adequate sleep, incorporating daily exercise and movement breaks, eating a variety of fiber and antioxidant rich plant foods while reducing intake of fatty foods, taking nature breaks and doing some form of meditation are key strategies for fatigue recovery, optimizing brain function and energy renewal. These strategies have also been shown to have synergistic effects. Certainly other factors such as socially interacting with other humans, living with purpose, and practicing positivity are also important for our energy and mental health.

Additional Resources

For guided 5-minute movement breaks and a 5-minute guided meditation go here. For more on keeping your brain healthy, click here. For more on helpful sleep practices and the science of sleep, go here.

About the Author

Sharon McDowell-Larsen, PhD, is an exercise physiologist and for over 20 years managed the *Fitness for Leadership* module of the *Leadership at the Peak*, CCL's course for senior executives. Prior to joining CCL, she worked in the Sports Science Lab at the US Olympic Training Center. She has published research on the relationship between regular exercise and 360-degree ratings of leadership effectiveness, lifestyle behaviors of senior executives and the impact of stress on elite athletes. Sharon has written and been quoted in numerous articles on executive fitness and leadership stress, which have appeared in the Wall Street Journal, Forbes, the Washington Post, the San Diego Union-Tribute, HR Magazine, and South China Morning Post. She also authored CCL's white paper, "The Care and Feeding of the Leader's Brain" and coauthored *Dealing with Leadership Stress*, a CCL guidebook. Additionally, she is a competitive mountain biker and triathlete.

References

[1] K. Martin, R. Meeusen, K. Thompson, R. Keegan and B. Rattray, "Mental fatigue imparis endurance performance: A physiological explanation," *Sports Med*, vol. 48, no. 9, pp. 2041-2051, 2018.

[2] M. Lorist, M. Boksem and K. Ridderinkhof, "Impaired cognitive control and reduced cingulate activity during mental fatigue.," *Cogn Brain Res*, vol. 24, pp. 199-205, 2005.

[3] J. Berke, "What does dopamine mean?," *Nat Neurosci*, vol. 21, no. 6, pp. 787-793, 2018.

[4] C. Drake, T. Roehrs, J. Shambroom and T. Rother , "Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed," *J Clin Sleep Med*, vol. 9, no. 11, pp. 1195-1200, 2013.

[5] J. Bourre, "Effects of nutrients (in food) on the structure and function of the nervous system: Update of dietary requirements for the brain. Part 2: Macronutrients.," *J. Nutr Health & Aging*, vol. 10, pp. 386-398, 2006.

[6] J. Fowler, "Purine release and inhibition of synaptic transmission during hypoxia and hypoglycemia in rat hippocampal slices.," *Neurosci Lett*, vol. 157, pp. 83-86, 1993.

[7] D. Weaver, "The suprachiasmatic nucleus: a 25-year retrospective," *J Bio Rhythms*, vol. 13, no. 2, pp. 100-112, 1998.

[8] E. Van Someren and R. Riemersma-van der Lek, "Live to the rhythm, slave to the rhythm," *Sleep Med Rev*, vol. 11, no. 6, pp. 465-484, 2007.

[9] C. Kirisoglu and C. Guilleminault, "Twenty minutes versus forty-five minutes morning bright light treatment on sleep onset insomnia in elderly subjects," *J Psychosom Res*, vol. 56, no. 5, pp. 537-42, 2004.

[10] M. Boubekri, I. Cheung, K. Reid and et. al., "Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study," *JCSM*, vol. 10, no. 6, pp. 603-611, 2014.

[11] C. Clerkin, M. Ruderman and E. Svetieva, "Tired at work: a roadblock to effective leadership," Center for Creative Leadership, Greensboro, 2017.

[12] X. Meng, Y. Li, Y. Zhou and et. al., "Dietary sources and bioactivities of melatonin," *Nutrients*, vol. 9, p. 367, 2012.

[13] N. Pratheepawanit, J. Johns, S. Porasuphatana and et. al., "Dietary intake of melatonin from tropical fruit altered urinary excretion of 6-sulfatoxymelatonin in healthy volunteers," *J Agri Food Chem*, vol. 61, pp. 913-919, 2012.

[14] G. Howatson, P. Bell , J. Tallent, B. Middleton, M. McHugh and J. Ellis, "Effect of tart chery juice (Prunus cerasus) on melatonin levels and enhanced sleep quality," *Eur J Nutr*, vol. 51, no. 8, pp. 909-916, 2-12.

[15] H. Lin, P. Tsai, S. Fang and J. Liu, "Effect of kiwifruit consumption on sleep quality in adults with sleep problems," *Asia Pac J Clin Nutr*, vol. 20, no. 2, pp. 169-174, 2011.

[16] M. Slag, M. Gannon and F. Nuttall, "Meal stimulation of cortisol secretion: a protein induced effect," *Metabolism*, vol. 30, no. 11, pp. 1104-8, 1981.

[17] K. Johnson, "Gut microbiome composition and diversity are related to human personality traits," *Human Microbiome J*, vol. 15, 2020.

[18] C. Cotman, N. Berchtold and L. Christie, "Exercise builds brain health: key roles of growth factor cascades and inflammtion," *TRENDS in Neurosci*, vol. 30, no. 9, pp. 464-472, 2007.

[19] D. King and E. Caine, "Cognitive impairment in major depression," in *Neuropsychological Assessment of Neuropsychiatric Disorders Vol I*, Oxford, Oxford University Press, 1996, pp. 200-217.

[20] J. Berke, "What does dopamine mean?," *Nat Neurosci*, vol. 21, no. 6, pp. 787-793, 2018.

[21] L. Middleton, A. Robertson and M. Hampson, "A single session of exercise increases connectivity in sensorimotor-related brain networks: A resting-state fMRI study in young healthy adults," *Frontiers in Human Neurosci*, vol. 8, no. 625, pp. 1-9, 2014.

[22] Y. Chang, J. Labban , J. Gapin and J. Etnier, "The effects of actue exercise on cognitive performance: A meta-analysis," *Brain Res*, vol. 1453, pp. 87-101, 2012.

[23] P. Droubay and D. Puppione, "Dietary fat-induced postprandial lipemia: effect on arterial oxygen saturation and plasma lactate, triglyceride, and cholesterol levels in subjects with angina pectoris.," *Am J Clin Nutr*, vol. 33, no. 6, pp. 199-207, 1980.

[24] A. Alipour, J. Elte, H. van Aaanen and et. al., "Novel aspects of postprandial lipemia in relation to atherosclerosis," *Atheroscler Suppl*, vol. 9, no. 2, pp. 39-44, 2008.

[25] J. Cohen and G. Berger, "Effects of glucose ingestion on postprandial lipemia and triglyceride clearance in humans," *J Lipid Res*, vol. 31, no. 4, pp. 597-602, 1990.

[26] C. Thomsen, H. Storm, J. Holst and K. Hermansen, "Differential effects of saturated and monunsaturated fats on postprandial lipemia and glucagon-like peptide 1 responses in patients with type 2 diabetes," *Am J Clin Nutr*, vol. 77, no. 3, pp. 605-11, 2003.

[27] T. Regan, K. Binak, S. Gordon, V. Defazio and H. Hellems , "Myocardial blood flow and oxygen consumption during postprandial lipemia and heparin-induced lipolysis," *Circulation*, vol. 23, pp. 55-63, 1961.

[28] L. Edwards, A. Murray, C. Holloway and et. al., "Short-term consumption of a high-fat diet impairs whole-body efficiency and cognitive function in sedentary men," *The FASEB J*, vol. 25, pp. 1-9, 2010.

[29] H. Fukuzaki, R. Okamoto and T. Matsuo, "Studies on pathophysiolgoical efects of postalimentary lipemia in patients with ischemic heart disease," *Japanese Cir J*, vol. 39, no. 3, pp. 317-324, 1975.

[30] P. Rajendran, T. Rengarajan, J. Thangavel and et. al., "The vascular endothelium and human diseases," *int J Biol Sci*, vol. 9, no. 10, pp. 1057-1069, 2013.

[31] H. Matsuoka, "Postprandial microvascular dysfunction," *Circ J*, vol. 73, pp. 1399-1400, 2009.

[32] C. Ng, A. Chan and A. Cheng, "Impairment of endothelial function-a possible mechanism for atherosclerosis of a high-fat meal intake," *Ann Acad Med Singapore*, vol. 30, pp. 499-502, 2001.

[33] M. Blendea, M. Bard, J. Sowers and N. Winer, "High-fat meal impairs vascular compliance in a subgroup of young healthy subjects," *Meatbolism*, vol. 54, no. 10, pp. 1337-44, 2005.

[34] R. Vogel, M. Corretti and G. Piotnick, "Effect of a single high-fat meal on endothelial function in healthy subjects," *Am J Cardiol*, vol. 79, no. 3, pp. 350-354, 1997.

[35] M. Tushuizen, R. Nieuwland , P. Scheffer and et. al., "Two conecutive high-fat meals affect endothelial-dependant vasodilation, oxidative stress and cellular microparticles in healthy men," *J Thromb Haemost*, vol. 4, no. 5, pp. 1003-10, 2006.

[36] A. Marray, N. Knight, L. Cochlin and et. al., "Deterioration of physical performance and cognitve function in rats with short-term high-fat feeding.," *FASEP Journal*, vol. 23, pp. 4353-4360, 2009.

[37] L. Corsinovi, F. Biasia, G. Poli and G. Isaia, "Dietary lipids and their oxidized products in Alzheimer's disease," *Mol Nutr Food Res*, vol. 55, no. Suppl, pp. 161-172, 2011.

[38] R. Molteni, R. Barnard, Z. Ying, C. Robers and F. Gomez-Pinilla, "A high-fat, refined sugar diet reduces hippocampal brain-derived neurotrophic factor, neuronal plasticity and learning," *Neuroscience*, vol. 112, pp. 803-814, 2002.

[39] C. Rossi, A. Angehucci, L. Costantin and et.al., "Brain-derived neurotrophic factor (BDNF) is required for the enhancement of hippocampal neurogenesis following environmental encrichment," *Eur J Neurosci*, vol. 24, pp. 1850-1857, 2006.

[40] B. Cartes, I. Nunez, M. Cofan and et. al., "Acute effects of high-fat meals enriched with walnuts or olive oil on postprandial endothelial function," *J Am College Cardiol*, vol. 48, no. 8, pp. 1665-1672, 2006.

[41] L. Franzini, D. Ardigo, S. Valtuena and et. al., "Food selection based on high total antioxidant capacity improves endothelial function in a low cardiobascular risk population," *Nutr Metab Cardovasc Dis*, vol. 22, no. 1, pp. 50-57, 2012.

[42] D. Brock, C. Davis, B. Irvine and et. al., "A high-carbohydrate, high-fiber meal improves endothelial function in adults with metabolic syndrome," *Diabetes Care*, vol. 29, no. 10, pp. 2313-2315, 2006.

[43] J. Bowtell, Z. Aboo-Bakkar, M. Conway, A. Adiam and J. Fulford, "Enhanced task-related brain activation and resting perfusion in health oder adults after chronic blueberry supplementation," *Apl Physiol Nutr Metab*, vol. 42, no. 7, pp. 773-779, 2017.

[44] A. Brickman, U. Khan, F. Provenzano and et. al., "Enhancing dentate gyrus function with dietary flavanols improves cognition in older adults," *Nat Neurosci*, vol. 17, no. 12, pp. 1798-1803, 2014.

[45] H. van Praag, "Exercise and the brain: something to chew on," *Trends in Neurosci*, vol. 32, no. 5, pp. 283-290, 2009.

[46] S. Medina, R. Dominguez-Perles, C. Garcia-Viguera and et. al., "Physical activity increases the bioavailability of flavanones after dietary aronia-citrus juice intake in triathletes," *FoodChem*, vol. 135, no. 4, pp. 2133-2137, 2012.

[47] X. Ye, S. Bhupathiraju and K. Tucker, "Variety in fruit and vegetable intake and cognitive function in middle-aged and older Puerto Rican adults," *Br J Nutr*, vol. 109, no. 3, pp. 503-510, 2013.

[48] E. Nurke, H. Refsum, C. Drevon and et. al., "Cognitive performance among the elderly in relation to the intake of plant foods. The Hordaland health study," *Br J Nutr*, vol. 104, no. 8, pp. 1190-1201, 2010.

[49] E. Wightman, C. Haskell-Ramsay, K. Thompson and et. al., "Dietary nitrate modulates cerebral blood flow parameters and cogntive performance in humans: a double-blind, placebo-controlled, crossover investigation," *Physiol Behav*, vol. 149, pp. 149-158, 2015.

[50] T. Presley, A. Marogan , E. Bechtold and et. al., "Acute effect of a high nitrate diet on brain perfusion in older adults," *Nitric Oxide*, vol. 24, no. 1, pp. 34-42, 2011.

[51] K. Jonvik, J. Nyakayiru, P. Pinckaers and et. al., "Nitrate-rich vegetables increase plasma nitrate and nitrite concentrations and lower blood pressure in health adults," *J Nutr*, vol. 146, no. 5, pp. 986-993, 2016.

[52] R. Dominguez, E. Cuenca, J. Mate-Munoz and et. al., "Effects of beetroot juice supplementation on cardiorespiratory endurance in athletes. A systematic review," *Nutrients*, vol. 9, no. 43, pp. 1-18, 2017.

[53] N. Murtaza, L. Burkke, N. Vlahovich and et. al., "Analysis of the effects of dietary pattern on the oral imcorbiome of elite endurance athletes," *Nutrients*, vol. 11, no. 3, p. 614, 2019.

[54] M. Petrie, W. Rejeski, S. Basu and et. al., "Beet root juice: an ergogenic aid for exercise and the aging brain," *J Gerontol A Biol Sci Med Sci*, vol. 72, no. 9, pp. 1284-1289, 2017.

[55] H. van Praag, "Exercise and the brain: something to chew on," *Trends in Neurosci*, vol. 32, no. 5, pp. 283-290, 2009.

[56] J. Yin, S. Zhu, P. MacNaughton, J. Allen and J. Spengler, "Physiological and cognitive performance of exposure to biophilic indoor environment," *Building and Environ*, vol. 132, pp. 255-262, 2018.

[57] M. Bermann, J. Jonides and S. Kaplan, "The cognitive benefits of interacting with nature," *Psychol Sci*, vol. 19, no. 12, pp. 1207-1212, 2015.

[58] R. Atchley, D. Strayer and P. Archley, "Creativity in the wild; improving creative reasoning through immersion in natural setting," *PLOS one*, vol. 7, no. 12, pp. 1-3, 2012.

[59] M. Opezzo and D. Schwartz, "Give your idea some legs: the positive effect of walking on creative thinking," *Am Psychol Ass*, vol. 40, no. 4, pp. 1142-1152, 2014.

[60] J. Zullo, Drake D, L. Aron and et. al., "Regulation of lifespan by neural excitation and REST," *Nature*, vol. 574, no. 7778, pp. 359-364, 2019.

[61] D. Dentico, D. Bachhuber, B. Riedner and et. al., "Acute effects of meditation training on the waking and sleeping brain: Is it all about homeostasis," *Eur J Neurosci*, vol. 48, no. 6, pp. 2310-2321, 2018.

[62] G. Christie, T. Hamiltion, B. Manor and et. al., "Do lifestyle activites protect against cognitive decline in aging? A review," *Frontiers Aging Neurosci*, vol. 9, pp. 1-12, 2017.

[63] D. Sherzai and A. Sherzai, The Alzheimer's Solution, New York: HarperCollins Publishers, 2017.

[64] A. Moore and P. Malinosdki, "Meditation, mindfulness and cognitive flexibility.," *Conscious Cogn*, vol. 18, pp. 176-186, 2009.

[65] M. Bhasin, J. Dusek, B. Change and et. al., "Relaxation response induces temporal transcriptome changes in energy metabolism, insulin secretion and inflammatory pathways," *PLoS One*, vol. 8, no. 5, p. e62817, 2013.

[66] B. Holzel, J. Carmody, M. Vangel and et. al., "Mindfulness pratice leads to increases in regional brain gray matter density," *Psychiatry Res*, vol. 191, no. 1, pp. 36-43, 2011.

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