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FEATURED ARTICLES

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INTERNATIONAL YOUTH NEUROSCIENCE ASSOCIATION

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Letter From the Editors

Sojas Wagle, Robert Morgan, Anita Singh, and Scott Massey

Dear Readers,

Welcome to the fourth issue of the second season of the IYNA Journal! We greatly appreciate your readership, continued or new.

With this issue, we have redesigned our journal process so that we now have a rolling basis for article publications. This means that every article that is submitted before the deadline will not necessarily be published for that specific issue, but publication in a future issue is virtually guaranteed if the author makes changes to their article as directed by the editors' suggestions . We at the IYNA believe that it is important that the author and editors put in enough time to make the article as best as it can be. Through this updated process, the editing process is not rushed, and there is less downtime between journal issues, which has been shown to decrease productivity. Even though a rolling basis means less articles per issue (e.g. there are only six for this issue), it is crucial to prioritize quality over quantity to ensure that authors are given the opportunity to improve their scientific writing skills along the way as well. That being said, here are some previews of articles in this release:

In the General Neuroscience section, Anish Natarajan stresses the importance of considering neuroscience research in determining school schedules and curricula. In the Disease section, Emily Yuan describes in depth the symptoms and etiology of eating disorders, such as anorexia, bulimia, and binge eating disorder. In the Research section, Riria Saito explains the neurological implications of playing video games and their associated benefits. In the Neurotechnology section, Kylie Fuller illustrates the use of brain imaging technology and complex algorithms to predict depressive and suicidal behavior in at-risk individuals. In the Neuroscience and Society section, Nathiya Vasantha Kumaran cautions against the negative ramifications of social media on the developing identities of adolescents via the toxic effects of peer influence, and Esthefani Chávez Hinostroza informs and reviews cognitive neuroscience. Finally, in the Interview section, Chinmayi Balusu interviews Dr. Igor Grant, the Chair of the Department of Psychiatry at the University of California, San Diego School of Medicine, to learn more about his research on HIV/AIDS and its associated neurocognitive disorder.

We would like to recognize all of our dedicated editors and assemblers 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 feel free to contact us at info@youthneuro.org. We hope you enjoy reading this issue as much as we enjoyed editing it!

Best Regards,
Sojas Wagle - IYNA Journal Editor-In-Chief
Anita Singh, Robert Morgan, Scott Massey - Senior Editors

The Neuroscience Behind Education

Anish Natarajan

Introduction

The question regarding the role of neuroscience in modern education is one that has interested both researchers and educators over the past few decades. As the understanding of cognitive development expands and new studies overturn and reaffirm different beliefs and practices, the field of neuroeducation is becoming more influential in schools around the world. The formative assessment–a staple of standardized education for nearly 2000 years–has been shown to play a beneficial role in enhancing student learning and long term potentiation. New studies are being conducted to establish the link between the ability to play musical instruments and synaptic growth, and new research has instigated a push for reform in school timings. Through the study of neuroeducation, it is possible to capitalize on these critical periods of development during childhood.

History in Education

It is almost uniformly believed amongst educators that the standardized test plays an integral role in quantifying intelligence within a large populace. In 165 BC, the first test in recorded history was implemented throughout Imperial China to act as a filter for candidates applying for a state government position. Executives in the Han Dynasty believed a nationwide test of memorization and speaking skills would help select only the most qualified contenders. Students were required to memorize Confucian proverbs and write an eight-paragraph essay developing an argument. Since the era of the Han Dynasty, standardized examinations have been a staple of education as a credible means of determining a student's knowledge on a subject. In recent years, a growing number of schools throughout the nation are calling for more comprehensive tests that do not involve rote memorization, an activity that has now acquired a negative connotation in the eyes of the public.

The Neuroscience Behind Memorization

Direct evidence for the link between rote memorization and their direct results upon neuroanatomy were not fully supported by empirical evidence until recently. In 2006, University College of London Professor of Cognitive Neuroscience Eleanor Maguire conducted a study involving the neural structure of London taxi cab drivers. Her findings revealed a larger than average posterior hippocampus, a region of the brain involved with memory and spatial awareness [1]. The process of creating a memory relies primarily upon the stimulation of N-methyl-D-aspartate receptors in the brain during a process called Long Term Potentiation (LTP). During LTP, calcium ions are released into the synapse, causing the release of cyclic adenosine monophosphate (cAMP), which in turn stimulates the release of cAMP-response element binding protein (CREB). Together, the effects of cAMP and CREB result in stronger synaptic connections as well as the growth of the synapse itself, leading neuroscientists to believe that the formation of memory is crucial to neural development throughout life. The process of rote memorization is nothing but a more active form of the passive generation of new memories.

There is a significant misconception amongst educators that memorization often takes place in lieu of a genuine understanding of the subject material. A recent study conducted by Australian psychologist John Biggs regarding these different methods of learning assessed this issue in regards to the translation of qualitative factors, such as intelligence, into quantifiable sums such as the grade point average (GPA). He refers to the connection between memorization and understanding as "constructive learning," where it is taken upon the student to adopt their own learning methods or activities in order to help them gain an understanding of the material. Thus, memorization has the potential of leading to a genuine understanding of a subject if it happens to be the preferred learning strategy of a particular student.

Natural Intelligence and Education

Intelligence is due, in large part, to polygenetic factors influencing the development of nervous tissue. During critical periods in childhood, humans must be exposed to a variety of stimuli to truly develop the synaptic connections necessary for a healthy cognitive development. These processes continue well into schooling, leading researchers to believe that increasing educational complexity corresponds to the exacerbated effects of gene expression. In one study conducted by Columbia University professor Douglas Ready, a statistical analysis of the effects of socioeconomic status on learning involved computing the literacy rates of students across the socioeconomic spectrum. A growth curve analysis showed that despite the fact that low socioeconomic status generally indicated poor performance overall, attendance rates were the primary determining factor. Repeated exposure to a learning environment had a causal nature in the initiation of LTP, and to a larger effect, memory [2].

Attention and Learning

The human body is conditioned to a day-night cycle known as the circadian rhythm. This cycle is primarily due to the presence of chemicals within the human body, namely adenosine and cortisol, which mediate alertness and sleepiness. Throughout the day, energy stored within the bonds of adenosine triphosphate (ATP) is broken down into its components of adenosine and three phosphate groups. This gradual buildup of adenosine accumulates during the day, where it is resynthesized in mitochondrial centers in cells at night [3]. Cortisol, on the other hand, has the reverse effect. Cortisol is a hormone secreted by the adrenal cortex in large amounts in response to a signal from the hypothalamus, a brain structure which mediates the detection of noxious stimuli that threaten homeostasis. However, cortisol is also released during the day in a waveform pattern, resulting in peak times of alertness. Despite several attempts to reform school timings both domestically and internationally, there has not been a significant response from educators to instigate change. The American Academy of Pediatrics issued a statement in 2014 advocating for later start times to enhance students' overall learning, effectively capitalizing on the understanding of how attention and memory storage work throughout the day. New research is currently being done to help integrate the fields of neuroscience and education to better aid in the teaching of youth around the world [4].

Research Frontiers

Neuroeducation is a rising field of study that is steadily gaining traction amongst educators and researchers alike. Several new and exciting inquiries are being made by neuroscientists around the world, including the association between non-academically oriented activities on cognitive development, memory, and learning.

A paper published by University of Geneva professors Ewa Miendlarzewska and Wiebke Trost outlined a study using neuroimaging to detect plastic changes in the brains of adult musicians. Described as a 'multisensory motor experience,' the authors constructed the definition of playing an instrument as requiring a complex set of skills, such as "reading a complex symbolic system (musical notation) and translating it into sequential, bimanual motor activity dependent on multisensory feedback; developing fine motor skills coupled with metric precision; memorizing long musical passages; and improvising within given musical parameters," all of which contribute to an enhancement of executive function in the cerebral cortex [5].

Another study conducted by researchers in Michigan State University collected data from 214 6th grade students at a public school in order to test the effects of a physical education on academic performance. While no statistically significant correlation between enrolling in the physical education class and standardized test scores was seen, students who were engaged in physically rigorous exercise as an extracurricular (i.e. sports) performed much higher than those who were not [6]. Strenuous exercise promotes brain-derived neurotrophic factor (BDNF), a trophic factor which nourishes and stimulates neurons [7]. Already in the UK there has been a significant

push towards making physical education a requirement for students on the basis of supporting healthy cognitive development.

While several new approaches to efficient pedagogy are being looked into, neuroeducation has opened up new ways to address childhood issues, such as attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) as well. A qualitative study conducted in Singapore attempted to elicit a comprehensive list of strategies and practices used by primary school teachers in their efforts to aid their students' understanding of the source material. The study showed that the most effective way to convey material to a student with a learning disability was not through a complete rehabilitation of the curriculum, but rather, the implementation of slight accommodations in order to push students to perform well. Another key element to help those with learning disabilities grasp concepts was goal-setting. Students who spent a specific amount of allotted time on activities performed better on assessments given by the researchers than those who did not [8]. In addition, a plethora of new studies are being conducted worldwide to find a way to diminish the debilitating effects of brain disorders through cognitive behavioral therapies and teaching techniques.

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The Neurology Behind Eating Disorders

Emily Yuan

Abstract

Eating disorders are biopsychosocial disorders that affect eating habits. They can come in many forms, such as anorexia, bulimia, and binge eating disorder, with anorexia having the highest death rate among mental illnesses [1]. Despite the undeniable impact that societal pressure and social media have on the development of eating disorders, genetic factors that dictate brain development play a significant role in the onset of these life changing diseases as well [3]. Studies have shown that individuals with eating disorders have altered activity in multiple brain areas and have abnormal neurotransmitter activity [1].

Eating Disorders

Eating disorders are serious mental illnesses that affect over 30 million Americans. These disorders stem from biological, psychological, and social factors and are described by having abnormal eating habits, ranging from anorexia nervosa to pica to orthorexia. Although there definitely are environmental factors that play a large role in the onset of these diseases, such as societal pressure, there is also a neurological basis for eating disorders. Before delving into the details about the cellular mechanisms altered in victims, we need to first understand how these disorders affect individuals.

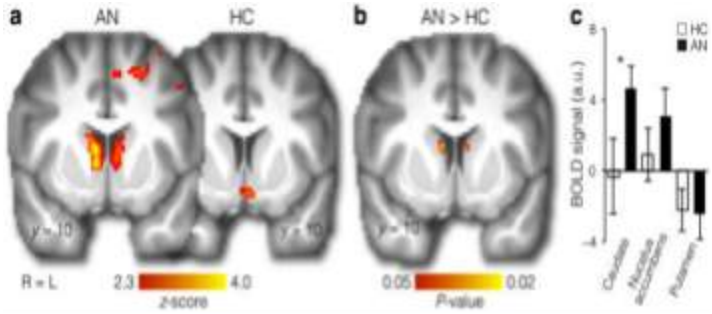
The Anorexic Thought Process

So what is going on inside the mind of someone with an eating disorder? Research has found that those with eating disorders think differently from most people. It was initially thought that individuals with anorexia nervosa were able to override primary drives through self control. This self control is exercised by anorexics when constantly choosing low fat and low calorie food. However, even when they attempted to recover from the eating disorder, they were unable to overcome their desire to opt for the low calorie and low fat food options,

demonstrating that the persistent selection of these foods is not simply a matter of self control [1]. Although this study focused on individuals with anorexia nervosa, these differences in thought processes can also be seen in people with other eating disorders, such as bulimia or Prader-Willi syndrome [1].

Dr. Joanna Steinglass conducted a study to understand how eating disorders impact decision making when it comes to food. She used fMRI imaging to monitor the brain activity of women with anorexia nervosa (AN) and healthy controls (HC) as they made food related decisions. The women were asked to choose between two items – chocolate cake and carrots. Unsurprisingly, the women with anorexia prefered the carrots to the chocolate cake. However, they used a different brain structure than healthy individuals to make their decision. As opposed to the prefrontal cortex, patients suffering from anorexia nervosa utilized the dorsal striatum [1]. Since the dorsal striatum plays a key role in decision making, rewards, and habitual behaviors, an increase in this area's activity suggests that the anorexic subjects' decisions to eat the carrots were habitual [1]. No matter how hard they tried, their brains would automatically direct them towards the lower calorie option [1].

In AN (Fig. 1), a correlation with choice values was observed in the dorsal striatum, whereas no above threshold correlation was observed in HC (Fig. 2). Additionally, no above-threshold correlations were observed in the ventral striatum in either group, and no differences were found between HC and AN groups. (**b**) Parametric analysis of choice strength showed significantly greater activity in the dorsal striatum in the AN than in the HC group. (**c**) To illustrate the pattern across the dorsal and ventral striata, in an independent analysis, data was extracted from the right caudate, right nucleus accumbens, and right putamen. Differences between the HC and AN groups were seen in the caudate, but not in the nucleus accumbens or putamen [1].



(Fig. 1) Distinct neural systems engaged in food choice

Neurotransmitters

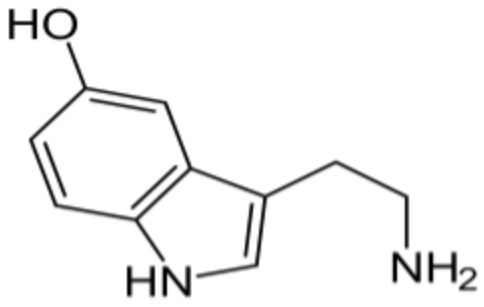


Fig. 2

Studies have shown that abnormalities regarding several neurotransmitters are associated with the onset of eating disorders. The two that have been the most extensively studied are the mood regulating hormone serotonin and histamine [2].

Anorexics often have reduced levels of serotonin in their blood, since they do not have enough nutrients to synthesize this neurotransmitter [2]. As they continuously starve themselves, the body responds by increasing the number of serotonin

receptors to utilize the remaining serotonin more efficiently [2]. These receptors are still present after individuals recover, often making them anxious and emotional when they eat [2]. People who have been previously diagnosed with anorexia physically feel better when they abstain from eating for this reason, making recovery extremely difficult without professional help [4]. In addition, anorexic patients are more likely to have a mutated 5-HT2A receptor for serotonin [4]. This mutated receptor increases the amount of serotonin in the brain during a non-starved state, leading to anxiety and obsessive behavior [10]. Since food further increases serotonin levels, the discomfort associated with increased serotonin deters anorexics from eating, a major obstacle in the road to recovery [10].

Individuals with bulimia are also affected by abnormalities in serotonin levels. In contrast to anorexics, whose psychological symptoms are caused by increased serotonin levels, bulimics have lower than average levels of serotonin after long periods without eating, such as during sleep. The decreased serotonin levels leads to binge eating and irritability when these individuals wake up [12]. Serotonin affects binge eating disorder in a similar fashion, where the depressed mood caused by low serotonin levels leads to binge eating

Histamine also plays a central role in the development of anorexia nervosa. Histamine is often associated with the immune system, but it is also linked to appetite and taste perception [10]. Increases in histamine concentration in the blood decreases food intake, while blocking these histamine receptors increases hunger [10]. Additionally, histaminergic activity is increased by sudden food intake after starvation, discouraging the individual from eating [10]. Histamine's effect on the body is mediated by the H1 receptor, which is found in higher concentrations in certain areas of the brain affected by eating disorders [5]. The increased number of histamine receptors increases the body's sensitivity to histamine fluctuations, thus decreasing hunger within that individual.

Genetics

Relatives of individuals with anorexia nervosa are over 10 times more likely to have an eating disorder, yet not everyone with an eating disorder has a relative with that same disorder [7]. The trend of familial eating disorders can have two explanations. The traits can be heritable and passed down to children genetically, or these traits can be learned, as exposure to behaviors can evoke those same behaviors in children [7]. What does this mean? Eating disorders most likely stem from a variety of factors. There have been no conclusive results about the reason behind eating disorder development. Some studies have found that there is a strong genetic influence in developing eating disorders, while others have found that environmental factors play a more significant role [7].

Twin studies using identical and fraternal twins helped to differentiate between the effects of environmental and genetic factors. These studies found that identical twins had a higher similarity in developing anorexia and bulimia than fraternal twins, and they estimated that binge eating, self-induced vomiting, and dietary restraints were between

46-72 percent heritable [3]. Attitudes about body image and weight preoccupation were estimated to be 32 to 72 percent genetic [3]. These attitudes were also found to develop later in life. Studies of 11 year olds have found no significant genetic variation in body perception, while the variance in these attitudes can be accounted for by genetics in 53 to 57 percent of 17 year olds [3]. This correlates with the average age of onset for anorexia nervosa, which is 16-17 and bulimia nervosa, which is 18-19 [6]. Personality traits related to the development of eating disorders, such as increased level of emotionality, stress reactivity, and perfectionism, have also been found to be influenced by genetics [3].

Molecular genetics studies have been used to try to identify genes linked to eating disorders, with certain groups reporting an increase in the -1438/A allele of the 5-HT2A gene as well as other serotonin-related genes in individuals with anorexia nervosa [3]. The 5-HT2A gene codes for the serotonin 2A receptor, which increases the amount of serotonin receptors in a non-starved state [10]. This receptor is involved in many complex mental illnesses with research still underway about its specific function [8]. Women with anorexia are more likely to have a mutated 5-HT2A serotonin receptor [3]. Another study found a possibility for linkage of anorexia and bulimia on chromosomes 4, 11, 13, and 15 with the peak NPL score on chromosome 4 [3].

More research must be done to come to more conclusive results about the specific genes related to eating disorders; however, there is an indisputable correlation between genetics and eating disorders [3]. While some studies have been done to support these genetic findings [3], others have found that eating disorders are really a combination of genetic and environmental factors. There are currently three types of genetic environments (G-E) identified: Passive, Evocative, and Active [9]. A genetic environment is the interaction between the predisposed genetics and the environment a person is exposed to. Passive G-E occurs simply though the sharing of genetic information. Evocative G-E occurs when family members reinforce certain perceptions that are predisposed by genetics. Active G-E is when an individual who is genetically predisposed to have an eating disorder actively seeks out an environment that reinforces their perspective as a result of their genetically determined qualities [9].

Treatment and Further Research

Of course, an important goal of eating disorder research is to develop a better understanding of these disorders and develop better treatment plans for victims. Correlation studies that analyze the predictors of treatment success for anorexia nervosa found that self-reported emotional avoidance (behavioural/cognitive avoidance, low acceptance) and submissive behaviour predicted clinical outcomes [13]. Social cognitive (emotion recognition, emotional theory of mind) and neurocognitive performance (set-shifting, detail focus) had limited predictive ability [13]. While eating disorder treatment is sometimes successful, many victims suffer from relapse [13].

Although there have been many studies done on various aspects of eating disorders and eating disorder treatment, there is a huge amount of uncertainty regarding each of the eating disorders. In comparison to many of the other significant mental illnesses, eating disorders receive only a fraction of the funding per patient [14]. For example, the NIH budget for eating disorders is only ⅓ that of PTSD, despite the fact that anorexia nervosa is the deadliest mental disorder [14].

As shown in the studies above, there have been many links drawn between different factors and the onset of eating disorders; however, these correlations have not allowed scientists to pinpoint an exact cause for this deadly disease [14]. Since many different factors lead to the development of eating disorders, research cannot be restricted to the cellular level. Especially in a society where media plays a huge role in our lives, psychological and sociological studies must be conducted to evaluate the impact the environment has on affected individuals [14].

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The Effects of Video Games On Our Brain

Riria Saito

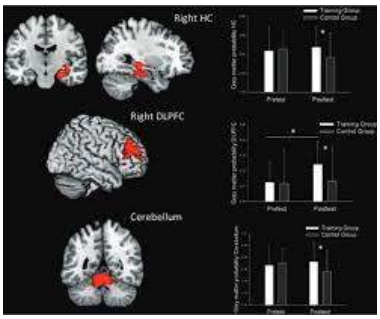
Introduction

Video gaming has become a popular activity these days. According to the 2017 report by the ESA (Entertainment software association), 67 percent of American households own a device used to play video games [6]. Recent research shows that video games may have some positive effects on our brain. S Kühn, T Gleich, R C Lorenz, U Lindenberger & J Gallinat found that playing console games causes increases in the amount of gray matter in the brain. Craig Stark and Dane Clemenson showed that a 3D game improves memory formation. Adam Gazzaley developed a game called "NeuroRacer" and observed how it impacts cognitive skills.

Induced Structural Plasticity

Our brain has the ability to modify its structure over the course of our lifetime. This ability is called brain plasticity. Research has shown that brain plasticity affects the amount of gray matter in the brain through playing a video game for a few minutes a day [1].

In the research study, participants were randomly assigned to either a video game training group or a passive control group. The training group was directed to play the video game *Super Mario 64* on a portable Nintendo DS XL console for at least 30 minutes a day over a period of 2 months [1]. Participants in the training group experienced notable gray matter increases in some areas of the brain, such as the right hippocampal formation, right dorsolateral prefrontal cortex, and bilateral cerebellum. Gray matter is crucial for spatial navigation, strategic planning, working memory, and motor performance [1].



Through the analysis of these results, researchers concluded that future research should apply video game training in the clinical context to prevent against mental disorders, such as post-traumatic stress disorder (PTSD) and schizophrenia [1].

Figure 1. "Brain regions showing a significant group (training vs control) time (pre vs post-test) interaction in gray matter volume. Bar graphs depict the interaction effects for the clusters displayed, error bars illustrate s.d., *t-test, P00.05. DLPFC, dorsolateral prefrontal cortex; HC, hippocampal formation"[1].

Improved Memory Formation

Playing 3D video games can boost memory formation, according to University of California, Irvine neurobiologists Craig Stark and Dane Clemenson [2]. For their research, they recruited non-gamer college students to play either a video game with a 2D environment (*Angry Birds*) or one with a 3D setting (*Super Mario 3D World*) for 30 minutes a day over two weeks. The clear differences between 2D and 3D are complexity of the view and the amount of spatial and nonspatial information to be learned. In *Super Mario 3D World*, players must explore and learn an array of intricate information on each level [2].

Students took memory tests before and after the two week period. Then, they were given a series of pictures of everyday objects to study. Next, they were shown images of the same objects, new images, and other images that portrayed items that differed slightly from the original items. Subsequently, they were asked to categorize them all with the end goal of testing the hippocampus, a part of the brain involved in the production and initial storage of memories [2].

The participants who played 3D video games improved their scores on the memory tests. Their memory performance increased by about 12 percent, which is the same amount by which memory performance typically decreases between the ages of 45 and 70. On the other hand, the 2D gamers did not improve their memory score results, suggesting that there was no improvement in their hippocampal memory function [2].

In previous studies on rodents, researchers showed that environmental enrichment resulted in the growth of new neurons that became entrenched in the hippocampus' memory circuit and increased neuronal signaling networks[2][3].

Researchers also noted some commonalities between the 3D games that the humans played and the environment the rodents explored. 3D games have much more spatial information and complexity compared to 2D games because of the increasing amount of information there is to learn. In any case, this kind of learning and memory not only stimulates but requires the hippocampus. Essentially, the next phase in this research is uncovering which factor of the environment of 3D games stimulates the hippocampus [2].

Improved Cognitive Skills

A study led by neuroscientist Adam Gazzaley of the University of California, San Francisco developed a game called *NeuroRacer* to help elderly individuals improve their cognitive skills [4].

NeuroRacer is a 3D video game in which players steer a car along a winding, hilly road with their left thumb while keeping an eye out for signs that randomly pop up. If the sign is a particular

shape and color, players have to shoot it down using a finger on their right hand. This multitasking exercise requires a mix of cognitive skills: attention focusing, task switching, and working memory or the ability to temporarily hold multiple pieces of information in the mind [4].

Gazzaley and his colleagues recruited 46 participants aged 60-85, and put them through a 4-week training period with a version of *NeuroRacer* [4]. After training, participants drastically improved at the game and achieved higher scores than untrained 20-year-olds. Additionally, this increased cognitive performance skill remained six months later without practice [4].

Before and after training, the scientists also conducted a plethora of cognitive tests on the participants. Certain cognitive abilities, such as working memory and sustained attention, improved. Both skills are important for daily tasks, from reading a newspaper to cooking a meal [4]. They also found that activity in the prefrontal cortex of the brain, which is associated with cognitive control, increased. Activity also increased in a neural network linking the prefrontal cortex to the back of the brain [4].

Conclusion

Several studies have shown that video games can be beneficial to us from a neuroscientific perspective. However, it is too early to conclude that spending as much time as possible on video games would be advantageous to our cognitive abilities. In fact, video games do have negative aspects. For example, some research studies imply a connection between video game addiction and mental disorders [5]. Additionally, it is impossible to say all video games are benign, since all the research studies mentioned in this article were conducted using specific video games (*Super Mario 64, Super Mario 3D World*, *Angry Birds* and *NeuroRacer*). Nevertheless, playing certain video games in moderation may have positive impacts on our brain after all.

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Recent Algorithms Can Accurately Predict and Diagnose Depression

Kylie Fuller

Abstract

Depression and anxiety are two of the most common mental illnesses [3], yet they are also two of the most difficult to diagnose. Advances in diffusion tensor imaging and support vector machine learning algorithms are enabling researchers to diagnose and predict an individual's risk of developing depression, anxiety, and suicidal tendencies more accurately than clinicians [2]. By analyzing neuroimaging data from brain scans and identifying patterns, supercomputers are detecting similarities and differences between healthy and ill brains that are nearly impossible to recognize otherwise [2]. Recent studies are paving the way for future use of these novel technological advances and are providing promising information on fractional anisotropy and how it relates to depression in the brain.

Diffusion Tensor Imaging

Diffusion tensor imaging (DTI) is a magnetic resonance imaging method for characterizing microstructural changes or differences by measuring restricted diffusion in a tissue [1]. More simply, DTI scans map brain connectivity and allow for the comparison and determination of various abnormalities in brain tissue [1]. Although similar to MRI scans in that they both use water diffusion, DTI tags water molecules to discern the extent to which they are microscopically diffused into the brain and the direction to which they are more likely to diffuse [2]. MRI scans utilize water diffusion in the brain to generate an image that reveals blood flow and brain structure on a less focused scale [2], while DTI specifically displays white matter [2]. Molecular diffusion is dictated by interactions with macromolecules, fibers, and membranes, which allows DTI scans to display differences in white matter fiber structures, tissue construction, and model brain connectivity [1].

DTI's most common application is measuring differences in responses to treatment of white matter neurological disorders, such as Alzheimer's disease and multiple sclerosis [2]. Fractional anisotropy— the extent to which diffusion is directional— is commonly used to characterize DTI scans, since the produced images demonstrate the direction in which water molecules diffuse [2]. Due to the ability of DTI scans to provide such information, they are becoming a preferred method

of inferring white-matter tractography, a technique for visually displaying neural tracts and their connections to other areas of the brain [1]. Being able to clearly see the neural connections of water matter in the brain is unequivocally essential to understanding white matter diseases [1]. By providing this function, DTI scans can potentially be used to develop an improved understanding of the causes and behaviors of life-altering disorders like cerebral palsy.

Support Vector Machine Learning

Machine learning is a subfield of computer science that incorporates pattern distinction and computational learning to construct algorithms that allow computers to learn from and make predictions based on data given to them [4]. A specific field of machine learning, support vector machine learning (SVM), analyzes data to make classifications [4]. More specifically, these machines use statistical processes to discern connections between sets of data and then categorize them into respective groups [4], much like dividing cards in a deck based on suit. Machines are provided with training examples marked as being in one category or the other, which then allows for the generation of a model that will assign future examples to either category [4]. In recent years, support vector machine learning has become a novel method for analyzing fMRI data, making predictions by combining information from different elements representing given values on a 3D grid, called voxels, in fMRI scans [5]. A growing number of studies are using machine learning classifiers to obtain new information from neuroimaging data [5]. Due to the complexity of the brain, using machine learning algorithms is often necessary to discern the complex information [5]. Each brain is visually represented by 175 voxels, which are similar to pixels in representing a given brain mass, so it is impossible to detect complex differences between scans simply by looking at them unaided [5]. Algorithms, on the other hand, with the ability to closely analyze brain scans can detect these miniscule, subtle patterns much more accurately than the human eye.

Predicting Depression, Anxiety, and Risk of Suicide

Depression and anxiety are two of the most common mental illnesses in the United States. They affect 40 million adults in the U.S., 18% of the population [3]. Many people suffering from either of these disorders do not receive a proper diagnosis or treatment partially because depression and anxiety disorders can be difficult to identify due to how different the symptoms can be in individual patients [3]. While subjective experiences of depression are correlated with physical differences in neurophysiology, researchers have still been unable to find a method of consistently and accurately predicting the risk of developing depression or anxiety [3]. However, recent advances in diffusion tensor imaging (DTI) and support vector machine learning (SVM) algorithms may allow researchers and clinicians alike to readily predict an individual's risk for depression and anxiety through in-depth neuroimaging analysis [2].

David Schnyer, a cognitive neuroscientist at the University of Texas at Austin, is using DTI scans along with SVM to predict depression and anxiety [2]. In his study, Schnyer analyzed DTI

brain scan data from 52 treatment-seeking patients with depression and 45 healthy control patients and then matched a subset of depressed individuals with healthy individuals based on common characteristics, such as age and gender [5]. An SVM received example scans of individuals who were marked as healthy or diagnosed with depression [2]. The machine used these models to create two categories into which new scans can be placed: those that are healthy and those that could be diagnosed with depression [2]. Schnyer then fed DTI scans from the study participants into the machine, which found statistically significant differences in fractional anisotropy between healthy subjects and those diagnosed with depression or anxiety [2]. The study demonstrated that machine learning can accurately classify people who are at risk for or diagnosed with depression in comparison to healthy control subjects [7]. The results also contributed to neuroscience's understanding of how depression presents itself in the brain. Alterations across various areas of the brain, rather than just one, appear to contribute to depression [2]. While the results are promising, more research is necessary until such techniques can be used for clinical diagnosis.

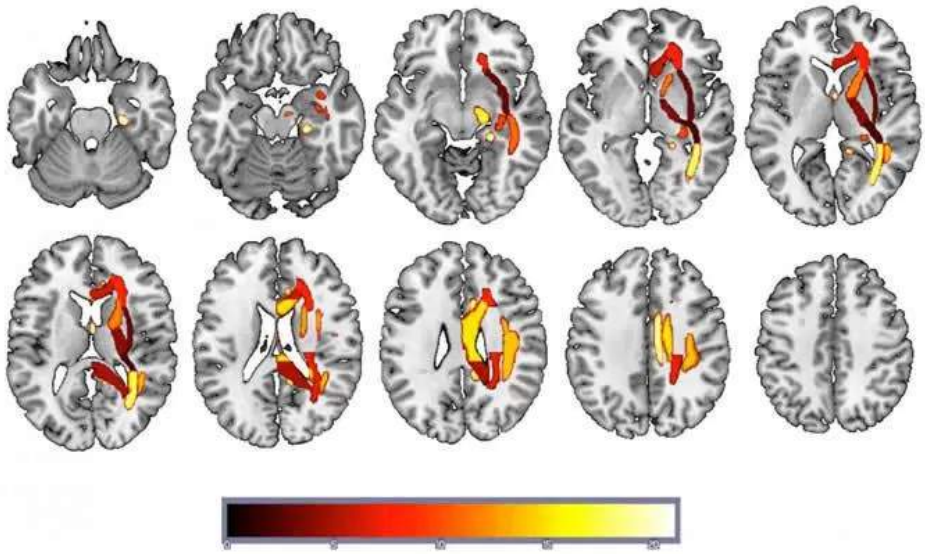

Figure I. Regions differing in fractional anisotropy as shown from machine learning solution. The heat color map demonstrates the level of contribution to the machine learning solution with the darkest areas having the greatest level of contribution. [2]

Nonetheless, similar studies have been conducted that revealed comparable results, offering a promising outlook for this up-and-coming technology as it relates to predicting suicide. Suicide is the tenth most common cause of death in the United States and over 40,000 people commit suicide every year [6]. Furthermore, it is the leading cause of death among adolescents [6]. Still, little is known about the neurological aspects of suicide, and the warning signs are difficult to predict [6]. In fact, a recent meta-analysis [7, 8] that included 365 different cases of suicide over the past 50 years

revealed that no single risk factor alone can accurately and clinically predict an individual's risk of suicide [7].

Despite the remaining scientific ambiguity surrounding suicide prevention, researchers are actively seeking and discerning new strategies to improve upon suicide prediction and prevention. A researcher at Florida State University and a data scientist from Vanderbilt University enlisted the help of machine learning algorithms to improve suicide prediction methodology, providing clinicians with a possible method for predicting suicide up to two years in advance with 80% accuracy [8]. Much like Schnyer's study, medical information (such as medications, prior diagnoses, body mass index, and demographics) from suicidal individuals and victims was given to a machine, which successfully connected patterns among these cases [7]. The computer accurately identified 80-90% of cases as suicidal, at risk for suicide, or healthy [7]. Though studies are still developing, continued research into the coalition of machine learning and diffusion tensor imaging could open the door to a deeper understanding of both mental illnesses and white-matter tractography.

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How Does Media Use Influence Brain Development In Adolescence?

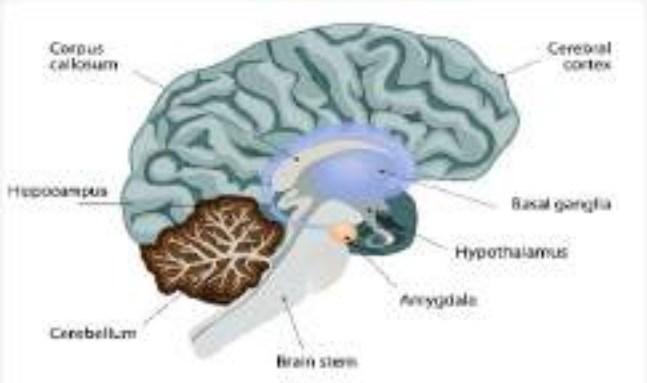
Nathiya Vasantha Kumaran

Abstract

For the current generation of adolescents, technology has been integrated into every aspect of their lives, including school work, entertainment, and communication among peers. With an increasing number of teenagers owning mobile devices, such as smartphones, the number of accounts on social media platforms, such as Facebook, Instagram, Twitter, and Snapchat, continue to grow daily. Even though these websites allow teenagers to easily share information, pictures, and opinions with the public, the constant pressure to be accepted by peers has negative effects on a developing brain. During adolescence, many different regions of the brain are developing, especially those which deal with the social and emotional aspects of life. Thus, this makes teenagers more sensitive to online rejection and peer influence [1].

Developing Regions of the Brain During Adolescence

Between childhood and adulthood, teenagers go through a developmental stage referred to as adolescence. Up until this time period, parental influence is more significant than society on an individual; however, during puberty, this changes. In addition to changes in the way in which teenagers extract information from their surroundings, the organ responsible for processing this information, the brain, also goes through modifications. Different structures, as well as cognitive and socio-affective functions, develop within the brain. After extensive research, scientists have concluded that regions of the brain known for social understanding and communication, including the medial prefrontal cortex and amygdala, go through the most alterations during this time period [2]. The prefrontal cortex, an important area of the brain



used for planning, memory, organization, and regulating mood, continues to mature throughout childhood, ultimately resulting in adults having better reasoning skills. The amygdala, which is known for emotional processing, goes through extensive changes during adolescence as well. In addition to the maturation of specific regions of the brain, specific processes also are further developed. The white matter pathways, which play an important role in the central nervous system by connecting spatially separated areas and fostering efficient information exchange, go through changes that allow humans to better control their behavior [3]. During childhood, many humans believe that reward comes immediately after an action is completed; however, with the development of white matter pathways, people are able to recognize that reward isn't always immediate. Another important function of the brain that is drastically developed during this span of life is the connections between brain cells, formally known as synapses. Although the brain goes through its first cycle of synaptic production followed by pruning, the elimination of unused brain connections, between birth and the age of three, the second cycle takes place during puberty. The process takes place in girls at the age of 11 and in boys at the age of 12. By the time the individual reaches the age of 13, the amount of grey matter has been significantly reduced [4]. Since the teenage brain is constantly undergoing changes, it is important to keep in mind that the activities in which they take part can shape the way their brains develop.

Teenagers and Acceptance

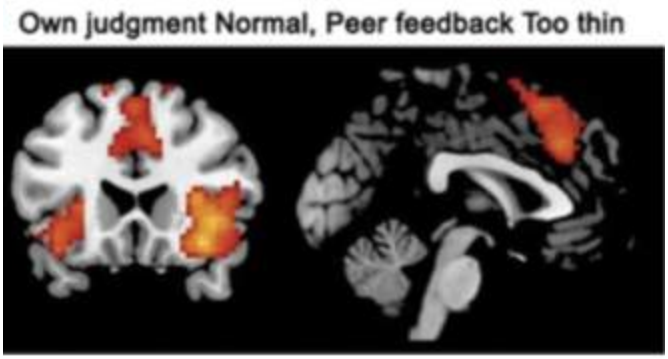
Due to the numerous changes that take place in various regions of the brain during adolescence, especially in areas connected to social behavior, it is likely that social media has a significant impact on development. From the very early stages of life, humans are constantly yearning to be accepted by their peers. However, this need for acceptance is not a new concept. In the past, our ancestors evolved to favor group living, as it helped them survive harsh environments and ensured safety [4]. Even though the concept of acceptance is one that individuals have struggled with for generations, today's teenagers have the additional pressure of being accepted online. Each social media platform with which teenagers engage has a way to convey to a user how much they are accepted by their peers. The more the comments, likes, and followers, the more accepted the person is considered to be.

Although it may not seem like these artificial measures of popularity have an impact on the development of a teenage brain, it has been proven that the brain responds to social acceptance the same way it does to receiving other rewards [6][7]. By conducting extensive research, scientists have discovered that individuals perceive social rewards, such as receiving money, in two different overarching regions: the basal ganglia, located at the base of the forebrain, and the prefrontal cortex, located in the frontal lobe. Within the basal ganglia, both the ventral striatum and ventral

tegmentum are responsible for how the brain reacts to social rewards. Meanwhile, in the prefrontal cortex, the ventromedial prefrontal cortex is responsible for processing emotional responses through decision making and self-control [8]. Since all of these areas are still developing in

adolescents, the feeling of acceptance is especially important during this time period due to its impact on one's identity.

Peer Influence



During adolescence, individuals become more interested in the opinions of their peers than those of the adult figures in their life. Accordingly, teenagers are more likely to post and interact with images that they believe the majority of society, more specifically their friends, will accept. Researchers have found that girls are especially sensitive to body image on social media and have preconceived notions about how someone should look. When a teenage girl with lower self-esteem was showed an image of the ideal body image, the activity levels in the anterior cingulate cortex were greater. The anterior cingulate cortex, the area of the brain responsible for connecting the emotional limbic system and the cognitive prefrontal cortex, has an impact on the way one regulates one's emotions [10]. The image on the left confirms this finding as well as the hypothesis that different areas of the brain become more active after a teenager changes his or her opinion due to peer influence [1]. This evidence suggests that social media has an influence on the way one attempts to portray oneself since teens are constantly trying to prove to themselves and their peers that they fit society's definition of perfection.

However, peer influence doesn't solely impact the type of posts individuals share on social media platforms; it also impacts how teenagers interact with posts in their feed. By analyzing prior studies, researchers have found that people are more inclined to like a post with a greater amount of likes than one with a fewer amount. For example, if a teenager saw a post with a hundred likes that had also been liked by a large percentage of their friends, then that teenager is more likely to interact with it than a post with only one like [11]. When viewing an image with a greater number of likes, the amount of activity in the ventral striatum increases. In this experiment, researchers concluded that older adolescents, including upper high schoolers and college students, were more impacted by this form of peer influence, since the activity in the ventral striatum was greater. Based on the information which scientists have uncovered, it can be inferred that peer influence through media presence during adolescence can greatly impact the way an individual perceives not only themselves but the world around them.

Going Forward

During adolescence, teenagers go through mass amounts of developmental changes in their brains, especially in areas responsible for social interaction. The social regions of the brain are easily impacted by external stimuli, including acceptance, whether it be online or in real life. In an era where social media platforms are becoming an ever important part of our social lives, an increased amount of teenagers are using them. Since individuals begin to explore these platforms around the same time they go through these changes, their self-esteem may become affected, since they are constantly being judged by others online. In order to ensure that individuals don't suffer from a lack of self-esteem, it is important for adults to boost teenagers' confidences. Without proper confidence boosts, individuals can begin to perceive themselves in negative ways due to what they have been exposed to online.

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Cognitive Neuroscience: A Critical Social Review

Esthefani Chávez Hinostroza

Introduction

Each human being has different ways of expressing themselves and acquiring notions about their environment, their actions, and their internal states to achieve a personal balance. This balance forms their identity, characterizes their behavior, and guides their particular interpretation of the world. These expressions are represented in a cognitive, emotional and behavioral way whose interrelation has a biological basis that define the mental functions of an individual and the subsequent behavior that they will adopt. Endemic diseases, current needs of technological implementation and incidence of crimes need an immediate response. Therefore, it is opportune to establish a connection between neuroscience and cognitive psychology from a social perspective. As this connection is made one will be able to further understand how changes in a person's cognitive processes may change their individual behavior and determine their development within a community. In this article, a critical analysis of the implications of cognitive neuroscience: public health, technology administration, and legislation and legal order will be presented.

Influence on Public Health

Public health is an essential component for the development of a society since it is meant to improve and sustain the personal well-being, both physical and mental, of the population. Research in cognitive neuroscience plays a fundamental role in mental well-being as it furthers our understanding of diseases of the brain and mind. For example, neurodegenerative diseases are studied by using neuroimaging techniques to evaluate cerebral functioning. Several scientific fields and techniques are integrated to develop interventions to improve the quality of life of those who suffer from such diseases. Additionally, such a multidisciplinary approach may also be beneficial in to protecting vulnerable social groups, such as those suffering from Alzheimer's disease.

In 2005, the Healthy Brain Initiative emerged in the United States as a collaboration between the Centers for Disease Control and Prevention and the Alzheimer's Association with the goal of transferring the focus of public health to cognitive health. The Healthy Brain Initiative created a plan that focuses on the dissemination of scientific knowledge to the population, the assessment of their scientific effectiveness and reliability of cognitive health programs, the adequate management

of such programs, and the efficient collection of information on cognitive health [1]. These strategies will promote improvements in health in order to provide interdisciplinary support to the citizens, both those who are suffering from cognitive health issues and those who may wish to prevent such issues from occurring, some of which are discussed below.

The study of mental disorders, such as depression and anxiety, is enabling scientists to discover more about their incidence, prevalence and new treatments. These pathologies constitute an issue that concerns the world population, and therefore play an essential role in the improvement of public health. Currently, they imply a great personal and social cost whose course produce a maladjustment for the individuals. It is expected that in the future we may be able to use alternative methods according to the symptoms and signs of depression based on models of brain structure and function, considering the mechanisms associated with this disorder and the responses to its treatment to optimize its results. [2].

Likewise, addictions represent a serious problem to society because they produce instability within a community. A lack of order and compliance with societal norms, family dysfunction, and increased insecurity may all be outcomes of addiction within a community, especially when addiction begins at an early age. Community members suffering from addiction become risk factors within that community, threatening to disrupt the normal order of the community [3].

Taking such potential issues into account, it is easy to see that research in neuroscience is providing valuable knowledge through its look into addiction. One specific area of great interest has been nicotine's addictive mechanisms and the impact of messages aimed both at spreading of smoking and its prevention. Neuroimaging reveals new features about unconscious responses to information that go on to influence addictive behavior, such as the higher occipital activity in the primary visual cortex, in front the presentation of spots with a high "message sensation value" (MSV), a measure of sensory intensity of the features of an advertisement and an important factor of Public service announcements (PSA) impact. On the other hand, for spots with a lower MSV had significantly higher activity in the frontal and temporal cortices in areas related with memory encoding. This result suggests that more attractive and stimulant ads do not always lead to smoking. Through this type of research, we are able to analyze the impact of tobacco promotion and anti-tobacco campaigns and potentially increase mental well-being within both individuals and communities [4].

Rates of addiction directly affect levels of violence, corruption, and death [5]. Studying addictions allow for the development of effective evaluation, diagnosis and rehabilitation techniques that favor healthy habits. Thus, this research contributes to the effects of physical and emotional dependence that make it a public health problem above social exclusion, a stigma that surrounds the use and abuse of drugs [6].

Influence on Technology Administration

Applied technology has become a fundamental component of any occupation that uses multimedia tools. Current education is becoming more interactive through the development of new pedagogical technology with an increasing focus on teaching software that encourages reasoning and logic in problem solving. Through practice-oriented (using unsupervised repeated practice), needs-oriented (such us the use alternative methods for students that suffer of reading difficulties), and age-independent teaching methods that utilize meaningful digital implementation (linking the abstract concepts with the physical concepts that allow better learning), students are faced with challenges that encourage practice and persistence [7].

Utilizing technology in teaching may increase both intrinsic and extrinsic motivation within students: that is to say a student's own internal motivation to learn as well as the motivation from family and friends may increase with the use of technology. For example, by reaching out to children of different conditions in diverse environments, educative technology encourages reciprocal learning in which a set of students share their knowledge and experiences together online or by being close in a study environment. Likewise, neuroscience research shows that learning mechanisms and the individual characteristics in each learner improve the ability to learn [8].

In addition, the dissemination of these technologies allows for superior academic training, resulting in an improvement of the cognitive abilities of the students, a more favorable attitude towards studying and better overall performance in the teaching-learning process. Through the personalization of the educative strategies according particular needs of students, the foment of collective creativity and multimodality of teaching offers a more enriching learning experience [9].

New technologies can also help teach adults new skills, allowing them to stay mentally active and healthy, in addition improving performance during collaborative work, discussion, and critical reflection in activities of continuous training that technology applied to education provide to retired adults [10].

Influence on Legislation and Legal Order

Neuroscientific evidence, such as Electroencephalography (EEG), Magnetic resonance imaging (MRI), Computed tomography (CT) and Single photon emission computed tomography (SPECT), is becoming more commonly used to prove innocence of the accused in criminal hearings [11]. In the United States between 2005 and 2012, more than 1585 court rulings refer to the use of neurobiological tests to reinforce the defendants' argument. In 2012, more than 250 cases indicated that the defendants committed criminal acts by "influence of their brain" more than by their own will, and 5 percent of homicide trials and 25 percent of death penalty trials sought to reduce liability using neurobiological data [12]. In that context, this type of evidence can be beneficial in making important decisions regarding personal responsibility while remaining unbiased [13].

Different models of clinical neuroscience indicate that there is a significant biological basis for antisocial behavior, information which is important in both understanding the origin of social violence and preventing potentially dangerous behaviors [14]. These studies have found the prefrontal cortex, cingulate, temporal cortex, angular gyrus, amygdala, and hippocampus, which are

involved in moral judgement, are often structurally or functionally impaired in people with antisocial tendencies, as seen in Fig. 1 [15]. There has been a great deal of research surrounding potential genetic influences of antisocial behavior, such as the monoamine oxidase A (MAOA) gene, which has been hypothesized to increase the likelihood of antisocial behavior when coupled with childhood mistreatment. [16]. Now, as we uncover more information about potential neurological bases for such behavior, some researchers are beginning to focus on investigating which genes encode the specific cerebral deficiencies found in antisocial groups [14].

Research into populations predisposed to develop maladaptive behaviors has the potential to improve the neurocognitive functioning of at-risk individuals through early prevention, decreasing rates of violence and crime. Given the behavioral dysfunction of the offenders, interventions are needed at the cerebral level to approach the problem at its roots. A recent study of transcranial magnetic stimulation (TMS) therapy shows an enhancement of the neural excitability of the prefrontal cortex leading to some improvement of attitudes toward the fulfillment of social norms imposed by the punishment. Likewise, a reduced prefrontal function in antisocial individuals has been reported in brain images, for which the improvement of the functionality of this area could favor the prevention of crime [17]. Emerging research in neurocriminology has resulted in discoveries that understand crime from the biosocial perspective, information which will eventually go on to change the way we develop and implement legal policies to predict the occurrence of violence and contribute to the decreasing of criminality.

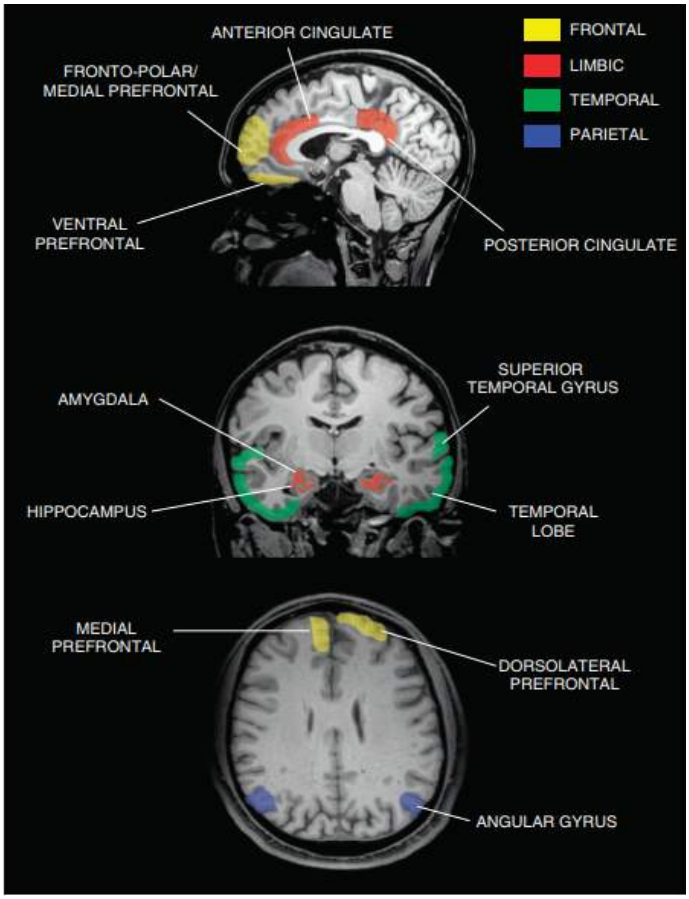

Fig. 1. Illustration based on midsagittal (top), coronal (middle), and axial (bottom) MRI slices of the brain regions found to be structurally or functionally impaired in antisocial, violent, and psychopathic populations **[15]**

Cognitive neuroscience focuses on the neural bases of cognition. It is the means to know how an individual can satisfy his or her own demands of self-development at multiple levels, and how behavior is produced to achieve progress. This science applied to public health, technology administration and legal order will allow society to, in time, vastly improve the general population's quality of life and better understand and solve future political, cultural and ethical dilemmas that comprise social advancement.

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Interview: Neurological Complications of HIV/AIDS

Chinmayi Balusu

Introduction

I had the honor of interviewing Dr. Igor Grant, the Chair of the Department of Psychiatry at the University of California, San Diego School of Medicine. Dr. Grant is involved in research on HIV/AIDS, drug and alcohol abuse, and chronic stress in the elderly; currently, his research is focused on the effects of HIV, methamphetamine abuse, and the effect of aging on the acceleration of injury on the central nervous system (CNS) [1]. In this interview, Dr. Grant talks about what led him to pursue research in HIV/AIDS, potential treatments, and the biggest challenges he has faced while researching the effects of the disease on the nervous system.

Chinmayi Balusu (CB): What is your particular field and what led you to pick it?

Figure 1. Dr. Igor Grant. [2]

Dr. Igor Grant (IG): By training, I am a neuropsychiatrist, which means I am a medical doctor who also received training in psychiatry and some training in neurology. My research interest has always been in how different diseases and also drugs of abuse may impact the brain and behavior. HIV, as you know, is a viral disease and it can affect the brain. My interest in HIV came from my more general interest in neuropsychiatry and brain-behavior relationships.

CB: What are the effects of HIV and AIDS on the brain?

IG: HIV is a virus. When it enters the body, it can also enter the brain because obviously the brain is fed by blood vessels, and blood that is contaminated by the virus can allow the virus to enter the brain. Also, the virus causes inflammation, which means that there are certain kinds of immune cells in the blood that actually carry the virus. Sometimes, these will also cross into the brain across the blood-brain barrier. The virus can get in just by diffusion through blood, and it can cause an inflammatory response in the brain. The injury can be either functional, meaning the brain is not happy and not working right, or actual damage that can be irreversible.

CB: What type of treatments are there right now for HIV and AIDS?

IG: This is a bit of a complicated question so let me answer it in parts. Let's say that a person belongs to a group where they are at a high risk of becoming infected with HIV. You could actually give them a low dose of medicine that can prevent the person from becoming infected in the first place. Now, once a person does become infected, you want to treat very early because what you want to do is prevent the spread of the virus throughout the body, especially to the brain. Once a person has an established infection, then your job is to eradicate the virus; however, as of now, none of our drugs are able to do so completely. What they can do is suppress the virus so that you can't find it in the blood using regular tests. But the virus can still be lurking around in different parts of the body, including the brain. Then, you have to be sure that you keep treating the person with whatever are the most effective antiviral drugs. Not everyone responds to these medicines in the same way. It depends on your own physiology as well as the characteristics of the virus. Viruses have a common ancestry but they have some differences. Some viruses are more sensitive to one drug compared to others, but as long as you can keep the virus under very good control, you are less likely to have the various effects of the disease. The final point is that there is some research that says some of these antiviral drugs are better at getting into the brain than others, so they may possibly be more effective. The blood-brain barrier is set up so that it doesn't allow random things in there and so sometimes it does not allow medicines. You have to find the medicines that penetrate into the brain.

CB: What kinds of drugs are used to treat HIV?

IG: There are different classes of drugs, such as antiviral drugs. What antiviral drugs try to do, in general terms, is they try to interfere with different parts of the virus's reproductive cycle. The way HIV works is it gets inside your cells, mostly the immune cells, and it hijacks the genetic material of that cell to make its own genetic parts. So what you want to do with

these medicines is interfere with different parts of the cycle of replication of the virus. The current treatment involves giving several classes of drugs so that you kind of hit the virus at several points because biological organisms are built to get around problems. The virus can evolve and it can start to do different things to get around the drug. But if you have several points of blockage it's much more difficult for the virus to develop resistance.

Figure 2. HIV/AIDS Antiviral Drugs. [3]

CB: When it comes to the virus getting across the blood-brain barrier, is there a certain way in which the spread of HIV would have a further impact on the brain?

IG: Inflammation is an important part of how the HIV disease progresses. What the inflammation does, that is, if you have a lot of inflammatory cells and molecules in your bloodstream, is that it can actually change the permeability of the blood-brain barrier. It sort of weakens and opens up the doorway so that various kinds of leakage develop across the blood-brain barrier. If you have other diseases or conditions that also produce inflammation, that can make this process worse. For example, I am currently looking a lot at methamphetamine use. In addition to producing high stimulation, it can also kick up the inflammatory system by itself, without HIV. When you put the two together then you have more inflammation that can make conditions worse. So these coexisting diseases and certain kinds of drugs of abuse can all make things a little bit worse

CB: What is one of the biggest challenges you have faced in researching HIV/AIDS?

IG: I think one of the big challenges in working in brain disease, in general, is that as opposed to other organs, the brain is really not accessible to biological inspection. Let's say you have some sort of problem with your liver. You can actually put in a needle and take a little piece out to look at it. But you can't put a needle in the brain and take a piece out to take a look at it. You have to use methods, such as brain imaging and neurocognitive testing, which is basically testing people's memory, attention, etc. So there are a number of approaches, but, in a sense, they are all indirect. Some of what we know about the effects of HIV comes from studies of people who have died from these diseases. We can look at their brain specimens and do autopsies. So that's one big challenge in this field: you can't actually take the organ and look up pieces of it. A lot of it is inferential.

CB: Even though more than 50% of patients with HIV have been diagnosed or will be diagnosed with neurocognitive disorders, why do you think it is not very well-known?

IG: I think in part it's because many of these cognitive disorders are very mild in nature so they're subtle. You need to very carefully evaluate a person's memory, attention, and other functions to detect it. Often people with HIV will say: "You know I'm actually not as sharp as I used to be. I kind of lose track of things more than I used to." It's not the case where people are wildly demented, but there is a small subset of people who develop dementing disorders. In the past, before we had really good treatments for HIV, the rates of these more severe cognitive disorders was much higher, about 15 percent. A lot of those are what we call asymptomatic, meaning that unless you look for it or unless a person reports it you can't find it.

CB: Is it possible that HIV can increase the risk of developing dementia, such as Alzheimer's?

Figure 3. HIV/AIDS. [4]

IG: We don't know that for sure. It's more likely the case that people who have chronic HIV disease, even if it's well-treated, still have this inflammatory response that is in the background. What that can lead to is cardiovascular disease and cerebrovascular disease, so there's some evidence for these processes, as opposed to Alzheimer's itself. Let me put it this way: our organs have a limited number of ways in which they respond to injury. If you take the liver, for example, and give it some kind of poisonous substance, the person will turn yellow because of jaundice. The brain is the same, whether it's developing a problem through an Alzheimer's process, vascular injury, or because of tiny strokes and problems like that. It hasn't been determined for sure. We've looked at the brains of some people with HIV who died in their fifties or sixties, and they have some of the protein changes that we find with Alzheimer's and Parkinson's more than we would expect at that age, so it could be multiple factors coming together.

CB: What are the current stages doctors use when determining the severity of a patient's condition?

IG: First of all, there could be no complications, so the person is just normal. As you said, 50 percent or more have no problems at all. If you look at their brains after they die,

their brains look fine. The first stage is what we call asymptomatic neurocognitive impairment (ANI). I consider the ANI stage as kind of a preclinical stage. There's something there but the patient is basically doing okay. The next stage is mild neurocognitive disorder which means that the person has some impairment in memory, attention, or whatever it may be, and it has some effect on their daily life. For example, if they are students it takes them a lot longer to study something or to comprehend something. They need to exert a lot more effort. People may start relying on other people to help them or use a lot more technology. The final stage is the stage of HIV dementia where a person has cognitive dementia, and they are no longer able to function well.

CB: Does age play a role in how severely HIV/AIDS affect the brain and nervous system?

IG: Yes, it does to some degree. First of all, unfortunately, the older you get, the less good your cognitive function is in certain areas. There is kind of an unfortunate line that shows that if you're 60 or 70 you're just not doing as well on cognitive functions. Older people are usually fine with verbal skills so there is an age-related decline naturally even if you don't have any disease. What we find with HIV is that the decline is amplified. It's as though if you tested someone who is 50 or 60, they might be performing like a 55 or a 65-year-old.

CB: What is the connection between HIV/AIDS and syphilis?

IG: There is not a direct connection except that there are two things: they are transmitted similarly through unprotected sex with an infected person and syphilis can produce lesions or sores in the sexual organs. HIV can enter your body easier if there are these sores where the mucosal barrier has broken down. For example, we have a lot of germs in our mouth but our body is protected all the time by the mucosa, the moist skin inside of the mouth. If you have sores you're more likely to get an infection of some sort. Syphilis itself can produce inflammation and a neurological condition. It does appear that people who are syphilis positive are more likely to have these neurocognitive impairments. It's troubling because syphilis promotes this inflammatory state of HIV.

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