The Lowdown on Longhand: How Writing by Hand Benefits the Brain

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My Catholic school third grade teacher was extremely tough on me. Her biggest gripe was my handwriting, which looks more like an EKG scan than penmanship. For years, I harbored not-so-fond memories of her, but now I know that her strictness about penmanship was actually helping my brain develop. Recently, scientists have shown that longhand writing benefits the brain.

Today, cursive writing is becoming a lost art as note taking with laptops becomes more and more prominent in classrooms. But what we are losing is much bigger than a few scratches on a page -- we are losing a robust way of learning.

There has been much debate on the use of laptops for note taking in classrooms. The pro side sees laptops as an efficient way of collecting and storing information. The con side sees laptops as an opportunity for distractions and multitasking. What's missing is an understanding of how taking notes by longhand influences the brain. Recent studies have shown that students taking notes with laptops performed worse on conceptual questions than the students taking notes by longhand. In short, they had the information on their computers, but did not have an understanding of that information in their brains.

So in this age of technology, I'm suggesting that students take notes with paper and pen. It's a crazy idea, but hear me out.

A Plea for Penmanship

When students take notes with their laptops, they tend to mindlessly transcribe the data word for word, like speech-to-text software. But taking notes verbatim is not the point. What is lacking in their note-taking-by-laptop is the synthesis, the re-framing, and the understanding of the information. Students that transcribe with laptops have shallow connections to what's being presented to them. However, those who are taking notes by hand are processing the information and representing it in a way that makes sense to them. They are learning.

Now, I'll be the first to say that longhand writing is so 19th century. But we need to answer a question: do we want students to have a deep or shallow connection to the information we're giving them? While we live in a world of short sound bytes where news is thrown at us unprocessed, this should not be the mode for schools. In the 21st century, the ability to connect knowledge in new ways is more important than the knowledge itself. So students with deeper connections to information can link it in new ways -- they can create.

The Pen is Mightier

All this begs the question of how we can incorporate longhand in a digital age. What about a daily notebook, written by hand?

A lost art in the world of science is the lab notebook. In it, scientists write down observations, impressions, and all the variables and outcomes of an experiment. If you are teaching STEM classes, might I suggest that you resurrect the lab notebook and have students personalize it? Give them assignments where they have to hand-draw pictures of what they see and what they predict. Let them figure out how to visually represent these things -- without digital pictures, by the way. The data says that taking images with a camera does not improve one's memory either, so these notebook entries must be written or drawn. Skill doesn't matter. What we are fostering are experiential links in a child's brain, and one of the best pathways is through their fingers.

If you are not teaching STEM classes, have students carry a personal notebook in which they write down observations and draw things by hand on whatever topic. We are trying to create more connections to information, and developing fine motor skills along the way.

If you have a classroom with lots of technology, try to integrate note taking. Often when I give my PowerPoint slides to students, I pass out a version that doesn't have all the information that students are seeing on the screen, which means that they need to fill it in by hand. And when I glance over their notes, I see how their work doesn't always look the same. This is great because my students are doing the most important thing we can teach them -- they are learning how to teach themselves.

So let us not confuse efficiency with the real goal of teaching. Teaching is not a job of cramming as much as we can into a brain. It is about learning. And getting students to learn means that we must use every pathway to connect them with the information. Using laptops reinforces the Industrial Revolution ideal that every kid should get the information in the same way, and that it should come out the same way. But by occasionally replacing the laptop with a pen, learning happens, which is why we got into this business in the first place.

A **motor skill** is an intentional movement involving a motor or muscular component, that must be learned and voluntarily produced to proficiently perform goal-oriented task, according to Knapp, Newell, and Sparrow.

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Development of motor skills[edit]

Due to the immaturity of the human nervous system at the time of birth, children grow continually throughout their childhood years. Many factors contribute to the ability and the rate that children develop their motor skills. Uncontrollable factors include: genetic or inherited traits and children with learning disorders. A child born to short and overweight parents is much less likely to be an athlete than a child born to two athletically built parents. Controllable factors include: the environment/society and culture they are born to. A child born in the city is much less likely to have the same opportunities to explore, hike, or trek the outdoors than one born in the rural area. For a child to successfully develop motor skills, he or she must receive many opportunities to physically explore the surroundings.

Infantile: Early movements made by very young infants are largely reflexive. An infant is exposed to a variety of perceptual experiences through the senses. Gradually, the infant learns that certain involuntary, reflexive movements can result in pleasurable sensory experiences, and will attempt to repeat the motions voluntarily in order to experience the pleasurable sensation.

- 6 months – can sit straight
- 12 months – takes first steps
- 24 months – can jump
- 36 months – can cut with scissors; runs on toes

Influences on development[edit]

Stress and arousal: stress and anxiety is the result of an imbalance between demand and the capacity of the individual. Arousal is the state of interest in the skill. The optimal performance level is moderate stress or arousal. An example of too low of arousal state is an overqualified worker performing repetitive jobs. AN example of stress level too high is an anxious pianist at a recital.

Fatigue: the deterioration of performance when a stressful task is continued for a long time, similar to the muscular fatigue experienced when exercised for a rapid rate or lengthy period of time. Fatigue is caused by over-arousal.

Fatigue impacts an individual in many ways: perceptual changes in which visual acuity or awareness drops, slowing of performance (reaction times or movements speed), irregularity of timing, and disorganization of performance.

Vigilance: the effect of the loss of vigilance is the same as fatigue, but is otherwise caused by the lack of arousal. Some tasks include jobs that require little work and high attention.[1]

Stages of motor learning[edit]

The stages to motor learning are the cognitive phase, the associative phase, and the autonomous phase.

Cognitive Phase: When a learner is new to a specific task, the primary thought process starts with, "what needs to be done?" Considerable cognitive activity is required so that the learner can determine appropriate strategies to adequately reflect the desired goal. Good strategies are retained and inefficient strategies are discarded. The performance is greatly improved in a short amount of time.

Associative Phase: the learner has determined the most effective way to do the task and starts to make subtle adjustments in performance. Improvements are more gradual and movements become more consistent. This phase can last for a long time. The skills in this phase are fluent, efficient and aesthetically pleasing.

Autonomous Phase: this phase may take several months to years to reach. The phase is dubbed "autonomous" because the performer can now "automatically" complete the task without having to pay any attention to performing it. Examples include walking and talking or sight reading while doing simple arithmetic.,[2]

Feedback[edit]

During the learning process of a motor skill, feedback is the positive or negative response that tells the learner how well the task was completed. Inherent feedback: after completing the skill, inherent feedback is the sensory information that tells the learner how well the task was completed. A basketball player will note that he or she made a mistake when the ball misses the hoop. Another example is a diver knowing that a mistake was made when the entrance into the water is painful and undesirable.

Augmented feedback: in contrast to inherent feedback, augmented feedback is information that supplements or “augments” the inherent feedback. For example, when a person is driving over a speed limit and is pulled over by the police. Although the car did not do any harm, the policeman gives augmented feedback to the driver in order for him to drive more safely. Another example is a private tutor for a new student of a field of study. Augmented feedback decreases the amount of time to master the motor skill and increases the performance level of the prospect. Transfer of motor skills: the gain or loss in the capability for performance in one task as a result of practice and experience on some other task. An example would be the comparison of initial skill of a tennis player and non-tennis player when playing table tennis for the first time. An example of a negative transfer is if it takes longer for a typist to adjust to a randomly assigned letters of the keyboard compared to a new typist. Retention: the performance level of a particular skill after a period of no use.[2]

Types of tasks[edit]

Continuous tasks: activities like swimming, bicycling, running; the performance level is just as proficient as before even after years of no use.

Discrete tasks: an instrument or a sport, the performance level drops significantly but will be better than a new learner. The relationship between the two tasks is that continuous tasks usually use gross motor skills and discrete tasks use finer motor skills.[2]

Gross motor skills[edit]

Gross motor skill requires the use of large muscle groups to perform tasks like walking, balancing, crawling. The skill required is not extensive and therefore are usually associated with continuous tasks. Much of the development of these skills occurs during early childhood. The performance level of gross motor skill remains unchanged after periods of non-use.[3]

Fine motor skills[edit]

Fine motor skill requires the use of smaller muscle groups to perform tasks that are precise in nature. Activities like playing the piano and playing video games are examples of using fine motor skills. Generally, there is a retention loss of fine motor skills over a period of non-use. Discrete tasks usually require more fine motor skill than gross motor skills.[3]

Gender differences in motor skills[edit]

Men and women differ in motor skill ability. In general, men are better at gross motor skills while women are better at fine motor skills.[*citation needed*] Gender differences in brain physiology are often cited by scientists to explain these differences.[4] Many of the regions of the brain responsible for motor skill reside in the frontal lobe, basal ganglia, and cerebellum.

The regions of the frontal lobe responsible for motor skill include the primary motor cortex, the supplemental motor area and the premotor cortex. The primary motor cortex is located on the precentral gyrus and is often visualized as the motor homunculus. By stimulating certain areas of the motor strip and observing where it had an effect, Penfield and Rassmussen were able to map out the motor homunculus. Areas on the body that have complex movements, such as the hands, have a bigger representation on the motor homunculus.[5]

The supplemental motor area, which is just anterior to the primary motor cortex, is involved with postural stability and adjustment as well as coordinating sequences of movement. The premotor cortex, which is just below the supplemental motor area, integrates sensory information from the posterior parietal cortex and is involved with sensory guided planning of movement and begins the programming of movement.

The basal ganglia are an area in the brain where gender differences in brain physiology is evident. The basal ganglia are a group of nuclei in the brain that are responsible for a variety of functions, some of which include movement. The globus pallidus and putamen are two nuclei of the basal ganglia which are both involved in motor skills. The globus pallidus is involved with voluntary motor movement, while the putamen is involved with motor learning. Even after controlling for the naturally larger volume of the male brain, it was found that males have a larger volume of both the globus pallidus and putamen.[6]

The cerebellum is an additional area of the brain important for motor skills. The cerebellum controls fine motor skills as well as balance and coordination. Although women tend to have better fine motor skills, the cerebellum has a larger volume in males than in females, even after correcting for that fact that males naturally have a larger brain volume.[7]

Hormornes are an additional factor that contributes to gender differences in motor skill. For instance, women perform better on manual dexterity tasks during times of high estradiol and progesterone levels, as opposed to when these hormones are low such as during menstruation.[8]

An evolutionary perspective is sometimes drawn upon to explain how gender differences in motor skills may have developed, although this approach is controversial. For instance, it has been suggested that men were the hunters and provided food for the family, while women stayed at home taking care of the children and doing domestic work[*citation needed*]. Some theories of human development suggest that men's tasks involved gross motor skill such as chasing after prey, throwing spears and fighting. Women on the other hand used their fine motor skills the most in order to handle domestic tools and accomplish other tasks that required fine motor control.[4]

Speech-Language Pathology/Stuttering/Fluency-Shaping Therapy/Motor Learning and Control

Wikibooks

Motor learning and control is the study of how our brains execute complex muscle movements. *Motor* means *muscle* in this context.

This section will explain how we learn complex, precise movements, eventually perform a skill without even thinking about it. You'll also learn about the role of cognition (mental attention): many of these skills can only be performed when we *don't* think about them. Our performance degrades when we exert conscious control.

Four Steps from Sensation to Execution[edit]

A muscle movement takes about 200 milliseconds (one-fifth of a second) to execute:

1. *Sensation*, or neural transmission from sensory receptors in your eyes, ears, etc., to your brain, takes about 15 milliseconds.
2. *Perception*, which retrieves long-term memories to organize, classify, and interpret your sensations, takes about 45 milliseconds. In other

words, *perception* changes *sensation* data into perceived information or meaning.

3. *Response selection* takes about 75 milliseconds. You use current perception and past experiences to formulate a course or action. For example, in baseball, a batter watches the pitcher and decides whether to swing at a pitch, hit to left field or right, etc. Psychologists differentiate conscious *decisions* from unconscious *translations*, or relating a particular stimulus to a particular response.
4. *Response execution* of an action plan—a step-by-step sequence of events that make up the planned movement—takes about 15 milliseconds. In these events, motor neurons carry signals from the brain or spinal cord to muscles.

Closed-Loop Motor Control[edit]

We perform muscle movements with either *open-loop* or *closed-loop* motor control.

Closed-loop motor control uses perception to consciously, continuously adjust muscle movements. E.g., threading a needle. You look at the needle. You look at the thread. You move the thread towards the needle. You look at the needle again. You look at the thread again. You correct your movement. You do this dozens of times until the thread is through the needle.

Each *stimulus-response* adjustment takes at least 200 milliseconds (one-fifth of a second). If you make ten adjustments, the task takes at least two seconds.

Closed-loop motor control has two advantages. It enables precise control, and it enables execution of novel movements (activities you've never done before). E.g., threading a needle on the deck of a rolling ship.

Closed-loop motor control has two disadvantages. It's slow, and it requires your full attention.

Closed-loop motor control is good for learning new skills, or for executing skills you rarely need. But you don't want to use closed-loop motor control for fast-paced, frequently used skills.

Open-Loop Motor Control[edit]

200 milliseconds—a split second—may seem fast, but it's too slow for many motor tasks. For example, a gymnast's double-back somersault requires muscle movements lasting only tens of milliseconds.

How is it possible to execute a muscle movement in tens of milliseconds, when the sensation to execution cycle requires about 200 milliseconds? Simple—don't do the sensation, perception, and response selection stages. Just do the response execution. This final stage of muscle movements can be performed in as little as 15 milliseconds. This is called *open-loop motor control*. Open-loop motor control is the execution of preprogrammed movements, called a *motor program*, without perceptual feedback.

The colloquial term for this is "muscle memory." For example, gymnasts practice hours each day for years, until they can execute complex routines seemingly effortlessly.

After winning the gold medal in gymnastics at the 1984 Olympics, Mary Lou Retton said that coach

Bela [Karolyi] can really teach, I've learned so much from him. Many long hours were spent in the gymnasium…repetition, feedback, repetition, and experimentation. Somehow, after a lot of bumps and bruises, it got easier, as if I could float.

Karolyi added,

Someone should be able to sneak up and drag you out at midnight and push you out on some strange floor, and you should be able to do your entire routine sound asleep in your pajamas. Without a mistake. That's the secret. It's got to be a natural reaction.

Open-loop motor control has two advantages:

1. It's fast. You can execute muscle movements in tens of milliseconds.
2. It requires no attention. Movements under open-loop control are *automatic* and mentally *effortless*.

Open-loop motor control has three disadvantages:

1. If your motor program contains errors, you'll execute the errors. You can't stop and adjust a mistake. You may not even be aware that you made a mistake.

2. Developing open-loop control of a motor skill requires long practice—especially for adults. Children learn some motor skills easily, that adults struggle for years to master.
3. Novel or new situations can't be handled. E.g., in the 2000 Olympics, officials set the gymnastic vault two inches too low. The officials didn't correct the height until 18 of the 36 women had performed. These 18 athletes performed poorly, eliminating their hopes of winning medals. The American hopeful, Elise Ray, suffered a "devastating fall."

Learning New Motor Skills[edit]

Use closed-loop motor control for learning a new motor skill. Then gradually increase your speed until you can perform the motor skill with open-loop motor control.

For example, if you take tennis or golf lessons the coach will have you start with swinging the club or racquet slowly. When you've perfected your form, your coach will have you gradually increase the speed and force, while continuing to use your perfect form. After extensive practice you'll be executing perfect open-loop motor programs. You'll smash the ball hard and fast and accurately without thinking about your elbows or knees or anything other than the ball.