WHAT NEUROSCIENCE HAS LEARNED ABOUT THE BRAIN SINCE GRAD SCHOOL AND WHY WE SHOULD CARE

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Introduction

BioSource Software is one of NRBS' growing list of sponsors. Our website is biosourcesoftware.com.

We are a leading international provider of BCIA-accredited educational resources for biofeedback, HRV biofeedback, neurofeedback, and qEEG professionals.

We teach the science of biofeedback and neurofeedback, independent of equipment, software solutions, normative databases, or personal perspective.

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Introduction

This webinar will review several exciting developments in neuroscience with implications for clinical and optimal performance practice:

1. Addiction
2. Depression
3. The integration of HRV Biofeedback with Neurofeedback
4. Evidence-based strategies to improve sleep

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Introduction

After this webinar, participants will be able to:

1. explain the role of drug-induced frontal lobe under-activity in addiction
2. explain the implications of the neurogenic model of depression for treatment
3. describe how HRV biofeedback can support neurofeedback
4. summarize evidence-based strategies to improve sleep

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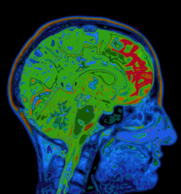
ADDICTION



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Addiction

There has been a paradigm shift to a more complete model of addiction.

The view before 1969 was that addiction is fueled by a state of drug dependence. According to this negative reinforcement model, addicts ingest their next dose to avoid or escape unpleasant withdrawal effects.

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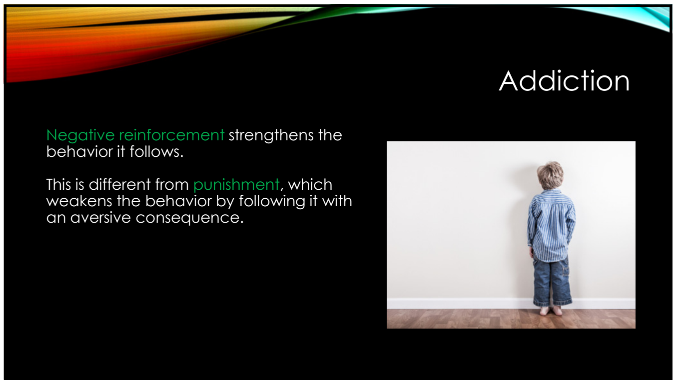
Addiction
Negative reinforcement strengthens the behavior it follows.
This is different from punishment, which weakens the behavior by following it with an aversive consequence.

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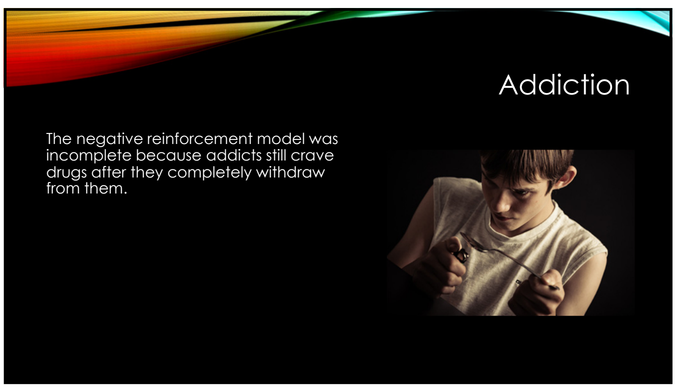
Addiction
The negative reinforcement model was incomplete because addicts still crave drugs after they completely withdraw from them.

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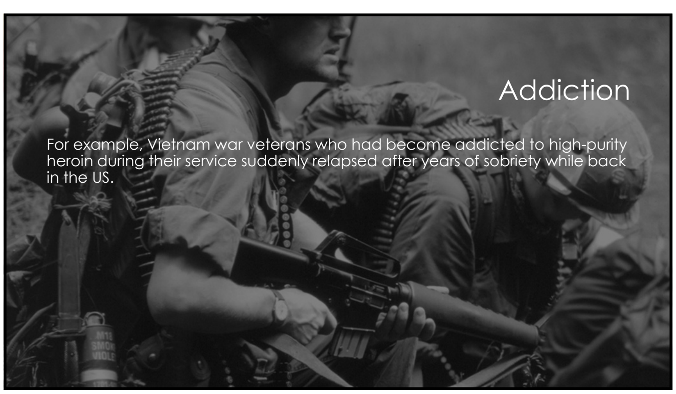
Addiction
For example, Vietnam war veterans who had become addicted to high-purity heroin during their service suddenly relapsed after years of sobriety while back in the US.

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Addiction

A more complete model of addiction emerged when researchers demonstrated that nonhuman animals will self-administer virtually all the addictive drugs abused by humans.

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Addiction

The revolutionary new view was that a drug's reinforcing properties are due to its actions at specialized receptors.

If you breed animals without the necessary receptor, they won't self-administer the drug.

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Addiction

These studies showed that animals will:

1. inject abused drugs without physical dependence
2. prefer the place where they received the drug
3. expend considerable effort to obtain more of the drug
4. still work for the drug if it produces aversive consequences like shock
5. relapse after withdrawal when exposed to stressors, drug cues, and the original drug

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Addiction

Which other species does this resemble?

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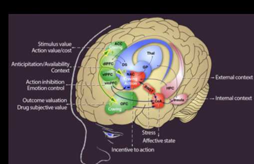
Addiction

Chronic drug use produces many changes that promote relapse:

1. weakened frontal lobe response to primary reinforcers (e.g., food), which become less pleasurable

2. increased drug craving due to frontal lobe overactivity in response to stressors, drug cues, and the original drug

3. compromised frontal lobe ability to resist craving, anticipate consequences, and inhibit risky behavior



Graphic courtesy of George and Koob (2013)

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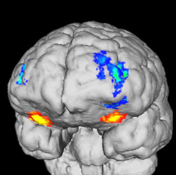
Addiction



Long-term compulsive drug use can produce a phenomenon called hypofrontality in which the metabolic activity of the prefrontal cortex (PFC) and the performance of executive functions is compromised.

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Addiction

Executive functions include the cognitive processes that control attention, inhibition of behavior, working memory, cognitive flexibility, reasoning, problem solving, and planning (Breedlove & Watson, 2020).

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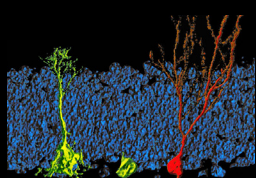
Addiction



Abused drugs can interfere with neurogenesis, the creation of new neurons, and the repair of damaged neurons via proteins like BDNF.

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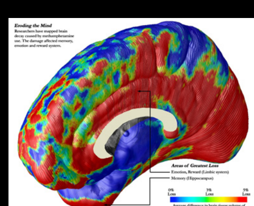
Addiction

These dual processes can result in cell death (apoptosis) and reduced brain volume.

Graphic courtesy of Paul Thompson and Edythe London.



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Addiction

A compromised prefrontal cortex engages in impaired long-term planning, decision-making, and moral judgment.

Hypofrontality underlies the loss of control and relapse.

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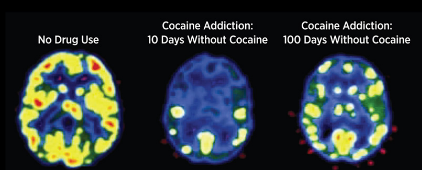
Addiction

Full recovery of these functions may not occur after 4 months of drug abstinence (Advokat et al., 2021).



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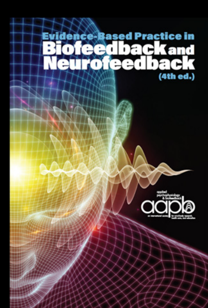
Addiction

Sokhadze and Trudeau (in press) assigned a level-3 rating (probably efficacious) for neurofeedback for alcohol and drug dependence.



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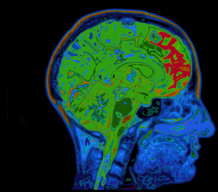
DEPRESSION



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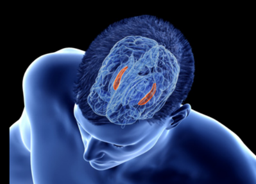
Depression

Existing neurons can repair or remodel themselves.

The brain makes new neurons, especially in the frontal cortex and hippocampus.

About 50 percent of depressed patients have some abnormality in their physiological responses to stress.

Hippocampal neurons are among most sensitive to stress-induced damage.



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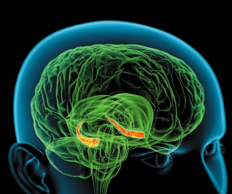
Depression



A variety of stimuli can damage neurons and decrease neurogenesis.

Several factors are known to repair neurons (e.g., BDNF) and increase neurogenesis, including antidepressant drugs.

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Depression

Stressful situations reduce hippocampal and frontal cortical neurogenesis and damage existing neurons.

Depression is now viewed as a neurodegenerative disorder involving atrophy of neurons in the hippocampus and frontal cortex.

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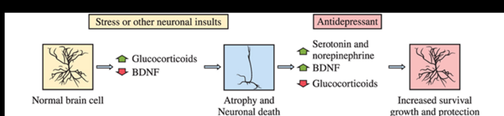
Depression

SSRIs like fluoxetine that interfere with serotonin reuptake may promote hippocampal neurogenesis and increased BDNF levels. Cognitive behavior therapy (CBT), HRV biofeedback, and neurofeedback may produce similar changes.



Advokat/Comaty/Julien, *Julien's Primer of Drug Action*, 14e, © 2019 Worth Publishers

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Depression

Traditional antidepressants are limited by five problems:

1. 3-to-8-week delay in symptom improvement
2. 30 to 40 percent response to the initial treatment
3. "poop out" effect in which drugs lose effectiveness
4. significant side effect burden
5. worsening of prognosis compared with no drug treatment

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Depression

A New Antidepressant Class

Ketamine provides rapid, transient depression relief, 70 percent response rate, increases in synaptogenesis (low-dose IV).

The FDA approved an esketamine nasal spray (Spravato) for treatment-resistant depression in adults (Krystal et al., 2020); Zheng et al., 2020).

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Depression

The drug must be administered in a certified facility with the patient observed for at least 2 hours before discharge.

Dosing is twice weekly for 4 weeks, then once weekly. Patients are not to drive until after a restful night's sleep.

Sedation, cognitive impairment and dissociative reactions are major side effects.

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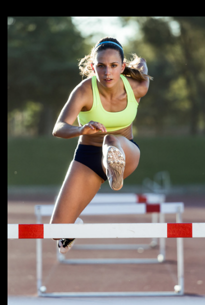
Depression

The neurogenic theory of depression suggests that successful treatment should:

1. improve stress management skills to lower chronic cortisol levels
2. minimize substance use (e.g., alcohol) to restart neurogenesis
3. increase exercise to lower cortisol, increase BDNF, and restart neurogenesis



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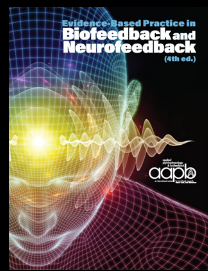
Depression

Meehan, Shaffer, and Zerr (in press) assigned a level-5 rating (efficacious and specific) for biofeedback and neurofeedback for depression.



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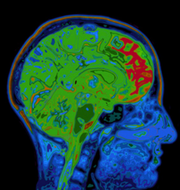
HOW HRV BIOFEEDBACK CAN SUPPORT NEUROFEEDBACK



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HRV Biofeedback

Michael and Lynda Thompson recommended starting neurofeedback with HRV biofeedback training in their AAPB Distinguished Scientist presentation.

HRV biofeedback can support neurofeedback several ways.

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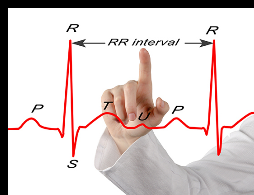
HRV Biofeedback

Let's define our terms:

"HRV is the organized fluctuation of time intervals between successive heartbeats defined as interbeat intervals" (Shaffer, Meehan, & Zerr, 2020).



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HRV Biofeedback

Why is HRV important?

HRV plays a vital role in regulatory capacity, executive functions, health, and performance.

A healthy heart can rapidly adjust to sudden challenges due to the cooperation of interlocking and better-calibrated control systems. HRV is crucial to health, performance, and resilience.

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HRV Biofeedback

HRV biofeedback trains clients to increase vagal (parasympathetic) tone.

Neural activity from the heart travels to the brain via the autonomic nervous system. The ascending vagus nerve influences the brain centers associated with thinking, decision-making, reaction times, long- and short-term memory, and self-regulation (Shaffer, McCraty, & Zerr, 2014).

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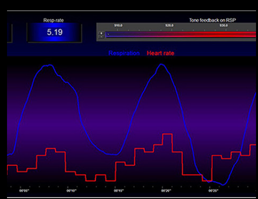
HRV Biofeedback



HRV biofeedback training addresses several problems that can frustrate neurofeedback:

1. dysfunctional breathing
2. inattention
3. lack of stress tolerance

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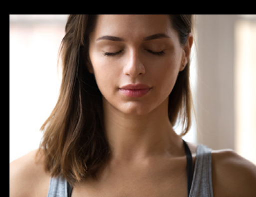
HRV Biofeedback

1. HRVB Corrects Breathing Mechanics

Breathing assessment should always precede HRV biofeedback and neurofeedback because dysfunctional breathing can frustrate training success.

Respiration assessment can provide a roadmap for correcting breathing mechanics before initiating training.



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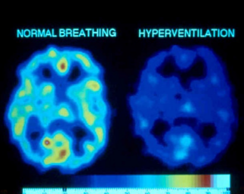
HRV Biofeedback



Overbreathing may be the most common breathing problem. It involves a mismatch between breathing rate and depth due to excessive breathing effort and subtle breathing behaviors like sighs and yawns can reduce arterial CO_2.

Its expulsion of CO_2 can produce a spectrum of medical and psychological symptoms (Khazan, 2020).

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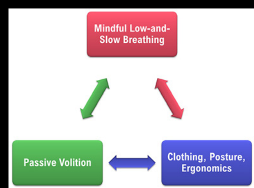
HRV Biofeedback

We encourage "low and slow" breathing.

Breathing should be mindful with focus on the abdomen, effortless, between 5-7 breaths per minute, supported by loose clothing, posture, and ergonomics that promote healthy breathing.



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HRV Biofeedback

Encourage your clients to breathe effortlessly (Peper & Tibbets, 1994).

Your client should experience their body "breathing itself."

Breathing is 5-7 bpm for adults.

The pauses following expiration are longer than those following inspiration.

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HRV Biofeedback

Discourage typical deep breaths.

They should breathe at a comfortable depth (like smelling a flower), exhaling longer than inhaling. Breathing will calm your client when its depth and rate satisfy their resting body's metabolic needs (Khazan, 2021).

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HRV Biofeedback

2. HRVB Increases Attention

Optimal performance is more than excellent physical conditioning.

The disciplined or trained capacity for heightened attention is essential to achieving optimal performance and succeeding in neurofeedback.

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HRV Biofeedback

3. HRVB Improves Stress Tolerance

Stress tolerance, coping with high-stress conditions while maintaining optimal cognitive functions, is very important for children diagnosed with ADHD, elite athletes, and special forces.

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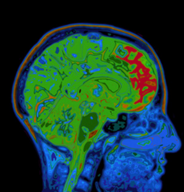
EVIDENCE-BASED STRATEGIES TO IMPROVE SLEEP



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Sleep

We can divide sleep into non-REM (NREM) sleep which contains three stages and rapid eye movement (REM) sleep.

Stage 3 sleep (NREM3), termed slow-wave sleep and REM sleep are arguably the most crucial stages. Following total sleep deprivation, we spend more time in Stage 3 on night one and in REM on night two (Breedlove & Watson, 2020).

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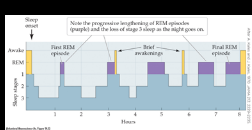
Sleep



An average night's sleep contains 4-5 cycles, 90-110 minutes each.

Adults spend about 20% of total sleep in REM.

Early cycles contain more stage 3 slow wave sleep (SWS), while later cycles contain increasing amounts of REM sleep (Breedlove & Watson, 2020).

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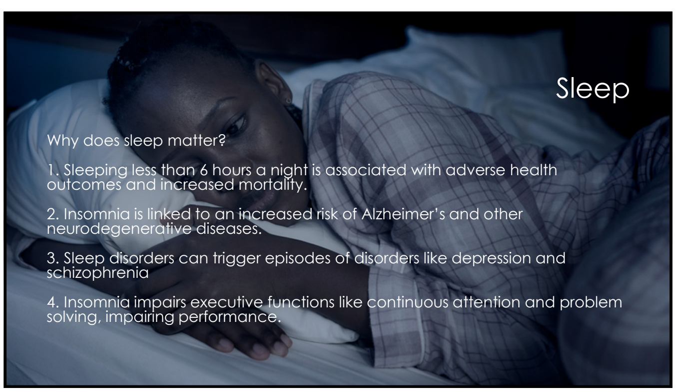

Sleep

Why does sleep matter?

1. Sleeping less than 6 hours a night is associated with adverse health outcomes and increased mortality.

2. Insomnia is linked to an increased risk of Alzheimer's and other neurodegenerative diseases.

3. Sleep disorders can trigger episodes of disorders like depression and schizophrenia

4. Insomnia impairs executive functions like continuous attention and problem solving, impairing performance.

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Sleep

Harvard Medical School (2019)

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Sleep

The Impact of the COVID-19 Pandemic

"Insomnia perpetuates itself" (Hardin, 2020).

The pandemic risks worsening insomnia due to:

1. the disruption of routines, including exercise

2. loss of time anchors (e.g., commuting to work)

50

Sleep

3. reduced daylight exposure; increased screen time

4. excessive napping and oversleeping

5. worry and anxiety due to financial and health uncertainty, amplified by COVID fatigue, loss of privacy, and social media

6. social isolation, grief, and depression

7. family/work stress due when entire families shelter in place

51

Sleep

8. major increase in screen time, resulting in reduced melatonin release and less sleep pressure

9. stress-related fatigue that robs you of energy and motivation when you wake up

10. increased substance misuse and relapse of substance use disorders

11. relapsing or worsening of health problems (SleepFoundation.org, 2020)

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SLEEP

National Sleep Foundation recommendations

- **Newborns (0-3 months):** Sleep range narrowed to 14-17 hours each day (previously it was 12-18)
- **Infants (4-11 months):** Sleep range widened two hours to 12-15 hours (previously it was 14-15)
- **Toddlers (1-2 years):** Sleep range widened by one hour to 11-14 hours (previously it was 12-14)
- **Preschoolers (3-5):** Sleep range widened by one hour to 10-13 hours (previously it was 11-13)
- **School age children (6-13):** Sleep range widened by one hour to 9-11 hours (previously it was 10-11)
- **Teenagers (14-17):** Sleep range widened by one hour to 8-10 hours (previously it was 8.5-9.5)
- **Younger adults (18-25):** Sleep range is 7-9 hours (new age category)
- **Adults (26-64):** Sleep range did not change and remains 7-9 hours
- **Older adults (65+):** Sleep range is 7-8 hours (new age category)

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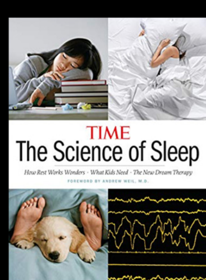
Sharon Begley and Inna Khazan separately contributed several evidence-based strategies.

Good sleep hygiene is critical for successful neurofeedback training.



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Sleep

1. Stop hitting the snooze button.

Why? When you return to sleep and then awaken minutes later, you may experience the grogginess of sleep inertia. This can interfere with attention and memory.

55

Sleep

Instead? Make your sleep schedule more consistent and allow morning light to awaken you and adjust your circadian rhythm.

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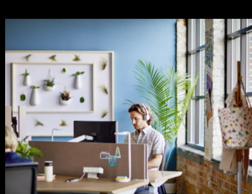
Sleep



2. Experience daylight.

Why? Daylight is one of the most effective circadian cues. In one small study (Boubekri et al., 2014), workers with windows reported better global sleep quality and fewer disturbances than those without.

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Sleep

How? When your office desk doesn't provide sunlight, you can walk during your lunch hour to reconnect with this circadian cue. Alternatively, use a full-spectrum lamp.

58

Sleep

3. Avoid blue light before bed.

Why? Blue light from an iPad after 9 pm can delay your circadian rhythm by an hour and reduce the restfulness of even 8 hours of sleep (Chang et al., 2015).

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Sleep

In addition, exposure to bright screens 2 hours before bedtime can delay sleep onset.

60

Sleep

Instead? Swap a paperback for an iPad. Apple's Night Shift mode still significantly suppresses melatonin which regulates your circadian rhythm (Nagare et al., 2018).

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Sleep

4. Skip alcohol before bed.

Why? While alcohol may help you get to sleep more quickly, it reduces REM sleep (Ebrahim et al., 2013) and increases nighttime urination. This can cause drowsiness, impaired concentration, and failure to integrate new information.

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Sleep

5. Exercise to lengthen sleep time.

Why? Thirty minutes of afternoon exercise at least three times a week increased elderly participants' sleep duration 45-60 minutes after 4 months (Baron et al., 2013).

63

Sleep

Cautions? Don't exercise 4 hours before bedtime because exercise activates your nervous system and raises core body temperature.

Passive stretching and yoga are fine (Khazan, 2019).

64

Sleep

6. Put away the clock once in bed.

Why? Looking at the clock while in bed can increase activation and anxiety, disrupting your sleep.

65

Sleep

Instead? Cover or remove clocks and hide your cell phone.

66

Sleep

7. Watch eating and drinking before bed.

Why? Since digestion slows when you sleep, heavy meals 4 hours before bedtime can awaken you. This is critical if you experience heartburn.

Drinking fluids before bedtime can increase the frequency of nighttime urination, fragmenting sleep.

Instead? Limit food intake to light snacks and stop liquids 2 hours (alcohol at least 3 hours) before bedtime.

67

Sleep

8. Don't nap.

Why? Stanford sleep researcher Donn Posner compares napping to eating snacks before dinner.

Naps make us less drowsy since they decrease sleep pressure.

However, naps are less disruptive for habitual nappers (Hirschlag, 2020).

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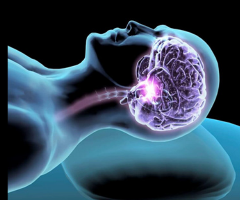
RECOMMENDED READING, TED TALKS, AND REFERENCES



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Recommended Reading

I. Z. Khazan, F. Shaffer, R. R. Lyle, D. Moss, & S. Rosenthal (Eds.). *Evidence-based practice in biofeedback and neurofeedback* (4th ed.). Association for Applied Psychophysiology and Biofeedback.

Improving sleep: A guide to a good night's rest. A Harvard Medical School Special Health Report.

Khazan, I. (2019). *Biofeedback and mindfulness in everyday life*. W. W. Norton & Company.

Walker, M. (2018). *Why we sleep: Unlocking the power of sleep and dreams*. Scribner.

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Recommended TED Talks

Foster, R. (2013). *Why do we sleep?*
"Russell Foster is a circadian neuroscientist: He studies the sleep cycles of the brain. And he asks: What do we know about sleep? Not a lot, it turns out, for something we do with one-third of our lives. In this talk, Foster shares three popular theories about why we sleep, busts some myths about how much sleep we need at different ages -- and hints at some bold new uses of sleep as a predictor of mental health."

Gartenberg, D. (2017). *The brain benefits of deep sleep.*
"There's nothing quite like a good night's sleep. What if technology could help us get more out of it? Dan Gartenberg is working on tech that stimulates deep sleep, the most regenerative stage which (among other wonderful things) might help us consolidate our memories and form our personalities. Find out more about how playing sounds that mirror brain waves during this stage might lead to deeper sleep -- and its potential benefits on our health, memory and ability to learn."

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Recommended TED Talks

Iliff, J. (2014). One more reason to get a good night's sleep.
"The brain uses a quarter of the body's entire energy supply, yet only accounts for about two percent of the body's mass. So how does this unique organ receive and, perhaps more importantly, rid itself of vital nutrients? New research suggests it has to do with sleep."

Walker, M. (2019). Sleep is your superpower.
"Sleep is your life-support system and Mother Nature's best effort yet at immortality, says sleep scientist Matt Walker. In this deep dive into the science of slumber, Walker shares the wonderfully good things that happen when you get sleep -- and the alarmingly bad things that happen when you don't, for both your brain and body. Learn more about sleep's impact on your learning, memory, immune system and even your genetic code -- as well as some helpful tips for getting some shut-eye."

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References

Advokat, C. D., Comaty, J. E., & Julien, R. M. (2019). *Julien's primer of drug action*. Worth Publishers.

Baron, K. G., Reid, K. J., & Zee, P. C. (2013). Exercise to improve sleep in insomnia: Exploration of the bidirectional effects. *Journal of Clinical Sleep Medicine, 9*(8).

Begley, S. (2018). *The 9 new sleep rules. The science of sleep*. Time.

Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C.-H., & Zee, P. C. (2014). Impact of windows and daylight exposure on overall health and sleep quality of office workers: A case-control pilot study. *J Clin Med, 10*(6), 603-611.

Breedlove, S. M., & Watson, N. V. (2020). *Behavioral neuroscience*. Sinauer Associates.

Chang, A.-M., Aeschbach, D., Duffy, J. F., & Czeisler, C. A. (2015). Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. *PNAS, 112*(4), 1232-1237.

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References

Ebrahim, I. O., Shapiro, C. M., Williams, A. J., & Fenwick, P. B. (2013). Alcohol and sleep I: Effects on normal sleep. *Alcohol Clin Exp Res, 37*(4), 539-549.

Hirschlag, A. (2020). Naps don't work for everyone. Genetic differences are why. *Washington Post*.

Khazan, I. (2019). *Biofeedback and mindfulness in everyday life*. W. W. Norton & Company.

Khazan, I. (2021). Respiratory anatomy and physiology. BCIA HRV Biofeedback Certificate of Completion Didactic workshop.

Krystal, J. H., Charney, D. S., & Duman, R. S. (2020). A new rapid-acting antidepressant. *Cell, 181*(1), 7.

Nagare, R., Plitnick, R. N., & Figueiro, M. G. (2018). Does the iPad night shift mode reduce melatonin suppression? *Lighting Research and Technology, 51*(3), 373-383.

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References

Nishida, M., & Walker, M. P. (2007). Daytime naps, motor memory consolidation and regionally specific sleep spindles. *PLOS ONE, 2*, e341.

Peper, E., & Tibbetts, V. (1992). Fifteen-month follow-up with asthmatics utilizing EMG/incentive inspirometer feedback. *Biofeedback and Self-Regulation, 17*(2), 143-151.

Shaffer, F., McCraty, R., & Zerr, C. L. (2014). A healthy heart is not a metronome: An integrative review of the heart's anatomy and heart rate variability. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2014.01040

Shaffer, F., Meehan, Z. M., & Zerr, C. L. (2020). A critical review of ultra-short-term heart rate variability norms research. *Frontiers in Neuroscience*.

Zheng, W., Cai, D. B., Xiang, Y. Q., Zheng, W., Jiang, W. L., Sim, K., Ungvari, G. S., Huang, X., Huang, X. X., Ning, Y. P., & Xiang, Y. T. (2020). Adjunctive intranasal esketamine for major depressive disorder: A systematic review of randomized double-blind controlled-placebo studies. *Journal of Affective Disorders, 265*, 63–70.

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