

What You Don't Know About Your Brain: A Mini-Archive of  
Essential Neuroscience for a Happier, Healthier, Longer Life

By

Truitt Breelle Shelts

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Approved by:  
Dr. Matthew Mars  
Public & Applied Humanities

My Honors Thesis  
Abstract and Author's Note

Halfway through my senior honors thesis, I scrapped it.

At the tailend of my senior fall semester, winter graduation posts riddled my Instagram feed; one in particular led me to gut months of well-researched work and start over. The particular post was a slideshow of W.A. Franke Honors students graciously accepting their diplomas before a crowd of peers and proud parents. Behind them, giant flat screens on either side of the stage announce each graduate's name, major, and honors thesis topic. Suddenly, I began thinking about my thesis projecting boldly on that screen in less than 6 months.

*Dang.*

A tickmark in a long list of graduation requirements, albeit one I got to play with, was now something else entirely. For the first time in the execution of my thesis, I thought about the sheer number of eyes that would cross my work. Not just during graduation – but in the honors archives, publications, and my personal bubble. I had an opportunity to present a mass and diverse audience with nearly anything I desired.

At this point, I had found myself already settled on a niche sub-topic of cognitive science. Prospectus written, drafts submitted, and well on my merry way to a satisfactory thesis. However, I began to realize I had chosen personal interest over wide-spread applicability.

*Had I fumbled an opportunity to truly connect the field of neuroscience to something greater?*

This seed of doubt would be watered soon enough.

During a recent family dinner, I realized the neuroscience “fun facts” I had been relentlessly regurgitating during my breaks from school weren't falling on deaf ears. The neverending brain

dumping (no pun intended) was beginning to affect how my family members approached their day-to-day lives.

***“Did you know your brain...”*** has become a catalyst for the integration of better sleep habits, new exercise routines, stronger relationships, and more. Because they, in fact, did not know their brains worked that way.

And then it struck me: *my thesis is sitting right in front of me!*

Regular people who would never find themselves in an upper-division neuroscience class who could very well go their entire lives without being exposed to the brain health knowledge that I was. Folks unaware that a simple diet tweak or change in routine was the fix they were looking for, not medications or expensive treatments.

I made it my mission to condense 3 years of my undergraduate career into six easily-digestible articles, tackling the most essential neuroscience everyone should know for a happier, healthier, longer life.

These are the fundamentals of brain health that, I believe, should be plastered across social media, nightly dinner table conversation, or at the very least, a part of our basic high school education.

Essentially, what you don’t know – but should!

It’s written in a journalistic tone for an easy read, but chock-full of peer-reviewed research and data from reputable journals, keeping junk science and false promises at bay.

I’ll do my very best to translate all the murky, scientific jargon into something anyone can connect with – neuroscience can be an intimidating world, but it doesn’t have to be. And if these articles guide at least **one** person down a path of healthier habits,

I call that a thesis well done.

## Taking Out The Trash: Sleeping 7-8 Hours Flushes Out Dementia-Linked Proteins

### Sleep Lost, Waste Found

In our modern grind culture, statements like “I run on coffee and four hours of sleep” or “sleep is for weekends” call for praise. Lack of rest has become a warped indicator of work ethic and subtle competition to see who can survive on the least amount of Zs.

*Yeah, I pulled an all-nighter studying for this test. Second one this week!*

Despite being an admission of neglected health, sleep deprivation is worn like a badge of honor.

And for those able to leave work at the office, sleep isn’t lost to productivity but leisure. Late night scrolling or aimless binge-watching to compensate for a day devoid of relaxation – a behavior cleverly coined “Bedtime Revenge Procrastination.”<sup>1</sup>

But whatever the motive, those late-night antics leave more behind than unsightly eyebags.

Forgoing quality sleep is like canceling on your brain’s clean-up crew. Bins brimming with cognitive waste, if not taken out, start to spoil the surrounding anatomy.

Specifically, the regions responsible for protecting and preserving memory are left to rot.

Those bloodshot eyes starting to seem a lot less of a flex, huh?

Like cancer, the onset of memory problems arise when normal biological processes fail. In all brains, even healthy ones, dementia-linked proteins like **tau** and **B-amyloid** exist.<sup>2</sup>

They’re harmless and even helpful. That is, until they aren’t.

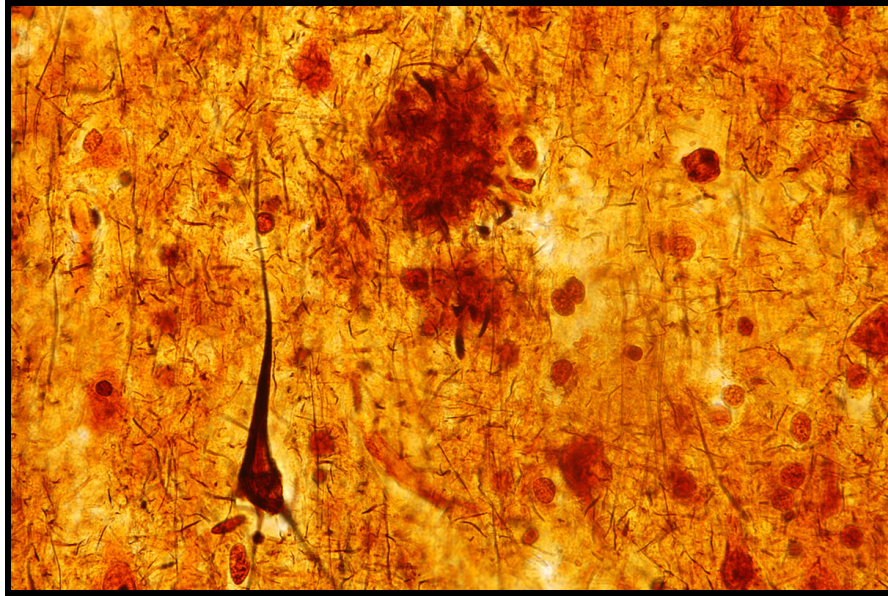
In excess, tau tends to clump together into twisted tangles inside brain cells. Meanwhile, B-amyloid forms sticky plaques outside of them. The build-up starts slowly corroding nearby brain tissue, interfering with neuron communication

Like blockades in the flow of your mind’s traffic; thinking and memory is jammed.

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<sup>1</sup> Stanford Student Affairs. (n.d.). *Sleep corner: Revenge bedtime procrastination*. Stanford University.

<sup>2</sup> Yamada, K., Cirrito, J. R., Stewart, F. R., Jiang, H., Finn, M. B., Holmes, B. B., Binder, L. I., Mandelkow, E. M., Diamond, M. I., Lee, V. M., & Holtzman, D. M. (2011). In vivo microdialysis reveals age-dependent decrease of brain interstitial fluid tau levels in P301S human tau transgenic mice. *The Journal of neuroscience : the official journal of the Society for Neuroscience*, 31(37), 13110–13117. <https://doi.org/10.1523/JNEUROSCI.2569-11.2011>



**Figure 1:** *A slice of brain tissue from a person who died with dementia revealing a destructive triangular tangle of tau protein.*<sup>3</sup>

Eventually, the traffic comes to a standstill. Roads close and there's no detours or ability to reinstall a normal flow. And once the obstruction is there, it's there for good.

With enough clogged neural highways, it's like being on a head-on collision course for brain disease.

But fear not!

Your brain has hired outside help to take care of the pile-up...

Each and every night, your immune system dutifully suits up for the graveyard shift.

### **Your Brain's Janitor**

During sleep our brain cells get more breathing room.

When you're catching Zs, the space between your brain cells extends by up to **60%** compared to waking hours.<sup>4</sup>

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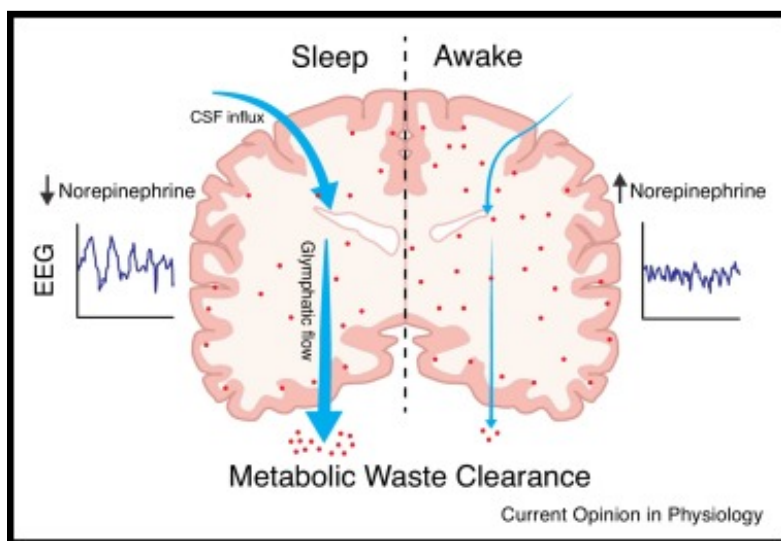
<sup>3</sup> Bhandari, T. (2019, January 24). *Sleep deprivation accelerates Alzheimer's brain damage*. Washington University School of Medicine in St. Louis.

<sup>4</sup> Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., O'Donnell, J., Christensen, D. J., Nicholson, C., Iliff, J. J., Takano, T., Deane, R., & Nedergaard, M. (2013). Sleep drives metabolite clearance from the adult brain. *Science (New York, N.Y.)*, 342(6156), 373–377. <https://doi.org/10.1126/science.1241224>

This extra wiggle-room allows cerebrospinal fluid (CSF) – the liquid that bathes our brain and spine – to flow more freely and efficiently throughout the brain’s network.<sup>5</sup>

As it circulates, CSF flushes out all the fluids chalked full of unwanted metabolic waste, like excess proteins like tau and B-amyloid, sitting stagnant around your cells. From there, the crud is directed into drainage pathways, kicked into the bloodstream, and ultimately filtered out by the liver and kidneys.

This systematic cleaning process is called **glymphatic drainage** and has recently been linked to helping protect the brain against neurodegenerative disease.<sup>6</sup>



**Figure 2:** Simplification of glymphatic drainage during sleep/waking states.<sup>7</sup>

But without sleep, glymphatic drainage never gets the extra workspace it needs to rinse out that lingering debris.

<sup>5</sup> Yamamoto, E. A., Bagley, J. H., Geltzeiler, M., Sanusi, O. R., Dogan, A., Liu, J. J., & Piantino, J. (2024). The perivascular space is a conduit for cerebrospinal fluid flow in humans: A proof-of-principle report. *Proceedings of the National Academy of Sciences of the United States of America*, 121(42), e2407246121. <https://doi.org/10.1073/pnas.2407246121>

<sup>6</sup> Cleveland Clinic. (2025, October 3). *Glymphatic system: What it is, function & how it works*.

<sup>7</sup> Mestre, H., Mori, Y., & Nedergaard, M. (2020). The brain’s glymphatic system: Current controversies. *Trends in Neurosciences*, 43(7), 458–466. <https://doi.org/10.1016/j.tins.2020.04.003>

In a small study, neurologists discovered that a single sleepless night caused tau levels to rise by about **50%** compared to a full night of sleep.<sup>8</sup> In another study, B-Amyloid levels increased up to **30%** overnight. Specifically, in regions of the brain linked to Alzheimer's.<sup>9</sup>

Essentially, sleep is like running a dishwasher.

During the day, dirty dishes pile up. At night, sleep turns the machine on. Cut the rinse cycle short? Dishes stay half dirty, stack up, and the whole sink gets clogged.

One of the rare times “brainwashing” is actually a good thing.

## **How to Support Glymphatic Drainage**

While most of our brains could benefit from morning alarms being pushed back an hour or two, how much sleep should we really be aiming for?

Here's what the research says:

The amount of *deep sleep* you get matters more than the total hours spent asleep.

One study found that the glymphatic system is working at its most efficient during stage 3 NREM (more commonly called “slow wave” or “deep sleep”).<sup>10</sup> During this stage, a decrease in norepinephrine (the “fight-or-flight” chemical) relaxes blood vessels and optimizes fluid flow.

After a point, quality sleep outperforms quantity.

In healthy adults, this deep sleep only lasts between 60 to 110 minutes total and takes 3-4 sleep cycles to achieve. For most, this can be accomplished in roughly 7 to 8 hours. Once your brain has satisfied its need for deep sleep, it shifts towards REM or lighter sleep for the rest of your dozing.<sup>11</sup>

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<sup>8</sup>Bhandari, T. (2019, January 24). *Sleep deprivation accelerates Alzheimer's brain damage*. Washington University School of Medicine in St. Louis.

<sup>9</sup> Lucey, B. P., Hicks, T. J., McLeland, J. S., Toedebusch, C. D., Boyd, J., Elbert, D. L., Patterson, B. W., Baty, J., Morris, J. C., Ovod, V., Mawuenyega, K. G., & Bateman, R. J. (2018). Effect of sleep on overnight cerebrospinal fluid amyloid  $\beta$  kinetics. *Annals of Neurology*, 83(1), 197, 204.

<sup>10</sup> Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., O'Donnell, J., Christensen, D. J., Nicholson, C., Iliff, J. J., Takano, T., Deane, R., & Nedergaard, M. (2013). Sleep drives metabolite clearance from the adult brain. *Science*, 342(6156), 373, 377.

<sup>11</sup> Carskadon, M. A., & Dement, W. C. (2011). Normal human sleep: An overview. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (5th ed.). Elsevier.

Research also indicates sleeping in a side-lying position may further support glymphatic drainage.<sup>12</sup> While drainage still happens if you're lying flat, getting gravity on your side seems to streamline the process.

Sorry back and tummy sleepers.

And while optimal sleep may nowadays feel like a luxury or even a waste of time, it might be what stands between you and a life-altering diagnosis.

Every 65 seconds, someone in the United States is diagnosed with Alzheimer's. And there are now more than 6.7 million Americans living with the disease, with the number projected to climb to 13 million by 2050.<sup>13</sup>

But you already have one of the most powerful protective tools at your immediate disposal. It's free, accessible, and you can start utilizing it today.

Your cleanup crew is ready to clock-in every night,

whether they can do their job is up to you.

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<sup>12</sup> Carskadon, M. A., & Dement, W. C. (2011). *Normal human sleep: An overview*. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (5th ed., pp. 16–26). Elsevier Saunders.

<sup>13</sup> Fisher Center for Alzheimer's Research Foundation. (n.d.). *Alzheimer's disease facts and statistics*. <https://www.alzinfo.org/understand-alzheimers/alzheimers-disease-facts-and-statistics/>

## Living a Novel Life: How Newness Grows the Brain and Stretches Time

### **Caveman Brain Likey New Things**

You've blacked out before, right?

I certainly have (happens to the best of us).

Wait, no. I don't mean it in *that* way.

Come on, this is an honors thesis. Get your mind outta the gutter.

I'm talking about what happens during your routine drive home from work. The one where you remember putting the key in the ignition and then, suddenly, you're pulling into your driveway.

*Woah, am I home already?*

Habitual experiences we've done a million times have a tendency to lull us into a mindless, zombie-like state. Interestingly, this evolutionary autopilot is designed to help us by conserving cognitive energy.<sup>14</sup>

Constantly on alert for danger, our ancestral brains were tired. And they certainly took advantage of the predictability of a known path or behavior. A repeated practice often indicated safety and allowed our attention-system to take a load-off.

So, instead of encoding *every* trivial drive home, our brain condenses them.

Afterall, why would you need hundreds of copies of the same experience?

If the primitive brain knows the outcome, there's little incentive to waste cognitive effort and space storing it. And with decreased memory formation, your sense of time goes into hyperspeed.

Both in the present and in memory.

It's like reminiscing on a 3-day tropical vacation versus a standard, uneventful couple weeks at home.

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<sup>14</sup> California Institute of Integral Studies. (n.d.). *Novelty keeps your brain healthy*.

In one case, you're met with originality at every turn: new food, music, and culture. Your attention-system is maxed-out. Days feel wonderfully long and every tidbit of the trip feels finely etched into your brain.

On the other hand, a stretch of days knee-deep in routine will leave you asking yourself,

*What did I even have for breakfast this morning?*

Essentially, your attention, memory, and sense of time boils down largely to how turned-on your brain is. By novelty, that is.

(Again, mind outta the gutter.)

### **Why Childhood Felt Longer & Happier**

Given what you just learned about novelty, it makes sense, huh?

Every day was jam-packed with novelty. Kiddie-you was constantly making new friends, learning new skills, and experiencing much of life for the very first time.

As you were confronted with this 24/7 unpredictability, that caveman brain of yours was constantly inclined to pay attention, store new memories, and time couldn't help but slow.<sup>15</sup>

The "reminiscence bump" began to take shape.

Research reveals that adults (age 40+) report an increased proportion of important memories from early childhood and adolescence in comparison to those made in adulthood.<sup>16</sup>

Even though we obviously continue to make memories as we age, the early clustering of our most-valued memories suggests ones made in the throws of novelty stick best.

Perhaps, an explanation for why the summers of youth felt neverending and now each passing year seems to be an extra \*click\* higher on the fast-forward button.

And for many of us childhood days didn't just feel longer – they felt undeniably happier.

Beyond the increased alertness for a saber-toothed tiger, novelty also has our hunter-gatherer brains spitting out dopamine (or that “feel-good” chemical) to encourage our exploration of the

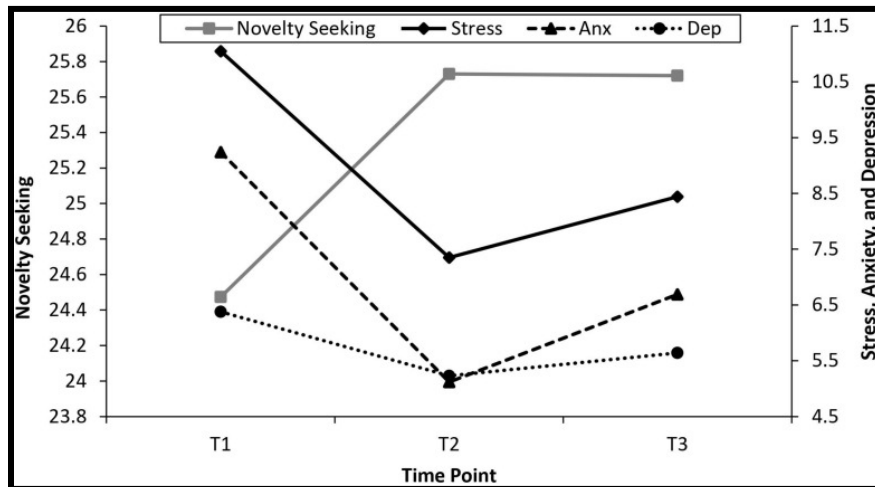
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<sup>15</sup> Iyer, S. (2024). *Why slowing down and seeking novelty can improve your life*. HuffPost.

<sup>16</sup> Koppel, J., & Rubin, D. C. (2016). Recent advances in understanding the reminiscence bump: The importance of cues in guiding recall from autobiographical memory. *Current Directions in Psychological Science*, 25(2), 135–140.

unknown.

Being boldly adventurous often led to discoveries like new crops, alliances, farmlands – all of which could’ve improved chances of survival.<sup>17</sup> Hence, why our brains reinforce novelty-seeking with “happy” chemicals that reduce those unhappy feelings.<sup>18</sup>



**Figure 1:** Growth trajectory for novelty seeking in relation to stress, anxiety, and depression.<sup>19</sup>

But, as we age, experiences begin to pile-up. Our brain is confronted with less newness and the frequent dopamine spikes from novelty decrease and, with it, the vividness of life.

We begin to lose grasp on our sense of “childlike wonder” with the world.

Admittedly a bit of a downer, but it also begs the question:

Could this mean that feeling isn’t gone, just simply not being triggered?

If happiness is the goal, collecting new and diverse experiences may be a far better strategy than collecting more material things like we’ve been conditioned to value.

Money may not be able to buy happiness, but perhaps novelty can.

<sup>17</sup> Wang, Y., Liu, Y., Yang, L. *et al.* Novelty seeking is related to individual risk preference and brain activation associated with risk prediction during decision making. *Sci Rep* 5, 10534 (2015). <https://doi.org/10.1038/srep10534>

<sup>18</sup> Miller, K. J., Gonçalves-Bradley, D. C., Areerob, P., et al. (2020). Physical activity interventions for improving cognition in older adults. *Cochrane Database of Systematic Reviews*, 2020(12).

<sup>19</sup> Li WW, Yu H, Miller DJ, Yang F and Rouen C (2020) Novelty Seeking and Mental Health in Chinese University Students Before, During, and After the COVID-19 Pandemic Lockdown: A Longitudinal Study. *Front. Psychol.* 11:600739. doi: 10.3389/fpsyg.2020.600739

## Tackling Goals with Novelty

You swear this time is different.

This is the year you'll start using that gym membership. Or become fluent in Spanish. Maybe even billing 40-hour weeks or achieving a 4.0 GPA.

You're locked-in for a couple weeks. Maybe even months. Then, a kind-of boredom hits. The routine starts to feel old. That initial excitement for achieving the end-goal dwindles.

You start slacking a little. Then a lot.

What was once a hunger to conquer has subsided into a weak, peckish grumble.

And eventually, you quit.

If this sounds like your New Year's resolutions or any dream you've chased – consider that a lack of novelty may be why you're struggling to cross the finish line.

Research suggests that integrating micro-novelty (new music, routes, people, etc.) into your routine may prolong intrinsic motivation and support goal-seeking behavior.<sup>20</sup>

Because dopamine responds to what is new, not just what feels good, we can effectively *trick* our brain into releasing this feel-good chemical and stimulating our reward-pathways.

For example – if you're struggling to stay committed to your early morning runs, deviating your route, playlist, or pace can wake up your inner-neanderthal.

*“This is unfamiliar, so I should pay attention.”*

Your caveman chemistry takes novelty as a sign that valuable resources may lie ahead, urging you to keep going. And all of the sudden, you start to perk up for that treacherous run and your brain starts to reinforce the idea that you should do this more often.

By refreshing newness, your brain's interest in a goal increases while the likelihood of quitting drops off. And your completion of goals may not just improve, but performance itself.

Research indicates that the increased dopamine levels experienced during a novel stimulus

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<sup>20</sup>Di Domenico, S. I., & Ryan, R. M. (2017). *The emerging neuroscience of intrinsic motivation: A new frontier in self-determination research*. *Frontiers in Human Neuroscience*, 11, 145.

lowers perceived effort-cost, speeds-up learning, and even improves creativity.<sup>21 22 23</sup>

Essentially, novelty makes that big ol' mountain you have to summit look a little less steep. You get a little quicker at remembering the route you saw in the guide and may even pivot better when the planned path is blocked.

## Improving Your Brain Health

Besides a refreshed perspective (increased motivation, attention, and such), novelty is also believed to be a formidable form of neuroprotective armour.

Novel experiences are thought to improve your neurons' ability to communicate with one another (called "synaptic plasticity").<sup>24</sup> This may aid in the ability to adapt to change, recover from stress, improve learning, and slow cognitive decline.<sup>25</sup>

In 2024, a human study found that engaging in a range of diverse down-time activities (artistic, social, cognitive, etc.) in early and midlife is associated with "more successful aging of functional brain activity". Particularly, preventing the development of dementia.<sup>26</sup>

Even older adults who started picking up new, cognitively-demanding hobbies showed improvements in their memory and reasoning.<sup>27</sup>

Can't teach a dog new tricks? Nonsense.

And for those without the time to pick-up Mandarin or master the accordion, even deviating your professional endeavors can have positive effects on brain health.

In one 17-year-long study, researchers found that middle-age workers with exposure to frequent changes in the diversity of their work-tasks displayed better processing speed, working memory,

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<sup>21</sup> Li, W. W., Yu, H., Miller, D. J., Yang, F., & Rouen, C. (2020). Novelty seeking and mental health in college students: The mediating role of intrinsic motivation. *Frontiers in Psychology, 11*, 600739.

<sup>22</sup> Bromberg-Martin, E. S., Matsumoto, M., & Hikosaka, O. (2010). Dopamine in motivational control: Rewarding, aversive, and alerting. *Neuron, 68*(5), 815–834.

<sup>23</sup> Inzlicht, M., Shenav, A., & Olivola, C. Y. (2018). The effort paradox: Effort is both costly and valued. *Trends in Cognitive Sciences, 22*(4), 337–349.

<sup>24</sup> Berto, R. (2014). The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. *Behavioral Sciences, 4*(4), 394–409.

<sup>25</sup> Erickson, K. I., Voss, M. W., Prakash, R. S., et al. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences, 108*(7), 3017–3022.

<sup>26</sup> Kempermann G. (2022). Embodied prevention. *Front. Psychol. 13*:841393.

<sup>27</sup> Voss, M. W., Vivar, C., Kramer, A. F., & van Praag, H. (2013). Bridging animal and human models of exercise-induced brain plasticity. *Trends in Cognitive Sciences, 17*(10), 525–544.

and more grey matter (GM).<sup>28</sup> Interestingly, the subject's gray matter increase was found in areas most vulnerable to age-related decline.

While these improvements won't be as dramatic as those gained from months of grueling marathon training or cutting out sugar, you'll begin to notice little improvements in work performance, communication skills, and daily functioning.

Even in a hyper-productive culture obsessed with the “grind,” novelty can still be found and be fruitful for the brain.

### **Novelty: Our Default Setting**

As a species, we are wired to be constantly experiencing.

In fact, research has shown we'd rather endure discomfort than nothing at all.

In one study, a significant number of participants (67% of men and 25% of women) preferred to subject themselves to *electric shocks* rather than sit with their thoughts for a mere 15 minutes.<sup>29</sup>

People would rather shock themselves than have no sort of stimulation – a testament to our need for constant stimulation.

But you don't have to dress-up your passport with stamps or jump out of an airplane to hit your brain's experiential quota. Quite the opposite.

Even little deviations like exercising at home, going on a walk around the block, taking a different route to the grocery store or pharmacy can scratch your brain's novelty itch.<sup>30</sup>

Your life doesn't have to change radically overnight to reap the benefits of novelty — just resist the pull of autopilot. When things feel routine and comfortable, take it as a signal to switch things up.

Afterall, life is far too short to let your brain turn off.

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<sup>28</sup> Di Domenico, S. I., & Ryan, R. M. (2017). The emerging neuroscience of intrinsic motivation: A new frontier in self-determination research. *Frontiers in Human Neuroscience*, *11*, 145.

<sup>29</sup> Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., Brown, C. L., & Shaked, A. (2014). Social psychology. Just think: the challenges of the disengaged mind. *Science (New York, N.Y.)*, *345*(6192), 75–77. <https://doi.org/10.1126/science.1250830>

<sup>30</sup> Heller, A.S., Shi, T.C., Ezie, C.E.C. et al. Association between real-world experiential diversity and positive affect relates to hippocampal–striatal functional connectivity. *Nat Neurosci* **23**, 800–804 (2020). <https://doi.org/10.1038/s41593-020-0636-4>

## Who knew? You got Two! The “Second Brain” and Mind-Gut Connection

### **You Got Brain**S**, Kid**

Roughly two feet below your brain, lies another.

And, no.

It’s not a second, pinkish-grey blob lodged in your abdomen (that would be cause for concern).

But it is a biological doppelgänger. And one with a shocking influence over our mood, sleep, motivation, and even risk for neurodegenerative disease.

From esophagus to where-the-sun-don’t-shine, over 100 million neurons line your digestive system with striking similarities in structure and chemical make-up to the ones running your main-brain.

Earning it the nickname “second-brain”, the enteric nervous system (ENS) uses its own brain-like wiring to regulate digestion, gastrointestinal hormones, and immune responses without the input of the brain or spine.<sup>31</sup>

But despite being uniquely independent from the central nervous system, this copycat network happens to have a *direct* landline to the brain.

And, when it calls, it wants to chat about a whole lot more than indigestion.

### **The Gut-Brain Link**

Your body’s longest nerve, the vagus nerve, acts as this information highway between these two systems. And while your brain can “talk” to your gut (think stress-induced tummy troubles), 80–90% of the information traffic runs from the gut up to the brain.<sup>32</sup>

And when the gut’s flora and fauna is thrown off, the brain is sure to hear about it.

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<sup>31</sup> Fleming, M. A., 2nd, Ehsan, L., Moore, S. R., & Levin, D. E. (2020). The Enteric Nervous System and Its Emerging Role as a Therapeutic Target. *Gastroenterology research and practice*, 2020, 8024171.

<sup>32</sup>Breit, S., Kupferberg, A., Rogler, G., & Hasler, G. (2018). Vagus Nerve as Modulator of the Brain-Gut Axis in Psychiatric and Inflammatory Disorders. *Frontiers in psychiatry*, 9, 44.

Even slight disruptions in the microbiome's feng shui can dish lethal blows to our cognitive health – just a deficiency or two in the gut can wreak cognitive havoc.

Take tryptophan, for example.

Most famously (and incorrectly) blamed for Thanksgiving food comas, this amino acid is an essential building-block for neurotransmitters that play a key role in maintaining our cognitive health.<sup>33</sup>

Found in most proteins (eggs, dairy, meat, nuts, and soy), tryptophan deficiency is rare given a standard diet. Yet the disruptions in how it's metabolized that are surprisingly common

Gut inflammation can impair the gut's ability to metabolize all (kinds of) nutrients and may even redirect them away from their typical duties. Like having an abundance of seeds with shoddy soil, the abundance of a nutrient means diddly-squat if the fields it's planted in are barren.

Therefore, even if your tryptophan intake is gold-standard, an inflamed gut from low fiber, poor sleep, alcohol, and stress will prevent tryptophan from even reaching your brain in the first place.<sup>34 35</sup>

And when tryptophan absorption levels dip too low, your brain pays the price.

At first, there's subtler symptoms: feelings of depression, trouble falling asleep, blunted motivation, and reduced attention.<sup>36</sup>

But over time, impaired tryptophan metabolism can put you at higher risk for devastating psychiatric diseases like schizophrenia and bipolar disorder.<sup>37</sup>

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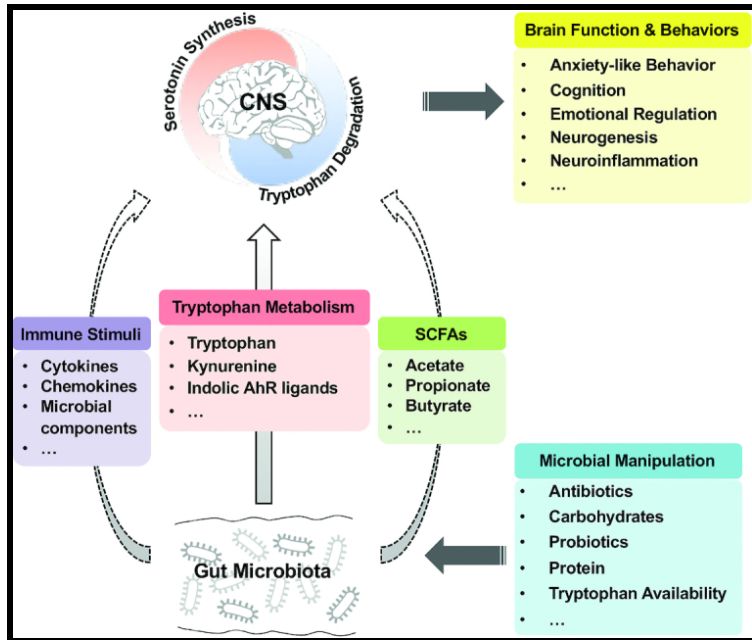
<sup>33</sup> Rogers GB, Keating DJ, Young RL, Wong ML, Licinio J, Wesselingh S. From gut dysbiosis to altered brain function and mental illness: mechanisms and pathways. *Mol Psychiatry*. 2016;21:738–48.

<sup>34</sup> Bose, M. M. (2025). *The HPA axis and kynurenine pathway: exploring the role of chronic inflammation and tryptophan metabolism*. (Review).

<sup>35</sup> O'Farrell, K., & Harkin, A. (2017). *Stress-related regulation of inflammation in depression: Central role of the kynurenine pathway*. *Brain, Behavior, and Immunity*, 62, 203–215.

<sup>36</sup> O'Mahony, S. M., et al. (2022). Gut microbiota modulation of tryptophan metabolism in stress and mental health. *Journal of Neurochemistry*. PMID: PMC9334550.

<sup>37</sup> Marx W, McGuinness AJ, Rocks T, Ruusunen A, Cleminson J, Walker AJ, et al. The kynurenine pathway in major depressive disorder, bipolar disorder, and schizophrenia: a meta-analysis of 101 studies. *Mol Psychiatry*. 2021;26:4158–78.



**Figure 1:** The potential role of tryptophan metabolism in the gut microbiota-brain axis.<sup>38</sup>

And tryptophan isn't a stand-alone case – From Prozac to Flintstone gummies, there are **dozens** of vital nutrients and therapeutic medications that rely heavily on a healthy, diverse gut for absorption, conversion, or activation.<sup>39 40</sup>

You can eat right and stock your medicine cabinet full of multi-vitamins, but without a proper microbiome/functioning gut, you could still wind up functionally deficient.

## A Dysregulated Gut Takes a Toll

From day-to-day mood to the integrity of memory, the microscopic residents of our gut have a surprisingly big effect on the well-being of our brain.

Simply transferring the gut bacteria of stressed mice and into healthy mice triggers a cascade of depression-like symptoms in the recipients.<sup>41</sup> And vice versa. Introducing “good” gut bacteria

<sup>38</sup> Gao, K., Mu, C. L., Farzi, A., & Zhu, W. Y. (2020). Tryptophan Metabolism: A Link Between the Gut Microbiota and Brain. *Advances in nutrition (Bethesda, Md.)*, 11(3), 709–723. <https://doi.org/10.1093/advances/nmz127>

<sup>39</sup> Cryan, J. F., O’Riordan, K. J., Cowan, C. S. M., Sandhu, K. V., Bastiaanssen, T. F. S., Boehme, M., ... Dinan, T. G. (2019). The microbiota–gut–brain axis. *Physiological Reviews*, 99(4), 1877–2013.

<sup>40</sup> Wilson, I. D., & Nicholson, J. K. (2017). Gut microbiome interactions with drug metabolism, efficacy, and toxicity. *Translational research : the journal of laboratory and clinical medicine*, 179, 204–222. <https://doi.org/10.1016/j.trsl.2016.08.002>

<sup>41</sup> Wang S, Ishima T, Zhang J, Qu Y, Chang L, Pu Y, et al. Ingestion of *Lactobacillus intestinalis* and *Lactobacillus reuteri* causes depression- and anhedonia-like phenotypes in antibiotic-treated mice via the vagus nerve. *J Neuroinflammation*. 2020;17:241.

into anxiety-ridden mice alleviated their anxious behaviors and even had neuroprotective effects.<sup>42</sup>

Whether the gut ecosystem fell into bacterial chaos or harmony, mental health quickly followed suit.

To probe this gut-brain connection even further, researchers severed the mice's vagus nerves (that information highway between the two) and negative behavioral effects were significantly reduced.<sup>43</sup>

And that very same messenger ferrying intel back-and-forth is likely capable of delivering much worse news. Recent animal studies suggest several neurodegenerative diseases may arise from dysfunction in the microbiome.<sup>44</sup>

Researchers have found that Lewy Bodies, a misfolded protein that causes Parkinson's (neurodegenerative disorder affecting motor control), can originate in the gut and travel to the brain via the vagus nerve.<sup>45</sup> Symptoms of the disease may even manifest in the gut years or decades before movement issues occur.

Severing of the vagus nerve once again proved to lower the risk of Parkinson's disease.<sup>46</sup>

But since we can't go around cutting our vagus nerves all willy-nilly (legally) to prevent disease and depression, how *do* we protect our brain from a vengeful gut?

## Protecting Your Microbiome

No need for \$7 kombuchas or trendy prebiotic sodas, start with these simple suggestions:

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<sup>42</sup> Tompa, R. (2025, March 6). *The gut-brain connection: What the science says*. Stanford Medicine.

<sup>43</sup> Ericsson AC, Hart ML, Kwan J, Lanoue L, Bower LR, Araiza R, et al. Supplier-origin mouse microbiomes significantly influence locomotor and anxiety-related behavior, body morphology, and metabolism. *Commun Biol*. 2021;4:716.

<sup>44</sup> Chen, S. G., Stribinskis, V., Rane, M. J., Demuth, D. R., Gozal, E., Roberts, A. M., Jagadapillai, R., Liu, R., Choe, K., Shivakumar, B., Son, F., Jin, S., Kerber, R., Adame, A., Masliah, E., & Friedland, R. P. (2016). Exposure to the functional bacterial amyloid protein curli enhances alpha-synuclein aggregation in aged Fischer 344 rats and *Caenorhabditis elegans*. *Scientific Reports*, 6, 34477.

<sup>45</sup> Breen, D. P., Halliday, G. M., & Lang, A. E. (2019). Gut-brain axis and the spread of  $\alpha$ -synuclein pathology: Vagal highway or dead end? *Movement Disorders*, 34(3), 307–316.

<sup>46</sup> Svensson, E., Horváth-Puhó, E., Thomsen, R. W., Djurhuus, J. C., Pedersen, L., Borghammer, P., & Sørensen, H. T. (2015).

Dietitians and neuroscientists alike recommend the Mediterranean diet.<sup>47</sup> High in fiber, polyphenols, and healthy fats, this diet best supports a microbiome chalked full of diverse and beneficial gut bacteria.

In a year-long study, the Mediterranean diet proved to enrich the gut microbiomes of over 600 subjects; specifically, with the “good” bacteria associated with improved cognition and reduced anxiousness.<sup>48</sup>

Also, incorporating more fermented foods (e.g. kimchi, yogurt, or sauerkraut) rich in prebiotics can also lower inflammation and add lots of healthy little bugs to your bacterial colony.<sup>49</sup>

On the flip side, there are a few microbiome party-fouls worth avoiding.

High in refined sugars, saturated fats, and ultra-processed junk, the typical ‘Western diet’ diet is unfortunately associated with reduced gut barrier function and increased risk for mental health issues.<sup>50</sup>

And while easier said than done, lowering chronic stress and prioritizing adequate sleep also reduces gut-inflammation.<sup>51</sup>

Protecting your gut microbiome really comes down to the basics. Your body thrives on clean eating and rest – no expensive health fads necessary.

If you’re hesitant to believe the “happy gut, happy life” sentiment, try implementing a few of these simple swaps and see how you feel.

You likely find fixing your gut improves far more than just digestion.

When it comes to mental health, cognitive decline, and overall brain health, we’re often quick to turn to therapy or prescription medication for help.

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<sup>47</sup>Aziz, T., Khan, A. A., Saeed, A., & Ahmed, S. (2024). Elucidating the role of diet in maintaining gut health to reduce the risk of obesity, cardiovascular and inflammatory diseases. *Nutrients*, 16(1), 28.

<sup>48</sup>Shoubridge, A. P., Choo, J. M., Martin, A. M., Keating, D. J., Wong, M.-L., Licinio, J., & Rogers, G. B. (2022). *The gut microbiome and mental health: Advances in research and emerging priorities*. *Molecular Psychiatry*, 27(4), 1908–1919. <https://doi.org/10.1038/s41380-022-01479-w>

<sup>49</sup>Wastyk, H. C., Fragiadakis, G. K., Perelman, D., Dahan, D., Merrill, B. D., Yu, F. B., Topf, M., Gonzalez, C. G., Van Treuren, W., Han, S., Sonnenburg, E. D., Elias, J. E., & Sonnenburg, J. L. (2021). Gut-microbiota-targeted diets modulate human immune status. *Cell*, 184(16), 4137–4153.e14.

<sup>50</sup>Shoubridge, A. P., Choo, J. M., Martin, A. M., Keating, D. J., Wong, M.-L., Licinio, J., & Rogers, G. B. (2022). The gut microbiome and mental health: Advances in research and emerging priorities. *Molecular Psychiatry*, 27(4), 1908–1919.

<sup>51</sup>Foster, J. A., Rinaman, L., & Cryan, J. F. (2017). Stress & the gut–brain axis: Regulation by the microbiome. *Neurobiology of Stress*, 7, 124–136.

But maybe the issue has never just been in our heads.

The problem might very well be right (approximately two feet) under our noses.

## Getting Your Fix: How Exercise Supports Your Dopamine System & Boosts Brain Performance

Often, the lead-up to the gym is chalked full of dread.  
A tinge of anxiety. A sprinkling of insecurity.

An utter inconvenience to interrupt a busy day with profuse sweating, torn muscles, and inevitable discomfort.

But, much less often, is there ever regret afterwards. Despite an unpleasant beginning and middle, most workouts typically end in:

*“I’m glad I did that. I feel good.”*

Strain quickly dissolves into satisfaction. Like a high-five for your brain, you’re smacked with a colossal dose of dopamine and biological payment for your efforts.

Coined as the “feel-good” chemical, dopamine gives rise to feelings of pleasure and plays a vital role in our brain’s reward system. It’s also a key neurotransmitter for healthy mood, motivation, memory, and learning.<sup>52</sup>

Dopamine surges are so enjoyable that we’re often driven to chase them artificially. For instance, drugs of abuse (opioids, cocaine, & nicotine) can trigger spikes up to **ten times** greater than natural rewards like exercise.<sup>53</sup>

As you could’ve probably guessed, being smacked with a tenfold dose of dopamine hosts a fair share of biological consequences.

Anytime your brain is overwhelmed with too much or too little dopamine, brain chemistry goes wack and you’re more likely to see a rise in depression, low motivation, tiredness, and even neurodegenerative diseases like Parkinson’s.<sup>545556</sup>

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<sup>52</sup>Watson, S. (2021, July 20). *Dopamine: The pathway to pleasure*. Harvard Health Publishing.

<https://www.health.harvard.edu/mind-and-mood/dopamine-the-pathway-to-pleasure>

<sup>53</sup> <https://www.yalemedicine.org/news/how-an-addicted-brain-works>

<sup>54</sup> Klein, M.O.; Battagello, D.S.; Cardoso, A.R.; Hauser, D.N.; Bittencourt, J.C.; Correa, R.G. Dopamine: Functions, Signaling, and Association with Neurological Diseases. *Cell. Mol. Neurobiol.* **2019**, *39*, 31–59.

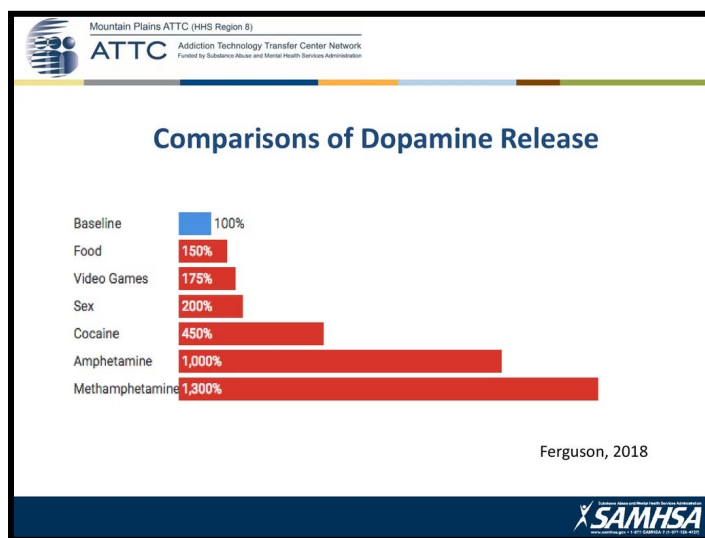
<sup>55</sup> Kim, Y.-S.; O’Sullivan, D.M.; Shin, S.-K. Can 24 weeks strength training reduce feelings of depression and increase neurotransmitter in elderly females? *Exp. Gerontol.* **2019**, *115*, 62–68.

<sup>56</sup> <https://my.clevelandclinic.org/health/articles/22588-dopamine-deficiency>

To compensate for the high influx, your brain starts eliminating dopamine receptors and stalling its natural dopamine production.<sup>57</sup> The human body craves equilibrium and is quick to adjust when the pendulum swings too far one way over the other.

By rewiring biology to adjust for the overwhelming surplus, the brain only further reinforces its dependency on artificial sources.

And this dysregulation occurs at varying levels for most of our favorite vices: drinking, gambling, shopping, video games, food, etc.<sup>58</sup> And that blissful spike is often quickly overshadowed by a less-than-pleasant crash.



**Figure 1:** *How much dopamine does an activity release?*<sup>59</sup>

The kind of deficit that leaves you yearning for a second cigarette or slice of cake more than you wanted the first. And it only becomes more potent as the spike increases.

But previously mentioned, nature does give us a formidable and trustworthy dopamine-dealer. And it brings less negative side-effects, a mere ~3% prevalence of addiction, and a plethora of health benefits.<sup>60</sup>

<sup>57</sup> Yale Medicine. (2022, May 25). *How an addicted brain works*. Yale Medicine. <https://www.yalemedicine.org/news/how-an-addicted-brain-works>

<sup>58</sup> Wise, R. A., & Jordan, C. J. (2021). Dopamine, behavior, and addiction. *Journal of biomedical science*, 28(1), 83. <https://doi.org/10.1186/s12929-021-00779-7>

<sup>59</sup> Lembke, A. (2021). *Dopamine nation: Finding balance in the age of indulgence*. Dutton Press.

<sup>60</sup> Macfarlane, L., Owens, G., & Cruz, B. del P. (2016). Identifying the features of an exercise addiction: A Delphi study. *Journal of behavioral addictions*, 5(3), 474–484. <https://doi.org/10.1556/2006.5.2016.060>

Despite being nestled somewhere between baseline and videogames, **exercise** does offer a unique kind of spike that makes it more than worthwhile.<sup>61</sup>

With no rapid crashes or circuit casualties, exercise compensates for its less methamphetamine-like effects by actually *strengthening* reward pathways. Instead of inflicting mayhem, exercise gradually increases dopamine levels and receptor availability.<sup>62</sup>

Essential, the payoff doesn't end when the workout does.

By raising your dopamine baseline, you'll likely feel a more stable sense of well-being and a drop in anxiety and depression.<sup>63</sup> And this isn't mere guess-work:

In one month-long study, healthy mice who engaged in consistent running on a wheel not only displayed a 40% increase in dopamine release but experienced elevated dopamine levels for an entire, exercise-less week after.<sup>6465</sup>

And if that isn't enough to knock your gym socks on, check out the additional chemical cocktails exercise could have you sippin' on...

## What are “Exerkines”?

The emergence of a whole new classification of molecules called “**exerkines**” has led the research community to double-down on the exploration of exercise and its ties to longevity.

Exerkines is a broad term that encompasses a variety of molecules in your body (e.g. hormones, proteins, etc.) that are released in multiple organ systems during physical activity. Systems like

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<sup>61</sup> Bastioli, G., Mancini, M., Patel, J.C. et al. Voluntary exercise increases striatal dopamine release and improves motor performance in aging mice. *npj Parkinsons Dis.* 11, 345 (2025). <https://doi.org/10.1038/s41531-025-01213-7>

<sup>62</sup> Tyler J, Podaras M, Richardson B, Roeder N, Hammond N, Hamilton J, Blum K, Gold M, Baron DA and Thanos PK (2023) High intensity interval training exercise increases dopamine D2 levels and modulates brain dopamine signaling. *Front. Public Health* 11:1257629. doi: 10.3389/fpubh.2023.1257629

<sup>63</sup> Marques, A., Santos, D. A., Ekelund, U., & Sardinha, L. B. (2021). *Bidirectional association between physical activity and dopamine across the lifespan: A systematic review*. **Brain Sciences**, 11(7), 829. <https://doi.org/10.3390/brainsci11070829>

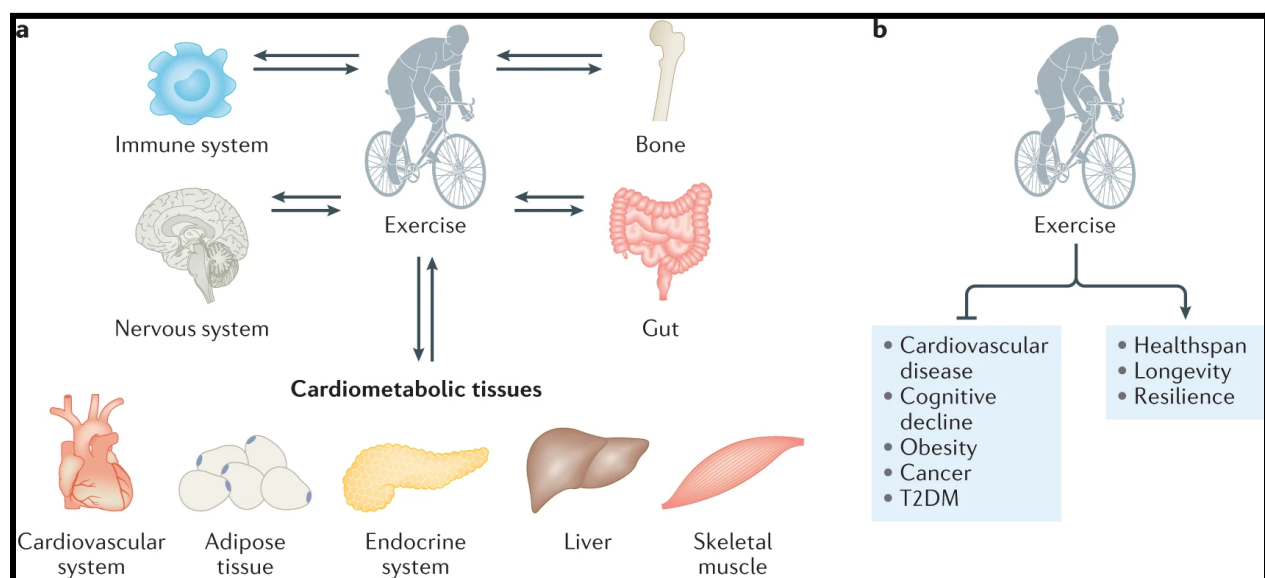
<sup>64</sup> Bastioli, G., Arnold, J. C., Mancini, M., et al. (2022). *Voluntary exercise boosts striatal dopamine release: Evidence for the necessary and sufficient role of brain-derived neurotrophic factor*. **The Journal of Neuroscience**, 42(23), 4725–4736. <https://doi.org/10.1523/JNEUROSCI.2273-21.2022>

<sup>65</sup> Bastioli, G., Mancini, M., Patel, J. C., Gamallo-Lana, B., Arnold, J. C., Mar, A. C., & Rice, M. E. (2025). Voluntary exercise increases striatal dopamine release and improves motor performance in aging mice. *NPJ Parkinson's disease*, 11(1), 345. <https://doi.org/10.1038/s41531-025-01213-7>

skeletal muscle (myokines), the heart (cardiokines), liver (hepatokines), and neurons (neurokines) to name a few.<sup>66</sup>

And while neurokines are this neuroscientists bread and butter, the broader benefits of exerkins throughout the body are associated with improved cardio health, liver function, immune-response, cancer resilience, and reduced gut inflammation.<sup>67</sup>

No matter where they're released, exerkins still manage to offer brain benefits. For instance, myokines released from your muscles are thought to cross over from your blood into the brain, increasing synaptic plasticity, memory function and mood regulation.<sup>68</sup>



**Figure 2:** Physical activity delivers wide-ranging health benefits, reducing disease risk and severity while enhancing healthspan, longevity, and overall resilience.<sup>69</sup>

“Movement is medicine” may seem like a cliché Instagram caption, but it holds more scientific weight than we give it credit for.

<sup>66</sup> Chow, L. S., Gerszten, R. E., Taylor, J. M., Pedersen, B. K., van Praag, H., Trappe, S., Febbraio, M. A., Galis, Z. S., Gao, Y., Haus, J. M., Lanza, I. R., Lavie, C. J., Lee, C.-H., Lucia, A., Moro, C., Pandey, A., Robbins, J. M., Stanford, K. I., Thackray, A. E., Villeda, S., Watt, M. J., Xia, A., Zierath, J. R., Goodpaster, B. H., & Snyder, M. P. (2022). *Exerkins in health, resilience and disease*. *Nature Reviews Endocrinology*, 18(5), 273–289. <https://doi.org/10.1038/s41574-022-00641-2>

<sup>67</sup> <https://www.nature.com/articles/s41574-022-00641-2>

<sup>68</sup> Yau, S. Y. et al. Physical exercise-induced hippocampal neurogenesis and antidepressant effects are mediated by the adipocyte hormone adiponectin. *Proc. Natl Acad. Sci. USA* 111, 15810–15815 (2014).

<sup>69</sup> Chow, L.S., Gerszten, R.E., Taylor, J.M. *et al.* Exerkins in health, resilience and disease. *Nat Rev Endocrinol* 18, 273–289 (2022). <https://doi.org/10.1038/s41574-022-00641-2>

## Brain Fertilizer

While this gym-rat may be partially biased, perhaps the coolest discoveries of modern neuroscience is that exercise stimulates the production of something called brain-derived neurotrophic factor (BDNF).

Referred to by researchers as “Miracle-Gro for the brain”, BDNF belongs to a family of proteins called “growth factors” which play a key role in our neuron’s survival, plasticity (essential for learning and memory), and dopamine release.<sup>70</sup>

Thought to “rescue” neurons vulnerable to neurodegenerative diseases like Huntington’s, Parkinson’s, and Alzheimer’s – BDNF is believed to keep your neurons healthy while simultaneously stimulating new brain cell production.<sup>71 72</sup>

## Fending-Off Dementia

And whether it’s the BDNF or some other biological mechanism at play, physical activity is consistently associated with major reductions in dementia risk.<sup>73</sup>

In a study tracking over 61,000 adults, people with higher cardiovascular fitness displayed a 35% lower risk of dementia. And for those that did develop it, the onset was delayed by about an estimate of 18 months.<sup>74</sup>

In another involving more than 90,000 participants, those who exercised for a mere 39.5 minutes a week displayed a decrease in dementia by **41%** compared to those with 0 minutes.

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<sup>70</sup> Bathina, S., & Das, U. N. (2015). Brain-derived neurotrophic factor and its clinical implications. *Archives of medical science : AMS*, 11(6), 1164–1178. <https://doi.org/10.5114/aoms.2015.56342>

<sup>71</sup> Alzheimer’s Research Foundation. (2023, February 8). *6 minutes to better brain health*. ALZinfo. <https://www.alzinfo.org/articles/prevention/6-minutes-to-better-brain-health/>

<sup>72</sup> Sleiman, S. F., Henry, J., Al-Haddad, R., El Hayek, L., Abou Haidar, E., Stringer, T., Ulja, D., Karuppagounder, S. S., Holson, E. B., Ratan, R. R., Ninan, I., & Chao, M. V. (2016). Exercise promotes the expression of brain derived neurotrophic factor (BDNF) through the action of the ketone body  $\beta$ -hydroxybutyrate. *eLife*, 5, e15092. <https://doi.org/10.7554/eLife.15092>

<sup>73</sup> Wanigatunga, A. A., et al. (2025). *Small amounts of moderate to vigorous physical activity are associated with big reductions in dementia risk*. Johns Hopkins Bloomberg School of Public Health. <https://publichealth.jhu.edu/2025/small-amounts-of-moderate-to-vigorous-physical-activity-are-associated-with-big-reductions-in-dementia-risk>

<sup>74</sup> Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., ... Willumsen, J. F. (2025). *World Health Organization 2020 guidelines on physical activity and sedentary behaviour*. *British Journal of Sports Medicine*, 59(3), 150–159. <https://doi.org/10.1136/bjsports-2020-102955>

Those that pushed it 140 minutes? Reduction jumps to an astonishing **69%**.<sup>75</sup>

While the direct cause of this decrease is not certain, research points to a potential link between exercise and a reduction in dementia-linked proteins in the brain.

In a six-month study, mice given access to a running wheel were found to have less amyloid buildup (a.k.a, the protein associated with Alzheimer's) and improved memory in comparison to their sluggish friends.<sup>76</sup>

So, exactly what kind of exercise should we be doing to reap all these glorious benefits?

### **For Immediate Mood Enhancement**

Winner: Cardio

Within the first 30 minutes of cardio, your brain floods with dopamine, serotonin, and norepinephrine improving mood and motivation. Endorphins rush in and linger, reducing pain and anxiety.<sup>77 78</sup>

An easy recipe for a cocktail of contentment. Plus, this delightful rejuvenation doesn't reach its peak until 2-3 hours later. Boo-yah.

### **Long-term Emotional Resilience**

Overall Winner: Combined Training (Cardio + Strength)

→ *Anxiety Reduction & Stress Management*

Regular cardio improves the connection between your emotional center and the brain's alarm system. This means being less reactive to stressors, faster to emotional recovery, and maintaining an overall calmer baseline.<sup>79</sup>

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<sup>75</sup> Wanigatunga A, Dong Y, Jin M ... Moderate-to-Vigorous Physical Activity at any Dose Reduces All-Cause Dementia Risk Regardless of Frailty Status Journal of the American Medical Directors Association, 2025; 26

<sup>76</sup> Fuller, O. K., et al. (2025). *Extracellular vesicles contribute to the beneficial effects of exercise on brain function in Alzheimer's disease models*. **iScience**. <https://doi.org/10.1016/j.isci.2025.00011>

<sup>77</sup> Basso, J. C., & Suzuki, W. A. (2017). The effects of acute exercise on mood, cognition, neurophysiology, and neurochemical pathways: A review. *Brain Plasticity*, 2(2), 127–152.

<sup>78</sup> Smith, P. J., & Merwin, R. M. (2021). The role of exercise in management of mental health disorders: An integrative review. *Annual Review of Medicine*, 72, 45–62.

<sup>79</sup> Gujral, S., Aizenstein, H., Kramer, A. F., & Erickson, K. I. (2017). Exercise effects on depression: Possible neural mechanisms. *General Hospital Psychiatry*, 49, 2–10.

### → *Depression Reduction & Improving Self-Image*

Building strength and lean muscle often goes hand-in-hand with improved self-esteem and confidence.<sup>80</sup> A fortified self-image both physically and emotionally (proving to yourself you can do hard things!) is thought to reduce depression

A combo of both cardio and strength training is a potent tool for long-term emotional wellbeing.

### **Cognition**

#### Overall Winner: Combined Training (Cardio + Strength)

#### → *Memory & Learning speed*

Combined training offers a potent tool in enhancing memory formation and speeding up learning by increasing blood flow, oxygen to the brain, and neurochemical release.

#### → *Executive Function*

Regular combined training improves attention control, mental flexibility, and decision-making, making it easier to stay organized and adapt to new challenges.<sup>81</sup>

### **So, How Much of Each?**

Since “cardio” can range from marathon training to a brisk treadmill stroll, let's be specific:

For cardio, 150-300 minutes of moderate-intense aerobic activity (brisk walk, hiking, casual cycling) per week or 75-150 minutes of vigorous activity (running/sprinting, HIIT-style workouts).<sup>82</sup>

And “strength-training” can vary pretty widely as well. Here’s a great place to start:

For strength, at least 2 days/per week of resistance training while targeting all major muscle groups is a great place to start. Push yourself hard and aim till near-failure.

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<sup>80</sup> Lubans, D. R., Richards, J., Hillman, C. H., Faulkner, G., Beauchamp, M. R., Nilsson, M., ... Biddle, S. J. H. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics*, 138(3), e20161642. <https://doi.org/10.1542/peds.2016-1642>

<sup>81</sup> Landrigan, J. F., Bell, T., Crowe, M., Clay, O. J., & Mirman, D. (2020). Lifting cognition: a meta-analysis of effects of resistance exercise on cognition. *British Journal of Sports Medicine*, 54(24), 1485-1495.

<sup>82</sup> World Health Organization. (2020). *WHO guidelines on physical activity and sedentary behaviour*.

But there's no need to morph into a biohacking gymbro overnight, just be consistent and the brain gains will speak for themselves.

## Emotional Physical Therapy: How EMDR Reprocesses Trauma and Rewires the Brain

### **A Quick Blurp –**

If you read the Author's Note, you may remember the brief mention of me uprooting my entire thesis at the halfway mark.

Hypothetically, of course.

(Would not recommend).

Shifting to more universal lessons on brain health for healthier, happier, longer lives allows my thesis to have a far broader impact than my original topic ever could.

Still, I'd be lying if I said it doesn't feel a little wrong.

That is, to *entirely* ignore the value of my initial thesis topic. Especially after the profound impact it's had on me and my siblings' brains.

And, honestly, the majority of readers may not even find this relevant (objectively, a good thing).

But, for those of you who do, or know someone who may benefit, perhaps this can feel like a form of essential neuroscience in its own way.

### **Introduction**

*(Content Warning: This article contains references to sexual abuse/assault.)*

Traumatic experiences are encoded differently in our brains than normal ones.

During the storage of a traumatic memory, our amygdala's activity (fear and threat detection) increases while activity in our prefrontal cortex (rational thinking and decision-making) decreases.<sup>83</sup>

Our rational brain loses its grip on the reins while our emotional brain picks up the slack, leading to experiences tied to distorted associations rather than rooted in reality.

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<sup>83</sup>Shin, L. M., Rauch, S. L., & Pitman, R. K. (2006). Amygdala, medial prefrontal cortex, and hippocampal function in PTSD. *Annals of the New York Academy of Sciences*, 1071, 67–79. <https://doi.org/10.1196/annals.1364.007>

This leaves traumatic memories highly emotional, fragmented, and sensory-driven.<sup>84</sup>

So, trying to untangle emotional anguish through thinking, reasoning, or talking it out is often not enough. No amount of intellectualizing can undo biological miswiring.

Similar to lingering dirt and debris slowing the scabbing of a scraped knee, healing psychological trauma may be stunted when the system has a physical obstruction.

Think of this psychotherapy treatment as the antithesis of a beaver, effectively removing the dams and driftwood preventing the flow of healing.

## **How It Works**

The anti-beaver is called “EMDR”.

Eye Movement Desensitization and Reprocessing (EMDR) is an increasingly popular therapeutic intervention that combines talk therapy with “bilateral stimulation” to help reprocess traumatic memories.

Bilateral stimulation simply refers to stimulating both hemispheres of the brain through a bodily stimulus that rhythmically shifts left-to-right. Research suggests it mimics a brain state similar to REM (rapid eye movement) sleep where the reprocessing of emotional memories naturally occurs.<sup>85</sup>

When performed in a therapist’s office, this can take a few different forms:

### Visual

Side-to-side eye movements are guided either by a therapist’s finger or, more commonly, a 2-foot light bar that gently moves a soft light back and forth in a steady rhythm.

### Auditory

Similar to a grade school hearing test, auditory cues bounce from your left-to-right ear through a pair of headphones. Except in therapy, there’s no hand-raising and the tone is much more gentle.

### Tactile

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<sup>84</sup>EMDR Therapy: What It Is, Procedure & Effectiveness. (2022, March 29). Cleveland Clinic. Retrieved April 12, 2026, from <https://my.clevelandclinic.org/health/treatments/22641-emdr-therapy>

<sup>85</sup> Landin-Romero R, Moreno-Alcazar A, Pagani M and Amann BL (2018) How Does Eye Movement Desensitization and Reprocessing Therapy Work? A Systematic Review on Suggested Mechanisms of Action. Front. Psychol. 9:1395. doi: 10.3389/fpsyg.2018.01395

Achieved through hand-held buzzers, soft vibrations alternate between hands. Hand-tapping can also be used. However, it's more effective when the rhythm is externally guided rather than self-regulated (better to focus on unpacking the baggage than on the tune playing in the back).

All of these methods stimulate both sides of the brain in conjunction with talk therapy where a therapist guides you using prompts, open-ended questions, and “notice how...” statements.

As you revisit the trauma, bilateral stimulation increases activity in your “logic” centers while reducing activity in regions that drive the fear response. This works to reintegrate traumatic memories in a more adaptive, less distressing way.<sup>86</sup>

Some say it takes you from being an actor on the stage to becoming a person in the audience. You gain emotional distance and detachment. And with it, a reclaimed sense of control; a role-switch that fundamentally changes the way you see your trauma.

And for patients like Maggie, this is unmistakably true.

### **Survivor to Observer: Maggie's EMDR Experience**

A young woman known under the pseudonym “Maggie” was sexually molested by her father as a child for years.<sup>87</sup> Despite being only five at the time, she simply couldn't overcome the misplaced notion that it was somehow her fault.

And this unconscious belief that she was to blame left Maggie explosively angry and manifested in the form of self-destructive behavior.

Her life was full of drugs, abusive and dangerous boyfriends, frequent altercations with bosses, and constant moving because she could never tolerate her roommates (nor they her).

But as a bright PhD psychology student, Maggie recognized this couldn't go on forever.

Around the same time she decided to join a therapy group, she was introduced to EMDR at a professional training event. Maggie eagerly described her first EMDR session to the group.

The session had launched her into vivid flashbacks of her trauma with details as visceral as the weight of her father's body on hers and the tinge of alcohol on his breath. But as she relived the experience in unison with EMDR, her perspective shifted.

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<sup>86</sup> Herkt, D., Tumani, V., Grön, G., Kammer, T., Hofmann, A., & Abler, B. (2014). Facilitating access to emotions: neural signature of EMDR stimulation. *PloS one*, 9(8), e106350. <https://doi.org/10.1371/journal.pone.0106350>

<sup>87</sup> van der Kolk, B. A. (2014). *The body keeps the score: Brain, mind, and body in the healing of trauma*. Viking.

She began to watch everything unfold, not through the eyes of her five-year-old self, but from the perspective of a twenty-nine-year-old woman.

For the first time, Maggie could see just how small and powerless she was in comparison to her father. She could separate what she *felt* about the assault from what was *true*.

She burst into tears and said: “It’s over now. I now know what happened. It wasn’t my fault. I was a little girl and there was nothing I could do.”

After a few more EMDR sessions, Maggie’s therapy group noticed she was much less angry. She began dating a very different kind of man than she had before. And eventually, she left therapy feeling confident she had resolved her trauma.

And while stories like this seem like they’d be few and far between, the mind-boggling part about EMDR is that success like this is common amongst PTSD patients.

### **The Crazy Part? It Really Works.**

The stats seem almost too good to be true.

No, really.

For people who experienced a single-trauma event (like a car accident, assault, or natural disaster), one study revealed 84-90% of patients no longer met PTSD criteria after just three 90-minute EMDR sessions. In some studies, 100% achieved remission after a mere six sessions.<sup>88</sup>

When it comes to repeated traumatic experiences or childhood trauma, EMDR still showed strong results with 77% of patients no longer meeting PTSD criteria after six sessions.

And for those without PTSD or trauma, EMDR can still offer meaningful relief for a wide range of mental health conditions.

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<sup>88</sup> Shapiro F. (2014). The role of eye movement desensitization and reprocessing (EMDR) therapy in medicine: addressing the psychological and physical symptoms stemming from adverse life experiences. *The Permanente journal*, 18(1), 71–77. <https://doi.org/10.7812/TPP/13-098>

Research suggests EMDR may be just as effective as Cognitive Behavioral Therapy (traditional talk-on-a-velvet-sofa therapy) in reducing anxiety symptoms in fewer treatment sessions.<sup>89 90</sup> And nowadays with frequent access to therapy feeling like a luxury, having access to cost-effective treatment matters.

Some studies also suggest EMDR therapy may even beat out traditional anti-depressants like Prozac for treating depression, making it a particularly good treatment route to explore before medicating.<sup>91</sup>

EMDR is also used as a treatment option for dissociative disorders, eating disorders, obsessive-compulsive disorders, and personality disorders<sup>92</sup>

EMDR has been growing in popularity in recent years, with over 100,000 medical professionals licensed and millions of patients treated worldwide.<sup>93</sup> However, it is still a relatively new technique, and folks don't always know it's an option.

Maybe the only thing standing between you or someone you care about benefiting from EMDR is simply the fact you didn't know it exists

Thus, why I am talking (or typing, I suppose) your ear off about it.

Because you can understand trauma stem to stern and down to the roots – how it seeps into relationships, self-worth, and day-to-day life. The exact smells that trigger it. How it walks, talks, and breathes. An expert witness to your own damage –

And it won't be enough. Not if the rational self is kept in the dark.

EMDR yanks the curtain down and flips on the fluorescents, exposing all the distortions wreaking havoc in the shadows.

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<sup>89</sup> van der Kolk, B. A., Spinazzola, J., Blaustein, M. E., Hopper, J. W., Hopper, E. K., Korn, D. L., & Simpson, W. B. (2007). A randomized clinical trial of eye movement desensitization and reprocessing (EMDR), fluoxetine, and pill placebo in the treatment of posttraumatic stress disorder: treatment effects and long-term maintenance. *The Journal of clinical psychiatry*, 68(1), 37–46. <https://doi.org/10.4088/jcp.v68n0105>

<sup>90</sup> Power, K. G., McGoldrick, T., Brown, K., Buchanan, R., Sharp, D., Swanson, V., & Karatzias, A. (2002). A controlled comparison of eye movement desensitisation and reprocessing versus exposure plus cognitive restructuring, versus waiting list in the treatment of posttraumatic stress disorder. *Journal of Clinical Psychology and Psychotherapy*, 9, 299-318.

<sup>91</sup> Khan AM, Dar S, Ahmed R, Bachu R, Adnan M, Kotapati VP. Cognitive Behavioral Therapy versus Eye Movement Desensitization and Reprocessing in Patients with Post-traumatic Stress Disorder: Systematic Review and Meta-analysis of Randomized Clinical Trials. *Cureus*. 2018 Sep 4;10(9):e3250. doi: 10.7759/cureus.3250. PMID: 30416901; PMCID: PMC6217870.

<sup>92</sup> *EMDR Therapy: What It Is, Procedure & Effectiveness*. (2022, March 29). Cleveland Clinic. Retrieved April 12, 2026, from <https://my.clevelandclinic.org/health/treatments/22641-emdr-therapy>

<sup>93</sup> *What is EMDR?* (n.d.). EMDR Institute. Retrieved April 12, 2026, from <https://www.emdr.com/what-is-emdr/>

So, in lieu of spending thousands on traditional therapy and prescriptions, consider EMDR as a potential treatment option. For you or a loved one.

## **Parting Words – My EMDR Experience**

A bit TMI for a thesis?

Yeah. 100%.

But I never retreat from the opportunity to share my EMDR experience – we all have baggage and if one of us finds a way to make the load a little less heavy, shouldn't we share it?

While it's only anecdotal, I firmly believe that EMDR has fundamentally changed the way I carry my childhood trauma.

Like so many people, I can talk circles around my trauma and explain why my behavior was textbook. Intellectualizing, and such.

Traditional therapy warranted little results because *I knew* I had unhealthy coping mechanisms and exactly the tainted soil they grew from – it was like paying someone to tell me things I very much already knew like,

“Have you considered your fear of abandonment in relationships is tied to your mother leaving?”

Well, duh.

Safe to say talk therapy wasn't my cup of tea.

Meanwhile, my little sister was having the opposite experience and finally starting to show progress of her own. The difference? Her therapist had been integrating little, hand-held buzzers into their sessions. Within a few months, what was once crippling anxiety had normalized.

My interest was piqued to say the least.

This was the first time ever hearing about EMDR and I jumped down a rabbit hole of research papers. After reading the same stats I shared with you, I quickly scheduled a session for myself.

That first EMDR session was a doozy.

I have never felt such an odd array of emotions: cried like a baby, recalled vivid details of events that had happened a decade prior, and then got super drowsy (remember the REM sleep connection). Weird.

It was like I was face-to-face with it all for the first time. And instead of staring down a creature I could describe every feature and angle of, I was just looking at my own reflection.

*Huh. Yeah, that's me.*

And this may sound silly, but I really couldn't see it before. Not without first tweezing out the rotten parts from myself – as if it all had happened to some other girl I knew.

After that first session, I felt unmistakably different and, with a few months of consistent EMDR therapy, I watched my admittedly not-so-healthy impulses quiet.

Perfectionism is less of a visceral experience now. My need for control has loosened. And I find myself more rational about relationships, my self-talk more positive, and the compartmentalizing of my trauma largely eroded.

And I have been shouting from the rooftops about EMDR ever since.

Whether you've exhausted all other options or are just starting your therapy journey, I say, give EMDR a shot. After all EMDR has done for me, my family, patients like Maggie, and a mind-boggling amount of success cases,

how could I not share it with the world?

## Loneliness Kills: How Social Connection Predicts Longevity & Improves Cognitive Health

### **Even Hairy-er, The More the Merrier**

Many moons ago, the difference between survival and becoming saber-toothed kitten kibble was defined by our ability to rely on others.

Isolation meant vulnerability.

No tribe, no protection.

Banding together in groups made hunting, raising children, and fending off predators much easier for our hairy-er ancestors. So, unsurprisingly, evolution began to lean towards favoring social behaviors and traits.<sup>94</sup>

Threats to our social connections activate the same brain regions that process survival threats.<sup>95</sup>

And alas, our brains still hold on to that biological wiring for social connection and proximity to others. And this isn't a secondary, backburner desire but a necessity on par with eating.

No, literally.

In a study of 40 healthy, socially-connected young adults, participants completed two separate trials: 10 hours of social isolation vs. 10 hours of food fasting. After completing each condition, subjects were shown pictures related to their deprived needs: their favorite social activities and favorite foods.<sup>96</sup>

Whether it was joking around with friends or alfredo pasta, participants' "craving" system lit up when confronted with the stimulus it was missing.

Research revealed the desire to indulge in socializing and subsistence both stem from the same system. Both types of cues triggered a spike in the midbrain, the region that drives our behavior towards relieving unmet needs.

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<sup>94</sup> Von Hippel, W. (2018). *The social leap: The new evolutionary science of who we are, where we come from, and what makes us happy*. New York: Harper Wave.

<sup>95</sup> Eisenberger N. I. (2013). Social ties and health: a social neuroscience perspective. *Current opinion in neurobiology*, 23(3), 407–413. <https://doi.org/10.1016/j.conb.2013.01.006>

<sup>96</sup> Tomova, L., Wang, K.L., Thompson, T. *et al.* Acute social isolation evokes midbrain craving responses similar to hunger. *Nat Neurosci* 23, 1597–1605 (2020). <https://doi.org/10.1038/s41593-020-00742-z>

Essentially, these thoughts are torn from the same cloth:

*“Look, Taco Bell! You haven’t eaten in hours – get in that drive-thru line.”*

*“Look, your friends are here! You’ve been alone all day – go hang out with them.”*

Both act as a cognitive nudge towards fulfilling a distinct biological need.

To the brain, isolation isn’t just a matter of emotional discomfort but an indicator that our survival is at stake. Isolation is viewed as a deprivation needing to be corrected with socialization in the same way we fix hunger with food.

And if the desire to connect is starved out, the weight of chronic loneliness begins to take a physical toll.

## **Loneliness and its Effect on Brain Health**

The brain’s integrity is built-up by community and turned to ash in solitude.

Seemingly rivaled only by the fountain of youth itself, a healthy network of social connections has been shown to boost odds of long-term survival by **50%**.<sup>97</sup>

Meanwhile, chronic isolation is associated with a **50%** increased risk of dementia.<sup>98</sup>

Research has consistently linked strong social connections to lower mortality risk, while the health risks of social isolation exceed those associated with smoking **15 cigarettes a day**.<sup>99</sup>

Loneliness sets us up for faster cognitive decline, poor executive function, and reduced gray matter in memory areas of the brain.<sup>100</sup>

Biology favors interconnectedness and has little tolerance for prolonged isolation.

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<sup>97</sup> Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspectives on psychological science : a journal of the Association for Psychological Science*, 10(2), 227–237. <https://doi.org/10.1177/1745691614568352>

<sup>98</sup> National Academies of Sciences, Engineering, and Medicine (2020) Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System, The National Academies Press, Washington, DC. 10.17226/25663

<sup>99</sup> Kidambi, N., & Lee, E. E. (2020). Insight into Potential Mechanisms Linking Loneliness and Cognitive Decline: Commentary on "Health Factors as Potential Mediator the Longitudinal Effect of Loneliness on General Cognitive Ability". *The American journal of geriatric psychiatry : official journal of the American Association for Geriatric Psychiatry*, 28(12), 1284–1286. <https://doi.org/10.1016/j.jagp.2020.08.015>

<sup>100</sup> Guarnera, J., Yuen, E., & Macpherson, H. (2023). The Impact of Loneliness and Social Isolation on Cognitive Aging: A Narrative Review. *Journal of Alzheimer's disease reports*, 7(1), 699–714. <https://doi.org/10.3233/ADR-230011>

But how do these physical symptoms emerge from something that seems like a purely psychological burden?

The answer is simple and rooted in the same precursor behind nearly every health problem under the sun: stress.

Particularly, the stress state the brain slips into when it thinks you're separated from your tribe and vulnerable.

To our animal brain, stress means danger and danger means potential harm.

In an attempt to stay a step ahead, the brain triggers the same immune response associated with infection and tissue damage in an effort to repair incoming wounds.<sup>101</sup>

But our modern stressors are psychological, social, financial, or emotional – real physical injury rarely ever comes.

And all that biological doomsday prepping comes at a cost.

Chronic stress fuels inflammation, suppresses immune function over time, and increases the risk of a laundry list of diseases ranging from cancer to Alzheimer's.<sup>102</sup> Our defense systems are built to handle short bursts of danger, not operate with a triage unit on permanent standby.

And with social isolation a major predictor of mortality, researchers have started asking a bigger question: if loneliness can worsen health outcomes, can social connection help protect us once disease/injury has already taken root?

In one study, scientists induced strokes in male mice and then divided them into two groups: those left to recover alongside a female partner and those kept in isolation.

Seven days later, the results were jarring.

All of the paired mice survived.

But, in the isolated group, survival rates dropped to only **40%**.<sup>103</sup>

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<sup>101</sup> Mariotti A. (2015). The effects of chronic stress on health: new insights into the molecular mechanisms of brain-body communication. *Future science OA*, 1(3), FSO23. <https://doi.org/10.4155/fso.15.21>

<sup>102</sup> Hawkley, L. C., & Cacioppo, J. T. (2003). *Loneliness and pathways to disease*. *Brain, Behavior, and Immunity*, 17(1), 98–105.

<sup>103</sup> Ohio State University. (2009, March 23). *Social isolation makes strokes more deadly, study finds*. Ohio State University.

Having to heal with no support system didn't just hurt the mice's odds of survival, it decimated them. Reiterating the role connection plays in our physiology's ability to function, social support proves itself as not just an influence on survival but a *critical* factor.

The simple belief that we have people “there for us” changes the way our cells operate.

And this protective effect on the brain isn't just reserved for extremes like repairing stroke wounds, social connection can shield you in your daily life too.

## **How Our Connections Shapes Our View of the World**

Even in our perception of everyday challenges, the ability to lean on others serves as a buffer against the brain's stress response.

To investigate the tie between social support and response to life stressors, one study exposed 16 married women to the anticipation of a mild electric shock while holding either their husband's hand, a stranger's hand, or no hand at all.<sup>104</sup>

Participants who were able to hold their husband's hand during the angst of awaiting a shock showed reduced activity in their brain's fear center. And the women in higher-quality marriages felt even greater relief.

Even holding a stranger's hand improved their stress responses.

And it's because having a “tribe” to lean on puts our biology at ease and equips us to take on everyday life with greater resilience. We have unconscious assurance to take on risks, pursue new challenges, and navigate adversity.

The quality of our social support spills into how we take on the world around us.

And beyond just diminishing how we experience stress, socialization helps us see the world clearer too. Interacting with others keeps us mentally sharp by stimulating attention, memory, and strengthening neural networks over time.<sup>105</sup>

Afterall, nothing is as unpredictable as people.

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<sup>104</sup> Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: social regulation of the neural response to threat. *Psychological science*, 17(12), 1032–1039. <https://doi.org/10.1111/j.1467-9280.2006.01832.x>

<sup>105</sup> Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). *Social relationships and mortality risk: A meta-analytic review*. *PLoS Medicine*, 7(7), e1000316. <https://doi.org/10.1371/journal.pmed.1000316>

And unpredictability not only makes the brain work overtime, but the novelty triggers dopamine (the “feel-good chemical”) in the process leading us to feel happier and more affirmed in our choices\*.

And alongside dopamine, the serotonin and oxytocin released during social interaction create a neurochemical cocktail of reward, bonding, and emotional reassurance that reinforces our drive to continue to connect with others.<sup>106</sup>

*\*See Article Two for more on novelty & dopamine.*

## **The Big Picture Stuff**

We built a society on hustle culture and individualism faster than our brain could catch-up.

A healthy social life is often treated like a backburner luxury reserved for when the “real work” is done.

But we’re social creatures with brains shaped by thousands of years of survival made possible by connection and cooperation with one another. With **1 in 3** adults in the U.S. reporting they feel lonely, the health consequences of the mismatch are becoming apparent.<sup>107</sup>

For many of us, it took having the ability to socialize stripped away to understand its role as a serious risk factor for our health.

During COVID-19, loneliness and isolation became the new norm. Our access to our friends, coworkers, and social network was reduced to a fraction. In just the first year of the pandemic, depression and anxiety increased by 25%.<sup>108</sup>

We not only faced a worldwide pandemic, but what the Surgeon General described as an “epidemic of loneliness”.<sup>109</sup>

We watched our mental health suffer alongside our capacity to be around others. The rate at

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<sup>106</sup> Love T. M. (2014). Oxytocin, motivation and the role of dopamine. *Pharmacology, biochemistry, and behavior*, 119, 49–60. <https://doi.org/10.1016/j.pbb.2013.06.011>

<sup>107</sup> Town M, Eke P, Zhao G, et al. Racial and ethnic differences in social determinants of health and health-related social needs among adults — Behavioral Risk Factor Surveillance System, United States, 2022. *MMWR Morb Mortal Wkly Rep*. 2024;73(9):204–208.

<sup>108</sup> World Health Organization. (2022, March 2). *COVID-19 pandemic triggers 25% increase in prevalence of anxiety and depression worldwide*.

<sup>109</sup> Office of the Surgeon General (OSG). (2023). *Our epidemic of loneliness and isolation: The U.S. Surgeon General’s advisory on the healing effects of social connection and community*. U.S. Department of Health and Human Services. <https://www.hhs.gov/sites/default/files/surgeon-general-social-connection-advisory.pdf>

which antidepressants were prescribed to young people rose to 64% faster than pre-pandemic.<sup>110</sup>

When mental health started to go awry, our gut-reaction was to medicate; our healthcare system quicker to treat symptoms than to reconcile root causes.

But what if instead of putting pen to prescription pad, we acknowledged that our animal brains are simply responding to being deprived of a biological need?

If instead of defaulting to medication, doctors had prescribed daily phone calls to loved ones, recommended socially-distanced hangouts, or helped patients adapt to their new social norms?

So much time, money, and suffering could be spared if social connection was treated as a first-line intervention rather than a bonus to a busy life.

Ignoring its influence on mortality, cognition, immune health, stress resilience, and recovery from disease may be one of modern healthcare's biggest blind spots.

It may be too late to undo what was overlooked before,

but it isn't too late to consider it now.

*A warning from former U.S. Surgeon General Vivek H. Murthy:*

“Given the profound consequences of loneliness and isolation, we have an opportunity, and an obligation, to make the same investments in addressing social connection that we have made in addressing tobacco use, obesity, and the addiction crisis.

...If we fail to do so, we will pay an ever-increasing price in the form of our individual and collective health and well-being. And we will continue to splinter and divide until we can no longer stand as a community or a country. Instead of coming together to take on the great challenges before us, we will further retreat to our corners—angry, sick, and alone.”

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<sup>110</sup> Kao-Ping Chua, Anna Volerman, Jason Zhang, Joanna Hua, Rena M. Conti; Antidepressant Dispensing to US Adolescents and Young Adults: 2016–2022. *Pediatrics* March 2024; 153 (3): e2023064245. 10.1542/peds.2023-064245