FEATURED ARTICLES

“The Impact of Cannabis on Academic Achievement: Brain Development, Cognitive Functioning, and Mental Health”
- Nevenka Bolini

“Cognitive Behavioral Therapy: Justifying its Use for Rehabilitation in Multiple Sclerosis Patients”
- Kristen Ngai

“Neuro-Doping: Is it The Dope Way to Improve Athletic Performance?”
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## INTRODUCTION

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## GENERAL NEUROSCIENCE

| The Impact of Cannabis on Academic Achievement: Brain Development, Cognitive Functioning, and Mental Health | Nevenka Bollini | pages 6-14 |

Cannabis is one of the most widely used substances by adolescents in the United States. Statistics have shown that adolescent cannabis users are more likely to drop out of school and are less likely to pursue a higher education. Academic performance is affected by adolescent cannabis use by three means: brain development, cognitive functioning, and mental health. Adolescents may also become more susceptible to depression and physiological issues. Not much is currently known about the complex pathways and links between cannabis and academic performance, but more research should be conducted as adolescent years are vital in development and cannabis use may hinder such growth.

| Impact of Trauma on Immigrant Children | Emily Guadarrama | pages 15-22 |

Immigrant children often experience high levels of trauma, which often has long-lasting and profound effects on their mental and physical health. The morphology and functioning of the brains of trauma survivors show remarkable differences from their healthy peers, such as fast biological ageing, thinning of cortices involved in social and emotional processing and an increased likelihood of further diseases in adulthood. Furthermore, the survival of adverse childhood experiences, which may include unaccompanied immigration into a foreign country at a young age, has been linked to lasting changes in brain structures including the hippocampus, anterior cingulate cortex and amygdala. Children who immigrate may experience developmental delay and difficulty adjusting to their new life, resulting in psychological issues, discrimination and high crime rates. This situation is further complicated by low access to healthcare services due to their often illegal status. Government programs, such as DACA, provide services for these children, which may have a directly positive effect on their well-being.

| Social Media’s Influence on Adolescent Behavior | Lydia Kennemer | pages 23-30 |

During adolescence, the brain goes through a significant change in gray and white matter in the brain. The increase of white matter is due to synaptic density decreasing in the prefrontal cortex and the decrease of gray matter is due to synaptic pruning, which shows a later development of frontal and temporal lobes than occipital and parietal lobes. Social media can become an addiction because it causes tendencies such as fixation, compulsive use, mood modification, tolerance, and withdrawal - constant use of social media to reduce social anxiety can lead to a social media addiction. Comparisons that arise from social media can
cause anxiety in adolescents who seek approval in the number of likes on their posts. Passive social media use increases by symptoms of depression, loneliness, body dissatisfaction, and stress. On the other hand, social media can enhance friendships but diminish academic success by causing lack of sleep or poor sleep quality.

The Effect of Musical Stimulation on Cerebral Activity and Anxiety: A Literature Review

Eshaan Gandhi

Music, an integral part of culture and lifestyle, poses several neurological benefits when used leisurely. By using EEG data to collect electric neurological activity, researchers noted that gamma waves—brain waves found to increase cognitive function, memory, and focus—were found when participants listened to instrumental music. More EEG data suggests that music may simultaneously decrease anxiety and induce a calm state. Furthermore, an fMRI study found increased brain activity within the default mode network when listening to music, indicating the presence of alpha waves, which induce tranquility. More research suggests that music may lower heart rate or cause the hypothalamus to release anxiety-reducing hormones. An increased prescription of music therapy can hence be used to induce anxiety-alleviating effects in populations.

DISEASES AND DISORDERS

Cognitive Behavioral Therapy: Justifying its Use for Rehabilitation in Multiple Sclerosis Patients

Kristen Ngai

Characterized by symptoms of muscle weakness, tremors, loss of vision, pain, and paralysis, multiple sclerosis is a disease that affects many worldwide with no definitive cure. As the disease develops, the patient's immune system attacks the body's tissues, destroying a coating of nerve fibers in the myelin sheath. The excruciating symptoms that many patients face affect their mental health as well: there are high rates of anxiety and depression, which calls for the need of Cognitive Behavioral Therapy (CBT) - a type of talk therapy. Cognitive Behavioral Therapy connects a person's thoughts, feelings, and behaviors to help patients better cope with their symptoms. Physicians can contribute to a more unified approach of Cognitive Behavioral therapy by individualizing and personalizing treatment interventions. Despite the potential drawbacks of Cognitive Behavioral Therapy, this method should be used to help patients approach their disease symptoms in a more hopeful way.

Neurological Causes of Dysphagia

Lesansunga Mulunda & Champion Lumamba

Swallowing, or "deglutition," involves moving food from the mouth to the stomach, which itself is a process that involves many muscles and nerves. A malfunction in this process may lead to difficulty in swallowing - dysphagia. Dysphagia affects a large portion of the elderly and is a common cause of morbidity. In "Neurological Causes of Dysphagia", authors Lesansunga Mulunda and Champion Lumamba explore the topic and its causes from a neurological perspective.

The Ability of Neural Stem Cells to Treat Spinal

Rithvik Marri
Cord Injury

This article examines the impact of neural stem cells and its applications in spinal cord injuries (SCI). SCI impacts hundreds of thousands of people every year, and it is quite expensive to manage. However, stem cell therapy has emerged as a potential treatment option. With this treatment, issues like chronic inflammation at the injury site and loss of neurons can be addressed. While early results are encouraging, there are still many unanswered questions, such as the best times to implant these stem cells. Moreover, significant research needs to be conducted in order to ensure the safety of neural stem cell implantation.

Using Artificial Intelligence in the Diagnosis of Eating Disorders
Krishnaveni Parvataneni

This article focuses on different eating disorders such as anorexia, bulimia and binge eating and the various ways by which they can be detected using artificial intelligence. Bulimia nervosa is characterized by cycles of binging and purging while patients with anorexia nervosa tend to have unusual eating habits, limiting how much they eat and exercising a lot. Multiple features, some gender-based, like menstrual cycles, some psychological, and some demographic, have been used to train models, including elastic nets, decision trees, Naive-bayes and K-means clustering on the detection of eating disorders, a prominent model being the XGBoost, or eXtreme Gradient Boosting. This is suitable for diagnosing eating disorders quickly, during routine appointments, catching them before the quality of life drastically decreases.

NEUROETHICS

Neuro-Doping: Is it The Dope Way to Improve Athletic Performance?
Evan Park

Transcranial direct current stimulation, also known as tDCS, is a novel tool capable of stimulating synaptic plasticity of the brain via a low-current electricity flow from a positive to a negative electrode. Numerous studies analyzing the effects of tDCS on professional athletes have discovered that the subjects were stronger, more fatigue resistant and overall performed better when compared to controls. These effects can be explained by stimulated functioning of several brain areas which play a role in decision making and goal-directed behaviour. However, the use of tDCS raises several ethical issues that need to be addressed. These include the potential of deepening the economic divide between professional and younger athletes due to its high costs, as well as the unknown ecological impact and dangers associated with the use of an under researched equipment. The topic of discussion surrounding the use of this tool has many arguments on both sides, and more analysis will likely be needed to resolve the problem.

The Neuroethics of Global Mental Health Treatment
Renee Ngai

The COVID-19 pandemic has exacerbated the ongoing mental health crisis among adolescents and adults, highlighting gaps in mental health treatment worldwide. Despite everyone, across the globe, having a right to health, a lower socioeconomic status often compromises access to mental health treatment. Lower access to higher education and financial hardships make lower income families more susceptible to stress and anxiety, which can often be an indicator of mental health disorders. Neuroethics hence needs to conduct research in
middle and low income countries, while taking into account possible cultural barriers or benefits when seeking to close the mental health treatment disparity.
Dear Readers,

Welcome to the fourth installment in the sixth season of the IYNA Journal! Fall is in full swing, and we know many of you are rotating your time commitments between classes, extracurriculars, family, and friends. That’s why we’re pleased you’ve joined our editors and authors in exploring the latest updates in neuroscience.

Thanksgiving is approaching fast! In the spirit of gratitude, we would like to acknowledge the contributions of our readers, who never fail to impress us with their burning passion for knowledge. As the number of members in the IYNA reaches 9,000, it’s important to step back and recognize how far the journal has come. Without your support, we would have never been able to carry out our mission of increasing awareness about neuroscience and inspiring the next generation of leaders. We are truly thankful for everyone’s involvement with the journal. With that being said, here are some previews of the essays published this month:

Nevenka Bolini explores the impact of cannabis on the brain’s development and its relation to academic performance, Kristen Ngai justifies the use of cognitive behavioral therapy for patients with multiple sclerosis, and Evan Park examines the ethical implications of neuro-doping to improve athletic performance.

We would like to recognize all of our dedicated editors for helping us make this issue the success that it is. You can see all of their names and positions on our Contributors page. If you have any questions, comments, or suggestions for us, please email apan@youthneuro.org. We hope you enjoy reading this issue as much as we enjoyed editing it!

Best Regards,
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The Impact of Cannabis on Academic Achievement: Brain Development, Cognitive Functioning, and Mental Health

Nevenka Bollini

Abstract

Aside from alcohol and tobacco, cannabis is the most widely consumed substance by adolescents in the United States. Adolescent cannabis users are more likely to drop out, not pursue higher education, and maintain a lower income. This paper discusses how academic performance is influenced by teenage cannabis use through three potential mechanisms: brain development, cognitive functioning, and mental health. Exposure to cannabinoids breeds psychological dysfunction, rendering teens more vulnerable to dependence, depression, and psychosis. Ultimately, further research should untangle the complex causal pathways between adolescent cannabis use and academic performance, given the compelling existing evidence of detrimental outcomes. The period of adolescence is pivotal: the susceptibility of teens to the harmful ramifications of cannabis heightens the urgency for schools and policymakers to challenge the belief of the drug as a “safe” substance.

Introduction

Cannabis is the most widely used illicit drug among adolescents in the United States. In the past year alone, nearly one-third of high school seniors used cannabis recreationally [1]. This leads millions of teens on a road to detrimental outcomes: Cannabis use is associated with panic attacks, psychotic symptoms, affective disorders, and physical impairments such as respiratory and cardiovascular disease [2]. An overview of three potential underlying mechanisms is provided: brain development, cognitive functioning, and mental health. While commonly perceived by adolescents as a low-risk substance [3], cannabis may harm academic success by disrupting neurological processes, compromising cognitive abilities, and increasing risk of psychological illnesses.
Effects of Cannabis on Academic Performance

Adolescents who smoke cannabis have poorer educational outcomes - they are less likely to fulfill their academic goals and pursue higher education [4][5]. A longitudinal study, which observes the same subjects for a prolonged period of time, followed over 400 adolescents aged 14-17. It was concluded that cannabis use is correlated with increased disengagement and decreased planning and valuing of education [6]. Such disengagement often manifests through increased rates of school absenteeism [7]. Teenage engagement with cannabis on a continued basis is also associated with lower grades and Grade Point Average (GPA) and higher truancy and dropout rates[4][8].

Further, cannabis use exhibits a host of long-term consequences for adolescents: teens who engage in heavy cannabis use are significantly less inclined to pursue a bachelor's degree and complete college than nonsmoking classmates [9][10]. Economic opportunities are limited; adolescents who smoke cannabis are more likely to retain household incomes that are less than $30,000 [11]. Heavy marijuana use may result in grave repercussions including “greater need for socioeconomic assistance, unemployment, criminal behavior, and lower satisfaction with life” [12]. In comparison to high-achieving peers, adolescents with poor school performance also typically find themselves experiencing higher anxiety levels, lower happiness, and lower self-esteem later in life [13].

Brain Development

Cannabis use is linked to a variety of detrimental outcomes in terms of neurological maturation during adolescence. The teenage brain harbors a heightened vulnerability to drugs and neural dysfunction, as maturing neurotransmitter systems enhance sensitivity to cannabis and cannabinoid receptor interactions [14]. While cannabis may influence the development and functioning of several aspects of the adolescent brain (e.g. hippocampus, orbitofrontal cortex, cerebellum, and basal ganglia), this paper focuses on three examples: the endocannabinoid system (ECS), synaptic pruning, and white matter [15].

The ECS supports the neurological establishment of stress and reward circuitry [16]. It modulates neuronal cell development (including proliferation, migration, and differentiation), synaptic plasticity, and emotional homeostasis [17][18]. Extended use of cannabis may cause the overactivation of the ECS, therefore inducing alterations to neurobiological functions (e.g. synaptic plasticity), and impairing maturational refinement long-term [17][19]. ECS impairment can be consequential for learning, psychomotor speed, memory, and attention, which are crucial skills for academic success [20]. In addition, ineffective regulation of stress and anxiety - which the ECS supports - can relate to lower GPA [21].

Chronic cannabis use during teenage years may also influence synaptic pruning, a neurodevelopmental process that resurges during adolescence and is essential for forming functional neural networks (see Figure 1) [22][23]. Excessive exposure to Tetrahydrocannabinol (THC), the primary psychoactive component of cannabis, during critical periods of maturation
disrupts synaptic transmission and neurocircuitry in the central nervous system (CNS) [24][25]. Adolescent cannabis use may breed inefficient synaptic pruning, particularly in the hippocampus and prefrontal cortex, which may in turn harm cognitive skills crucial for academic success [26][27][28].

Constituting approximately half the brain, white matter refers to networks of myelinated tracts within the CNS which allow for communication between various areas of gray matter [30]. Altered white matter in adolescents may cause abnormal axonal and myelin maturations and disrupted fiber integrity [31]. Chronic cannabis use among adolescents is associated with an overall decreased functional connectivity of the brain, ultimately leading to poor academic outcomes [32]. For example, the development of cerebral white matter tissue is highly correlated with reading proficiency in adolescents [33]. White matter integrity in Broca’s area predicts grammar success, including language analytic abilities [34]. Additionally, irregularities in white matter microstructure (e.g. lower neurite density) are associated with poorer mathematics performance in teens, including on standardized test scores such as the Preliminary Scholastic Aptitude Test (PSAT) [35][36]. A study using diffusion tensor imaging, which detects how water diffuses along white matter tracts, found that fractional anisotropy (measuring restriction of water diffusion) in the corpus callosum had a positive association with intelligence quotient (IQ). This indicates that white matter may have a pronounced effect on visuospatial working memory, creativity, and fluid reasoning [37]. Clearly, white matter development has a profound influence on a wide range of academic abilities, making its connection to cannabis use during adolescence an urgent concern.

Cognitive Functioning

Cannabis has been shown to impair several essential cognitive abilities [38]. A longitudinal study following over 1,000 youth from birth to adulthood found those who used cannabis in early adolescence had the greatest reduction in IQ, did not rebound back to their predicted intellectual trajectory, and experienced long-lasting cognitive impairments even after abstinence [16]. Since cannabis alters cognitive functions both during acute intoxication and for days following, students may perform at a cognitive level below their natural capability, therefore interfering with their abilities to learn at school and achieve challenging educational goals [12]. As cognitive performance has shown to be a significant predictor of school achievement for students, this may explain the association between regular cannabis use and low academic achievement (e.g. poor grades) [39]. Below, two cognitive abilities in particular are discussed — attention and working memory — which have been demonstrated to be determining factors for linguistic and mathematical abilities [40].
Attention involves cognitive subprocesses (e.g. selective attention, sustained attention) that are adversely affected by cannabis use [41]. Selective attention, the ability to focus on a desired input and filter out distracting information, may support neural circuits vital for literacy skills, including the ability to approach mathematical word problems with reasonable strategy [42]. Similarly, sustained attention, which refers to the ability to maintain focus on a specific stimulus across a prolonged period of time, has been shown to moderate verbal and numerical intelligence and GPA among junior and senior high school students [43][44].

Working memory refers to the storage of a limited amount of information while executing cognitive tasks such as comprehension and reasoning [45]. A study on adolescent neurocognitive performance found former and current heavy cannabis users (over 200 lifetime cannabis use episodes) performed significantly lower on tests of working memory [38]. Studies have found working memory to aid in synaptic comprehension and phonological processing, therefore maintaining skills crucial for reading and grammatical fluency [46]. In terms of reading abilities, working memory becomes increasingly valuable for comprehension including decoding and vocabulary skills [47].

**Mental Health**

Frequent cannabis use among adolescents is associated with developing cannabis dependence, depression (including suicidal ideation), and psychotic disorders. [48][49][50].

Teenage cannabis users are at high risk for developing dependence: adolescents may be nearly four times as likely to develop cannabis dependence within two years of the first use. A study led by researchers at the National Institute on Drug Abuse found the prevalence of cannabis use disorders to be higher in adolescents than young adults: within one year since initial cannabis use, nearly 11% of adolescents had developed a substance use disorder in comparison to about 6% of young adults [48]. With up to 50% of teens who consume cannabis daily developing dependence, heavy cannabis use may be associated with a decline in academic performance and engagement in school by causing issues with memory, grades, and attendance [16][51]. A study following over 1,000 participants from birth to age 38 suggested a causal relationship between cannabis dependence and reduced educational attainment (e.g. lessened pursuit of higher education, IQ decline) [52]. This further underscores the necessity of early intervention and treating the adolescent population with special care and consideration.

Depression is a common mental disorder characterized by persistent sadness and lack of interest in important activities and aspects of daily life, including performance at school [52]. Heavy cannabis use during adolescence predicts depressive psychopathology and spiked risks for suicidal behavior, thoughts, and attempts in teens [10][53]. A systematic review and meta-analysis of over 23,000 adolescents concluded that cannabis use significantly raises the risk of developing depression and suicidality in young adulthood, breeding reduced academic motivation [10][49]. A study examining 83 adolescents found major depression interfered with attendance, homework completion, social relationships with peers, and the ability to concentrate in class [55]. While teens
with depression may be more likely to seek out illicit drugs in the first place, there is evidence that continually using cannabis worsens depressive symptoms instead of relieving them [56][57]. Given the association between depression and reduced academic performance, cannabis use among adolescents should therefore be taken seriously.

Studies have indicated a strong correlation between adolescent cannabis use and psychotic disorders, such as schizophrenia [58]. A review of youth who began cannabis use as adolescents in comparison to the age of 25 found compelling evidence supporting that early initiation of cannabis increases psychotic symptoms [59]. A 2022 systematic analysis of 591 studies concluded both high- and low-frequency cannabis usage significantly relates to an increased risk of developing schizophrenia, compared to peers who never used cannabis [60]. THC exposure may also exacerbate symptoms of psychosis in already diagnosed adolescents [61]. Psychotic disorders are undeniably harmful to academic performance: a meta-analysis of over four million individuals found that by age 16, teens who later developed psychosis had poorer academic and mathematics achievement and were less likely to pursue higher education [62]. While specific individuals may be more vulnerable to developing a psychotic disorder in the first place, these findings nevertheless highlight the detrimental effects of adolescent cannabis use on mental well-being and academic performance [50].

**Conclusion**

Cannabis use may have severe consequences for adolescent academic performance. First, impacted neurological maturation (e.g. overactivation of the ECS, inefficient synaptic pruning, disrupted white matter development) is likely to suppress educational success. Second, cannabis further inhibits critical cognitive functions (e.g. selective and sustained attention, working memory) that are demonstrated to be direct predictors of academic success. Third, the development of mental illnesses - including cannabis dependence, depression, and psychotic disorders - simultaneously interferes with emotional well-being and performance in the classroom. Future research may focus on examining the causal pathways between adolescent cannabis use and academic performance, as well as identifying what pushes adolescents to undertake these risks. Since cannabis jeopardizes educational achievements for adolescents through such profound mechanisms, schools and policymakers should emphasize greater awareness to correct the perceived low risk of cannabis for teens. Such efforts could be pivotal in curtailing the negative effects of teenage substance abuse.

**References**


Impact of Trauma on Immigrant Children

Emily Guadarrama

Abstract

After leaving their home country, Immigrant children endure a great amount of trauma, which can often stay with them up until adulthood. Their journey can be categorized into three phases: Premigration, Migration, and Resettlement. Many children experience psychological trauma and long-term mental health risks, such as PTSD, depression, suicidal tendencies and anxiety. Whether a child is traveling with their parent(s) or has been separated from their parent(s) can also influence the child’s well-being. An unaccompanied child is often driven to gain an education, but simply cannot due to difficulties in access. While brief detention as a child can result in psychological trauma and long-term mental health risks, migrating as an adult can have an advantage on the individual’s mental health. Government policies such as DACA can have a positive effect on the individual’s mental health. When an immigrant child needs health services they are less likely to have a regular health service provider and typically only use emergency and hospital services. These children have survived adverse childhood experiences (ACEs) which have been proven to be linked to an increased risk of mental and health issues in adulthood, such as experiencing alcohol and/or substance abuse issues.

Neurological Trauma Processing

Trauma affects several regions in the brain, including the amygdala, insula, ventromedial prefrontal cortex, and hippocampus [1]. In a study conducted by Colich et al. it was found that children who experience early life adversity, such as abuse, poverty, and/or violence experience faster biological aging than children with no exposure to trauma [2]. Thinning in the ventromedial prefrontal cortex, which is involved in social and emotional processing, and the frontoparietal network, which is involved in sensory and cognitive processing, are all associated with trauma [2]. Research has shown that trauma is more common in women and groups that have a higher incidence of intergenerational trauma, such as refugees [3]. The common symptoms following childhood trauma survivors can be categorized into somatic symptoms, emotional dysregulation, interpersonal instability, avoidance, re-experiencing and dissociation, disorders of memory, and shame. These symptoms can make it difficult for survivors of childhood trauma to disclose their trauma, if they choose to at all. Childhood trauma exposure can result in likelihood of trauma exposure later in life, which is correlated with poor adult outcomes [4], such as an increase in health
and mental health risks [3]. A study performed by Medizabal et al. reveals that traumatic events have been linked to a higher risk of heart disease, diabetes, neurologic conditions such as strokes, headaches and epilepsy [6]. Exposure to any type of trauma is associated with psychotic experiences, including hallucinations, delusions, and experiences of thought interference [7].

The hypothalamic-pituitary-adrenal (HPA) axis is eminently responsive to environmental adversities both in childhood and adulthood [9]. Studies have shown that the HPA axis is often involved in the development of behavioral phenotypes associated with depression. Previous studies have also reported an association between childhood trauma and higher levels of pro-inflammatory markers, including the acute phase protein C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-a (TNF-a). These findings provide evidence that traumatic childhood events significantly impact the inflammatory immune system. In addition to those findings, researchers found that different types of trauma exposure impacted the inflammatory markers differently. For example, CRP appears to be largely related to parental absence during early childhood. Testing on rodents demonstrates that maternal separation is associated with elevated TNF-a levels in the periphery and cerebrospinal fluid, as well as in the prefrontal and hippocampus brain regions [9].

Adverse childhood experiences (ACEs) are possible traumatic events that occur between the ages 0-17. ACEs include experiencing violence in the home or community, growing up in a household with substance abuse and mental health problems, and instability due to parental separation [10]. ACE-related disorders such as PTSD, depression, borderline personality disorder, and obesity are all associated with lasting effects on the hippocampus, amygdala, and the anterior cingulate cortex (ACC) [11]. Studies have shown that there is a reduced volume of the hippocampus...
in individuals with ACEs compared to those without ACEs. The anterior insula, superior temporal gyrus, and parahippocampal gyrus have all been shown to be hyperactive in those with ACEs. This indicates that increased activation in these regions may aid in early detection of threatening stimuli, which is an adaptive ability due to experiencing childhood trauma. ACEs such as parent-child separation have been associated with alterations in reproductive traits, prenatal distress, and childbirth experiences [12]. It has also been found that exposure to early life stressors can affect different brain regions during different phases of neurological development [12]. Childhood stress is associated with reduced hippocampal volume in adults and white matter microstructure in the corpus callosum is affected in both children and older adults. Adults who had experienced childhood trauma showed a volume reduction in the ACC. The ACC is a structure that regulates emotion reactivity via connections to the amygdala, which is why reductions in these regions result in altered emotional reactivity [12] [12].

The Journey of an Immigrant Child

There are several motives as to why children and their parents immigrate. An unaccompanied child can be classified as a person who “is under the age of 18 and who is separated from both parents and is not being cared for by an adult who by law or custom has responsibility to do so” [13]. The term “refugee” is given to an individual who ees their home country out of fear for their safety and goes to a refugee camp where they can wait indefinitely for conditions to allow them to return home or be accepted for resettlement in another country [14]. An undocumented individual is someone who enters a country without proper authorization documents or enters legally, but overstays their visa [14]. The primary causes leading to unaccompanied children’s immigration are high levels of political and structural violence and concentrated crime in their home country [13]. Other reasons may include lack of access to education, health care, and employment in their home country. The journey these children undertake has several different phases: premigration, migration, and resettlement [14]. Premigration refers to the period of time before leaving one’s home country. Many children in the pre-migration phase have never had a healthy upbringing due to dysfunctional schools, unsafe water and neighbors, and so forth. Researchers also found that different countries have differing reasons as to why children travel alone. For example, it was argued that children migrated from Mexico and Central America to the U.S to reunite with their parents who themselves migrated to the U.S for labor jobs. It was also observed that children from Guatemala, Honduras and El Salvador were found to have applied for asylum in any other country they could get into. Nevertheless, children were migrating for a better life than the one they were offered in their home country [13].

Migration is the actual decision to flee one’s home country. During this stage, families experience the highest risk level of families being separated; unaccompanied children are exceptionally vulnerable, and at risk of being financially in debt to criminal smugglers [14]. Many children hop on trains, ride in cargo trucks, walk in the desert, cross the Mediterranean Sea at night in tightly packed boats, or travel by foot through forest and mountain areas. These conditions can expose them to trauma, dangers, and life-threatening situations [13]. In fact, it was found that gender plays a role in shaping the children’s experiences, because girl migrants have a higher likelihood to
be exposed to sexual violence by the smugglers, authorities, and criminals they face. According to Menjivar and Perreira, 6 out of 10 Central American women and girls are victims of sexual violence during their journey through Mexico [13]. As a result, it has become more common for Central Americans and Mexican migrants to shift routes, and travel through more dangerous terrain to avoid border control [13]. Upon arrival at a destination, it is common for refugee children to live in a refugee camp where they can potentially spend much of their childhood in. These camps are usually overcrowded, unsanitary, dangerous, and can sometimes, but not always offer education for the child [14].

Resettlement is heavy with stress, disappointment, trauma, and overall negative feelings. In the U.S., detained minors are typically transferred to the Department of Homeland Security where their age will be verified to ensure that the child meets the definition of an unaccompanied child from a country isolated from the U.S. [13]. Refugees do not get to choose their location to resettle, and they’re prone to resettlement in low-resource areas. These low-resource communities have exposure to crime and violence, which can lead to further stress and mental illnesses, some of which include PTSD, depression, and anxiety [14]. These issues can greatly harm unaccompanied children as they have no trusted adult figures to ease them through this transition. Refugee children have also shown high rates of posttraumatic stress disorder, both on arrival and in the United States post-migration [15].

Figure 2. Display of core stressors which can create substantial challenges to adaptation and development, and in some cases can promote important growth or empowerment in immigrant children [17].
Parental Influence on Immigrant Children's Experience

Throughout the years the number of unaccompanied children immigrating to the U.S. from Central America has increased drastically, and as many as 35% are eventually placed into long-term foster care [16]. Unaccompanied immigrant children are typically placed in shelters or other facilities by the U.S. Department of Health and Human Services (HHS) Office of Refugee Resettlement (ORR) [17]. In some cases, the ORR releases children into the care of community sponsors, some of which include adult family members or non-family individuals, across the country for the duration of their immigration cases. According to Linton et. al., the average length of stay for unaccompanied children was 34 days, but some children remain in ORR custody for longer periods of time, for various reasons. Studies have shown that detained children had negative physical and emotional symptoms. In addition to those symptoms, it was found that the children could experience developmental delay, poor psychological adjustment, and inadequate functioning in school [17].

Although half of migrant children travel unaccompanied, many others travel with one or both parents. Mothers' posttraumatic stress and depressive symptoms can significantly increase the effect of mothers' past distress on their children's adjustment [18]. This can be an indicator of intergenerational trauma which gives a better understanding as to why many children of immigrant mothers experience poor health and well-being [18]. According to O'Higgins, Ott, and Shea, an unaccompanied minor suffers from overly high levels of mental health problems, some of which include PTSD, depression, and anxiety, compared to children who migrate with their parents or peers who are not migrants [19]. Research has also shown that children who migrated without their parents were more likely to be eager to learn English and gain a better education. However, their eagerness to do these things is often hindered due to difficulties in access, confusion about their rights, and language barriers [19].

Mental and Emotional Impacts and Resulting Behavior

According to Kim, Schwartz, Perreira, and Juang, children who are undocumented, unaccompanied, or refugees are at elevated risk for mental health problems [15]. Even brief detention periods and migration times have been proven to cause psychological trauma and induce long-term mental health risks for children. In contrast, migration as an adult can result in mental health advantages [15] [17]. The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) performed by Perreira, provided evidence that prolonged exposure to U.S. culture, such as attending school and living in a U.S home, led to higher rates of moderate to severe psychological distress, depression, and anxiety. The National Survey on Drug Use and Health is another study that found evidence of immigrant health advantages, particularly in 15- to 17-year-olds, for externalizing problems such as crime, violence, and drug misuse. Due to the lack of legal status of these children, their mental health is often untreated [15]. Government policies and programs are one way to reduce mental health problems in immigrant children. For instance, the Deferred Action for Child Arrivals (DACA), which provides temporary relief from deportation and renewable work permits, has shown to have positive consequences for mental health even just by qualifying for the program. An individual meeting the DACA criteria eliminates the risk of deportation, receives access to
employment opportunities, and benefits from increased income due to employment—all of these can raise hope and reduce physiological stress, directly improving the individual’s mental health [20].

Another link between immigrant children and poor mental health is discriminative experiences [15]. Whether it is discrimination against the children’s parents or the children themselves, discrimination results in an increase in mental health issues. Kim, Schwartz, Perreira, and Juang all found that Latino adolescents experienced a high level of ethnic discrimination, high rates of bullying, few positive experiences in social support, and high risk of depressive symptoms and smoking. Immigrant children whose heritage language was not English were at a higher risk of suicidal behaviors. Bicultural stress is the pressure to adhere to both heritage and U.S. cultures, which has been found to be associated with more risk-taking behaviors and depressive symptoms in both U.S. born and immigrant adolescents [15].

Inadequate Mental Health and Healthcare Services

Immigrant children are less likely to have a regular health service provider, preventative services, primary and dental care, and specialized health services [21]. In a study performed by Markkula et al., it was found that migrant children typically only used emergency and hospital services. From this study, it was found that 30% of migrant children had access to a regular source of care, 20% had access to vaccines, 18% had access to mental health resources, 16% had access to hospitals or emergency services, 14% had access to oral health, and 13% had access to primary care [21]. Lack of mental health services can also be correlated to immigrant parents and their lack of willingness, out of fear of facing legal issues, to search for these services. Other major obstacles result in difficulty accessing care, such as language barriers, lack of awareness, stigma, and negative attitudes towards and by providers [22].

Adulthood, Traumas, and Lifelong Effects

Adverse childhood experiences (ACEs) have been associated with an increased risk of mental and health issues in adulthood [5]. When an individual with ACEs was compared to one with no ACEs, it was found that the individual with ACEs was three times more likely to report more days of mental distress and eight times more likely to experience alcohol and/or substance abuse problems [5]. It has also been observed that Latino men are at a high risk for alcohol/substance use disorders, such as developing benzodiazepine (a PTSD treatment) use problems. Early interventions have been recommended [23] like utilizing other treatments for the individual’s PTSD such as psychotherapy, serotonergic antidepressants and adrenergic inhibitors [24]. It has been recommended to practitioners to screen for PTSD when Latinos exhibit symptoms of depression, anxiety, and/or substance problems and make proper referrals [25].
References


Social Media’s Influence on Adolescent Behavior

Lydia Kennemer

Abstract

Adolescence can be described as an aging period ranging from puberty to early adulthood. The brain of an adolescent goes through changes that can result in significant brain responses and behavior. Their cognitive control, social state, and emotional state undergo adjustments throughout this period. During such an important period, frequent social media use influences these individuals’ daily lives, so it is important to know the effects of the usage. It is common for adolescents to own and use a cellphone through which they can access social media. Social media can affect an adolescent’s mental health, social and emotional behavior, academic life, and sleep.

Adolescent Brain Development

The term "adolescent" can be defined as an individual during the period between entering puberty to the early ages of adulthood [1]. Puberty and aging contribute to the ongoing changes in the development of the adolescent brain. Although a person’s brain reaches its total volume at the end of childhood, a study conducted by José Javier Miguel-Hidalgo state that during the period of adolescence, the brain goes through changes in regions that result in distinctive brain responses and behavior [1]. Magnetic resonance imaging (MRI) has revealed that adolescents go through a significant change in gray and white matter in the brain. White matter contains myelin sheath-covered axons and gray matter consists of neuronal-cell bodies, dendritic trees, and synapses. Diffusion tensor imaging (DTI) uses fractional anisotropy (FA) and means diffusivity (MD), which measures the direction and mean diffusion of water, measure between space of axons, to detect white matter; the tracts mature during an individual’s adolescence period. The increase of white matter is due to synaptic density (number of synapses per neuronal volume) decreasing in the prefrontal cortex during adolescence. The gray matter decreases during adolescence suggesting synaptic pruning, (elimination of extra synapses) which shows a later development of frontal and temporal lobes than occipital and parietal lobes [1].

Along with functional brain development, adolescents’ cognitive control can be measured [1]. Cognitive control can be described as being able to adjust behavior and actions to reach the desired goal, which can be improved in childhood and leisurely during adolescence. During adolescence executive functioning, task inhibition, working memory, or task switching are related to
an increase in activation in the parietal cortex and both a decrease and increase in the lateral prefrontal cortex (lPFC). During young ages, activation of the rostrolateral PFC for relational reasoning and inferior frontal gyrus for response inhibition. Improvement in cognitive function during adolescence allows them to have better organizational skills and memory retrieval [1].

In addition to cognitive control, an adolescent goes through adjustments in their social and emotional cognitive function [1]. In the social brain, adolescence has a greater activation in the medial PFC and reduced activation in the temporal cortex compared to adults (Figure 1) [1]. When receiving emotional stimuli or presenting an award, the amygdala and striatum peak in activation. In Figure 1, the cortical regions that are highlighted show that during adolescence there is a decrease in the gray matter and cortical thickness. It is also presented that the amygdala increases and the striatum decreases during adolescence. In the social brain, the medial prefrontal cortex (MPFC), anterior temporal cortex (ATC), posterior superior temporal sulcus (pSTS), and temporal-parietal junction (TPJ) are key regions of adolescent’s thinking networks [1].

One of the psychological and physiological problems that adolescents go through is stress. Stress can change the brain function and responses in behavior [2]. Throughout life, individuals are faced with situations that can lead to stress. The individual can respond to stress through the sympathetic nervous system which leads to the "flight-fight" response. Slower response to stress that a person can go through is mediated by hypothalamic-pituitary-adrenal (HPA) axis [2]. Adolescents possess a heightened stress-induced hormonal response because of important shifts in the HPA axis reactivity. These adjustments in the stress activity have yet to have answers on what mediates and what impacts they may have on an individual. The stress-sensitive limbic and cortical
brain that continue to mature may be susceptible to this shift responsiveness. However, disturbance in the maturing adolescent brain may add to the increase of stress-related disorders such as anxiety and depression [2].

**Media Use and Adolescent’s Mental Health**

Cellphones and technology play a significant role in today’s society in American lives. In 2018, it was reported that 95% of adolescents use or own a smartphone [3]. Cell phones have many different uses such as staying in touch with friends and family, capturing photos, social media, work, and sometimes even schoolwork. With 85% of young people using some form of social media, teenagers can communicate with other people through a screen. Facebook, Instagram, and Twitter are examples of social media networking sites. Social media can be considered an addiction because it causes tendencies such as fixation, compulsive use, mood modification, tolerance, and withdrawal. Researchers have found some correlation between a social media addiction and some mental health disorders, such as anxiety and depression. For instance, someone suffering from anxiety may turn to social media to avoid interactions in real life. Someone with social anxiety may browse through apps to pass time. Scrolling through apps may give them a sense of control thus reducing social anxiety that comes from face-to-face interactions. Researchers point out that the constant use of social media to reduce social anxiety can lead to a social media addiction [3].

In addition to social anxiety, adolescents can have general anxiety disorders. In adolescents, symptoms of anxiety can overlap with symptoms of depression [4]. Anxiety can manifest from using social media, where adolescents may compare themselves with peers in a negative manner or replace physical interaction with apps such as Facebook, Instagram, and Snapchat. On applications such as Facebook and Instagram, users can post pictures and videos, and other users can interact with the post with likes and comments. Seeking approval in the numbers of likes, positive comments, and followers can promote exorbitant social comparison in youth. It can also increase anxiety-related traits and trigger pre-existing symptoms of anxiety that are diagnosed. Specifically, Instagram usage was found to be linked with general anxiety in boys and also body dissatisfaction in girls. This can suggest that female adolescents are more prone to compare their physical appearance with celebrities deemed to be socially attractive or with other peers [4]. Teenagers acquire physical awareness of their bodies and peers and a sense of identity development. Posting “selfies”, or self-photos, is heavily practiced by youth through various applications. Being exposed to a vast number of posts can lead to body image dissatisfaction. Body image dissatisfaction can be defined as one’s figure not meeting the standards of the desirable figure [4].

Social media usage has been associated with symptoms of depression including, persistent sadness, changes in eating patterns, loss of interest in usual activities, and irritability. Passive social media use is identified as browsing through other users’ feeds or scrolling through comments and news feeds. Research has linked this behavior with depression because of its ability to trigger depression symptoms such as a loss of interest in usual activities or sadness. Passive social media use seems to be increased by symptoms of depression, loneliness, and a higher level of stress [4].
Humans in general are social beings and, therefore, require social interactions in their daily lives. Individuals gain relationships throughout life to help fill their social needs. Relationships during the adolescent stage have been recognized to have complex structures with various qualities [5]. Adolescents’ relationships can vary from different social complexity levels and forms. Friendships are a primary form of relationship during the adolescent stage that are important for emotional and social development. Friendship progresses from preschool age, which is characterized by play, to preadolescence, which consists of spending more time with friends and engaging in conversation among their peers. However, in adolescence, friendships become more complex and are generally characterized by having similar interests with their friends. Social status also becomes significant. Friendships can have a positive or negative impact on youth. For example, having helpful friends during stressful times can have a positive impact, while friends that gossip or spread rumors can have a negative impact. Research has told us that the main use of social media amongst college students is to fill social needs [5].

It was reported that social media can have a positive impact on adolescents like enhancing the social contact between adolescents [5]. Other benefits include independence, communication, and a sense of emotional connection with others. It was reported that 88% of preadolescents and adolescents use social media to keep in touch with existing friends and feel closer to them. Jordan-Conde found that late adolescents frequently use Facebook to discuss intimate subjects but they do not use it to form romantic relationships. A concept called ”the Internet enhanced self-disclosure hypothesis” was constructed by authors Patti M. Valkenburg and Jochen Peter[5]. It argues that adolescents’ use of the internet to increase social connectedness and wellbeing leads to an increase in self-disclosure. These authors conducted a study to support their claim which included that exchanging text messages increased friendship quality due to intimate online self-disclosure. Michal Dolev-Cohen and Azy Barak propose that adolescents can have an outlet for their emotions when distressed through instant messaging [5]. In their study conducted it was found that adolescents found emotional relief after a conversation with their peers. However, Kearney reported that interactions adolescents encounter on Facebook do not give the same amount of friendship quality compared to face-face interactions [5]. Moreover, it is important to consider adolescent personality characteristics such as introversion and extraversion when it comes to interacting on social media [5]. Valken reported that individuals who are deemed to be more extroverted are more likely to present themselves as older and more flirtatious [5].

In addition to being able to communicate with peers, there is access to news feeds and general information about different topics. Social media can be a source to deliver health information and prevention info about various infections to youth [6].Although public health information is abundant, others suggest that social media can have negative health consequences due to the false sense of privacy and the spread of provocative ideas [6].

Furthermore, adolescents’ risky sexual behavior and the consequences are a concern in public health [6]. Risky sexual behaviors can lead to sexually transmitted infections (STIs) and unplanned pregnancies. It was concluded by Landry that adolescents who logged into a social media
account at least once per day were more likely to engage in sexual activities. Frank also had similar finding that consisted of teens who uses an immoderate of technology had a higher increase of sexual risky behavior. Frank also found that teens who send or receive more than 120 messages a day and spend more than 3 hours on social media are more likely to be involved in unhealthy use of technology. He found that 72% of social networkers and 75.8% of texters send messages and photos that they wouldn't want their parents to find. Teens (56.4%) admitted that they use messaging and social media to go drink alcohol (41.5%) or make plans to have sex (27.4%) [6].

A study was conducted to analyze the relationship between social media and risky sexual behaviors and if parent monitoring mediates the relationship [6]. The study involved 555 Latins from Maryland, United States, ages ranging from 13-19 years old. The method for this study consisted of the participants completing baseline and follow-up surveys, and a mixed-effects linear regression was used to examine the objective of the study. The results have shown an increase in sexual risk behaviors between baseline and follow-up surveys. Adolescents sending more than one-hundred text messages a day had higher sexual risk scores. However, there was a decline in sexual risk scores because of higher parental monitoring. It was concluded that parent monitoring is essential for moderating sexual risk behaviors [6].

Along with analyzing the relationship between adolescents’ social and emotional behavior and social media, it is justifiable to consider the relationship between social media and academic performance.

**Academic Life**

In the United States, adolescents are a huge percentage of social media and smartphone users [7]. As a result, it is questioned whether social media "dependency" affects an adolescent. A study was conducted to examine the relationship between addictive phone use and academic performance. The study was conducted on 918 students in grades seven through twelve in three schools. The measures were completed by participants during physical education class over two weeks at the start of fall semester 2017 and spring semester 2018. The order of testing of the measure of the study was consistent among all three schools, completing surveys through laptops.

The individuals who reported using a smartphone were included in the final measurement, which left 641 participants (53.8% female) [7]. Participants were asked to report the occurrence of symptoms of smartphone addiction on a Likert scale from 1 (never) to 5 (always) [7]. A sample question for the survey was “During the last year, how often have there been times when all you could think about was using your phone?”. Adolescents were asked to complete nine items and identify which apps they use most to identify the problematic use of smartphones. Participants were also asked how many hours they use social media (Facebook, Twitter, or Instagram) and responses included a Likert scale (ranging from 0-5 hrs). They also were asked how frequently they use social media apps while doing homework and responses include a Likert scale ranging from 1 (never) to 4 (often). Additionally, students reported the grades they usually received ranging from 1 (mostly A’s) to 4 (mostly D’s). Results indicated that there was a correlation between poorer academic
performance and excessive use of social media multitasking during homework. Therefore, smartphone addiction may be a risk factor for poor academic performance [7].

As previously stated it is known that a strong dependency on smartphones can contribute to poor academic performance in adolescents [7]. In school, students receive homework to help further their understanding of a topic that is taught to them. Researchers wanted to find out more about digital multitasking among high school students when completing homework [8]. Digital multitasking can be defined as simultaneously completing tasks while using a digital device. It is shown that Digital multitasking can hurt a student’s academic performance. For example, a class that constantly digital multitasks shows lower grades, test scores, and overall GPA. It also can affect comprehension, recognition, and recall during reading assignments. A study further explored the effects of digital multitasking when it was done during homework. It involved 135 students from 4 U.S. public high schools to look into how teens felt about digital multitasking. Researchers found that teens were distracted 38% of the time due to the use of digital devices and mind-wandering. The 64% of teens surveyed supposed they should pay more attention and wanted to try plans to help decrease distractedness, such as silencing phones. The students spent about 204 hours trying to finish homework but kept getting distracted [8].

Along with digital devices affecting the completion of homework in adolescence, different researchers wanted to observe how learning and memory was affected with a smartphone present [9]. The study consisted of the Smartphone Addiction Scale (SAS), a scale that measures a person addictiveness to smartphones based on a six point Likert Scale (1 - “strongly disagree” and 6 - “strongly disagree”), a memory task that was completed by 119 undergraduate students [9]. It was discovered that students who use a smartphone have a lower recall accuracy than those who don’t use a smartphone. The results presented a negative relationship between phone conscious thought, the number of times a person thinks about their phone, with memory recall. However, there was not a relationship between SAS and memory recall. Researchers discovered that there was a negative effect on an individual’s memory and learning with a smartphone nearby due to the presence of a smartphone and an increased phone conscious thought affecting learning and memory [9].

Sleep Quality

Obtaining an adequate amount of sleep contributes to the proper functioning of the brain, so all ages need to get an appropriate amount of rest every day. Adolescents spend at least a third of each day sleeping, which makes it a core behavior among them [10]. Bedtimes become later as adolescents age, because of delays in the circadian system and changes to the homeostatic sleep-regulating system, and the time waking up depends on school start times. Studies show that teens in the U.S. lose approximately about 90 minutes of sleep each school night from 11-12 years old to 17-18 years old. The average amount of sleep was 6.9 hours for high school seniors [10].

Poor sleep quality and later bedtimes in adolescents is often caused by excessive internet use [11]. A study was conducted to evaluate the correlation between internet addiction and sleep quality in adolescents. The study was conducted in a peri-urban area in Nepal with 390 adolescents
completing a questionnaire survey. Poor sleep quality was measured by the Pittsburgh Sleep Quality Index and internet usage was measured by the Internet Addiction Test. Results showed that 21.5% of the participants were identified with borderline internet addiction and 13.3% with possible internet addiction. It was discovered that 31% of the participants had poor sleep quality, and internet addiction was associated with poor sleep quality. Adolescents with an internet addiction were more at risk to have poor sleep quality [11]. Furthermore, a crossover experimental study showed that usage of electronic screens (e.g., an individual using social media) before going to sleep resulted in an increased time to fall asleep, a decrease in melatonin secretion, a delay in the circadian clock, and rapid eye movement sleep, and reduced alertness in the next morning [12].

All in all, during the period of adolescence, brain structure goes through changes and development. In the company of rising numbers of adolescent users of social media, researchers question the effects on their behavior. Current research shows, social media impacts mental health and contributes to anxiety and depression syndromes, influences social and emotional behavior, has negative effects on academic influence, and contributes to poor sleep quality.

References


The Effect of Musical Stimulation on Cerebral Activity and Anxiety: A Literature Review
Eshaan Gandhi

Abstract
Around the world, people listen to music for entertainment, culture, and even pleasurable feelings. However, a significant proportion of people that listen to music are unaware of the hidden neural benefits that it provides when it is used leisurely. In fact, with rising numbers of people with high levels of cortisol due to harmful changes in society, the usage of music as therapy to lower the anxiety levels of individuals is a possibility. Using a combination of electroencephalogram, pulse, skin reaction, and survey data from a variety of studies, we found evidence for the beneficial usage of music as an antidepressant. The habitual listening of music stimulates the auditory cortex and was found to have a relaxing effect. Our findings suggest that music can have a strong effect on the human psyche due to the natural stimulation of the auditory cortex and other areas of the cerebrum, which can have hormonal and somatic related effects indicating a feeling of reward and relaxation.

Introduction
Music is an art that is listened to by a significant number of people around the world, and ultimately, has developed into an international language. Approximately 7.11 billion people around the world listen to music, which is about 93% of the global population [9]. However, there are numerous neurological benefits that music can provide to a significant number of people who are unaware of such benefits. Furthermore, there is a significant amount of information that scientists are unaware of regarding the association between music and neuroscience, particularly, how emotions are created as a result of physiological brain activities which are induced by music. With the lack of information that is available on these topics, scientists don’t have an adequate understanding of underlying neuroscience mechanisms that could be used to improve the well-being of people, specifically, by creating different therapies for those with...
anxiety or other neurological deficiencies. In this paper, scientific information regarding the stimulation of the cerebrum through music will be discussed through a literature review regarding EEG, pulse, dermatologic reaction, and individual assessment data to address this problem and determine the effectiveness of potential therapies (See Figure 1).

**Electroencephalography Data**

By using EEG to detect stimulations in brain activity, the benefits of music in a neurological sense can be seen. EEG is a non-invasive and painless method of collecting authentic electric neurological data. In an experiment conducted by Jessica Sharmin Rahman et al., 24 students at the Australian National University listened to classical, instrumental, and pop music through noise-canceling headphones to ensure that the collected data would be affected exclusively by the music. The goal of this experiment was to understand how different genres of music, which contain different rhythms, affect electrical signals within the cerebrum. Results of the experiment showed that gamma levels—the brain wave with the highest frequency—were found among all the types of music, and the strongest brain wave activity was found when participants listened to instrumental music [3]. Gamma waves in particular have been found to increase cognitive function, efficiency in memory, and focus. [3]. These findings illustrate just a few of the benefits that music can offer, including reductions in the common condition of anxiety. In fact, according to Dr. David Lewis-Hodgson, listening to music that doesn’t have a lot of words can reduce anxiety levels by up to 63% [10].

In a study by Dr K Vijayalakshmi et al., 10 subjects were recruited and given an audio sample of alpha music in the frequency range of 8–12 Hz. For each subject, three EEG recordings were taken to ensure representative data would be collected. Results of the study show that based on the EEG patterns, there was an increase in the maximum amplitudes of alpha brain waves after 6 minutes of listening to alpha music or after 12 minutes of listening to alpha music [7]. Furthermore, there was a 40% decrease in the maximum amplitude of beta brain waves from the initial value [7]. This study shows the benefits of listening to music in regards to a reduction in anxiety as alpha brain waves induce feelings of calm and indicate a restful and relaxed brain [3,11]. On the other hand, the release of significant amounts of beta brain waves is associated with significant amounts of stress [3,11]. As a result of listening to music, alpha waves significantly increase while beta waves significantly decrease, which has been proven to decrease anxiety as a whole (See Figure 2) [21]. With this, there also may be a connection between the music of a certain frequency that could potentially cause a certain frequency of brain wave to be more prevalent when it is played.
To emphasize the results of this study, R W Wilkins et al. conducted a study in which 21 young adults were recruited based on their favorite type of music. Before the scanning, participants filled out a questionnaire so directors were aware of their favorite song, favorite genre, and least favorite genre. For each subject, brain activity within the cerebrum was scanned using an fMRI. Results of the study showed significant brain activity within the default mode network (DMN), a network of interacting brain regions that are activated when an individual becomes unfocused on their external environment [12], as well as the auditory cortex (See Figure 3) [8]. The recognition of such brain activity within the DMN indicates the presence of alpha waves, specifically inducing tranquility [20]. In the discussion of these findings through EEG, it can be concluded that electrical activity through various brainwave frequencies is significantly more prevalent in different parts of the cerebrum when music is played compared to when it is not, which can have attentive and emotional benefits. Not only this, but it can be determined that different genres may also have different beneficial effects on how these brainwave frequencies behave based on rhythmical devices or the prevalence of words. The continuation of the usage of EEG to study the connection of the stimulation of brain wave frequencies through playing music is vital to the further development of research within this field.
Stimulating brain activity through music can also influence other parts of the body. The organs that show the most change, excluding the brain, are the heart and skin. To start, significant changes in pulse behavior were seen in a study conducted by Samitha Siritunga et al., who collected the pulse rates of 127 randomly selected asymptomatic individuals aged from 45 to 65 years old. Samples of pulse rates were taken before and after listening to classical Indian music, which typically starts with slow rhythms but slowly increases to rapid and exciting rhythms, for 22 minutes to see if a significant change occurred. Similarly, the pulse rates of 125 randomly selected individuals with the same conditions as the study group acted as a control group in which they sat in silence for 22 minutes. The pulse rates of the individuals from both groups were collected using an OMRON IA2, a blood pressure monitor. Results of the study showed that the individuals who listened to 22 minutes of classical Indian music showed a decrease in pulse rate by about 6.7% (77.5 BPM → 72.3 BPM), which was statistically significant at α = 0.01 [6]. With a decrease in pulse rate, the cortisol levels within the body likely decreased, indicating a decrease in anxiety as high levels of stress are associated with faster heart rates. [13]. As a result, the body will start to feel more relaxed, indicating that music can have a beneficial stimulative effect on how a person is feeling.
Furthermore, listening to music can affect another organ: the skin. In a study conducted by Matthew E. Sachs et al., 20 participants listened to their favorite collection of songs. During the listening phase, whenever the participants felt a frisson, they pressed a button. Results showed that around 50% of the participants had a skin-related reaction to the music (See Figure 4) based on the number of times the button was pressed as well as the skin conductance responses of the subjects through the usage of finger electrodes [5]. Not all the reactions could be detected by the button alone, as past literature has shown that using the button alone does not account for all skin conductance responses, which is why two measurement types were necessary. This study also found a significant yet innocuous decrease in heart rate as a result of the subjects listening to their favorite songs [5]. The reactions that occur on the skin as seen in the study can indicate that the hypothalamus is releasing anxiety-reducing hormones [14]. According to Roni Granot, the phenomenon of receiving frissons down the spine or getting goosebumps is a result of immense pleasure, which comes from the release of dopamine in the brain [2]. This indicates that the human brain understands that listening to music is a beneficial experience for the person listening, in which it releases dopamine, which is why many people feel pleasure when listening to music. The physical changes of listening to music come in the form of goosebumps or frissons, which is a side effect of the significant amount of dopamine that is released [2].

**Individual Assessment Data**

In some situations such as music, data is best collected by individual opinion through surveys and questionnaires rather than bodily reactions to natural occurrences. This allows scientists to collect data based on emotions and compare it to the data that is found in EEG, pulse, or dermatologic reaction data, and create associations with different types of information within those.
fields. Individual assessments were demonstrated in a study conducted by Tiffany Field et al. [14] chronically depressed adolescents with significantly high levels of cortisol, the stress-inducing hormone, agreed to listen to 23 minutes of popular music, all with varying rhythms and harmonies. Results through the completion of a Music Rating Scale (MRS) showed that after listening to the music provided by the study, the adolescents averaged 22.3 on a 30-point scale on how the music made them feel [1]. This study suggests that individuals who listen to music, regardless of rhythmical classification, tend to enjoy the experience of music, therefore boosting their happiness and decreasing levels of anxiety [1,2]. Such data can be compared to EEG, pulse, and skin reaction data, which also show how music can stimulate the brain, directly causing reductions in stress hormones.

Implications

Based on the results found in this review, many implications of music as a natural stimulator or antidepressant have been found. Specifically, evidence for music as a natural stimulator can be seen in the difference between test scores before and after an individual listens to music. For example, listening to Mozart for 10 minutes can increase mean IQ scores by 8 or 9 points, which is known as the Mozart effect [16]. Similarly, individuals who listen to music have been proven to have higher attentiveness than those who don't listen to music [17]. In addition to being an excellent natural stimulator, music can also be utilized as a natural antidepressant [18]. As discussed throughout this paper, listening to music allows for anxiety levels to significantly decrease, which is evident by EEG, pulse, skin-related reaction, and individual assessment data. With music therapy being increasingly used to treat anxiety, the positive effects that music has on those with high levels of cortisol can reach larger populations through verified prescriptions [19]. The usage of music therapy should be further acknowledged to assist individuals with severe anxiety-inducing effects.

Conclusion

In summary, the lack of education regarding the positive effects of cerebral stimulation through music is an international issue that needs to be addressed. Although about 93% of the international population currently listens to music for cultural or recreational reasons, a significant amount of people have not been made aware of the stimulating effects music has to offer. By using EEG, pulse, skin-related reaction, and individual assessment data to persuade populations to advocate for the extended usage of music for cerebral stimulation, it may potentially increase their overall well-being. With anxiety being an increasingly prevalent issue, the usage of music to alleviate the effects is an extremely dynamic method. The increased prescription of music therapy should be administered to further induce anxiety-alleviating effects in larger populations. Further research based on the stimulation of the cerebrum through music could focus on implementing the effects of music into the cerebrum, without having to listen to music using technological advancements. Through this literature review, the benefits of the extended usage of music worldwide have been proved through the significant evidence in support of the stimulating and anxiety-reducing effects that music has on all populations.
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Glossary

- **Electroencephalography (EEG):** A graphic representation of the differences in electrical activity between various cerebral areas that is created by signals between cerebral neurons
- **Harmony:** The process of conjoining individual sounds to generate a whole sound containing several vibrational units
- **Rhythm:** Repeated patterns of movement or sound vibrations
- **fMRI:** Functional magnetic resonance imaging
- **Dopamine:** A chemical released in the brain that makes you feel good
- **Frisson:** A psychophysiological response to rewarding auditory and/or visual stimuli

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Cognitive Behavioral Therapy: Justifying its Use for Rehabilitation in Multiple Sclerosis Patients

Kristen Ngai

Abstract

Multiple sclerosis (MS) is a degenerative disease that damages the nerve fibers of the central nervous system, affecting 2.8 million people worldwide [1]. A therapeutic intervention, known as Cognitive Behavioral Therapy (Cognitive Behavioral Therapy), can be used to treat anxiety and depression in multiple sclerosis patients. First, this article starts with an introduction of multiple sclerosis and the cultural disparities of Cognitive Behavioral Therapy. Then, the article examines the ethical considerations related to Cognitive Behavioral Therapy. Lastly, this essay transitions into discussing the current controversies and the future implications of using Cognitive Behavioral Therapy in multiple sclerosis patients.

Multiple Sclerosis: An Overview

A middle-aged woman sits quietly near a windowsill, trying to predict when her next multiple sclerosis relapse will be. Pain radiates through her spine and her legs, forcing her to carry a cane each time she limps across her bedroom. Tears roll down the woman’s shriveled cheeks as she recalls the wonderful memories she had with her family before her diagnosis.

She is not alone. Multiple sclerosis is a disease that affects roughly 2.8 million people worldwide and has no definitive cure. As the disease develops, a patient’s immune system attacks the body’s tissues, which destroys a coating on nerve fibers in the central nervous system called the myelin sheath [2]. Symptoms of multiple sclerosis include: muscle weakness, tremors, loss of vision, pain, and even paralysis. Unfortunately, multiple sclerosis is highly unpredictable and patients experience unexpected relapses that worsen over time.
More importantly, the excruciating symptoms that multiple sclerosis patients face greatly alters their overall quality of life. 30-40% of multiple sclerosis patients experience depression [3]. Furthermore, 34-70% of early diagnosis of multiple sclerosis patients suffer from anxiety [3]. The overwhelmingly high rates of anxiety and depression demonstrates the necessity of Cognitive Behavioral Therapy, a type of talk therapy, to alleviate these psychological symptoms in multiple sclerosis patients.

Cognitive Behavioral Therapy and Cultural Disparities

Although there are drugs to alleviate the symptoms of multiple sclerosis, these drugs alone cannot cure the disease and need to be supplemented by other cognitive therapies. For instance, depression is a significant symptom in multiple sclerosis patients that may lead to suicidal ideation, and is not curable with only antidepressants. Therefore, Cognitive Behavioral Therapy is a type of talk therapy that connects a person’s thoughts, feelings, and behaviors to help multiple sclerosis patients better cope with their symptoms psychologically (Figure 3).

However, much more work is needed for a more unified approach of Cognitive Behavioral Therapy when accounting for patients of different cultures and ethnic backgrounds. Currently, there are prominent cultural disparities in the quality of therapy. For instance, the percentage of African American and Latinos who continue treatment after 3 months was found to be 30% lower than the White population, which is largely due to the imbalance of education among people of different ethnicities [7]. This reveals the importance of education and awareness among people of different ethnic backgrounds. Furthermore, physicians can individualize Cognitive Behavioral Therapy based on a person’s cultural views. Physicians may alter therapy plans when a patient is being culturally sensitive or if they are openly discussing different cultures when conducting Cognitive Behavioral Therapy. Therefore, cognitive therapy can be conducted in a more effective and inclusive way if physicians individualize their treatment interventions.

Ethical Considerations of Cognitive Behavioral Therapy

When conducted in a small group setting, Cognitive Behavioral Therapy can be as effective as medication for treating multiple sclerosis [3]. First, Cognitive Behavioral Therapy is beneficial because it teaches participants practical and helpful strategies to cope with their disease symptoms [2]. Secondly, Cognitive Behavioral Therapy focuses on redirecting a patient’s thoughts and improving their behaviors to improve the level of anxiety in multiple sclerosis patients. For instance, if a patient begins to accept the pain that they are experiencing and strives to control their negative mindset when dealing with each multiple sclerosis relapse, they can be more mentally stable.
However, Cognitive Behavioral Therapy poses disadvantages to some patients when not used appropriately. First, Cognitive Behavioral Therapy requires a patient to confront their own emotions and anxieties, which can make them feel emotionally vulnerable when being surrounded by a group of strangers [4]. In addition, Cognitive Behavioral Therapy only addresses current problems in multiple sclerosis patients, and does not address other underlying factors, such as financial obstacles, which may cause depression or anxiety in multiple sclerosis patients [3]. Thirdly, due to the structural therapeutic sessions (Weekly 30-60 min sessions ranging from 12-20 weeks) provided in Cognitive Behavioral Therapy, it may not benefit patients with more complex mental needs such as the Comorbid Diagnosis of Anxiety and Depression (CAD) [4].

Despite the potential drawbacks of Cognitive Behavioral Therapy, it should still be used as a method of treatment for multiple sclerosis patients as it helps them approach their disease symptoms in a more hopeful and accepting way. As shown in a study done by Gromisch in 2020, 95% of MS patients had an improvement in depression and overall quality of life when placed in Cognitive Behavioral Therapy [3]. To make each session more effective, it is also important for physicians to evaluate and personalize each session of Cognitive Behavioral Therapy so that it is most suitable for each patient’s needs. For instance, depending on the severity of the disease and a person’s age, the length and intensity of the therapy can be altered. The intersection between neuroethics and Cognitive Behavioral Therapy lies in the specificity of the therapeutic sessions and targeting multiple sclerosis-specific symptoms in order to achieve a higher efficacy rate.

Conclusion and Future Directions

Neuroscience and ethics allows us to investigate the variation in therapeutic options for depression and anxiety in multiple sclerosis patients. The studies pointed out from above reveal the pros and cons of using Cognitive Behavioral Therapy in treating and preventing both anxiety and depression symptoms [2]. Although some patients may not benefit greatly from Cognitive Behavioral Therapy, positive thinking and perseverance is still an important skill for patients when facing adversity.

In order to address the society’s ethical concerns of the therapy, future research can be done on altering the timing and the intensity of each therapy session and tailoring each therapeutic session to the individual. Cultural differences can also be incorporated into Cognitive Behavioral Therapy so that people of different ethnic backgrounds can be benefited as well. Hence, each Multiple Sclerosis patient can benefit more from Cognitive Behavioral Therapy and retain a better quality of life and a healthier mental state.
References


Abstract

Swallowing, also known as deglutition, is a process that involves the movement of substances from the mouth to the stomach. It involves dozens of muscles and nerves in the oral cavity, pharynx, larynx, and esophagus which work together to facilitate this process. An impairment in the function of deglutition can lead to difficulty in swallowing or dysphagia. Dysphagia affects a large population of the elderly and is a common cause of morbidity and mortality. This paper reviews the neurological causes of dysphagia.

Physiology of Swallowing

Swallowing refers to the movement of substances from the mouth to the stomach via the pharynx and esophagus. It is a complex process involving muscles from the oral cavity, pharynx, larynx and esophagus [1]. It occurs via both voluntary and involuntary action in three main phases which include the oral phase, pharyngeal phase and esophageal phase [2].

The oral phase can be divided into an oral preparatory phase, where the bolus undergoes manipulation in readiness for swallowing, and an oral propulsion stage that involves elevation of the tongue, an action that results in the movement of the bolus posteriorly into the pharynx. The phase that follows is the pharyngeal phase. This phase begins as the bolus enters the posterior mouth and pharynx. It stimulates the epithelial swallowing receptors and transmits impulses to the brain stem, which initiate a series of autonomic pharyngeal muscle contractions. These in turn result in the upward pull of the soft palate to cover the posterior nares, swinging back of the epiglottis over the opening of the larynx and elevation of the hyoid-laryngeal complex [1][3]. The final phase, the esophageal phase, involves the action of peristaltic waves that propel the food downward to the stomach (see figure 1) [4].
Dysphagia

Dysphagia is defined as difficulty in swallowing or as an objective impairment resulting in an abnormal delay in the transit of a liquid or solid bolus. It can be classified as oropharyngeal or esophageal, that is, the difficulty in swallowing originates from the oropharyngeal or esophageal phase of swallowing [6]. From a subjective perspective, dysphagia can be defined as a patient’s sensation of a delay in the transit of a liquid or solid bolus during swallowing. Both the objective and subjective definitions are essential in that a patient can lose the sensation of the delay in swallowing but objective tests will show evidence of the delay. Patients suspected of dysphagia should therefore undergo tests to confirm the diagnosis due to the fact that neuronal sensory dysfunction can potentiate or attenuate the patient’s symptoms [7][8].

Dysphagia is a common problem in the elderly and is associated with complications such as the increased risk of aspiration, aspiration pneumonia, malnutrition, decreased quality of life, prolonged hospital stay, and increased morbidity and mortality [9]. The management of dysphagia depends on a broad understanding of the cause and associated symptoms.

Figure 1. Shows the stages of swallowing [5]
Difficulty in swallowing may occur during the oropharyngeal phase or the Esophageal phase. Causes can be neurological, muscular, or anatomical or can be due to mechanical obstruction or motility disorders respectively [10] [11].

**Neurological Causes of Dysphagia**

Damage to the nervous system interferes with nerves responsible for starting and regulating swallowing. It is this interruption in the functionality of these nerves that results in dysphagia.

Some examples of neurological conditions implicated in the development of neurological dysphagia include Parkinson’s disease, multiple sclerosis, myasthenia gravis, amyotrophic lateral sclerosis and poliomyelitis.

**Parkinson’s disease**

Parkinson’s is a chronic neurodegenerative disorder of the central nervous system that affects the motor system. It is a slowly progressive disease which worsens with the development of non-motor symptoms. Typical clinical features involve resting tremor, rigidity and movement disorders consisting of bradykinesia with postural instability occurring in the later stages of the disease. Cognitive and behavioral problems may also occur such as depression, anxiety and apathy. [12][13]

Parkinson’s disease is due to the death of cells in the substantia nigra, a region of the midbrain, leading to dopamine deficiency [14]. The mechanisms of injury that lead to cellular death in Parkinson’s disease include misfolding and aggregation of a protein called alpha-synuclein in the neurons, abnormal protein clearance, mitochondrial dysfunction, and neuroinflammation [12].

The cells affected are located in the brain’s Basal ganglia, and these cells are dopaminergic (DA) neuromelanin-containing and noradrenergic neurons in the locus coeruleus [15]. These cells are responsible for the secretion of dopamine, which is essential for the coordination of motor activity. The basal ganglia normally exert a constant inhibitory influence on a wide range of motor systems and this prevents the inappropriate activation of motor systems. When a particular motor system wants to perform a particular action, inhibition is reduced to that system releasing it. The function of Dopamine is to facilitate the release of inhibition, therefore high levels of dopamine promote motor activity while low levels require greater exertion of effort for any given movement or motor activity as seen in Parkinson’s disease [16]. The net effect is hypokinesia. Patients of Parkinson’s disease eventually develop oropharyngeal dysphagia due to the effects of the disease on the muscles of the face, neck and throat [17].
Multiple sclerosis

Multiple sclerosis (MS) is an autoimmune disease of the central nervous system, it is the most common demyelinating disease which is characterized by chronic inflammation, gliosis and neuronal loss [18][19]. Perivascular lymphocytic infiltrates, and macrophages cause damage to the insulating covers of nerve cells of the central nervous system resulting in a disruption in the ability of parts of the nervous system to transmit signals [20]. The exact etiology of MS is unknown, however factors involved in pathogenesis can broadly be grouped into three categories which include immune factors, environmental factors and genetic associations [21]. MS affects muscle strength and muscular coordination, both of which are involved in swallowing [22].

Amyotrophic lateral sclerosis

Amyotrophic lateral sclerosis (ALS) also known as Lou Gehrig’s disease, is a neurodegenerative disease of motor neurons. “The pathology of amyotrophic lateral sclerosis is characterized by degeneration and gliosis of axons within the anterior and lateral columns of the spinal cord. Motor neurons within the spinal cord anterior horns and Betz cells within the motor cortex are also lost” [23]. ALS affects both upper and lower motor neurons, it has a variable pattern of onset and commonly begins with degeneration of lower motor neurons with symptoms such as muscle stiffness, muscle twitches and gradually increasing weakness and muscle wasting. ALS can manifest, initially with either, symptoms of the limbs such as weakness in the arms or legs, or, with symptoms associated with the pons and medulla of the brainstem known as the bulb or bulbar area of the brain. symptoms of the pons and medulla that could be noted could include difficulty speaking or swallowing [23] [24].

Another degenerative cause of dysphagia is progressive supranuclear palsy, a degenerative disease of the cervical spine [7].

Myasthenia Gravis

Myasthenia gravis is a common neuromuscular disease that affects the neuromuscular junction of the skeletal muscles. The muscles that are affected by this disease include muscles of the eyes, throat and extremities. Myasthenia gravis is an autoimmune disease, that occurs in genetically susceptible individuals with precipitating factors such as infections, immunization, surgeries, and drugs [25]. In Myasthenia gravis, autoantibodies against the specific postsynaptic membrane proteins are formed. These autoantibodies include immunoglobulin IgG1, IgG3 and sometimes IgG4 (without activation of complement). These autoantibodies block or destroy nicotinic acetylcholine receptors (AChR) at the junction between the nerve and muscle hence reducing the transmission of electrical impulses across the neuromuscular junction resulting in muscle weakness [26][27].
Poliomyelitis

Poliomyelitis is an infectious disease caused by the polio virus; it is a highly infectious disease transmitted by fecal-oral contamination with lymphatic replication. Since the 1980s there has been a worldwide vaccination effort which has almost completely eradicated the disease [28] [29]. Primary infection can lead to viral replication in oropharyngeal and gastrointestinal lymphatic tissues, the infection can also spread to the Central nervous system causing paralytic poliomyelitis. After the spread to the CNS, the virus preferentially replicates and destroys the motor neurons within the spinal cord, brain stem, or motor cortex. Some of the early symptoms of paralytic poliomyelitis include stiffness in the back and neck, asymmetrical weakness of various muscles, sensitivity to touch, difficulty swallowing and muscle pain [30][31].

Neurogenic dysphagia due to trauma

Owing to the large variety of structures involved in swallowing, different pathophysiologic mechanisms can lead to dysphagia [32]. Neurogenic dysphagia results from the impairment of the oral and pharyngeal phases of swallowing due to neurologic disorders [33]. In addition to this, dysphagia may also result from trauma due to several causes. Traumatic brain injury, for example, results in impaired oropharyngeal function, cognitive deficit and behavioral problems that can affect swallowing and hence lead to dysphagia [34]. It has also been noted to result in frequent aspiration which points to an impairment of the pharyngeal phase of swallowing wherein the action of the epiglottis in covering the airway is impaired [35].

A study also showed a considerable percentage of swallowing or oral motor problems in head-injured patients on admission [36]. Trauma due to oro-tracheal intubation and the mere presence of an endotracheal or tracheostomy tube usually indicated in trauma patients could result in a disruption of the function of the larynx in swallowing [37]. Laryngeal trauma and non-ideal positioning are other trauma-related causes of dysphagia [38][39].

Conclusion

Dysphagia may result from either neurological causes such as Parkinson’s disease, myasthenia gravis, poliomyelitis, multiple sclerosis and amyotrophic lateral sclerosis or from trauma to any of the structures involved in swallowing. It becomes more prevalent with age, affecting a large population of the elderly and may lead to various complications such as aspiration pneumonia, malnutrition or choking, all of which lead to increased risk of morbidity and mortality among those affected. A better understanding of the causes can help prevent the modifiable risk factors and ultimately help in the clinical care of patients suffering from dysphagia.
Glossary

- Betz cells: the largest neuron of the cerebral cortex located in the primary motor cortex
- Bolus: a soft mass of chewed food.
- Degenerative: a disease in which the function or structure of the affected tissues or organs changes for the worse over time.
- Gliosis: a fibrous increase of glial cells in damaged parts of the central nervous system.
- Locus coeruleus: a nucleus in the pons of the brainstem involved with the physiological responses to stress and panic.

References


The Ability of Neural Stem Cells to Treat Spinal Cord Injury

Rithvik Marri

Abstract

Stem cells have been extensively studied to determine their potential in medicine. It has been found that neural stem cells have the ability to regenerate nervous system tissue, something previously thought to be impossible in adults. Spinal cord injury is one of the most damaging central nervous system diseases. It can lead to partial or full paralysis and significant decrease in quality of life. Neural stem cell therapy could be a vital step towards the future of spinal cord injury treatment and rehabilitation. This article will discuss in depth about both stem cell therapy and spinal cord injury with a focus on the different ways neural stem cells have been acquired and used to treat the disease.

Introduction

Spinal cord injury (SCI) is a debilitating disease that dramatically affects the life of those who suffer from it. It is estimated that 250,000 to 500,000 people globally are diagnosed with an SCI every year. Those who live with it, have to also live with a debilitating neurological and social burden. They often are at risk for other health conditions and are more likely to die prematurely compared to the general population. Most people with an SCI are not viewed the same as the rest of society due to mobility issues and negativity surrounding their condition. SCI is typically treated symptomatically with no overall cure existing till now. The constant upkeep and rehabilitation required for someone with SCI is more expensive than other similar diseases of the nervous system [1]. For these reasons and others, stem cell therapy has been explored as a potential treatment for SCI due to the ability of stem cells to differentiate and replace damaged or dead cells in the case of an SCI. Specifically, neural stem cells, the multipotent cells that give rise to neurons and glial cells, have been used in studies and trials to investigate their therapeutic effect on SCI. Early results have been encouraging, but further research and innovation is required before stem cell therapy is considered to be the norm to treat SCI.

About Spinal Cord Injury

Spinal cord injury is damage to the spinal cord caused either by trauma (examples include vehicle crashes) or by disease and degeneration. Once the damage occurs, the injury can be classified
based on the spinal cord level that was affected, with higher lesions in the cervical region, or the neck area, that can cause full or partial tetraplegia (all four limbs are paralyzed), to lower lesions that can cause paraplegia (where lower limbs are paralyzed). Symptoms also include loss of bowel and bladder control, exaggerated reflexes, and difficulty in breathing [2].

The pathophysiology of a spinal cord injury is incredibly important when considering different treatments. An SCI can be divided into phases, namely, an acute phase and a chronic phase. The acute phase happens from the initial injury to the weeks after, while the chronic phase follows in the months and years past that. The acute phase can then be broken down further into the primary injury and a secondary injury, seen in Figure 1.

The primary injury is the time when the lesion occurs, and that leads to instant cell death and hemorrhaging [3]. The secondary injury then follows, and causes large-scale damage to spinal cord tissues, including excitotoxicity, ischemia, edema, and other manifestations, shown in Figure 1. The secondary injury can also lead to necrosis that causes apoptotic signaling, which is a major reason for the degeneration at the lesion site and the demyelination of axons that lead away from the lesion [4]. This part of the acute phase can last minutes to weeks after the injury.

What makes it challenging to treat SCI is the chronic phase that comes months to years after the initial injury. The lesion site gradually grows due to disruption of the gray and white matter, resulting in cavity formation and inflammation. Reactive gliosis, the formation of large glial cells that surround the damaged tissue after injury, then occurs to close off the rest of the spinal cord from the lesion site, creating glial scar tissue that restricts the growth of axons from the lesion [4]. The microenvironment created at the injury site is inhibitory to cell self-repair, but the brain and spinal cord do have the ability to regenerate and make new circuits at the lesion. Therefore, the best therapy for SCI would be to modify the microenvironment and help restore the function to damaged neurons and glia [5].

**Stem Cell Therapy**

Stem cells have the unique ability to differentiate into various cells that can then structure and organize themselves into a living organism. It is due to this ability that stem cell therapy has long been seen as the future of disease prevention and treatment. It could be the next chapter in organ transplant, with no immune response and fewer cells needed to replace a failing organ. With the
prevalence of stem cell therapy in modern medicine, it has also made its way into treating central nervous system diseases, such as spinal cord injury.

The first stem cell used for therapy came from embryos, where embryonic stem cells or ESCs, were taken from mouse embryos and were shown to be able to differentiate into all three germ layers. ESC-derived oligodendrocyte progenitor cells were first used in a 2010 clinical trial with patients that had an SCI, and resulted in no reports of tumor formation or toxicity [3]. However, there are ethical concerns surrounding the use of human ESCs. Because they do need to come from human embryos, the embryo will be destroyed, potentially ending a life. The source and use of ESCs are important questions to consider when conducting research related to these cells.

An alternative to the ESCs that need to be extracted from early human embryos are adult stem cells. These are stem cells found in small numbers in adult tissues, like bone marrow and fat. The issue with adult stem cells, however, is that they do not have the same pluripotency, or ability to differentiate into many different types of cells, of ESCs [6]. As a result, sources of adult pluripotent stem cells were the focus of stem cell research.

Induced pluripotent stem cells were discovered in 2006 as a groundbreaking way to use the somatic cells of an adult and reprogram them to become pluripotent stem cells. Induced pluripotent stem cells, iPSCs, have used cells from skin and blood, and manipulated the genetic makeup so that the specific genes required to maintain a pluripotent cell were expressed. They are then transplanted back into the adult as part of the therapy [3]. Because iPSCs do not cause immune rejection and are easier to replicate than ESCs, they are seen as a better alternative to ESCs. The unintended, adverse effects that iPSCs may have on the patient, however, still require further research.

Neural stem cells, NSCs, can come from a variety of sources, shown in Figure 2. They can be taken from central nervous system tissue as adult stem cells, although they cannot be used as an autologous source. NSCs can also be the result of differentiation of ESCs or iPSCs, with the benefits discussed. And another, more novel, way of acquiring them is by changing somatic cells directly into neural stem cells, similar to how iPSCs are created, but skipping the step of pluripotent cells. This specific method has had very little testing done, but it is a prospective way to acquire more specific multipotent stem cells [3].

Figure 2. The sources and uses of neural stem cells [3]
Using NSCs to treat SCI

Stem cell therapy for SCI has been focused on grafting neural stem cells to the injury site to restore function lost by the injury. There are 3 main concerns to address with use of NSCs based on the pathophysiology of an SCI: the loss of neurons, the demyelination and degeneration of descending axons leading to poor signal connectivity, and the decreased amount of neurotrophic factors. These are the specific problems, along with the chronic inflammation at the injury site, that need to be addressed with different types and sources of cell therapy [7].

Neural stem cells, specifically in the CNS, eventually differentiate into neurons, oligodendrocytes, and astrocytes. Most of the damaged cells that need to be replaced after an SCI are neurons that then need to reconnect with the existing, undamaged neurons that are already part of the established circuit. Calcium imaging of neural stem cell grafts into SCI sites has shown that the NSCs organized into active synaptic networks whose behavior is very similar to that of the host networks. The host axons that regenerated into the graft did not have slow waves of excitation, indicating that the grafts behaved more like the original, healthy network, and not a damaged one. Furthermore, in early development, spinal cord neurons exhibit signals in rhythmic waves, compared to the more discrete activity of fully developed neurons. This more mature activity was also observed in the grafts, similar to postnatal activity [8].

A concern with the differentiation of NSCs at the injury site is the fact that the microenvironment of the SCI is more favorable to the differentiation of astrocytic glial cells than neurons, so few differentiated neurons exist compared to the total number of NSCs transplanted. As a result, increasing the neuronal differentiation potential of the microenvironment could also be beneficial to the treatment of an SCI. Two different ways to achieve the heightened neuronal differentiation is by regulating the microenvironment to make it favorable and intrinsically promoting neuronal differentiation through various factors. Using multiple biomaterials such as nanoscaffolds, hydrogels, and fibrin has shown improved neuronal differentiation that could better repair the damage caused by an SCI [9].

Neural stem cells have also been able to re-establish damaged long distance axonal connections. After grafting into the lesion site, the differentiated neurons have had their axons grow at surprisingly fast speeds and at high density, which could be indicative of how the NSCs would...
react after transplantation. The axons were also able to grow through gray and white matter, and even inhibitory glial scar tissue. Even in the most severe cases of SCI, the axonal regeneration was still incredibly effective [10]. And with the growth of axons, the synapses of the spinal cord tracts also need to be replaced. The chemogenetic stimulation of the grafted NSCs has helped synaptic formation to occur more efficiently, even in the host tissue surrounding the graft [11]. The ability to create synapses at a greater rate has shown that chemogenetic stimulation is a possible addition to neural stem cell therapy.

Another factor to consider is the use of neurotrophic factors to regulate the microenvironment created by the SCI and enhance transplanted NSCs. Multiple NSCs have been grafted with accompanying fibrin and growth factor mixtures, to encouraging results [10]. Figure 3, using fluorescence microscopy, shows the grafted neurons at the lesion site, indicating their ability to incorporate into the host tissue. A more direct way of introducing neurotrophic factors is by manipulating the NSCs to overexpress them before the transplant. With the NSCs and neurotrophins having a synergistic effect, the NSCs can be constantly supported and their survival chances increased. Specifically, NSCs overexpressing nerve growth factor, NGF, have been transplanted to the lesion core of an SCI and have had positive effects. NGF has been able to modify the inhibitory environment caused by the expression of myelin-associated inhibitors, like the glycoprotein Nogo, and inflammatory cytokines secreted by microglia and immune cells. Oligodendrocytes, the myelin sheath, and overall structure of the motor neurons were all able to be preserved by NGF-expressing NSCs [5].

The main therapeutic abilities of NSCs are the replacement of missing nerve cells, differentiation into neurons and oligodendrocytes, and the secretion of regenerative trophic factors. Transplanted NSCs can join the existing host network to rebuild the spinal cord circuits with axons from the host integrating into the graft. The new NSCs also release neurotrophic factors that promote the growth and maturity of the transplanted cells, allowing for increased differentiation of oligodendrocytes which then produce myelin to replace the myelin lost in the injury. Clinical trials have shown that NSCs transplantation can have a beneficial motor and sensory effect below the injury site. A potential future research focus would be combining NSC transplantation with other therapies in order to best treat the patient [12]. The current research for NSC therapy has been extensive, but more questions need to be answered before its widespread use.

**Remaining Questions**

There are still important elements to be considered about NSC therapy. The specific time to transplant is not always clear due to the different phases of an SCI. In the acute phase, a neuroprotective drug along with the transplant might be most beneficial, while in the chronic phase, a drug that breaks down the glial scar barrier would be more necessary. The optimal number of NSCs that need to be transplanted also needs further study, with early indications showing that there could be a range that varies with the severity of the injury [3]. The best route of administration can also vary. There is systematic and local administration, with local being more effective but containing more risks. Different methods that have been tested include intravenous, intrathecal, and
intramedullary injections [13]. Weighing the benefits and hazards is important in further testing to determine when to use each method of administration.

Another point is the cellular response to NSCs, specifically the tumorigenic capacity. When working with stem cells, there is always potential for tumors due to the rapid differentiation stem cells go through. Current research has shown that there is some tumor formation when working with the pluripotent derived NSCs, like the iPSCs that have been reprogrammed into pluripotent cells. It was shown that the tumorigenicity mainly came from epigenetic changes as a result of the factors used to create iPSCs [3].

The biggest obstacle, however, for the use of NSCs is the source of the cells. Research has been done to show prospective sources of NSCs that are safer than discussed options. Mesenteric neural stem cells come from autologous gut harvesting through endoscopic surgery. The procedure to isolate these NSCs is more simple and straightforward than to isolate other NSCs and can be done in the appendix to avoid critical damage [13]. Mesenchymal stem cells derived from adipose tissue have been the most common source of stem cells in recent times and it does have the ability to treat SCI, while also being the least traumatic stem cell type to acquire. Because they are adult stem cells and isolating them is minimally invasive, the same ethical concerns that exist for other sources of stem cells do not translate here [14].

Conclusion

Using neural stem cell transplantation is a promising way to treat spinal cord injury due to the ability to differentiate into cells that can repair the injury site and continue to support further recovery. The loss of neurons, the degradation of connective networks, and the inhibitory microenvironments that result from an SCI can be addressed with NSC therapy. Along with other combinatorial treatments, NSC transplantation has been able to render an SCI site and the host tissue around it to a functionable level that has provided sensory and motor improvement. However, significant further research needs to be done, specifically in clinical trials, to determine the success of NSC transplantation in a larger group of people, along with any adverse effects. As stem cells become a bigger part of modern medicine, the debate surrounding their use will grow as well. However, the potential is there, so it is a discussion well worth having. The ability to regenerate neurons and glia, which was seen as impossible, could be the future in neuromedicine.

Glossary

- **Excitotoxicity**: a phenomenon that describes the toxic actions of excitatory neurotransmitters that, when constantly activating receptors, leads to loss of neuronal function and cell death
- **Ischemia**: reduced blood flow to certain areas
- **Edema**: swelling caused by excess fluid trapped in tissue
- **Apoptotic signaling**: signals released to cells that command them to undergo programmed cell death.
- Autologous: obtained from the same individual.
- Fluorescence microscopy: optical microscopy that uses fluorescence to identify cells or tissue.
- Tumorigenic: the capacity to form or be favorable to form tumors.

References


Using Artificial Intelligence in the Diagnosis of Eating Disorders

Krishnaveni Parvataneni

Abstract

Anorexia nervosa, binge eating disorder, and bulimia nervosa are significant mental illnesses that are frequently disregarded. Such illnesses are categorized as eating disorders, which are often characterized by obsessions with one’s food intake, body weight, and body shape. As 24 million people in the United States alone suffer from eating disorders, timely management of illnesses including anorexia, bulimia, and binge eating disorder is necessary. Using an XGBoost model along with a Grid Search algorithm and Recursive Feature Elimination, an AI model trained on data from the National Longitudinal Study of Adolescent to Adult Health (ADDHealth) cut down the amount of patient data used to specific predictors and optimized the model’s accuracy.

Introduction

Over 28 million people in the US alone suffer from eating disorders such as anorexia, bulimia, and binge eating [1]. These disorders are characterized by an obsession with food, one’s weight, and/or body shape.

Patients with anorexia nervosa tend to have unusual eating habits, limiting how much they eat and exercising a lot. They often suppress their hunger, have a low body weight, and are dangerously thin [2]. This could have many detrimental effects, including potential organ damage.

Bulimia nervosa is characterized by cycles of binging and purging. This means that patients will eat uncontrollably, followed by purging the food from their body using laxatives, self-induced vomiting, fasting, or excessive exercise. Bulimics tend to have normal or slightly high body weight, but like in anorexia, are scared of getting fat, and are unhappy with their body shape. They are also very anxious and have peculiar eating habits, eating a large amount of food in a very short period of time. Bulimia also has complications like inflammation in the esophagus and parotid glands, kidney issues, and other mental health disorders like depression, anxiety, and OCD [3].

Finally, binge eating disorder is characterized by unusual eating habits in which patients are unable to stop eating, even though it feels out of control. These patients can present as overweight
or obese and often have binge episodes in which they eat large quantities rapidly. Unlike in bulimia, these patients don’t purge these extra calories, and a restricted diet could cause more binge episodes. Binge-eating Disorder has many social effects since there is often a social stigma against obesity. As a result, these patients face a poor quality of life, including in personal and work situations, and are often socially isolated [4]. Not all people under or over the normal BMI (Body Mass Index) range have an eating disorder - BMI alone does not diagnose an eating disorder, although receiving information about BMI may trigger one.

**Related Work**

The DSM-V (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition) is the standard for the diagnosis or categorization of mental illnesses.

The diagnostic criteria for anorexia nervosa, as set by the DSM-V include a restriction of energy intake, a significantly low body weight in the context of one’s developmental progress and demographics, basically corresponding to a low Body Mass Index (BMI), a fear of gaining weight or becoming fat, and a disturbance in experience of body weight or shape (See Figure 1) [5]. The DSM-V specifies two types of anorexia - restricting type and binge-eating/purging type. Restricting type anorexia is characterized by 3 or more months of the individual not participating in binging or purging behavior. In this type, dieting, fasting or excessive exercise is the cause of weight loss. In binge-eating/purging type anorexia nervosa, the individual has had “recurrent episodes of binge eating or purging behavior” in the last 5 months [5]. The severity of anorexia nervosa is measured based on BMI, with a BMI lower than 15 kg/m$^2$ being classified as extreme, BMI between 15 and 15.99 kg/m$^2$ being classified as severe, BMI between 16 and 16.99 classified as moderate, and any BMI above 17 that meets all 3 original criteria being classified as mild. The DSM-V notes that anorexia is of higher frequency in female adolescents than any other demographic, and onset is frequently connected to traumatic life experiences [5]. Anorexia is diagnosed most often in post-industrialized countries, like the US, much of Europe, Australia, and New Zealand. The DSM-V also states that although anorexia seems rare in US minorities, this may be because of a bias that results from these populations using mental healthcare service less frequently. Along with this, a patient’s hematology, serum chemistry, endocrine hormone levels, ECG, bone mass, EEG, and resting energy expenditure should be checked, since anorexia often has comorbidities, including leukopenia (decrease in leukocytes, the disease-fighting cells), hypercholesterolemia, high hepatic enzyme levels, decreased $T_3$ (Triiodothyronine levels),

![Figure 1. Depiction of the DSM-V Criteria for Anorexia Nervosa](image)
bradycardia, osteopenia/osteoporosis, and diffuse abnormalities [5]. Along with this, the reward pathways of recovered anorexia patients are different, with studies showing that when playing a guessing game, anorexics are unlikely to show a difference in brain activity when winning or losing money, unlike the control group [6].

According to the DSM-V, bulimia nervosa is characterized by recurrent episodes of binge eating, recurrent compensatory behaviors to prevent weight gain, each at least once a week for 3 months, self-evaluation based on body shape and weight, and episodes should not meet the criteria for anorexia nervosa. When 1-3 episodes of compensatory behaviors occur per week, bulimia is classified as mild; when this number rises to 4-7, it becomes moderate; 8-13 episodes per week is severe, and more than 14 episodes per week is extreme [8]. People with bulimia tend to have a BMI (body mass index) between 18.5 kg/m² and 30 kg/m². Along with this, menstrual irregularities are frequently seen in females with bulimia, while cardiac and skeletal myopathies have been seen in people who use Ipecac syrup, a drug once used as to treat poisons, to prompt vomiting. Similarly to anorexia, bulimia is more common in females and people from post-industrialized countries [8].

In Binge-Eating Disorder, patients usually have recurrent episodes of binge-eating, eating a relatively large amount of food in a relatively short period of time and experiencing a lack of control over eating behaviors, usually associated with discomfort or guilt after eating and rapid eating. Binge-eating disorder is more prevalent among people with severe obesity. Binge Eating Disorder is classified as mild if a person experiences 1 to 3 episodes per week, moderate per 4 to 7 episodes per week, severe for 8 to 13 episodes per week, and extreme for 14+ episodes per week. A 16 question assessment called the Binge Eating Scale can be used to diagnose Binge Eating Disorder. Such behavior usually occurs once a week over a period of 3 months and is not associated with any anorexic or bulimic behaviors. Similarly to anorexia and bulimia, binge-eating disorder is found most often in post-industrialized countries [9].

In clinical settings, a 2-part test for the diagnosis of clinical disorders - a physical check-up to rule out other possible causes and find any related deficiencies or diseases, and a psychological check-up that is common for all eating disorders, either the SCOFF questionnaire or the Eating disorder Screen for Primary care (ESP) - is used. Figure 2 shows a table of the questions in the ESP and SCOFF questionnaires. It has been found that the ESP diagnoses eating disorders with a sensitivity of 100% and a specificity of 71%, while SCOFF diagnoses eating disorders with a sensitivity of 78% and a specificity of 88%, meaning that the ESP was better at ruling out potential diagnoses [7].
Since eating disorders can lead to physical problems, including bradycardia, cardiac and skeletal myopathy, leukopenia, and many others, the use of an artificial intelligence model would allow for quicker diagnosis of eating disorders, like anorexia or bulimia, which would reduce mortality rates. Multiple features, some gender-based, like menstrual cycles, some psychological, and some demographic, have been used to train models, including elastic nets, decision trees, Naive-bayes and K-means clustering on the detection of eating disorders. Below is a table of some research advancements in the field of AI and eating disorders.

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<td>Machine learning enhances prediction of illness course: a longitudinal study in eating disorders [10]</td>
<td>415 females diagnosed with eating disorders; 320 follow-ups after year 1; 277 after year 2</td>
<td>Demographics, psychiatric symptoms, self-esteem levels, treatments</td>
<td>(a) ED diagnosis (b) presence of binge eating (c) presence of compensatory behavior (d) underweight BMI</td>
<td>Elastic net, logistic regression</td>
<td>Elastic net: (a) 62%, 61% (b) 77%, 71% (c) 88%, 85% (d) 93%, 89%</td>
<td>Bias due to presence of eating disorder, small sample size, and gender</td>
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<td>Exploring Eating Disorder Topics on Twitter: Machine Learning Approach [11]</td>
<td>123977 tweets “published by laypeople”</td>
<td>Eating disorder-related posts</td>
<td>(a) relevance of post to Eating Disorder (b) promotion of eating disorder in post</td>
<td>CNN-LS TM classifier (combines convolutional neural network and long short-term memory)</td>
<td>(a) 89% (b) 90%</td>
<td>biased; people who claim they have eating disorder, but may not actually be diagnosed w/ one; severity not measured, diagnostic criteria not</td>
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<td>Proposed Approach</td>
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<td>After analyzing existing studies in the field of AI and eating disorders, the use of an integrated AI framework to analyze and predict the incidence of eating disorders is proposed.</td>
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<td>For this study, the Wave III In-Home Interview Data of the Add Health database from the National Longitudinal Study of Adolescent to Adult Health was used. Data included in the dataset comes from a national survey of 20,000 adolescents who were in grades 7 to 12 between 1994 and 1995, being followed in 5 waves, the most recent one being between 2016-2018. Wave III, which this study is based on, was measured between 2001 and 2002, with biomarkers such as height, weight, Sexually Transmitted Diseases, HIV, and genetic factors being measured. This data includes the</td>
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demographics, home/family situation, relationships, work situation, and general well-being (physical, mental, and emotional). Analysis was centered around question H3GH8, “Have you ever been told by a doctor that you have an eating disorder, such as anorexia nervosa or bulimia?” [18]. The hypothesis for this project was that using an XGBoost model trained on the selected data from the Wave III Interview of the Add Health database would predict eating disorders with a relatively high accuracy.

In order to understand which features of the dataset had the highest correlation with question H3GH8 or could be predictors of whether or not the patient had an eating disorder, Recursive Feature Elimination (RFE) was used. Recursive feature elimination works by fitting a model multiple times and removing the features with the weakest correlations, until the desired number of features is reached. Cross validation was also added in to optimize the hyperparameters [14, 15, 16].

The model used was XGBoost, or eXtreme Gradient Boosting. XGBoost is a tree-based decision making model, similar to decision tree or random forest, that incorporates parallel-tree boosting, using a prediction model that originally provides weak predictions, but at every iteration, each tree is recalculated based on a gradient descent on the gradients of the difference between the target value (what the value should be) and the predicted value (what the model had) [17].

**Future Directions and Conclusion**

Based on existing research in the field of AI in eating disorder diagnostics and data from the National Longitudinal Study of Adolescent to Adult Health (ADD Health), the proposed model, an XGBoost model formed based on a combined approach grid search and recursive feature elimination with cross-validation, boasts a 97.2% accuracy. This proposal is suitable for diagnosing eating disorders quickly, during routine appointments, catching them before the quality of life drastically decreases.

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**References**


Neuro-Doping: Is it The Dope Way to Improve Athletic Performance?
Evan Park

Abstract
With chances of achieving the big leagues close to zero for the average aspiring athlete, sports have become increasingly competitive. Consequently, many athletes routinely search for different methods to better their athletic performance, whether it be stricter diets, longer training sessions, or even illegal doping. As a result of the ever-growing capacity of neuroscientific innovation, a new sports-related method termed “neuro-doping” has emerged in the form of transcranial direct current stimulation (tDCS), a tool designed to stimulate neural activity. In this study, several papers and articles directed at Halo Neuroscience, the first company to extend tDCS to athletes, are examined to understand the method's effects on athletes and ethical concerns that may arise. Also, there are several analyzed papers showing the strong correlation between tDCS and motivation. Despite these benefits, tDCS has many ethical issues that make its use in athletes questionable at the moment.

Doping in an Athlete’s World

The world is home to many athletes, including professional leagues such as the NBA, Premier League, and the NFL that offer the chance to garner fame, recognition, and wealth. In the pursuit of success, traditional methods such as a healthy diet and strict training often look daunting compared with a seemingly easier pathway such as doping. While generally frowned upon and mostly banned in regulated sports, tDCS remains a “doping loophole,” allowing athletes to artificially enhance their athletic prowess [1].

tDCS: How it Works

tDCS is a powerful tool that can vitalize the brain's synaptic plasticity [2]. Synaptic plasticity is very important as it can decide what types of synapses between neurons should be more active or diminished to help the brain adapt to new stimuli. Electrodes, placed on the patient's scalp allow a constant, low-current flow of electricity to directly arouse the brain with two mechanisms. Anodal stimulation depolarizes the neuron's resting membrane potential, increasing neuronal excitability and facilitating synaptic enhancement in the targeted area, while cathodal stimulation inhibits
neural activity by hyperpolarizing the resting membrane potential.

Studies have found that, when applied for roughly fifteen to twenty minutes, tDCS can safely and effectively improve brain function with limited adverse effects, including dizziness and tingling at the treatment site [4].

**Halo Sport: Changing the Sports Landscape Using tDCS with Proven Results**

While tDCS is still largely inaccessible for many athletes, researchers are actively searching for ways to allow wider use of the technology. Halo Sport, created by Dr. Brett Winglier, is a headphone set that incorporates tDCS [3]. Studies show many benefits from the usage of the product (Halo). Notably, one study from 2019 found that participants who utilized the stimulatory product performed better at an athletic competition compared to those given the placebo. Results found that
the group with Halo had a higher peak and average peak power than those stimulated with the placebo [6].

Similar benefits were found in professional athletes. In an experiment analyzing Olympic skiers, subjects were divided into two groups to assess improvement in training: a control group and a Halo group [7]. The net propulsion force exponentially increased in the Halo group after four weeks of training, allowing the skiers greater wind resistance and velocity. In addition to improved performance, the Halo group experienced better results from training, evidently showcasing the athletic benefits of neuro-doping.

**Diving Deep: How tDCS Affects an Athlete’s Motivation**

There is a strong correlation between athletic performance and usage of tDCS, but why does this happen? Athletes wanting to reach their full potential must have one thing: motivation. For the brain, many different structures help with different kinds of motivation. The orbitofrontal cortex (OFC) and the striatum are involved in decision-making and behavior based on pleasurable or challenging outcomes [11]. Motivation and judgemental decision-making are two functions of these two brain structures. The dorsolateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC) play an important role in developing a goal-directed system and calculating the association between action and reward [12]. As a result of making goals and taking executive actions to reach them, both help regulate motivation in the brain. Similarly, by creating pleasure and regulating reward states with dopamine, the amygdala and ventral striatum both contribute to forming motivation in the brain [13]. The dorsolateral prefrontal cortex has been extensively studied for motivation study purposes using tDCS, while most of these structures have been studied only to a lesser extent.

Motivation can help athletes in two ways: by pushing themselves in training and reaching their athletic potential and by avoiding unhealthy urges. Studies show that there is a strong correlation between the usage of tDCS and the effects of motivation.

During a Harvard University sham-controlled study in 2018, 36 tobacco subjects were randomly treated with tDCS or a sham-tDCS on the dorsolateral prefrontal cortex (DLPFC) for seven consecutive visits [15]. It was found that tDCS increased motivation to quit among smokers.
who smoke more than the average (7 cigarettes per day or more) but not among those who smoke less than seven cigarettes per day.

Results after a 4-week follow-up showed that the relationship between tDCS and high motivation aided in reducing the number of cigarettes consumed per day, while motivation to quit alone did not change the average number of cigarettes consumed per day [15]. Using tDCS on the DPC may prohibit athletes from using drugs or other harmful substances if the athlete has the initial motivation to quit.

Another study conducted by the University of Kent connected both tDCS and motivation in endurance athletes. This study was looking to determine whether tDCS with anodal stimulation

Figure 5: Diagram showing the purposes of each of the brain structures on motivation based on neural, psychological and behavioral level [10].

Figure 6: Image displaying approximate location of DLPFC, where the tDCS was targeted at [14].
on the left dorsolateral prefrontal cortex could improve inhibitory control. Greater inhibitory control can lead to less perception of muscle pain, discomfort, or other uncomfortable sensations like mental fatigue. It can also lead to longer training sessions and more time for improvements. In this trial, 12 healthy participants were randomly assigned to two groups (Sham or tDCS) and asked to perform Stroop and TTE (time to exhaustion test) [16]. The results show that those with the real tDCS had a lower reported RPE (rating of perceived exertion), experienced heart rate (HR), and errors in the Stroop tests when confronted with incongruent stimuli. Also, the participants with the tDCS were able to cycle for longer periods of time in the TTE tests than those with the sham-tDCS. As a result of these results, tDCS with anodal stimulation on the DLPFC can improve inhibition control and motivation in endurance athletes.

![Graph showing the difference between the two groups in TTE duration.](image)

From these two studies, there was a clear correlation between tDCS and motivation as treatment can create more inhibitory control and act as a motivation boost for athletes to avoid unhealthy substances. In addition to reducing work and pain for athletes, these effects will help them become more motivated as their goals can become more tangible.

**Tackling Issues That May Arise with tDCS Usage**

While strong evidence suggests that tDCS has the potential to improve an athlete’s performance and training capabilities significantly, the ethical implications remain a stagnant controversy. According to the Halo website, each tDCS set costs around $399 [9]. In professional teams or organizations, money is easily available to buy tDCS devices for their players. In recreational and youth sports, due to cost, these devices are still largely inaccessible. tDCS can create a greater economic divide in sports since those from a wealthier demographic can afford tDCS sets, while others can only wish to have one.

With the probability of becoming a professional athlete so low, youth sports have become increasingly competitive. The future use of tDCS sets may help youth athletes make it to the big leagues and differentiate the chances of passionate athletes. It is important to remember, however, that even with tDCS devices, many other factors that are unrelated to the brain can contribute to athletic performance such as genetics, diet, and location. It is impossible to provide equal resources to every athlete due to variable circumstances.
tDCS is a fairly new method that scientists are still researching, so the knowledge that is presented to the public now will differ in the future. If tDCS were to become available for general use now, it would likely lead to many misunderstandings between the general public and the neuroscience community. tDCS could be misused for periods longer than the recommended 15 minutes, resulting in unwanted or unknown safety hazards that are yet to be discovered by researchers.

Similarly, due to a lack of neuroscience education, athletes may misuse equipment. While research has not yet been conducted on the effects of using tDCS on unwanted areas of the brain, it is possible that this could become dangerous for the brain.

We also have to consider that tDCS sets are inventions, and so there might be unknown issues in the hardware of sets. How can athletes or their coaches safely fix their tDCS headsets without harming themselves or spending more money? If completely broken, can they be recyclable and unharmed to the environment? Will there be places available for users to repair tDCS sets cheaply and accurately so that the vast majority of users can reuse tDCS sets? There are many unanswered questions about the ethics of the usage of tDCS in athletes. Obstacles and issues must be overcome or changed before athletes can commercially procure tDCS sets on their own without medical supervision, despite tDCS’ potential benefits on performance and motivation.

**Aiming in the Right Direction: How tDCS Usage Can Become More Ethical**

As addressed in previous sections, there are arguments that both support and testify against the usage of tDCS in athletes. While both arguments are valid, plans should be proposed to allow tDCS usage to become more ethical.
For example, only professional athletes own these tDCS headsets. These athletes are devoted to and knowledgeable about their respective sports, so it would be more suitable to use tDCS devices due to their maturity. Also, tDCS devices can be able to equal the playing field and promote more competitiveness as professionals typically highlight the best of the best. We could see more “impossible” records and standout athletes that can greatly change the professional sports landscape. However, as a result, incoming rookie athletes may not be able to compete at the professional level since they have less experience with tDCS than other athletes. However, this plan could further the gap between youth sports and the big leagues simply because one is allowed to use tDCS. This plan may help promote tDCS in the professional sports leagues, but it brings a lot of disadvantages that could hurt sports ethics.

Another plan that could be established could be to have lower prices for tDCS, or for low-income athletes free. This plan can make tDCS available to any athlete, whether recreational or professional, making tDCS more inclusive. It can also prevent divisions in performance, socioeconomic status, and area of location. However, this plan may take over several years to be implemented. Because any athlete may be allowed to use them, more incidents and side effects may be experienced. With a greater audience of users, tDCS may have to be made in mass production, even if its materials are not recyclable. In addition to decreasing the level of safety, the environmental consequences may negatively impact environmental sustainability. Using tDCS globally may make sense under this plan, but there can be unintended consequences that can impact just more than the world of sports.

How about a plan where tDCS is still legal, but athletes themselves cannot give themselves treatment? This could shift the responsibility for the usage of tDCS from athletes to medical professionals and clinics. As athletes are watched under medical supervision, this would improve the safety of tDCS usage and help athletes better understand their brains. Also, the sports landscape would change as tDCS is still allowed. However, a tDCS session conducted in a medical facility or clinic may be costly as the average price is $1677.20 per session. This could lead to socio-economic
and geographic divisions and further the athletic gap between those who are more privileged and less privileged.

To answer the question of whether neuro-doping in the form of tDCS is ethical requires much more analysis. With tDCS, athletes can break through barriers once thought to be insurmountable and change the sports landscape for the better. However, tDCS can also be a danger as a source of many divisions that could also hurt sports ethics. There is plenty of evidence to support or deny the usage of tDCS in sports, making the question of allowing tDCS usage in athletes unanswerable. While we wait for tDCS to become ethical or unethical, one thing to remember is that it will change our perspective on artificial methods of improving athletic performance.

References


The Neuroethics of Global Mental Health Treatment

Renee Ngai

Abstract

In the recent mental health crisis that worsened among the COVID-19 pandemic, healthcare professionals have emphasised the importance of ensuring mental health treatment for all. This article examines the ethics of bringing mental health treatments to underdeveloped countries through a social, cultural, and scientific lens. In doing so, several global studies on mental health are highlighted.

Neuroethics and the Global Mental Health Crisis

A tearful teenager stares at the black screen on his computer monitor, slumping his shoulders. The soundless room is filled with tissues damp with tears. On the other side of the globe, another student trembles in her stuffy seat biting her nails and clutching her stomach before her final exam. A bead of sweat trickles down her flushed cheeks. These behaviors are all examples of the trend of declining mental health in teenagers and adults across the globe. After the COVID-19 pandemic hit, leading to school closures, mental health treatment gaps became a concern across the globe.

Although mental health and neuroethics are closely related to each other. Neuroethics is the crossroads between neuroscience and ethics. Specifically, neuroethics connects human morality to neuroscientific treatments [1]. Mental health treatments are deeply related to neuroethics. As a global issue, mental health treatments face ethical questions when western medicinal practices intervene with regional culture [2]. This article explores the neuroethics of mental health treatment across the globe through a cultural, economical, and scientific lens. In doing so, several studies on global mental health will be highlighted. This essay will then address the neuroethics of stimulants for other disorders, such as Attention Deficit Hyperactivity Disorder (ADHD).

The Mental Health Treatment Gap

Today, a billion people live with mental health disorders. In third-world countries, like those in Africa and Latin America, for example, there is a gap in mental health treatment, and 75% of people with mental health disorders do not receive treatment [3]. In a social-cultural context, there are cultural differences in defining the field of emotional health. For example, due to cultural
differences, the definition of emotional well-being is different in each country. In Asia, happiness is defined as being calm while in the United States it is defined as being excited [4]. Therefore, healthcare professionals trying to bring mental health treatment to lower-income countries have to ensure that the interventions for mental health disorders do not interfere with the social-cultural context in underdeveloped countries.

Moving on to anxiety, personality, psychotic, and eating disorders, mental health research has only been focused on a small portion of the world’s population. In fact, only 10% of the global population have participated in mental health research. Therefore, the current mental health treatments might not be culturally appropriate for all countries [4]. International studies have found that mental health disorders are underdiagnosed in lower income countries. Additionally, research studies primarily review wealthier countries. Therefore, a worldwide standard needs to be established to ensure that every individual across the globe has opportunities of equal diagnoses for mental health disorders.

**Human Rights and Mental Health Treatments**

Through an ethical lens, mental health treatments are also related to human rights. Human rights are defined mainly as the right to liberty, right to health, and right to education [1]. Mental health is integrated within an individual’s physical health, but not all individuals have access to mental health treatments. For example, lower-income countries do not have enough resources for mental health treatments [5].

A complete mental health treatment plan also involves brain imaging scans and patient counseling. At the crossroads between mental health and neuroethics lies the importance of patient empowerment. For example, brain imaging does not provide information on an individual’s emotions, but can create neurobiological models and biomarkers that can lead to accurate diagnoses of mental health disorders [7]. A sole focus on patient empowerment and examining the emotional well-being of a patient, on the other hand, provides a more subjective diagnosis [8]. Therefore, a neuroethical approach involves a balance of both patient empowerment and accurate diagnoses with brain imaging for accurate diagnoses.
Socio-economic Status in Mental Health Treatments

Individuals of different social statuses are often offered different levels of mental health treatment. For example, a study from the World Health Organization that comprised over 25 countries discovered that only 13.7% of lower-income families received mental health treatment, compared to 36.8% of higher-income families [9]. Reducing the disparities in mental health treatment is a vital part of neuroethics. Higher income families often have the ability to access higher education, making it easier for them to seek professional help for their mental health disorders. Lower income families also experience more stress and anxiety due to financial hardships, making them vulnerable to mood disorders.

Apart from mental health diagnoses, quality of treatment, such as that of psycho-pharmacotherapy, also varies according to social-economic status. Medications for mental health treatment are, unfortunately, sometimes misused by higher income individuals, while patients who actually need pharmacotherapy are unable to afford it [11]. For example, the use of stimulant medications to boost productivity in students are mostly used in privileged communities, giving wealthy students an unfair advantage over students from poor communities [10]. Mental health treatments should be reserved for those with mental health disorders, not for the enhancement or increasing of student performance.

Conclusion: Closing the Gap in Mental Health Treatment

As mental health becomes the center of attention across the globe, it is important to examine the neuroethics of mental health treatments. Culturally, bringing mental health treatment technologies to lower income countries might interfere with local cultures, which might pose an ethical issue. For example, there exists a clash between raising mental health awareness and the Chinese culture of prioritizing work and school over mental health care. Economically, higher income individuals will have an unfair advantage if they use stimulant medications to improve their performance. Equal access to mental health treatment should be a human right. Therefore, every individual should have equal access to mental health treatments. To close the mental health treatment gap, mental health research should be conducted in middle and lower income countries while taking into consideration the different cultures across the globe.
standaridized and ethical practice of mental health diagnoses and treatment also needs to be in place for equal mental health treatments internationally.

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