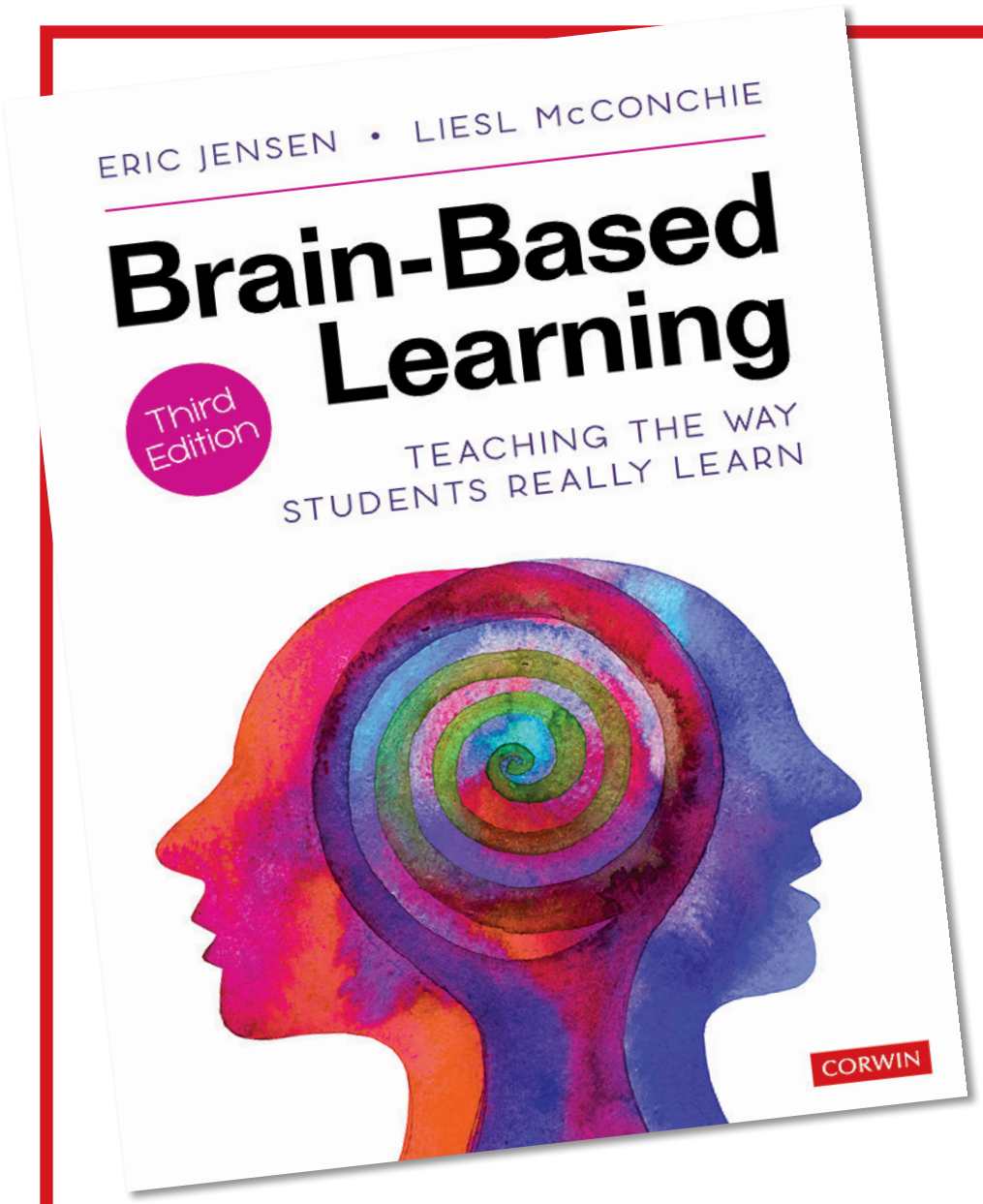


Thank you

FOR YOUR INTEREST IN CORWIN

Please enjoy this complimentary excerpt from *Brain-Based Learning, 3rd Edition*, by Eric Jensen and Liesl McConchie. In this chapter, the authors discuss how each of the senses impact learning.

LEARN MORE about this title, including Features, Table of Contents and Reviews.

CORWIN

How Our Senses Impact Learning 3

Let's begin with a few simple questions about senses.

- Do you ever have issues with pollen or asthma?
- Have you ever been carsick?
- Ever had one of those moments where you smelled something but could not identify it?
- Have you ever experienced a "gut feeling" about a situation?
- Have you ever had the sensation that someone was watching you?
- Have you ever stood near a waterfall and felt exhilarated?

In each of these instances your body is telling you that something is "wow," "different," or "off." Your body has sensory detectors that are designed to keep you informed about the world you live and learn in. This chapter is about not just the most popularly discussed senses, but *all* of them.

It is becoming more widely understood that we have more than the standard five senses: sight, sound, touch, taste, and smell. In fact, some experts suggest that we have up to 20 different senses. That may seem crazy to you, but for scientists a common mantra is, "If we can't measure it, maybe it does not exist." Yet of course, for centuries, no one had an empirical way to measure any emotions at all. Today,

thanks to scientific technological advances, we know that when you feel a certain way, specific brain structures are far more active (electrical activity) and there are clear, measurable changes in chemical releases in your brain and body (e.g., more stress is correlated with higher cortisol). That's why our senses are so important; our bodies and brains are impacted by sensory stimuli, whether that impact is easily measured or not.

What we can reasonably measure (there are**,** of course**,** a dozen or more ways to do that), we will provide evidence of. That often comes from studies with a control group and an experimental group. Researchers can do a pre- and post-test and find out whether the intervention in the experimental group had any effect on student learning. That difference gets us closer to the *effect size*. Throughout this book, you will see an occasional reference to the "effect size" of a particular strategy or teaching principle. An effect size is simply a number that tells you the impact an intervention (or you) has on student learning. An effect size of approximately 0.4 to 0.5 has been equated to about one year of academic growth. Clearly, a higher effect size is better than a lower one, but an effect size is just one, of at least a half dozen, ways to measure the impact something or *someone* has on student learning. To learn more about the role of effect sizes in making informed pedagogical decisions, how they are calculated, and why they matter to teachers, get a complimentary deeper dive at www.lieslmcconchie.com/effectsize.

Okay, back to our senses! When it comes to multisensory input, you should know that our brains are wired to pay conscious attention *to only one input at a time* (e.g., when you watch a movie, you often don't usually notice the soundtrack . . . until you *do* notice it more than the scenes in the movie). This tells us that while we can be wildly attentive to any one sense, most of the incoming overall sensory information is being processed nonconsciously. In short, throughout the day, most of what students experience consciously is just the tip of the sensory iceberg. We simply don't have the brainpower to effectively "multitask" by focusing on two, three, or four senses at a time. The brain is not designed to do that. That's why most of the sensory input we receive is not registered consciously.

Senses Are Signals

A sense is any conduit through which your body can perceive itself or the outside world. Eat a substantial meal and you will experience satiation—the sense of feeling full. Walk outside early in the morning

and your thermoception—sense of perceiving temperature—will process that cold air on your face (Sengupta & Garrity, 2013). Ever had that feeling that you were running late to an appointment, even though you hadn't looked at a clock? That was your chronoception, or sense and perception of time (Carstensen, 2006). Can you feel it acutely when the air is dry or humid? That sensation, hygrosensation, is even present in worms (Russell, Vidal-Gadea, Makay, Lanam, & Pierce-Shimomura, 2014).

Have you ever been carsick? You can attribute that unpleasant experience to your equilibrioception, your sense of balance. It comes from your vestibular system, in your inner ear. Have you ever known someone who seems to have a really good sense of direction? Humans possess proprioception, or awareness of the position and movement of the body. Then there is nociception, which detects the painful stimuli produced by physical events, such as stubbing your toe, or psychological events, such as the experience of social rejection. The "sense of internal pain" is as real as it gets (Woo et al., 2014). That's why even our mood is impacted by our senses. As an example of this, pleasurable sensory stimulations can protect us from mood disorders such as depression (Canbeyli, 2013).

Why is any of this significant to you as an educator? First, many of these sensory inputs have a direct impact on learning. If you don't have a high awareness of others around you, you'll likely get labeled as having low social intelligence. If you do have a good grasp of those around you, you'll likely do well in school (Meijs, Cillessen, Scholte, Segers, & Spijkerman, 2008).

And when it comes to awareness of the body's position and movement, or proprioception, students who have difficulty with proprioception often also have difficulty reading. Why? Because poor proprioception involves problems tracking one's body in relation to the ground (Han, Waddington, Adams, Anson, & Liu, 2015). This makes it hard for readers to similarly track the words on a page. There is strong support for the value of tracking-based activities in school, such as pointing and cross-crawls, especially with emerging readers (Anderson et al., 2013). Activities like balancing on a beam, walking along a drawn path, and pointing to various objects around the room improve both balance and reading skills.

In one study, participants were given two independent reading tests—one while *holding* the screen they were reading from (making use of proprioception), the other while only looking at the screen. They

read significantly faster during the test in which they were physically connected to their reading material (holding the screen) (Mihelčič & Podlesek, 2017).

Other senses could influence learning as well. It is possible that chronoception, one's sense of time, is a factor in excessive student tardies. Students' levels of satiation (their sense of feeling full or empty—i.e., hungry) most likely have a large impact on student achievement. Here is why: Drinking provides less satiation than eating, and consumption of beverages is up 20% compared to the caloric intake through solid foods over the past 30 years (Martin, Hamill, Davies, Rogers, & Brunstrom, 2015).

Smell

Another sense that impacts learning is our sense of smell. One explanation as to why aromas have such a strong impact on the brain is the close proximity of the olfactory bulb (a protuberance of the brain near the nose, which processes smell) to the limbic system (which is linked to emotion and level of excitement) (Johnson, 2011). Some of the more stimulating aromas are lemon, peppermint, orange, and rosemary. Many of these have been shown to improve attention, cognition, and memory (Sellaro & Colzato, 2017). Peppermint, for example, contains menthol, which provides the brain with more oxygen (Meamarbashi & Rajabi, 2013). Conversely, lavender, chamomile, rose, and bergamot are some of the more calming aromas. Lavender has been shown to reduce stress, improve sleep, and build trust (Rhind, 2012; Sellaro, van Dijk, Paccani, Hommel, & Colzato, 2015). Even with small amounts of just the right aroma, you can prime the brain to respond a bit differently.

IN THE CLASSROOM

Are you striving to build relationships based on trust between you and your students? Place a few sprigs of lavender in a cup on your desk to foster a more trusting relationship when they sit down to discuss something with you. Want to help students feel comfortable on the first day of school? Want to calm their nerves on test day? Explore similar uses of scent. How you use aromas in your classroom will depend on school policy, student allergies, and other resources available. Consider your options, and choose what will work best for you and your students.

Air Quality

Perhaps even more than the scent of the air, the quality and purity of the air impact the brain and, consequently, learning. People inhale up to 15,000 liters of air each day (Wood, Burchett, Orwell, Tarran, & Torpy, 2002). Any contaminants present in the air can have an effect. As an example, carbon dioxide (CO_2) emissions can be very harmful—they can impair cognitive and behavioral development, increase the likelihood of developing a respiratory illness, and cause multiple chronic diseases (Perera, 2017). Poor air quality hurts learning and concentration in schools, plus they are a health hazard for kids and teachers (Daisey, Angell, & Apte, 2003).

Students who attend schools in areas with high vehicular traffic experience less cognitive development than students who attend schools in less trafficked areas (Sunyer et al., 2015). Why? Because more nearby traffic creates more air pollution—both on the playground and in the classroom—and air pollution is a developmental neurotoxicant. It negatively impacts working memory, attention, and general cognition.

IN THE CLASSROOM

Placing plants in your classroom can help filter (and even absorb) some of the pollutants present in the air. Some of the most effective plants for classroom air filtering are spider plants, snake plants, peace lilies, and bamboo palm (Wolverton & Wolverton, 1993). They contribute substantially to the microbial abundance and diversity in the built environment, and they absorb toxins at a high rate (Mahnert, Moissl-Eichinger, & Berg, 2015).

Negative Ionization

Have you ever heard of "negative air"? In spite of its label, negative air is a desirable thing. The air around us is electrically charged by many environmental factors, including cosmic rays, friction caused by air movement, radioactive dust, ultraviolet radiation, and atmospheric pressure changes. In densely populated areas, the atmosphere's healthy balance of positive to negative ions can be disrupted. "Ion" refers to any atom or molecule with a net positive or negative electrical charge. Human activity, it seems, destroys negative ions and ultimately reduces the amount of oxygen in the air. Smoke, dust, smog, pollutants, electrical emissions, heating systems, coolers, and traffic exhaust are all culprits. The air can become too highly electrified

(i.e., contain too many positive ions), and the human reaction to it is counterproductive to learning.

The more negatively charged our air is, the better (Wallner, Kundi, Panny, Tappler, & Hutter, 2015). When the electrical charge in the air is too positive, it can cause you to feel groggy, lethargic, sleepy, or depressed. Have you ever noticed that when you stand in front of a waterfall, step outdoors just after a rain, stand atop a mountain, or just get out of a shower, you feel fresh and energized? In such cases, you may be enjoying the benefits of negative ionization.

Ion levels have been studied for their ability to speed recovery among burn victims and asthma sufferers, to stabilize alpha rhythms (brain-wave activity that is calm and restful), to positively impact reactions to sensory stimuli, and to reduce serotonin levels in the bloodstream (you may recall from Chapter 2 that serotonin is a stress hormone). Higher levels of alertness and an improved sense of well-being are definite learning enhancers. The primary message about aromas is this: Whether you "smell" it or not, what you are inhaling matters.

The three main sensory contributors to learning are sight, sound, and touch. There is evidence supporting these three factors as the main physical environmental factors that impact attention, problem-solving, and memory in the classroom (Xiong et al., 2018). Although a deep investigation into the effects of *all* sensory inputs would be beyond the scope of this book, a thorough discussion of the three main contributors in a school environment should help you derive some useful strategies. Figure 3.1 reminds us that there is the strongest evidence for the core physical environmental factors (sight, temperature, and acoustics), even though other senses play a part.

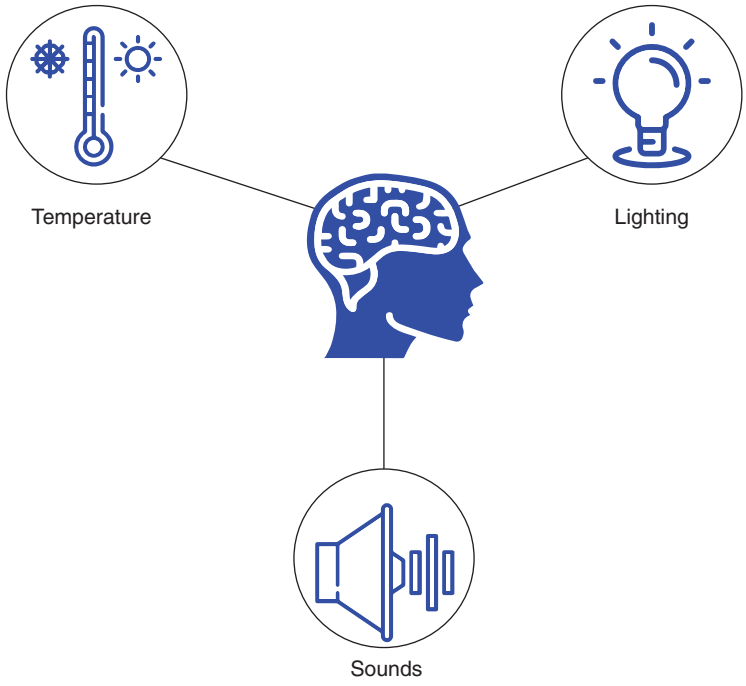
Sight

Approximately 80% of our sensory inputs are visual in nature. The main visual factors in a classroom are (1) physical environment and decorations, (2) lighting, and (3) seasonal impacts on learning. We open with a mention of the two mediums of sight: constant (ceiling/window lighting, teacher, and classroom walls) and intermittent (people and objects that move around). Our focus will be on the medium present for the greatest number of hours: the lighting.

The Physical Classroom Environment

Step into a classroom, and immediately your brain consciously and unconsciously begins to process the physical environment. It might

3.1 Core Physical Environmental Factors



conclude, *Wow! There is a lot going on in here*. Other classrooms communicate, *This feels more like a prison cell*. Or perhaps the feeling internalized is *It feels cozy in here*. There are many factors that contribute to the overall message a classroom sends to the brain—color, peripherals, decorations, and more.

Since the brain gives preference to novel stimuli, introducing more color into the environment can be a welcome change from the traditional black writing on white paper/board. Color has the ability to influence emotions, so it is important that you be purposeful in selecting the colors you use when decorating a classroom, designing a visual presentation, or creating handouts. Red is often subconsciously connected to negative emotions such as failure and anger. The colors most associated with positive emotions are yellow and white. In general, bright colors are associated with positive feelings, whereas dark colors are more commonly connected to inward or contemplative feelings (Sutton & Altarriba, 2016).

Peripherals are typically any sign, poster, or object placed on the wall or edge of the classroom. When used purposefully, peripherals can enhance student learning and recall (Lamb, Akmal, & Petrie, 2015).

For example, a poster or mind map summarizing the role of each punctuation symbol can reinforce new learning in language arts. Posting students' completed work on the walls can increase students' efficacy and sense of ownership of the classroom. A compelling question written on the side board that previews tomorrow's lesson can unconsciously pique students' curiosity and their motivation to be in class tomorrow. A poster that features a positive quote about perseverance may be unconsciously absorbed by all students and impact their choices for the better.

IN THE CLASSROOM

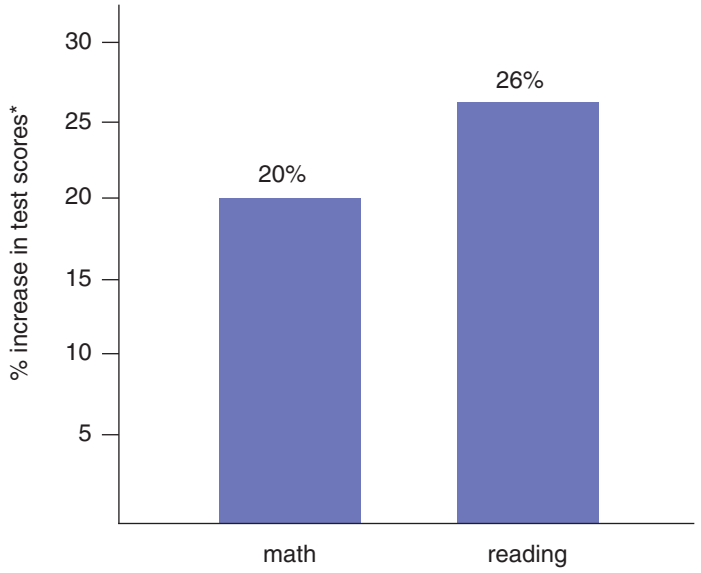
As you scan your classroom, can you verify the purposeful role of everything you see? Colorful and instructionally supportive environments are worth your time. Be aware that more is not always better when it comes to decorating your classroom. An overly decorated classroom can contribute to a condition called "cognitive load," or an overwhelmed working memory system that makes it difficult for the brain to process and store new information (Fisher, Godwin, & Seltman, 2014; Choi, Merriënboer, & Paas, 2014).

Lighting

Lighting strongly influences vision, which strongly influences learning. The right lighting helps make your students' eyes more comfortable in the classroom, which contributes to optimal learning. Even though we are rarely conscious of it, fluorescent lights have a flickering quality and a barely audible hum, which can have a very powerful impact on some of your students via the central nervous system.

Students who are exposed to fluorescent lights for extended periods of time (such as a full school day) are at greater risk of illness, dental cavities, poor academic performance, tardiness, and more. Lighting also impacts mood and can contribute to mental health challenges, including depression (Jean-Louis, Kripke, Cohen, Zizi, & Wolintz, 2005). The optimal light source for learning is natural light. Unfortunately, many school buildings were built before adequate research on lighting was widely available. Figure 3.2 illustrates what adequate natural lighting can do for learning.

3.2 Students in Classrooms With Longer Exposure to Daylight Show Greater Improvement in Math and Reading



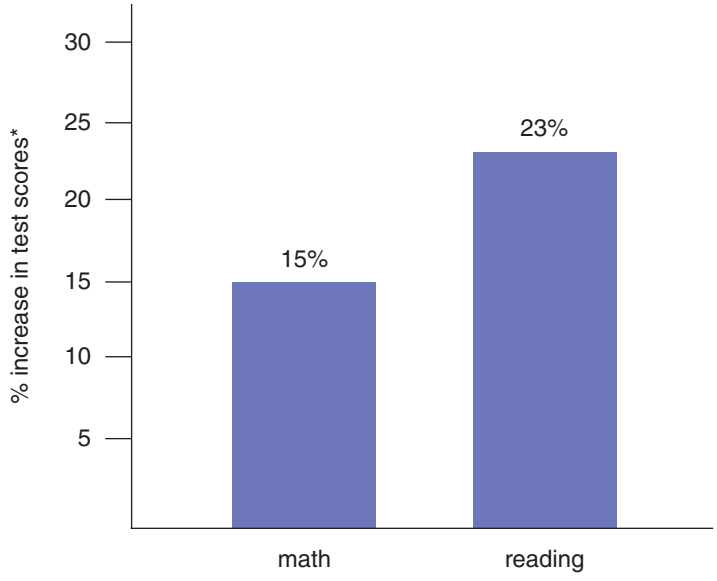
* as compared to students in class with the least exposure to daylight

Source: http://www.h-m-g.com.

The best-reviewed research on the impact of brighter daylight versus dimmer fluorescent lighting is quite compelling (Heschong, 2001). Researchers studied thousands of students in three states. Controlling for all other influences, they made the following findings:

1. Students with the most daylight in their classrooms progressed 20% faster on math tests.
2. Students with the most daylight in their classrooms progressed 26% on reading tests in one year compared to those with the least daylight.
3. Students in classrooms with the largest window areas progressed 15% faster in math and 23% faster in reading than those in classrooms with the smallest window areas.
4. In classrooms that had a well-designed skylight (one that diffused the daylight and allowed teachers to control the amount), students improved 19% to 20% faster than students in classrooms without a skylight.

3.3 Students in Classrooms With Larger Window Areas Show Greater Improvement in Math and Reading



* as compared to students in class with the smallest window area

Source: http://www.h-m-g.com.

IN THE CLASSROOM

Regardless of classroom construction, there are many options available for schools and teachers to capitalize on these findings. First, find opportunities for students to be in natural light. Send them on a walk and talk around the building. Move their group assignment to a table in the school quad/courtyard area (if you do so, create clear expectations for students about not disrupting other classes and staying within certain boundaries). For inside the classroom, you might try requesting alternative forms of lighting, perhaps replacing the current lightbulbs or supplementing your classroom fixtures with lamps or other forms of overhead lighting.

Most students perform best with bright light, so limit long stretches of overhead projector use, movies, and other practices that require a darkened classroom (Xiong et al., 2018). If your dominant format of instruction involves the lights being turned off, it is time to collaborate with your colleagues to diversify your instruction. Yet, some students prefer less brightness and do better in a more light-neutral environment, so be sure to pay close attention to any head movement, squinting, and

apparent stress among your students that would indicate bright light bothers them. Always ask, never assume, if they might prefer to sit away from the window. Their stress may go down and their learning may go up when the lighting is more comfortable to them, or they may have just wanted to move away from another student.

Seasonal Lighting

Seasonal affective disorder (SAD) is a pattern of reoccurring depressive episodes that commonly occurs during the winter months. It is estimated that the prevalence of SAD ranges from 1.5% to 9%, depending on one's geographic latitude (Nussbaumer et al., 2015). Those who suffer from SAD demonstrate impaired working memory, cognitive processing, and motor speed (Hjordt et al., 2017). Moreover, these challenges can remain prevalent during the bright summer months, when their depressive state is in remission.

Bright light therapy or infrared light treatment can reduce the risk of SAD by up to 50% (Nussbaumer et al., 2015).

IN THE CLASSROOM

Depending on your geographical location, it might be beneficial to acquire a light box or other form of natural light for the classroom. Encourage students to be outside in the winter months during daylight. Unless it is dangerous to their health due to extreme low temperatures, continue to hold recess, PE, lunch, and other activities outside during the winter. Be aware of any mood changes you notice in your students as the weather begins to turn late in autumn, and direct students who may have SAD to trained professionals for help.

Sound

It might sound obvious to state that being able to hear well in a classroom is important for learning. The acoustics of a classroom need to function in a way that allows for students to hear the teacher, for students to hear each other, and to minimize any extraneous and distracting sounds. A closer look at the variety of ways in which students' hearing is challenged in schools might have you wanting to make some adjustments.

Extraneous Sounds

The presence of extraneous sounds in a learning environment can significantly disrupt students' ability to process and store language. This effect has been repeatedly shown in studies of schools near airports, train stations, airports, and other sources of intermittent loud noises (Klatte, Meis, Sukowski, & Schick, 2007).

The presence of peripheral sounds can even be coming from inside the classroom. Loud air conditioning units, the humming from the fan of a computer, an overhead projector, or other electronics can also prove to be distracting. As one might suspect, the louder the sound, the greater the negative impact on students. This is likely due to the impact the volume has on students' central nervous systems—it provides too much stimulus, to the point of becoming a mild stressor that impairs cognition (Xiong et al., 2018).

Even those students having a side conversation in the back of the room are creating extraneous sounds that impair both the processing and storage of auditory information by other students. This is true even when students can still perfectly understand what the teacher is saying, amid the distracting side talk (Klatte et al., 2007).

IN THE CLASSROOM

If your school is adjacent to a loud source of extraneous noise (e.g., an airport or a highway), try to minimize the sound by keeping the windows and doors closed. Turn off any machine in your classroom that is not being used. Establish the expectation that students do not talk when others are speaking. If a student begins to talk while you are teaching, pause. Wait for him or her to stop talking (with a warm facial expression) and then proceed with your explanation. Be persistent in establishing this pattern early in the school year, and students will learn the life skill of respectful listening.

Music

Have you ever noticed how music can impact your mood, speed, efficiency, and even learning? If not, then see whether you press the gas pedal just a bit more heavily the next time your favorite upbeat song is played on the radio. Or consider the playlist you reach for when you are trying to fall asleep versus going for a workout. Music's impact can be felt on heart rate, as measured by the pulse, which tends to synchronize with the beat of the music we're hearing—the faster the music, the faster the pulse. A wise teacher can use this tool to help facilitate the ideal state for a learning activity.

IN THE CLASSROOM

Use calming music in your classroom to reduce anxiety or nervousness before a presentation, prior to exams, during a writing activity, or when students come back from recess with too much silly energy. Use energizing music to get students feeling alert and motivated for a challenging task. Consider how the lyrics of particular songs could emphasize important life skills and lessons you are teaching your students. Remember to be aware of students' preferences when it comes to style of music, and notice if any of your students seem to be stressed by the sensory stimulation the music provides. Seat those students away from the speaker, and possibly decrease the volume.

Keep in mind that lyrical music is best reserved for activities that do not involve memory formation (cleaning up; finding a partner; passing in papers; greeting at the door; celebrating mastery of a concept; moving into group seating arrangement, etc.). When students are engaged in an activity that requires more executive functioning (writing, reading, worked problems, group discussions, assessments, etc.) non-lyrical music is best, at a low volume. The lyrics of music, even in the background, can interfere with processing and contribute to cognitive load.

Another powerful way to use music in the classroom is to anchor specific songs to a particular behavior that supports student learning. This is especially helpful for tasks you ask your students to do regularly. Be purposeful in selecting the right lyrics and tempo for the particular task that students are expected to do: clean up, pass in papers, line up, move into groups, rearrange the desks, move to the reading rug, prepare their minds and bodies for yoga/mindfulness time, return to their seats, etc. Work with them to learn the cues, and present them with the challenge of completing the task before the song is over.

For an in-depth guide on how music can enhance your efforts in the classroom, see www.lieslmcconchie.com/music. The download contains more details on the science of music, when and how to use music to boost student learning and focus, as well as fabulous song lists, suggestions for speakers in your classroom, and more.

Who Does the Talking?

It's no secret that teachers do the majority of the talking in classrooms around the world. Considering the effect size of classroom discussion is 0.82, it is worth making efforts to balance the teacher/student talking time at around 50-50 (Hattie, 2017). Why is it so valuable

to introduce more student voice into the classroom? Well, there is the initial value of simply having a different voice to listen to in the room. Variety and novelty are strong predictors of student achievement (Oudeyer, Gottlieb, & Lopes, 2016). It also encourages more student ownership of the learning experience. Has it ever happened in your classroom that the way a student explained something made more sense to the class than your explanation?

IN THE CLASSROOM

Here are some suggestions to encourage more student voice. To begin with, ensure that you have established a safe classroom environment where students feel safe to speak up and are completely aware of your zero-tolerance policy for any form of teasing or bullying. Be thoughtful in determining what questions or topics to discuss to facilitate more student voice. Allow for thinking time (three to five seconds) after you air a question before asking for responses or calling on volunteers.

Remember to diversify your approach for more introverted students, who might be challenged by speaking to the entire class. Use the think-pair-share strategy to provide them with a safe one-on-one place to share their thoughts. Jigsaws (effect size = 1.20) are a powerful strategy to empower students to be in the teacher role in smaller groups. Become more conscious of all the times you are talking in class, and consider whether that is something a student could do instead.

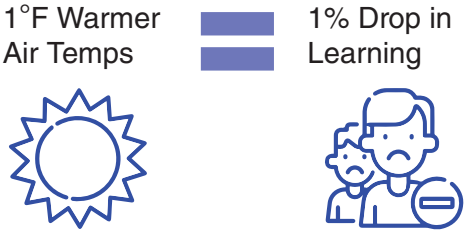
Touch

There are several ways in which the body is impacted through touch in a learning environment. The three most prevalent are (1) temperature, (2) tactile stimulation, and (3) overcrowded classrooms. We open with a mention of the two mediums of touch: constant (room temperature) and intermittent (people and objects we interact with). Our focus will be on the medium students have to deal with the most: the temperature.

Temperature

The ideal temperature for learning is no less than 68° and no more than 73° Fahrenheit (20°–23° Celsius) (Seppänen & Fisk, 2006). In general, being too hot is worse for learning than being too cold (despite some gender preferences), but both should be avoided. When our bodies are too hot, we experience a decline in both cognitive and physiological functions. Our attention time decreases, and our impulsivity increases; researchers have found this may lead us to perform

3.4 Heat Impacts Learning



Based on 21 million PSAT scores over 12 years, with students from all 50 states, heat matters. Without air conditioning, each 1°F increase in outside school-year temperature reduced the average amount learned that year by 1% on student tests.

Source: Cedeño Laurent et al. (2018), Goodman et al. (2019)

more poorly in cognitive assessments (Gaoua, Racinais, Grantham, & El Massioui, 2011). When our bodies are too cold, our concentration, vigilance, memory, and reasoning are affected (Taylor, Watkins, Marshall, Dascombe, & Foster, 2016) and we make more blunders (Pilcher, Nadler, & Busch, 2002).

The impact of heat on student learning and test performance has been tested among more than 10 million students. The results are as you might predict: When temperatures go up and there's no A/C, test scores go down. In classrooms without air conditioning, for every 1° Fahrenheit higher the outside school-year temperature, students

IN THE CLASSROOM

If your current classroom environment does not have a proper air conditioning system, here are a few suggestions to get you started on the path to a cooler room:

- Use social media and other communication channels to inform the community and school district of the poor learning conditions you are working to improve.
- Start a GoFundMe campaign (or other crowd-funding source) to raise enough money to purchase sufficient cooling equipment.
- Purchase a high-quality fan. If it doesn't provide enough cool air, place a tray of cold water or ice at the bottom of the fan. The air that it blows over the water and ice will be cooled. Some teachers report that even just tying ribbons to the fan so that everyone can see it's on makes students feel cooler.

learned an average of 1% less, as measured by PSAT scores (Goodman, Hurwitz, Park, & Smith, 2019). What's more, high indoor temperatures, such as during a heat wave, can have immediate effects on cognitive functioning among young adults (Cedeño Laurent et al., 2018).

Tactile Stimulation

Introducing a new sense to a learning experience often initiates the involvement of other senses too, thus increasing its impact. Each students' preference for tactile stimulation will fall somewhere on the spectrum between a sensory-seeker and a sensory-avoider. Students who are sensory-seekers will seek out more sensory input before information is best received and processed. Sensory-avoiders, on the other hand, can be overstimulated by tactile stimulation. A brain-based classroom would have options for all students.

Incorporating the sense of touch, or tactile stimulation, has more benefits than the ones directly related to touch. For example, it is well known that Braille is an effective method to teach people with visual impairments to read through touch. Those with visual impairments have heightened sensitivity to other senses. But what about those who are not visually impaired? When adults with normal vision were taught to read through Braille, they also demonstrated increased activity in visual and auditory areas of the brain, as well as the frontal lobe, known for its critical role in learning (Siuda-Krzywicka et al., 2016). Through the introduction of tactile stimulation, brain activity in other areas increased. We can see similar findings in fMRI brain scans of piano players watching a muted video of a piano being played—their auditory systems show activation, even though they cannot hear the music (Haslinger et al., 2005).

IN THE CLASSROOM

In the classroom, provide students with more opportunities for tactile stimulation. Do more experiments in science where students get to conduct the experiment rather than just watch the teacher demonstrate. In math, let students use manipulatives to learn their basic arithmetic, geometry properties, and even calculus-based rotations around axes. Have students work in groups to create story boards, dioramas, and so on based on the stories they are reading in language arts. In history, students can build models of ancient structures, 3D representations of their state and/or country, and places of historical or cultural significance. When students build, create, and work with manipulatives, they are creating an additional sensory experience; and they are also enhancing many other senses as well.

Overcrowded Classrooms

Overcrowding in classrooms impacts many of the sensory factors discussed in this chapter. It impacts the noise level, air quality, and limits mobility and opportunities for tactile stimulation and movement. Yet it is an unfortunate reality for too many teachers. The primary result in the brain from overcrowding (assuming all other variables are equal) is the stress of excessive closeness (Shah & Inamullah, 2012). In addition, or possibly as a result of stress, overcrowded classrooms are also associated with poorer academic achievement and behavioral problems at school, as well as the development of learned helplessness—a detrimental mindset that one's efforts do not produce worthwhile results (Evans, Lepore, Shejwal, & Palsane, 1998).

If you find yourself in an overcrowded classroom, consider strategies to create more space. Get creative with your seating arrangements and possibly even your seating furniture. Find the best arrangement given the space you have. Look around your school—is there another location that might be available for your use? An occasional stay-at-school field trip to the library, cafeteria, or auditorium could open up spacing for better movement. Consider your outdoor space also—being in a "green space" can help reduce stress—even if you stay indoors and can only see the green space through a window (Ekkel & de Vries, 2017).

The amount of sensory inputs that students are exposed to in a school environment has a tremendous impact on their learning capacity. A vast majority of these inputs are happening unconsciously; yet their impact may be greater than the ones students are more aware of. The exceptional teacher will give careful consideration to the variety of sensory inputs in his or her physical environment and teaching methods (both conscious and unconscious). He or she will make purposeful adjustments to eliminate any extraneous stressors in the classroom and incorporate elements (like those discussed in this chapter) that can enhance student learning.