How Arts Training Improves Attention and Cognition
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Does education in the arts transfer to seemingly unrelated cognitive abilities? Researchers are finding evidence that it does. Michael Posner argues that when children find an art form that sustains their interest, the subsequent strengthening of their brains' attention networks can improve cognition more broadly.

If there were a surefire way to improve your brain, would you try it? Judging by the abundance of products, programs and pills that claim to offer "cognitive enhancement," many people are lining up for just such quick brain fixes. Recent research offers a possibility with much better, science-based support: that focused training in any of the arts—such as music, dance or theater—strengthens the brain's attention system, which in turn can improve cognition more generally. Furthermore, this strengthening likely helps explain the effects of arts training on the brain and cognitive performance that have been reported in several scientific studies, such as those presented in May 2009 at a neuroeducation summit at Johns Hopkins University (co-sponsored by the Dana Foundation).

We know that the brain has a system of neural pathways dedicated to attention. We know that training these attention networks improves general measures of intelligence. And we can be fairly sure that focusing our attention on learning and performing an art—if we practice frequently and are truly engaged—activates these same attention networks. We therefore would expect focused training in the arts to improve cognition generally.

Some may construe this argument as a bold associative leap, but it's grounded in solid science. The linchpin in this equation is the attention system. Attention plays a crucial role in learning and memory, and its importance in cognitive performance is undisputed. If you *really* want to learn something, pay attention! We all know this intuitively, and plenty of strong scientific data back it up.

The idea that training in the arts improves cognition generally really is not so bold within the context of what we call activity-dependent plasticity, a basic tenet of brain function. It means that the brain changes in response to what you do. Put another way, behavior shapes and sculpts brain networks: What you do in your day-to-day life is reflected in the wiring patterns of your brain and the efficiency of your brain's networks. Perhaps nowhere is this more evident than in your attention networks.

1. For most of us, if we find an art that "works" for us—that incites our passion and engages us wholeheartedly—and we stick with it, we should notice improvements in other cognitive areas in which attention is important, such as learning and memory, as well as improving cognition in general.

Solid Data Begin to Emerge:

If our hypothesis is true, why have scientists been unable to nail down a cause-and-effect relationship between arts education and cognition—for example, "[X] amount of training in art form [Y] leads to a [Z] percent increase in IQ scores"? Such a relationship is difficult to confirm scientifically because there are so many variables at work; scientists have only begun to look at this relationship in a systematic, rigorous fashion.

Early tests of the idea that the arts can boost brainpower focused on the so-called "Mozart effect." A letter published in 1993 in the journal *Nature* held that college students exposed to classical music had improved spatial reasoning skills, which are important to success in math and science. This observation set off a wave of marketing hype that continues to this day. Despite numerous efforts, however, scientists have not reliably replicated the phenomenon. Nonetheless, these studies have involved only brief periods of *exposure* to music, rather than explicit musical training or practice.

2. More recent attempts to link arts training with general improvements in cognition have relied on a different approach. Researchers have focused on longer periods of engaged participation and practice in arts training rather than simple exposure to music. For example, in 2004, E. Glenn Schellenberg of the University of Toronto at Mississauga published results from a randomized, controlled study showing that the IQ scores of 72 children who were enrolled in a yearlong music training program increased significantly compared with 36 children who received no training and 36 children who took drama lessons. (The IQ scores of children taking drama lessons did not increase, but these children did improve more than the other groups on ratings of selected social skills.)

3. In a study published in the *Journal of Neuroscience* in March 2009, researchers Ellen Winner of Boston College, Gottfried Schlaug of Harvard University and their colleagues at McGill University used neuroimaging scans to examine brain changes in young children who underwent a four-year-long music training program, compared with a control group of children who did not receive music training.

4. In the first round of testing, after 15 months, the researchers found structural changes in brain circuits involved in music processing in the children who received training. They did not find the same changes in the control group. The scientists also found improvements in musically relevant motor and auditory skills, a phenomenon called near transfer. In this case, the improvements did not transfer to measures of cognition less related to music—termed far transfer. We do not know why far transfer to IQ, for example was found in the Schellenberg study and not in this one.

Taken as a whole, the findings to date tell us that music training can indeed change brain circuitry and, in at least some circumstances, can improve general cognition. But they leave unsettled the question of under what circumstances training in one cognitive area reliably transfers to improvements in other cognitive skills. From our perspective, the key to transfer is diligence: Practicing for long periods of time and in an absorbed way can cause changes in more than the specific brain network related to the skill. Sustained focus can also produce stronger and more efficient attention networks, and these key networks in turn affect cognitive skills more generally.

The practice of various art forms involves different sensory and motor areas in the brain. (Courtesy of M. Posner.)

Practicing a skill, either in the arts or in other areas, builds a rich repertoire of information related to the skill. Scientists conducting neuroimaging studies of many human tasks have identified networks of widely scattered neural structures that act together to perform a given skill, which may involve sensory, motor, attentional, emotional and language processes. The arts are no exception: Specific brain networks underlie specific art forms. As we practice a task, its underlying network becomes more efficient, and connections among brain areas that perform different aspects of the task become more tightly integrated.

This process is analogous to an orchestra playing a symphony. The music that results from the integration of orchestral sections is likely to sound more fluid the hundredth time they play a piece than the first time.

Training Attention Networks:

A large body of scientific evidence shows that repeated activation of the brain's attention networks increases their efficiency. Neuroimaging studies have also proved that the following specialized neural networks underlie various aspects of attention:

* the *alerting* network, which enables the brain to achieve and maintain an alert state;
* the *orienting* network, which keeps the brain attuned to external events in our environment;
* the *executive attention* network, which helps us control our emotions and choose among conflicting thoughts in order to focus on goals over long periods of time.

I have been particularly interested in the executive attention network. Executive attention skills, especially the abilities to control emotions and to focus thoughts (sometimes called cognitive control), are critical aspects of social and academic success throughout childhood. Empathy toward others, the ability to control reward-motivated impulses and even control of the propensity to cheat or lie have been linked scientifically to aspects of executive attention.

5/6. Researchers also have shown that measures of this network's efficiency are related to school performance.

Brain networks that underlie different aspects of attention include the alerting k, the orienting network and the executive attention network. Arts learning may contribute to improved cognition by improving the efficiency of the executive attention network. (Courtesy of M. Posner.)

Given the importance of the executive attention network, my colleagues and I wondered what might improve its efficiency. To find out, we adapted a series of exercises, originally designed to train monkeys for space travel, to investigate the effects of attention-training exercises in 4-to 6-year-old children. We randomly assigned the children to either a control condition (which involved watching and responding to interactive videos) or training on joystick-operated computer exercises designed to engage attention networks through motivation and reward (see the image at top right). After the children who did the computer exercises participated in five days of training for about 30 minutes per day, we placed noninvasive electrodes on the children's scalp to look at their brain activity; we found evidence of increased efficiency in the executive attention network. The experimental group's network performance, in contrast to the control group's, resembled performance in adults. Importantly, this improvement transferred to higher scores on IQ tests designed for young children.

These data suggest that increasing the efficiency of the executive attention network also improves general cognition as measured by IQ.

7. M. Rosario Rueda of the University of Granada, Spain, and colleagues subsequently replicated this key finding in an as yet unpublished study of Spanish children. Rueda found that attention training improved the children's abilities to delay reward, and the improvements persisted for at least two months after training.

In recent years, various approaches to training children to pay attention have been carried out in many different settings. The results show that tasks specifically designed to exercise the underlying networks can indeed improve attention, and that this kind of training can translate to better general cognition. In one of the strongest studies to support this finding, measures of cognitive control significantly improved in preschoolers enrolled in a yearlong training program that incorporated different activities designed to sharpen executive functions.

8. We expect that this training will positively affect the children's future academic performance, but this remains to be shown.

For many children, interest in a particular art form leads to sustained attention when practicing that art form. Moreover, engaging in art often involves resolving conflicts among competing possible responses, such as when choosing the correct note to play at a given moment. The ability to resolve conflict among competing responses is also a crucial aspect of attention training. For example, if you are to respond to a target arrow by pressing a key in the direction in which the arrowhead points, the addition of surrounding arrows pointing in the opposite direction will increase your reaction time and activate parts of the executive attention network.8 We expect, therefore, that arts training should exercise the executive attention network and, therefore, also should improve cognition generally.

One Size Doesn't Fit All

It seems unlikely that training in the arts will *always* improve general cognition, however, since so many factors are at play. No single art form is interesting to all people, and some people may never warm up to any type of art. Individual differences in relevant brain networks, which are probably genetically influenced to some degree, help explain this variability in both appreciation of and ability to create art. For example, one person may have an auditory system that easily discriminates between tones and a motor system optimized for fine finger control, which may predispose her to playing a musical instrument. Someone with agility, coordination and a good ability to imitate motions of others, on the other hand, might naturally gravitate toward dance or sports. These differences may also help explain why people are passionate about one type of art but not others.

The efficacy of arts training also depends on a child's temperament or personality. For example, openness, which affects behavior, may be a prerequisite to effective training, and may in part be genetically derived. We have found, for instance, that a gene that regulates the transmission of the chemical dopamine from one brain cell to another appears to modulate children's openness to parental influence. Our studies show that children with one form of this gene (the dopamine-4 receptor gene) show abnormally high sensation-seeking behavior if their parents show poor parenting skills, but not if their parents show good parenting skills.

9/10. An increasing body of evidence indicates that the brain's attention networks are also under some degree of genetic control. For example, certain genes seem to modulate an individual's ability to perform attention-related tasks, such as quickly responding to a warning signal or shifting attention from one external event to another. These genetic influences underscore individual differences in responses to training, and they may explain contradictory results in scientific studies investigating the links between arts training and cognition.

Apart from these caveats, exposure to the "right" art form can fully engage children's attention and can be highly rewarding for them. They may get so involved in learning the art that they lose track of time or even "lose themselves" while practicing it. I believe that few other school subjects can produce such strong and sustained attention that is at once rewarding and motivating. That is why arts training is particularly appealing as a potential means for improving cognition. Other engaging subjects might be useful as well, but the arts may be unique in that so many children have a strong interest in them.

With advances in neuroscience that are providing important new tools for studying cognition, it is important for researchers to work with educators to design and carry out studies that build upon the findings that arts training provides near-transfer effects, and determine whether this training also results in—and causes—far-transfer cognitive benefits. As we have seen, recent studies have transcended the failed paradigm of simply exposing people to the arts, and now concentrate on the effects of arts training over months and years. We need more studies like these to determine whether, beyond strong correlation, causation occurs. Arts training may influence cognition through other brain processes as well. Because arts training strengthens the brain network related to the art being practiced, other tasks that rely on the same brain circuitry or pieces of it presumably would be affected. For example, if music training influences the auditory system, we might also expect to see improvement in nonmusical tasks involving pitch In fact, Brian Wandell and his colleagues at Stanford University recently demonstrated that children who train in music or the visual arts showed improved phonological awareness, the ability to manipulate speech sounds, which is strongly tied to reading fluency. Moreover, the more music training they had, the better their reading fluency.

11. In addition, parts of the music network lie adjacent to brain areas involved in processing numbers, which might explain anecdotal reports of improvements in mathematics after music training. For instance, Elizabeth Spelke of Harvard University has found that school-age children engaged in intensive music training had improved performance in abstract geometry tasks.

12. Wandell and his team also reported preliminary data connecting experience in the visual arts with children's math calculation abilities.

13. Future studies will need to examine these possibilities in more detail. Another interesting aspect of the performing arts is that artists often prepare for their work by consciously entering a state of mind that they believe will elevate their performance, for example, via deep breathing, picturing the moment or other meditative techniques. Yi-Yuan Tang, a visiting professor at the University of Oregon from Dalian Medical University in China, recently reported that some forms of meditation can produce changes in the connection between the brain and the parasympathetic branch of the autonomic nervous system and, after just a few days of training, can lead to improvements in the same aspects of executive attention that are trained by specifically exercising this network.

14. This "attention state" also correlates with improved mood and resistance to stress. Our data suggest that meditation may contribute to generalized cognitive improvements in those who practice it.

The growing body of scientific work that suggests arts training can improve cognitive function—including our view, which identifies stronger attention networks as the mechanism—opens a new avenue of study for cognitive researchers. The new research findings also give parents and educators one more reason to encourage young people to find an art form they love and to pursue it with passion. Continuing research in this area can also help inform ongoing debates about the value of arts education, which has important policy implications given budgetary pressures to cut arts programs from school curricula.

From our perspective, it is increasingly clear that with enough focused attention, training in the arts likely yields cognitive benefits that go beyond "art for art's sake." Or, to put it another way, the art form that you truly love to learn may also lead to improvements in other brain functions.

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