

**Classroom of the Future?
An Ethical Discussion**



ADDERALL®

Adderall has been used in the treatment of attention-deficit hyperactivity disorder (ADHD). It is an approved drug that has been shown to improve concentration. Adderall works by altering the chemical balance of the brain.

Recent research suggests that Adderall might also be useful for improving memory performance in children and adults without ADHD. Thus, in the field of education, Adderall could be directly applied to improve student learning. For example, Adderall might be given to students before lessons, to improve their memory for the material and therefore their performance on subsequent tests.

Note that at the present time, the potential of using Adderall to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using Adderall improves educational outcomes for students who do not have ADHD. So far, the most known common side effects of Adderall are increased heart rate and dizziness. However, its potential long-term effects are unknown.

This scenario was written by Dr. Astrid Schmied and used in the paper: Schmied A, Varma S, Dubinsky JM: Acceptability of Neuroscientific Interventions in Education. *Sci Eng Ethics* 2021, 27:52.

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Oxytocin

Oxytocin has been suggested for the treatment of autism. It is an experimental drug that has the potential to improve sociability. Oxytocin works by altering the chemical balance of the brain.

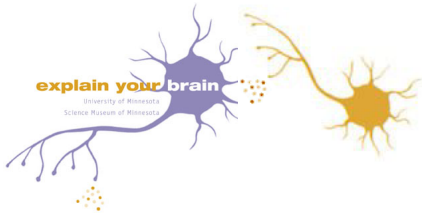
Recent research suggests that oxytocin might also be useful for increasing trust and generosity in children and adults without autism. Thus, in the field of education, oxytocin could be directly applied to improve student learning. For example, Oxytocin might be given to students to improve their cooperative attachments to other students, increasing their learning from group work.

At the present time, the potential of using oxytocin to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using oxytocin improves educational outcomes for students who do not have autism. So far, the most known common side effects of oxytocin are oversensitivity and irritability. Its potential long-term effects are unknown, however.

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Transcranial Direct Current Stimulation (tDCS)

Transcranial Direct Current Stimulation (tDCS) has been suggested for the treatment of depression. It is an experimental technique that has the potential to change brain activity. tDCS works by changing the brain, placing electrodes at the scalp surface that induce electrical currents.

Recent research suggests that tDCS might also be useful for acquiring new vocabulary words in children and adults. Thus, in the field of education, tDCS could be directly applied to improve student learning. For example, tDCS might be applied to students as they learn a foreign language, so that they can improve their memory for new vocabulary words, and ultimately their acquisition of the language.

However, the potential of using tDCS to improve educational outcomes is still unclear at the present time. Additional research is needed to establish whether or not using tDCS improves educational outcomes for students. So far, the most known common side effects of tDCS are a slight itching or tingling on the scalp. However, its potential long-term effects are unknown.

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Neuroprostheses

Neuroprostheses (deep brain stimulation) have been used for the treatment of tremors in Parkinson's disease. These are experimental devices that have been shown to change brain activity. A neuroprosthesis works by changing the brain: a surgically implanted device induces electrical currents.

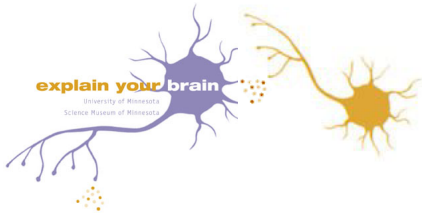
Recent research suggests that a neuroprosthesis might also be useful for directly transferring memories from one person to another. Thus, in the field of education, a neuroprosthesis could be directly applied to improve student learning. For example, a neuroprosthesis might be implanted in students and applied during lessons, to improve their memory for the material and therefore their performance on subsequent tests.

At the present time, however, the potential of using a neuroprosthesis to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using a neuroprosthesis improves educational outcomes for students. So far, the most known common side effects of using a neuroprosthesis are those associated with surgery such as bleeding and infection. Its potential long-term effects are unknown, however.

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Electroencephalography (EEG)

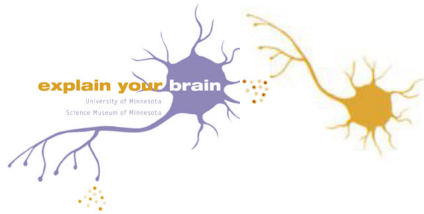
Electroencephalography (EEG) has been used to diagnose the cause of seizures in people with epilepsy. EEG is an approved technique that measures electrical activity coming from the brain using electrodes placed on the scalp.

Recent research suggests that EEG might also be useful for predicting the verbal ability of children and adults without epilepsy. Thus, in the field of education, EEG could be indirectly applied to improve student learning. For example, EEG might be used to identify infants who are at-risk for future reading difficulties when they enter school, so that they can benefit from early intervention programs.

However, at the present time, the potential of using EEG to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using EEG improves educational outcomes for students who do not have epilepsy. So far, the most known common side effect of EEG is irritation of the skin where the electrodes are placed. However, its potential long-term effects are unknown.

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Functional Magnetic Resonance Imaging (fMRI)

Functional Magnetic Resonance Imaging (fMRI) has been used in the diagnosis of tumors. fMRI is an approved technique that measures brain activity by exposing blood flow in the brain to strong magnetic fields in a scanner.

Recent research suggests that fMRI might also be useful for predicting the mathematical ability of children and adults. Thus, in the field of education, fMRI could be indirectly applied to improve student learning. For example, fMRI might be used to identify kindergarten children who are at-risk for mathematical learning difficulties, so that they can benefit from early intervention programs.

Note that the potential of using fMRI to improve educational outcomes is still unclear at the present time. Additional research is needed at this time to establish whether or not using fMRI improves educational outcomes for students. So far, the most known common side effects of fMRI are anxiety about being confined in the scanner and headaches. Its potential long-term effects are unknown, however.

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