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What brought you here today? Are you admiring your own hard work? Has a Nerve staff member shoved this copy into your hands? Or have you happened upon our magazine somewhere on campus? Regardless of how, we sincerely hope you gain something from its pages. In the midst of social media's reign on the spread of information, the options for learning and discovery are vast and incredible, and, more so than ever, easy. Though we can appreciate the effortlessness in accessing news in list format (with .gifs!) or in 140 characters or less, it is a breath of fresh air to be a part of a production like The Nerve. Despite intense course loads, extensive extracurricular activities, and personal research projects, staff members of The Nerve have made learning and the spread of information a priority. And, if you have read this far, we have reason to believe that you have made it a priority as well!

The Nerve had modest beginnings with a few students looking to create an outlet for their scientific interests in the brain and mind. Now in its fifth year and supported by a larger staff, The Nerve maintains these same, simple aspirations. Though we come from a wide range of intellectual interests and academic programs including neuroscience, psychology, computer science, biology, sociology and music, all of us are committed to learning and exploring. This is evident through the contents of this issue alone, with topics ranging from pesticides to transcendent experiences. However, we have found that the quest for information and understanding can be just as inspiring as its content. So, please, enjoy the scientific investigations within our journal, but don’t forget to appreciate the journey of discovery!

To the staff members of The Nerve—once again you have impressed us with your hard work and determination. We are very proud of this issue and you should be too! Returners—we see how you have challenged yourself to make improvements and we are inspired by your work. To the newbies—your fresh ideas have made this issue of The Nerve exceptional. We hope that you all continue to commit to excellence in all that you do, which hopefully includes more issues of The Nerve.

As always, we would like to thank Paul Lipton, Ashley Hoesing, the Undergraduate Program in Neuroscience, and the Mind and Brain Society for their continued support. The Nerve has provided many of us with a unique and creative outlet, but without your support and encouragement our ideas would not have come to life via this magazine. To future editors-in-chief, staff members, and supporters, we wish you all the best!

Shelbi Ferber and Kameron Clayton
Editors-in-Chief

“Somewhere, something incredible is waiting to be known.”
– Carl Sagan
Discovery of New Alzheimer’s Disease Markers in Cerebrospinal Fluid

Elizabeth Tingley

As baby boomers age, Alzheimer’s disease (AD) is at the forefront of neurodegenerative disease research. Although drugs and therapies exist to improve memory and other functions impaired by AD, no treatment for the entire disease exists. To be successful, a treatment must be administered before the brain is irreversibly damaged. However, the pre-symptomatic stage of AD occurs more than 10 years before any clinical presentation of the disease, making disease detection extremely difficult. Therefore, research that improves our ability to identify presymptomatic AD patients is a crucial first step in the development of treatments.

The hallmarks of Alzheimer’s disease are neurofibrillary tangles, which are composed of hyperphosphorylated tau protein, and plaques, consisting of aggregated amyloid-β (Aβ) peptides. Tau proteins serve as axonal microtubule stabilizers. While the function of Aβ peptides is not as clear, they may play a role in antimicrobial activity as well as protection against oxidative stress. To definitively diagnose AD, postmortem analysis of brain tissue is required to identify characteristic tangles and plaques, however, it is possible to diagnose AD with much less certainty in a living person by analyzing the presence of Aβ and tau in the patient’s cerebrospinal fluid (CSF). Though this method is not 100% effective even in individuals already exhibiting the symptoms of mild cognitive impairment.

To study potential treatments for Alzheimer’s disease, researchers must confirm a definitive diagnosis before any cognitive impairment begins. To understand this necessity, consider a hypothetical drug that prevents disease progression, including symptoms such as cognitive decline. The goal of a clinical trial would be to determine how effectively the drug works on AD. Trials would consist of one group suffering from AD and one clinically normal group, and compare those groups to each other and to a control not receiving the drug. If people in the drug-receiving group were not truly AD patients, they would not display cognitive decline following drug treatment. Thus, the drug would appear to treat AD while it actually may not be effective, thus undermining clinical trials. A definitive and accurate di-
The social and cognitive impairments associated with schizophrenia are widely established, and include impaired memory and reduced hippocampal volume as compared to healthy controls. However, the majority of schizophrenia research is less focused on the equally detrimental, secondary complications that these patients commonly endure. Sixty to seventy percent of patients diagnosed with schizophrenia have symptoms of depression and anxiety, and many patients show signs of cognitive decline. The primary goal of schizophrenia research is to understand the underlying causes of these impairments, and to develop effective treatments that can improve the quality of life for people with schizophrenia.

To address this issue, researchers are searching for a better diagnostic test for Alzheimer’s disease. A leading researcher in the effort to develop accurate early diagnosis of AD is Andrea Armstrong of the Department of Clinical and Experimental Medicine at Linköping University in Linköping, Sweden. To find clinically useful biomarkers, Armstrong and her colleagues focus on the initial neuropathy associated with AD afflicted brains. One of these changes occurs in the lysosomal systems of the cell. Research suggests that the plaques found in AD are caused, at least in some part, by the activity of lysosomes, which dispose of waste in the cell. In the brain of a healthy individual, the excess Aβ proteins are removed by lysosomes. In the brain of an AD patient, this process is not carried out properly, resulting in the accumulation of plaques. Armstrong and her team specifically explored whether CSF could be used to observe changes in the lysosomal network.

The group studied spinal marrow samples from 20 AD patients and 20 healthy control subjects, looking specifically for 35 proteins that are associated with the lysosomal network. The experiment revealed that six of the proteins were clearly greater in Alzheimer’s patients than in controls. These six proteins had not been previously identified as AD biomarkers. The discovery of these novel proteins brings researchers closer to fully understanding the disease pathology, a groundbreaking step towards the definitive diagnosis of Alzheimer’s disease in living people.


Exercise Training in Persons Living with Schizophrenia

Jamie Nagy

The social and cognitive impairments associated with schizophrenia are widely established, and include impaired memory and reduced hippocampal volume as compared to healthy controls. However, the majority of schizophrenia research is less focused on the equally detrimental, secondary complications that these patients commonly endure. Sixty to seventy percent of pa-
Patients with schizophrenia are overweight or obese, and these patients consequently develop an increased risk of cardiovascular disease and Type 2 diabetes. These secondary complications largely arise due to physical inactivity and the metabolic side-effects of psychotropic drugs. Although antipsychotic medications have drastically improved over the past several decades and provide significant benefits to most patients, the medi-

*Mapping. Artwork by Rachael Murphy.*
In their study, Bredin et al. faced complications with data interpretation. Additionally, many of these medications still have severe side effects that are typically associated with extreme weight gain and altered metabolic rate.

When we consider these secondary complications, a solely pharmaceutical approach is inadequate for patients living with schizophrenia. Indeed, supplemental non-pharmacological approaches also are necessary to improve quality of life. A group of Canadian researchers, Bredin et al. 2013, recently explored this theory by implementing exercise as a form of therapy for these patients. Previous research suggests a correlation between exercise and hippocampal integrity. Because of this, the current researchers hypothesized that individualized exercise prescriptions for schizophrenic patients may cause cognitive improvements and reduced negative symptoms associated with schizophrenia.

To explore the therapeutic role of exercise, Bredin et al. implemented a pilot study of 13 patients, consisting of seven males and six females, aged 21-45 years. Of note, the study only considered individuals with schizophrenia and did not provide a healthy control sample. Qualified participants were not already enrolled in a regular exercise program and did not have a history of other psychiatric disorders, amongst other inclusion and exclusion criteria. Additionally, four of the qualified patients were later withdrawn from the study due to non-adherence to appointments, prohibited drug usage, or relocation. Thus, we must consider the small sample size when evaluating the significance of this study’s results. Only nine participants completed the trial, and the researchers established specific criteria that made it difficult to find a representative sample of patients with schizophrenia. Nonetheless, the study has merit because it targeted a specific subgroup of patients, whom the researchers hypothesized were likely to have secondary health complications due to their physical inactivity.

Each patient in the study was distributed randomly to either an aerobic exercise or a resistance training intervention. The design used subjects as their own controls, comparing their pre-exercise data to program completion data. Patients remained on their medications throughout the program, and six of the patients were taking two or more concurrent medications. Because of the small sample size, Bredin et al. found limited statistically significant decreases in weight and symptoms between training groups and across training. However, the results indicated clinical relevance: all subjects from both groups exhibited physiological improvements in exercise tolerance measured after training.

However, during further clinical evaluation, Bredin et al. faced complications with data interpretation. One paradigm used self-reported data from patients to identify if they considered themselves to be more physically active during the exercise program. Notably, one participant reported that he did not engage in any physical activity, although the research staff monitoring him reported that he was involved in physical activity throughout the entire study. Therefore, the validity of self-reporting is questionable and alternative methods of qualitative reporting should be encouraged for future studies.

The primary conclusion from this pilot study is that exercise training and adherence to the program resulted in a slight reduction in body mass by the end of training, independent of exercise method, for patients with schizophrenia. Because this was a pilot study implementing a new non-pharmacological rehabilitative method for patients with mental disorders, the researchers did not draw many specific experimental conclusions. However, the clinical implications and potential hypotheses that result from this study are of greater interest. Anecdotal reports from the patients’ psychiatrists stated that the severity of symptoms of the patients enrolled in the program improved throughout the course of the study. Though difficult to draw specific conclusions, the implications is that patients who adhered to the program improved their clinical well-being. This study opens up the opportunity for new studies centered on these preliminary findings. From the data and anecdotal evidence, it seems appropriate to anticipate that patients with schizophrenia can be better integrated in society and become more independent if they are provided with opportunities to engage in enriching activities.

Bredin et al. state that patients with schizophrenia in their study required one-to-one instruction and supervision for exercise in small group settings. This is a difficult rehabilitative method to extend to mental health facilities due to the associated increases in cost: training of personnel and facility development would be enormous short-term expenses. However, in the long-term such funding would decrease the overall cost for society, as well as allow patients to function better and live healthier. Perhaps a move toward integrative therapies and research that focuses more on reintegration of the patient into society is necessary for the greatest benefits to all parties.

Music Void Pleasure: A Study on Music-Specific Anhedonia
Kameron Clayton

Much attention in the domain of music and the brain research has focused on “amusia,” or tone-deafness, a condition characterized by a deficit in processing musical pitch that occurs in about 4% of the population. The study of neural deficits associated with amusia has allowed researchers to understand and characterize pitch processing in normal individuals. Evidently, for these individuals, the emotional content of music is lost, and the resultant pleasure is lost. Many regard that in normal individuals music is a universal source of pleasure. However, a recent study by Robert Zatorre of McGill and a team of Spanish researchers from the University of Barcelona has challenged this notion, presenting evidence for a condition in which persons can perceive music without experiencing any of the autonomic changes associated with a pleasure response, while responses to other pleasurable stimuli are conserved.

The study consisted of two separate experiments. In the first, participants were asked to rank the degree of pleasure they experienced while listening to a given piece of music. In the second, subjects were presented with a money-reward task in which they had to respond quickly to a stimulus to gain money or avoid losing money. Both tasks activate reward-related neural circuits and lead to the release of dopamine as shown by Zatorre’s previous work. In both tasks, emotional arousal was physiological quantified by measuring heart rate and skin conductance response. In a preliminary survey, subjects responded relatively uniformly when asked about the pleasure they associate with money, sex, food, exercise, and drugs. However, responses varied significantly when asked about the pleasure associated with music. Additionally, all subjects were presented with a music emotion identification task in which they performed consistently above chance levels, suggesting that the capability to identify emotion in music is unrelated to a music-specific anhedonia.

Subjects were placed into three groups of ten based on their responses to the Barcelona Musical Reward Questionnaire (BMRQ), which assesses interindividual differences in music-induced reward, with a hyper-hedonic group, a hedonic group, and an anhedonic group. These three groups were an accurate predictor of the individual’s response to the musical task, i.e. both self-ratings and physiological measurement of pleasure responses in the musical task showed gradation between groups. However, in the monetary task, no significant differences were observed between groups, suggesting that anhedonia can be music-specific.

More globally, this study breaks apart the previously-held notion that anhedonia accompanies a deficit in perception, as music anhedonics all were able to distinguish pitch, emotion, and recognition of musical efforts. Importantly, it also shows that music anhedonia is not genre specific (e.g. a specific distaste for opera), but rather spans the domain of music. While there are global activation areas associated with pleasure (orbitofrontal cortex, ventral striatum, amygdala, insula, and thalamus), this study suggests that music anhedonics have an altered or “broken” connection between the perception and pleasure networks. By extension, we may then consider that such breakdowns in communication between the pleasure and perception networks could result in other forms of specific anhedonias.


Anti-Amyloid Treatment in Asymptomatic Alzheimer’s Disease
Maria Dekhtyar

As a research assistant at the Center for Alzheimer Research and Treatment, I have experienced first hand the logistics of launching a new clinical trial. For the past couple of months, I have been working in Dr. Reisa Sperling’s lab at Massachusetts General Hospital and Brigham and Women’s Hospital. The research team is in the process of introducing a new Alzheimer’s disease preventative clinical trial, called the Anti-Amyloid Treatment in Asymptomatic Alzheimer’s disease, or the A4 trial. This trial will recruit five thousand healthy adults, ages 65 and older, from across the country. Individuals will go through extensive screening involving memory testing, MRI and PET imaging, blood work, and lumbar punctures to determine eligibility.

One of the leading theories for the cause of Alzheimer’s disease is the build-up of amyloid plaques in the brain. Amyloid plaques are created by an accumulation of Aβ peptides. These amyloid plaques are synap-totoxins, destroying the connections between neurons, and lead to neuronal death. Those who are found to be “amyloid-positive,” defined as having a higher level of amyloid build-up in their brains, but without any clinical symptoms of Alzheimer’s disease, will be entered into the trial. These individuals will often perform normally on memory tests, but exhibit elevated levels of amyloid build-up on PET scans. To be eligible, subjects will have to find out their amyloid status, that is, the amount of amyloid that has accumulated in their brain. Though not one hundred percent accurate, this measure can be a very reliable predictor of how likely someone is to develop Alzheimer’s disease. Due to the potentially life-changing nature of this information, the A4 trial raises some ethical dilemmas, as people might not want to know.
The study aims to examine whether or not clearing out the amyloid will help prevent Alzheimer’s disease. Participants will take part in a randomized double blind trial and will receive either Solanezumab (Eli Lilly &Co) or placebo. Solanezumab is an amyloid-clearing drug chosen for the A4 trial due to its efficiency in clearing out amyloid plaques with the fewest side effects. Subjects will be followed for five years, during which they will receive multiple MRI scans, Amyloid and Tau PET scans, and cognitive testing at each visit. The hope is that the subjects receiving the treatment will perform about the same on their memory testing as they did when they entered the trial, meaning they did not experience cognitive decline.

Why is this trial so important? The researchers hope to learn if the drug can remove the pathology of Alzheimer’s disease before an individual begins to experience clinical symptoms. Cures for Alzheimer’s disease do not yet exist because by the time Alzheimer’s patients develop symptoms, the brain has deteriorated to a point where the disease cannot be reversed. However, if administered before symptoms begin to develop, Solanezumab might be effective as a preventative measure to ensure that Alzheimer’s disease does not develop later in life. In January 2014, testing centers were approved and nationwide recruitment began.

Better Vision Means Higher Intelligence?

Melissa Heller

Since the beginning of research on intelligence, psychologists have hypothesized that sensory awareness and intelligence are related by an underlying mechanism due to the ability to rapidly process stimuli and information.

In a study published in the journal Current Biology, Michael Melnick and other scientists asked 67 people to take IQ tests. The subjects then viewed a series of very short videos showing black and white stripes moving right or left. The videos, however, contained a trick: the stripes moved in a circular motion that differed in size. After each video, a participant made his/her best guess of whether the bars moved to the left or right. By doing this, the scientists were able to estimate perceptual processing speed. They previously found that as the size of the stimulus increases, motion detection of high contrast patterns become more difficult to perceive, which is counterintuitive. Called spatial suppression, this phenomenon reflects the ability of the brain to ignore background-like objects and respond selectively to objects that are perceptually relevant. Spatial suppression is limited to medium to high contrasts, like those used in this study.

In examining the vision test results and pairing those with the IQs of the participants, scientists found a stronger correlation between performance on the vision test and IQ than any other sense ever studied alongside IQ. This correlation was tested with a Monte Carlo simulation and found that 93% of all of the correlations were statistically significant. Because of this, scientists were able to determine that the participants with higher IQs were able to process what they saw more rapidly in the smaller frames, but they struggled more with what they saw in the larger frames. Interestingly enough, subjects with higher IQs struggled more than other subjects to detect the motion in the largest frames. The authors hypothesize that the brain perceives larger objects as “background” objects, and therefore ignores their movements, which proves how intelligence is not a measure of how much we see, but what details we see.

Melnick explains that while high IQ individuals are quick to perceive small moving objects, they are severely impaired in perceiving movements as the objects’ size increases. This finding may explain why those with high IQs have the characteristics that they do. These IQ scores were predicted by specific individual differences in sensory discriminations. High IQ is associated with motion perception impairments as the stimulus size increases. These results also link intelligence with low-level suppression of sensory information. These suppressive processes are a key constraint of both intelligence and perception. Therefore, information processing is implicated in the observed link between sensory discriminations and intelligence. According to the study, this finding emphasizes the importance of the brain ignoring irrelevant information and paying closer attention to more relevant information. The findings in this study underscore how both thinking fast and focusing selectively while ignoring distractions are an accurate measure of intelligence.

In his ‘Critique of Pure Reason’, philosopher Immanuel Kant endeavored to revise previously held notions in metaphysics and skeptical empiricism by synthesizing a fundamental framework about the transcendental principles of nature. Emphasizing the limitations of the human mind, Kant proposed there is greater reality past what can be gathered through sensory information; however, we may only understand it as it appears to us.¹ If one were born without the ability to perceive using any of the senses, would it negate the existence of an external world? Except for a few radical thinkers, most of us answer ‘yes’ to the hackneyed ‘When a tree falls in the forest...’ question. Using the same logic, how can we be sure that our brains are discerning actual, objective events and not just a speculative idea of them? Is there more to be known that we are normally unaware of? Perception cannot determine reality, only our mental model of it.

Mankind has pondered ontological concepts of nature and being throughout history. Attitudes toward these questions have played a significant role in guiding and shaping spirituality in religions, values in cultures, and personal belief systems about humanity’s purpose in individuals. However only recently have neuroscientists begun exploring these notions empirically. Correlations between neural phenomena and subjective experiences during altered states of consciousness have further advanced our understanding of the brain’s powerful perceptive capabilities. By examining research throughout this field, we may soon come to appreciate a new perspective on not only the beautifully intricate organization of the human brain, but perhaps something fundamental about the ornate workings of the universe itself.

Not one person, even an identical twin, will per-
ceive stimuli the same exact way. Such diversity in brain anatomy and wiring stems from both our genetic encoding and differing environments. However, some people are unique in their capable of experiencing two or more different types of stimuli simultaneously across modalities. These extraordinary sensors have a neurological condition called synesthesia. There are many different forms of synesthesia which may involve any modality. For example, sounds might produce sights of different colors, a dog’s bark may produce the color green, or the note C# could appear pink, the touch of certain objects may produce colors, or the names of people and objects could produce tastes, sounds, or smells. Neurologist Richard Cytowic has even studied a case of a man who can perceive geometric shapes sweeping down his shoulders and fingertips when he tastes or smells flavors of foods. The synesthete reports that he can vividly feel the objects’ weight and texture as if he is actually grasping it while eating.

Synesthetes have irregular sprouting of neural connections within the brain that leads to a breakdown of the boundaries that normally exist between the senses. Diffusion Tensor Imaging (DTI) validated that the degree of white matter hyperconnectivity in the inferior temporal cortex was responsible for the intensity of the multi-modal sensations. In addition, DTI studies have demonstrated extensive bilateral white matter abnormalities in temporal lobe epilepsy that extend far beyond the temporal lobe in patients who report very salient synesthesia-like experiences.

Cytowic proposes a disinhibited feedback theory, a reduction in the amount of inhibition along normally existing feedback pathways. In a normal brain, excitation and inhibition should be balanced. If regular feedback were not inhibited as usual, signals sent back from later phases of multisensory processing might affect earlier stages such that sounds can activate vision. Since complex interaction between brain systems enables us to perceive the external world as a unified whole, a theory which relies on preexisting neural connections may explain why certain drugs can induce cross-sensory perception.

Psychedelic drugs such as Lysergic acid diethylamide (LSD), psilocybin (psychedelic mushrooms) and dimethyltryptamine (DMT) heavily influence the transmission of serotonin (5-HT), which is known to regulate mood and arousal. Highly abundant in the dorsolateral prefrontal cortex, where sound and visual input are integrated, are postsynaptic 5HT2a receptors. Hallucinogenic molecules serve as agonists at these receptors, located on apical dendrites of pyramidal cells in layer V cortex. Pyramidal cells are known to play a critical role in complex object recognition in visual processing and have diverse intracortical projections mediating multiple pathways of sensory and perceptual feedback analysis, implicating them in binding sensory perceptions into a discrete event.

Though we can see a neural link between the two, reports of psychedelic experiences reach destinations far beyond that of synesthesia. Roland Griffiths, Ph.D., a professor at the Johns Hopkins Departments of Psychiatry and Behavioral Sciences and Neuroscience conducted a study investigating the psychological effects of psilocybin on test subjects in comfortable, supportive conditions. About the experiences, he described: “There’s a dimension of awesomeness, of profound humility, of the self being stripped bare. In the psychology of religion, mystical experience is well-described-unity, transcendence of time and space, noetic knowledge, sacredness, ineffability...the sacred dimension of revelation.”

There are many accounts similar to his, albeit documented by less ‘certified’ experimenters. Their journeys often begin with enhanced sensory integration and then crescendo into deep noetic insights and overwhelming awe for the whole essence of reality, consciousness, and their intertwining. One “psychonaut” describes “Conscience moves on different layers, melts with memories, visions, reality, and imagination. I have all kinds of visions: ...gold rings with turquoise, jade and lapislazuli swirling...the union of these rings gives me complete comprehension of everything, the absolute conscience.”

Another reported “Everything regarding the self becomes the earth and all my perceptions are the stars…I have seen every part through my observations...
and how they fit together, so I was worthy to view the Gestalt, the whole form, one singularity.\footnote{16}

It has been proposed that the newborn baby is a ‘super-synesthete’. In this hypothesis, newborns fail to differentiate input from different senses because connections between cortical areas are not pruned nor inhibited until later in development. The senses are not separate, but rather sights, sounds, feelings, and smells are one sensual “bouillabaisse.”\footnote{17,18,19} Could newborns, due to their complete unmasking of sensory boundaries, be feeling a merging with the ‘all-encompassing absolute’ that philosophers, artists, mystics, and scholars across religions and cultures strive to understand?

The psychopharmacology behind these subjective states is still not well understood. However, similar phenomena, which may occur even without drugs or a

\textit{Fractal Dreams.} Artwork by Rachael Murphy.
preexisting neurological condition, are even less understood. For example, the flickering Ganzfeld Experiment is a sensory deprivation technique in which a subject receives homogeneous and unpatterned sensory stimulation, typically in the form of white noise paired with halved ping-pong balls over the eyes. It elicits vivid colors, complex geometrical patterns, dream-like imagery, even whole scenes. One study hypothesized that mystical experiences were evoked by transient microseizures in the temporal lobe via unusual electrical coherence. Some believe these induced rhythms generate out-of-body experiences, space-time distortions, intense meaningfulness, and dreamy scenes. Interestingly, the flickering Ganzfeld creates deep states of relaxation, concentration, and altered states similar to those obtained through transcendental meditation in Indian Yoga and Zen Buddhism, techniques which can alter the brain’s electrical patterns.

Moreover, studies have shown that regular meditators commonly report synesthesia, with data that suggest that sense-merging can be cultivated through long-term meditative practice. Perhaps the most astonishing of all narratives is that of academic neurosurgeon Dr. Eben Alexander III, who has taught at Brigham’s and Women’s Hospital, Harvard Medical School, and other prominent universities. In his account “Proof of Heaven: A Neurosurgeon’s Journey into the AfterLife”, Dr. Alexander asserts that while in a seven day coma brought on by a meningitis-induced seizure, he had undergone a “hyper-vivid and completely coherent odyssey”, impossible according to global cortical involvement documented by his neurological exams. He chronicles seeing holy beings on millions of radiant butterflies, meeting angels, and hearing the voice of God. In his book he writes: “[there were] waterfalls, pools of water, indescribable colors, and above there were these arcs of silver and gold light and beautiful hymns coming down from them. Indescribably gorgeous hymns. I later came to call them “angels”, those arcs of light in the sky.” He goes on to express, like the psilocybin users, his new revelation of undivided unity throughout the universe, and how the concept is exactly what quantum physics is furiously attempting to unravel. He says “beneath the surface, every object and event in the universe is completely woven up with every other object and event. There is no true separation. Before my experience these ideas were abstractions. Not only is the universe defined by unity, it is also—I now know—defined by love.”

An extremely high dose of psilocybin would likely be almost identical to the effects to DMT, as it breaks down into psilocin (4-OH-DMT), which is structurally very similar to DMT. Though unlike any other psychoactive compound known, DMT has inspired users to report vehement transportation into grand alternate dimensions, where many claim to have seen intelligent alien beings or prominent religious figures (often outside one’s culture) that do not appear to be projections of their subconscious or memories. The report of Dr. Alexander and the account of this DMT user (as well as the psilocybin accounts) are shockingly alike: “with rainbow colors I felt myself morphing into various species. I was experiencing the unfolding of life itself, and realizing...life is directed by a simple life force of pure energy which operates on the smallest of conscious,
sentient levels...the entire universe is conscious and connected...and we are nothing more than containers of that pre-existing everlasting all-pervading consciousness. The energy, the confidence, the power the love in me began to surge, I felt it expand around me, encompassing everyone.”

Dr. Alexander claims that there was absolutely no explanation as to how a surreal adventure of that magnitude could be experienced while his cortex was entirely non-functional. Is the renowned Harvard neurosurgeon missing something here? His story and many others raise the question: is the sensation of what people call the spiritual a form of awareness created by brain chemistry, or is brain chemistry a necessary conduit to transcend into higher planes of spiritual existence? The empirical investigation into the mysteries of consciousness and metaphysics is not complete if it omits crucial parts of the human subjective experience of transcendence. Spirituality can be studied as an effort to understand the general principles of the inner world’s own access to reality, and this new frontier in neuroscience continues to grow. Changed by his near-death experience, Dr. Alexander vows to spend the remainder of his life investigating the true character of consciousness and reality, continually professing to both colleagues and the public that we are “more, much more, than our physical brains.”

Rachael Murphy is a senior studying neuroscience and psychology with a special interest in the intersection of cognitive science, philosophy, sociology, and physiology. After graduating Boston University, Rachael plans to pursue a career in medicine as a Physician Assistant.

3. ibid.
8. ibid.
26. ibid.
27. ibid.
Nishitha Shekhar

"He's an introvert" is a phrase that is commonly heard in social settings. The words “introvert” and “extrovert” are often used to describe someone’s personality, how outgoing they are, and ultimately, a character trait that can determine many of the social choices that a person makes. To be an introvert is to be someone who is socially reserved with a general preference for thinking and exploring one’s own mind and thoughts. In contrast, to be an extrovert is to be someone who is more socially open. However, there is far more to these persona descriptors than just their implications. There is a biological basis, and to be more specific, a neurological basis that determines whether a person will be an extrovert or an introvert. This basis is essential to the foundation of personality and contributes to the myriad life choices that one makes.

When researchers Costa and McCrae first finalized the Big Five, they had no idea to what extent many of the traits had a neurological basis. These five traits include neuroticism, agreeableness, conscientiousness, openness to experience, and last, but not least, extroversion and introversion. In the case of introversion and extroversion, neural mechanisms play a large role. The area or areas of the brain that gives rise to key aspects of personality are often debated. However, the brain’s reticular activating system (RAS) has been the structure of interest in recent introversion-extroversion studies. The RAS begins in the brainstem and extends into the cerebral cortex and is associated with regulating levels of arousal – the basis for introversion and extroversion. This implies that a higher level of arousal...
clearly, the brains of introverts and extroverts display differences in function. however, research has revealed that, like many issues in science, introversion and extroversion traits are largely a matter of both nature and nurture.
Nishitha Shekhar is a sophomore studying human physiology in Sargent College. Through her extracurricular and academic interests she hopes to intertwine the inner workings of the human body as well as the psychology behind the mind. Her research interests are focused on autism as a developmental disorder and its effects on personality and speech development. After graduating from BU, Nishitha plans on pursuing a Medical Degree and continuing with developmental disorder research.

3. Ibid.
5. Ibid.
6. Ibid.
8. Ibid.
9. Ibid.
10. Ibid.
11. Ibid.
12. Ibid.
15. Ibid.
Over the past few decades, pesticides have become increasingly popular in the United States because they help improve farm productivity and safeguard crops. But, as with many presumptive remedies, there is a catch: pesticides also have become feared due to the dangerous effects they could have on the nervous system. Recent studies have shown that these chemicals are correlated with Parkinson's disease, and can affect embryonic development in the womb. But where does the story begin?

It is no secret that honeybees are rapidly disappearing. Starting in 2006, honeybee hives have been decreasing at a rate of 30 percent each year, a phenomenon known as Bee Colony Collapse Disorder. Bees are essential to farming because many crops depend on them for reproduction, and their disappearance is leading to anxious farmers. Chensheng Lu of Harvard School of Public Health performed a field experiment on bees trying to find the cause of their disappearance. He established five different bee colonies and supplied each colony with high fructose corn syrup, which is what is most commonly used to sustain bees throughout the winter. In four of the colonies, he mixed the corn syrup with different amounts of a pesticide imidacloprid, and left the fifth colony clean to act as a control group. He found that the two hives with the highest doses of the imidacloprid corn syrup mix died off quickly, within 13 weeks of the start of the experiment.

Lu chose to perform the study with the pesticide imidacloprid because it is sprayed on corn crops for protection against different types of insects. This chemical makes its way into corn kernels, the main ingredient in the production of high fructose corn syrup. Studies have also shown that imidacloprid is a neurotoxin that causes death by paralysis. The honeybees with the highest dosage of this pesticide died because their muscle function was impaired by a blockade of receptors in the central nervous system.

With a study showing that pesticides can be destructive to honeybees, could these chemicals potentially have a negative impact on humans? The National Academy of Sciences conducted a study to determine the effects of pesticides on infants and children, if any. Scientists recorded the type and amount of food that infants and children ingested, and then tested the subjects for levels of chemicals in their bodies as well as the longitudinal effects of the chemicals. The organization came to the conclusion that “infants and children may have special sensitivities to certain toxic insults.” These toxins could “result in permanent brain damage during early brain development.”

Data from studies conducted at Harvard University and the University of Montreal revealed that 96 percent of the children they tested had traces of organophosphates, the basis of insecticides and herbicides, in their urine. Organophosphates are naturally cleaned from the body if ingested, but the large and persistent presence of this chemical in urine samples suggests that children are constantly exposed to it. Organophosphates also could prove to have an effect on the developing brain. The study found that children whose urine contained above average concentrations of organophosphates were more likely to develop ADHD.

Scientists also were curious to see if pesticides could have an effect on fetuses and newborns. A comparative study published in Environmental Health Perspectives, done on pregnant women living in New York City and California, set out to see if infants had any neurological damage after being exposed to acceptable levels of organophosphate pesticides set by the EPA. After testing the children’s cognitive abilities throughout their childhood, researchers learned that some children...
York City children who had been exposed to low and high levels of organophosphate chlorpyrifos in utero. She found that there was a thinning of the prefrontal cortex, an area of information processing and working memory, in these children. This thinning could potentially explain the drop in IQ found among children exposed to higher levels of pesticides. Rauh's brain scans also showed signs of sexual reversal in some of the cortical structures; areas normally large in girls were larger than average in highly exposed boys. This included areas related to sensory information processing and self-awareness. It is known that hormones can have a significant effect on the developing brains of infants and young children. Rauh hypothesized that chlorpyrifos are able to mimic certain hormones found in our bodies, altering the way the brain develops.

Pesticides also can have long-term effects on adults if exposed throughout a lifetime. Science Daily displayed deficits in memory and perception, compared to children who were pesticide free. A study done by the National Institute of Health further suggested that exposure to organophosphate pesticides during periods of critical development could reprogram signaling in the brain. This chemical was found to specifically affect adenylyl cyclase, an enzyme that plays regulatory roles in nearly all cells. The effects of the pesticides were still visible, even after the exposure had been discontinued. It was also found that children whose mothers lived on farms where pesticides are used, on average had an IQ seven points lower than children whose mothers had less exposure to pesticides. Virginia Rauh of Columbia University reported in Proceedings of the National Academy of Sciences that pesticides might alter brain structures. Rauh and her team took brain scans of 40 New York City children who were pesticide free. She found that there was a thinning of the prefrontal cortex, an area of information processing and working memory, in these children. This thinning could potentially explain the drop in IQ found among children exposed to higher levels of pesticides. Rauh's brain scans also showed signs of sexual reversal in some of the cortical structures; areas normally large in girls were larger than average in highly exposed boys. This included areas related to sensory information processing and self-awareness. It is known that hormones can have a significant effect on the developing brains of infants and young children. Rauh hypothesized that chlorpyrifos are able to mimic certain hormones found in our bodies, altering the way the brain develops.

Pesticides also can have long-term effects on adults if exposed throughout a lifetime. Science Daily
published an article describing two separate studies. One stated that people living near farms that use pesticides increased their chances of developing Parkinson’s disease by 75 percent. The second study focused on people who worked on the farm, and found that their chances of developing Parkinson’s disease were increased by 80 percent. These deadly effects result from the combinations of different pesticides being utilized on farms. Researchers found that the combined exposure to pesticides Ziram, Maneb, and Paraquat near any workplace can increase the risk of Parkinson’s disease. Dr. Beate Ritz of UCLA School of Public Health suggests, "Pesticides affecting different cellular mechanisms that contribute to dopaminergic neuron death may act together to increase the risk of Parkinson’s disease considerably." Ritz and her colleagues developed a geographic information system (GIS) that estimated a person's exposure to pesticides based on the distance the person lives from an affected area. Results of the GIS showed that exposure may have occurred years before the onset of the symptoms of Parkinson’s. UCLA Professor Jeff Bronstein performed genetic screens on different types of pesticides, where genetically modified cells were used to identify the specific pesticides that contributed to Parkinson’s. He found that protein alpha-synuclein accumulated in dopaminergic neurons with increased exposure to pesticides, thereby selectively killing them. When these pesticides were given to rodents, over time they started to show signs of Parkinson’s, such as tremors and rigidity.

A study done on rodents at the University of North Dakota suggested that the brain reacted to pesticides even at relatively low doses. Dr. Patrick Carr says that in some regions, the brain displayed loss of neurons after being exposed whereas in other regions, neurons were expressing chemicals in different amounts compared to the brains of control rodents. Carr also found that cells responsible for the production of myelin, insulation for neurons that helps transmit neural signals, were damaged or destroyed. This could be fatal because neurons without myelin are unable to effectively communicate with the rest of the brain.

The adverse effects of pesticides has recently become a field of interest because a significant number of people are ingesting chemicals without any knowledge of the potential short and long-term effects that these chemicals may have. Some have suggested that any chemical found harmful should be restricted, but Brenda Eskinazi of the University of California at Berkeley observes, "If you remove one chemical or class of chemicals from the list of pesticides growers can use, they’ll replace it with something we know even less about." Americans are arguing that the system by which pesticides are approved needs to be reviewed as it is becoming clear that no matter what the dosage level is, these chemicals are essentially a poison.
The Effects of Video Games on the Brain

Margaret Lehar

Over the past 30 years, video games have become an integral part of our culture, with estimates that close to 60% of Americans currently play some type of video game. Unsurprisingly, there has also been a surge in both popular and scientific interest in the potential consequences of playing video games. Video gamers, parents, politicians and the press often make contradictory claims about the effects that video games have on the brain, resulting in a flurry of sensationalist headlines. While one study will praise video games as a way to ‘boost brain power,’ another will warn that playing video games ‘damage the brain.’ However, viewing the influence that video games have on our brains as an either-or proposition does not do justice to the complexities and limitations of the studies involved, often creating an oversimplified picture of the effects which gaming has on the brain.

The polarization of opinions on this topic is likely a result of the fact that most people do not want to understand the myriad behavioral effects that playing video games can have, but instead seek a yes or no answer to the question of whether playing video games is harmful or beneficial to your brain. However, the answer to this question and ones like it are so broad that they are almost impossible to reduce to a simple yes or no. Even the term ‘video game’ itself is too general to be useful when analyzing their effects. As Professor of Cognitive Sciences at the University of Rochester, Daphne Bavelier, along with C. Shawn Green, Assistant Professor in the Department of Psychology at the University of Wisconsin-Madison explain, “one can no more say what the effects of video games are, than one can say what the effects of food are.” There are millions of individual games, hundreds of distinct genres, and they can be played on computers, consoles, hand-held devices and even cell phones.

To deal with this issue, most studies have focused on the genre of games known as action video games. These games are usually highly violent, first-person, shooting games. They are distinguished from games of other genres in multiple ways. For example, action games are high speed with objects quickly popping in and out of the visual field. High perceptual, cognitive, and motor loads are also characteristic of action games, meaning the player must monitor multiple characters simultaneously, while also having multiple possible motor plans to keep active before making a selection. Action games are also known for their unpredictability and emphasis on peripheral processing. Many studies have demonstrated a link between playing these types of games and an improvement in peripheral vision, attention, task switching, object tracking, decision mak-
ing, hand-eye coordination, and reaction time, among many others skills. However, some researchers claim that these are not so much general improvements in cognitive functioning as they are specific skills that can be transferred only to similar tasks. Although experienced players may be better at spatial navigation in video games than non-experienced players, they might not show the same improvement at similar navigation task in a real-world environment.

In addition, while action games have been the focus of a number of studies concerning the positive effects of video games, they have also been at the center of research that aims to analyze the negative effects of video games, including whether or not video games increase aggression. Dozens of psychological studies indicate that playing violent games increases aggressive thoughts, feelings and behaviors, in both the short term and the long term. Some studies have shown that playing violent video games reduces empathy and increase confrontational and disruptive behaviors in the real world. One of the most comprehensive meta-analyses conducted to date was led by Craig Anderson, Professor of Psychology at Iowa State University, which looked at 136 studies detailing 381 independent tests of association conducted on 130,296 research participants. The meta analysis found that violent game play led to significant increases in desensitization, physiological arousal, aggressive cognition and aggressive behavior. These effects can be expected to increase as the images and scenarios in action games become increasingly realistic.

Some studies have focused on how specific brain regions of players of violent games respond under varying circumstances. For instance, René Weber of Michigan State University and his colleagues had gamers play a violent game while undergoing functional magnetic resonance imaging (fMRI) of the brain. At various points in the game, the player's character was either fighting, in danger but not fighting, safe, or dead. By imaging players’ brain activity before, during, and after each encounter, the investigators found that immediately before firing a weapon, players displayed greater activity in the dorsal anterior cingulate cortex. This area is involved with cognitive control and planning, among other functions. While firing a weapon and shortly afterward, players showed less activity in the rostral anterior cingulate cortex (rACC) and amygdala. Because interaction between these brain areas is associated with resolving emotional conflict, their decreased functioning could indicate a suppression of the emotional response to witnessing the results of taking violent action.

That being said, violent video games alone are unlikely to turn a child with no other risk factors into a maniacal killer. Just as the specific beneficial or harmful effects are determined by the characteristics of the game, they are also likely determined by the characteristics of the individual playing the game. This is a crucially important factor to consider when discussing both the positive and negative effects of video games. Individuals with psychiatric disorders such as chronic depression, ADHD, bipolar disorders, Internet addiction, and anxiety spectrum disorders may be more susceptible to the negative effects of playing violent action video games, especially ones involving the shooting and destruction of other human beings, animals, and objects. However, it may be wise to maintain a degree of skepticism about these findings. Playing violent video games may not directly promote violent and aggressive behavior in the player. The studies merely suggest increases in the likelihood and risk for developing such aggressive behavior.

There are also a number of studies contradicting the idea that playing violent video games increase aggression at all. Some studies even claimed that playing violent video games decreased aggression in people since it promotes the interpretation of violence as fictional or unrealistic. Overall, there has been no consensus on whether or not video games cause an increase in aggression in any particular age group, and additional research needs to be conducted in this area before reliable conclusions can be drawn.

Another important issue to discuss when analyzing the effects of video games is the problem of video
game addictions. While not yet recognized by the American Medical Association as a psychiatric disorder, there does seem to be emerging scientific evidence that video-game play has the potential to become pathologically addictive. Neuroimaging studies suggest that the neuronal circuits and pathways involved with drug addiction also are involved with pathological video game addiction. Namely, the areas of the brain showing activation according to these fMRI studies involve the basal ganglia, parahippocampus, thalamus, prefrontal cortex and nucleus accumbens. Another study showed that video game addiction parallels the brain areas affected in alcoholics, such as the orbitofrontal and anterior cingulate cortex. This suggests that video game addiction may prove to be just as harmful to the lives of those affected as more commonly recognized addictions.

While many of the studies regarding the effects of videogames on the brain seem contradictory, these studies show a common trend: games have an impact on the brain, and occur at a level that overt behaviors do not immediately reflect. However, it is crucial that we improve our understanding of these effects and identify the elements of video games that can increase the positive influence on the brain while trying to exclude specific video game features that promote negative behaviors. Our population has become increasingly attached to screen delivered media in a variety of forms, and this is likely having an effect on how our brains are adaptively engaged in life compared with those of individuals from earlier generations. A better understanding and increased awareness of the consequences of these differences in brain is necessary for the benefit of societal and individual brain health.

Margaret is a freshman from Manchester, Massachusetts majoring in Biology. She enjoys learning about the behavioral aspects of neuroscience and plans to explore her interest this summer by interning at Dr. Patrick McNamara's lab in the Department of Neurology at the BU School of Medicine.

Pac Man Uncontrollably Guzzling Brains. Artwork by Benjamin Lawson.
Priming and its Effects

Shelbi Ferber

The subconscious mind has been a topic of intrigue and investigation for more than a century. Through his psychoanalytic work, Sigmund Freud first brought the unconscious mind into the scientific community’s awareness.1 His theories regarding the “id,” the unconscious part of the mind, were among the first to suggest that the unconscious mind could affect behavior.2 For instance, Freud argued that memories in the subconscious mind that are not consciously remembered can still affect behavior.3 While this idea of suppressed memory remains controversial, Freud was correct in thinking the subconscious mind can affect behavior and thought processes. Since then, researchers have developed several theories about the subconscious, especially concerning its role in attention. How do we choose what we consciously attend to and what remains beneath the cognizant mind? One theory suggests that as stimuli enter the brain, they are held briefly in sensory memory until the person chooses to attend to it.4 This theory can be demonstrated through our ability to repeat the last few words someone has said, even if we were not paying attention at the time. While this sensory memory can be useful, it only lasts for a few seconds. However, some studies suggest that we do not have to attend to sensory information for it to have an effect on behavior. Priming is the process of presenting implicit information that is not consciously attended to, yet influences thoughts and behavior.5 Research from the past three decades has led to a broader understanding of priming and how it affects everyday life. However, this particular research field has been under scrutiny since its beginning, and the controversy about its effects, both good and bad, remain.

The following is an introduction to priming, and its potentially positive and negative effects, meant to guide the reader to their own opinion on the validity of priming as an experimental phenomenon. Additionally, I will introduce the controversy regarding a highly published topic and hopefully encourage readers to continue their own investigation with a keen eye. Especially at a time when neuroscience breakthroughs involving brain training and self-improvement have been sensationalized in recent years, it is tempting to find promise in experimental effects like priming when they might not be there.

A Brief History of Priming

Priming was brought to public attention in 1957 when James Vicary claimed he could subliminally advertise products more effectively than regular advertising. Subliminal advertising outraged thousands of consumers who felt companies could exert too much control over consumers. In a famous experiment by Vicary, the words ‘EAT POPCORN’ and ‘DRINK COKE’ were flashed on to a movie screen for 20 milliseconds during a movie.6 The words were too fast for viewers to recognize them consciously, but he claimed that the presence of the words were enough to increase the sales of popcorn and Coke by a significant margin. While this study was later invalidated due to the inability of other researchers to reproduce the results, consumers were left with the uneasy feeling that advertisers were in total control.

As the craze developed, researchers suggested other ways of subconscious mind control, including backmasking, a method of delivering auditory messages by presenting them backwards.7 In a notorious lawsuit in the ‘80s, the mother of a teenage Ozzy Osborne fan sued the rock star, claiming that one of his songs played backwards tells listeners to commit suicide.8,9 As evident by the hundreds of YouTube videos featuring songs played backwards (my personal favorites featuring the late Tupac), backmasking and other supposed mind control techniques continue to be a topic of intrigue. While scientific testing of subliminal advertising has found its effects are minimal, this does not necessarily discredit priming. Strahan et al. suggested that in order for subliminal messaging to work, there has to be an initial desire that the message fosters.10 As evident by the hundreds of YouTube videos featuring songs played backwards (my personal favorites featuring the late Tupac), backmasking and other supposed mind control techniques continue to be a topic of intrigue. While scientific testing of subliminal advertising has found its effects are minimal, this does not necessarily discredit priming. Strahan et al. suggested that in order for subliminal messaging to work, there has to be an initial desire that the message fosters.10

In 1996, Bargh et al. conducted what is now one of the most highly cited experiments showing priming to have an effect on overt behavior. In this study, subjects’ walking speeds were recorded without their knowledge as they entered the room in which the experiment would take place.11 In the experiment room, a “Scrambled Word Test” was given in which the experimenters asked subjects to reorder words in a scrambled sentence so that the sentence made sense. Unbeknownst
to the subjects, each sentence contained a key word, like Florida, wrinkles, bingo, or retired, that primed the idea of being old. Subjects did not consciously recognize the sentences as associated with being elderly, yet these key words had the effect of slowing subjects’ pace as they left the testing facility. Thus, while subjects believed they were being asked to unscramble sentences, the investigation into their subsequent behavior demonstrated that it can be altered by something as innocuous as a word in a sentence. Other Scrambled Word Tests have extended these findings to patience, hostility, and honesty.14,15
You may think you have control of your mind, but do you?

The previous examples illustrate how priming may affect behavior. However, the effects it can have on the thought processes are even more interesting. Several researchers have done studies that test the effects of priming on test performance in students. Stereotyping is often the focus of such experiments. To show explicitly the effects of stereotyping on test performance, Spencer et al. created an experiment in which women and men were given the same math test, and only the test description given by the experimenter would change. If the test was introduced as having a gender difference, men and women show no significant difference in performance. However, if the test was introduced as having a gender difference, women scored much lower than men, even though the same test was given to the first group.

These effects are seen even when the stereotype is not explicitly stated, indeed, a better illustration of priming. In a groundbreaking experiment by Steele et al., when subjects were asked to state their race during pre-test demographic questions, African-American subjects performed significantly worse than African American subjects who were not asked to mark their race. They also performed worse than Caucasians who were asked to state their race. This shows that simply priming the connection between race and test performance can significantly lower test scores. Let us not confuse these results to mean that the tests are biased. Rather, it is actually the test takers’ own internal biases, caused by social cues, that are implicitly surfaced by priming subjects with pre-test questions on race and gender.

Stereotypes are embedded deep within our psyche, leading to discrimination even against our own gender or race. To explore this subject, Greenwald et al. developed a test which requires subjects to associate different objects, names, or ideas with one of two categories as fast as possible. This Implicit Association Test (IAT) can be used to test many different implicit preferences in people by comparing reaction times. The stereotype IAT, for instance, shows inherent biases for a particular race or gender. In this test the first category could be labeled “white” and “desirable” and the second category could be labeled “black” and “undesirable.” Subjects would make associations between items like “Jamal, war, love, weapons, happiness, family, suffering, wealth.” After the reaction times were recorded for the first test, the categories are switched so that the categories are “black” and “desirable” and “white” and “undesirable” then a similar word list is given to the subject while the reaction times for each item are recorded. The results of this study show that overall there is a higher reaction time when “white” and “desirable” are associated than when “black” and “desirable” are associated. Due to bias, it is inherently easier for subjects to associate “white” and “desirable,” leading to faster reaction times. Even though pre-test questions revealed that subjects explicitly stated that they were not partial to whites or blacks, an overwhelming majority (in this study 25 to 1) of subjects showed a preference for white on the IAT.

This test is available online at Harvard’s Implicit Project (https://implicit.harvard.edu/).

Take back your brain?

While the above studies may leave little hope in the quest to regain control of your brain, some ways that we can use priming for our benefit already have been discovered. Similarly, these effects can be applied to test performance. In a study by Dijksterhuis et al., subjects were primed with the idea of intelligence or stupidity. Subjects were randomly assigned to list as many words as possible that are related to or describe either intelligence or stupidity during a five minute period. Next subjects were asked to answer 20 multiple choice questions derived from a game of Trivial Pursuit. Post experiment questionnaires indicated that the subjects did not perceive the two tasks as related. However, when the first task primed the idea of intelligence, subjects performed better as measured by the number of correct answers on the multiple choice task. This effect was even stronger when subjects were given a specific stereotype within the intelligence or stupidity category, like professor or hooligan, respectively. Subsequent testing has shown similar results.

Does this indicate that one can replace studying with thinking about professors for the five minutes before the test? It seems unlikely. Though these results are tempting to take literally, this method of enhancing test performance is probably more likely to help in the same way that getting a good night of sleep before the test does. Many subsequent tests would need to be conducted in order to test the validity of the results for performance on different types of tests. Additionally, it is possible that intentionally recreating these types of exercises could reduce the effectiveness of priming.

Criticisms

While subconscious priming presents itself as both an intriguing and useful tool to both neuroscientist and those seeking access to the “id,” more research needs to be done to further evaluate the constraints of priming as it is known today. Recent studies have made claims about priming as a potentially effective tool for weight loss and increasing self-esteem. In conjunction with increasing intelligence, these experiments add up to truly incredible pieces of evidence about the power of the subconscious. However, criticism about the ability
to recreate the priming paradigms, such as intelligence versus stupidity, has risen. In 2013, Shanks et al. published a study that duplicated previous priming experiments of Dijksterhuis and others, but did not achieve any of the same test performance effects.\(^{24}\) The research group hypothesized that these misleading results published in some previous works could be due to confirmation bias. Though Dijksterhuis reported numerical results that supported the hypothesized direction of the priming effect, these results were not statistically significant.\(^{25}\) Doyen et al. completed a similar reevaluation of the walking speed experiment by Bargh et al. and found that the same effects could not be achieved despite larger sample size.\(^{26}\) Doyen et al. subsequently exposed that the experimenters expectations could have produced the effect found in the original study. When experimenters expected that the subject was primed with walking slower, the experimenter would record a subject’s walk down the hallway as slower.\(^{27}\)

In addition to these new studies, several psychologists whose studies have used priming techniques have been associated with scientific misconduct. Diederik Stapel and several others have been suspended or have resigned, and their publications are pending retraction.\(^{28}\) In the wake of these contradictory studies, Daniel Kahneman, winner of the Nobel Memorial Prize in Economic Sciences and well known for his research in consumer behavior and judgment, published his criticism of the group of priming researchers, stating that he felt a “train wreck was looming” due to the issue of data replication. Kahneman, a proponent of priming and its effects, provided one possible solution, involving an extensive, yet simple, collaboration of research groups, in his email to leading priming researchers such as John Bargh.\(^{29}\) He suggested that each research group attempt to replicate a previous priming study done by another group, with an open line of communication between the two and leaving all methods and data transparent to the public.\(^{30}\)

### Final thoughts

So does priming work? The results from the Implicit Association Test have been replicated over and over again, a testament to the ability of the subconscious to affect behavior. This test does not only work on race, but other stereotypes including gender and sexuality, age, and weight, suggesting that the effect is more general. With these results in mind, it seems that some of the above experiments could be a logical next step. To disregard priming as a whole due to its controversy over the years would be a rash decision. Some of the data has been replicated before Kahneman’s warning, and even after his suggestions, Bargh responded with an article entitled “Priming Effects Replicate Just Fine, Thanks.”\(^{31}\) Others have accepted the suggestion with open arms. Either way, it is clear that many of the claims need to be reevaluated and put into a better scope. Is the priming effect specific to a certain behavior, like walking speed or patience or intelligence, or is it more general? How long do the effects last? At best, we should be weary of the claims of priming, specifically those involving self-improvement, and use a watchful eye of the experimental techniques. Though, with the field under scrutiny, it is likely that more definitive answers about priming and its effects are on the horizon.

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8. Ibid.
11. Ibid.
14. Ibid.
19. Ibid.
21. Ibid.
24. Ibid.
25. Ibid.
27. Ibid.
30. Ibid.
You wouldn't expect someone with B.S. in Biological Sciences (specialization in Behavior, Ecology, Evolution, and Systematics) from the University of Maryland, College Park and a Ph.D from Boston University in Biology (Ecology, Behavior, and Evolution program) to spend the majority of his time in a neuroscience program; however, that is just where Dr. Mario Muscedere can be found. An HHMI Postdoctoral Faculty Fellow with the Undergraduate Program in Neuroscience, Dr. Muscedere found his calling mentoring undergraduates and conducting research on an often overlooked animal model – ants.

So, what caused you to go into Neuroscience, and Neuroethology in particular?
- I guess I started out mostly as a kid with animals. I was always one of those people who was turning up rocks looking at bugs and stuff like that. And when I went to college I was really interested in the evolution of behavior, how animals adapted to their environments. It was only after I got [to BU] that [my Ph.D advisor] suggested that maybe it would be productive to start looking at some of the proximate – physiological, neu-
robiological – factors that were influencing how the ants behave. Like what determines how they go through this task progression and how they learn to do new things.... My first year in grad school, I started basically teaching myself all these neuroscience techniques that I didn't know before. So I really started out as a pure biologist and then during my PhD I added on this neuroscience because I was interested in understanding behavior.

Are there any classes or opportunities that shaped this change in career path?

- I started working in some different labs - like a lot of undergraduates do, bouncing around from lab to lab – and I ended up in a lab that worked on termite social behavior. That was what kind of got me into social insects and social behavior. That lab, where I worked with termites and behavior, really taught me about how to do research, how to design experiments, how to present my findings. And then here, it was those initial discussions about what's my PhD going to be like, that really set me on the neuroscience path. And I am kind of going more and more down that path as the years have gone by.

Your current research is all related to social behavior and Neuroscience, but what specifically are you interested in and researching right now?

All of my projects center around understanding social behavior and understanding insect societies basically. So one thing that I am interested in is how individual ants decide what they are going to do, how do they know what they need to do, and what are the sensory capabilities they need to engage in those tasks.

One of the major correlates is age – so as workers get older they start going outside the nest. So what is happening developmentally as they age to trigger them to do that? So part of my research has been looking at how their brain actually remodels itself as they get older – so there is structural change in these different brain regions.

Another aspect of my research is looking at not structural change but modulation by neurochemicals like serotonin and dopamine. So, just like in vertebrates those neurotransmitters also function as modulators to sort of set the gain of aggression and all these different behaviors in social insects and seeing if they also affect their thresholds for olfactory sensitivity, like how sensitive are they to any specific odors. They may trigger these state changes to start them working outside of the nest.

The last thing that I am working on, in that regard, is the interplay between experience and just hardwired age related development. So, like I said, a lot of these things happen as ants get older, but to what extent is that going to happen no matter what – is it a programmed normal process or does it require them to experience certain things – do they have to smell a certain odor, do they have to have experience preforming certain tasks, do they have to learn how to do this stuff?

And then kind of separate to that is a bunch of comparative studies that I am interested in – dealing with much more broad questions such as – how does sociality in general affect nervous system evolution? So when animals become social and start living in social groups, what happens to their brains – is this similar to the social brain hypothesis in vertebrates, so does that apply to social insects as well.

Also, what happens when you get really small, like in ants – some ants have gotten really really really small – and what are the constraints that body size miniaturization puts on nervous system evolution – is there some lower limit beyond which you sort of get too small to do anything interesting [because] you're just not as complicated?

So almost all your studies focus on the ant model – that is kind of an obscure choice. What made you choose them as your animal model?

- You know, I am interested in ants because I love the richness of their social behavior. So in general with animals, and like I said as a kid I was always watching nature shows about lions and stuff in Africa, I am interested in animals that live in social groups – how do they interact, how do they deal with conflict, how do they cooperate with each other. There are a lot of insects that are studied pretty commonly in biology, fruit flies are probably the main one, but their social behavior is so uninteresting - you know they don't live in large groups, they meet each other to basically fight or court each other and mate, and that just isn't that interesting to me. Whereas ants, termites, bees, have this fairly rich social life where they compete with each other, work together to find food, to build a nest, and they rear the young. I think if you want to understand those types of social processes, you need to pick an animal that has this really rich social life and that's kind of what led me to social insects.

What do you find to be the most interesting part of your research?

- [Ants are] a huge group of animals, they make up more than half of the animal biomass in the tropics, really common and really successful animals and we really

Mario is a HHMI Postdoctoral Faculty Fellow in the Neuroscience Program.
don’t know all that much about them. I like working in an area where there is so much left to know, for some people that may actually be frustrating – working in an area where there are not a lot of other people working, where all the tools might not always be there. I really enjoy knowing that pretty much anything that I uncover is going to be something new. For research fields that have a lot of people working in them often research agendas are much more driven by necessity because if you are working on mice or rats or fruit flies, there are thousands of people researching them, and I like the freedom to address any of [neurosystem organization, learning, brain response to experience] topics that I am interested in and know that I am going to come up with something that no one knows.

Have you run across any major difficulties because of the lack of people in this fairly specialized field?
- Yeah, so there are costs to working on an animal like that. One is that in general it is always easier to explain to people what you do and why you do it if you have a very applied focus, so if you study Alzheimer’s disease, no one ever asks you why you do that. So there are all the concerns that come along with basic research – there is less funding, potentially. Also that lack of background knowledge that I talked about is kind of a double edged sword, so anything that you uncover, is going to be novel and interesting but there are not that many other people around working to help you. And also some of the technical tools aren’t there like transgenics, so I have to contend with those types of technical constraints.

How do you think your research has developed over time? Or is it something where you finish a study and you know exactly what to research now?
- I tend to try to build off of previous studies, I think most people try to do that, so I tend to try to work on a study in earnest, then analyze the data and think ‘What does this tell us, and what are the unanswered questions that fit, that arise from this?’ But at the same time, you do, I think, and most researchers probably do this, your research interests do change a little bit, or evolve as you get older, so new things start to interest you that maybe you weren’t aware of. [For example] when I first came to grad school I never really thought about the role of body size and brain organization but as more papers have been published about it recently I have started thinking that ants are a great system to study – because they have a really big brain to body size ratio, so they would be the perfect model systems to address these questions.

You have mentioned your own studies and experiments, and undergraduates are a big part of your lab experience. Have you always been involved in mentoring undergraduates?
- I have always worked with undergrads since the first semester I got to BU as a grad student, and that is something that has been really important to me, [and] it is actually one of the coolest parts of this job – working with students and allowing them to become scientists on their own.
The Undergraduate Program in Neuroscience is an interdisciplinary major leading to a Bachelor of Arts in Neuroscience that takes advantage of the rich neuroscience mission of multiple departments and campuses of Boston University. As a field, neuroscience has grown considerably over the last few decades through its integration of multiple disciplines; and, a current understanding of the field requires knowledge that spans traditional approaches while moving into the intersection between far-reaching technologies and new computational methods. This program combines breadth of exposure to the field as a whole with the opportunity for depth of experience in one of three central domains of neuroscience: Cellular and Systems, Cognition and Behavior, and Computational Neuroscience.

Neuroscience students will have access to the extensive resources and expertise of affiliated faculty across multiple departments and colleges throughout the university. A wide array of courses are offered through the departments of Biology, Chemistry, Computer Science, Mathematics & Statistics, Physics, Psychology, and Health Sciences in Sargent College. Together more than 50 upper level neuroscience electives are offered, including laboratory courses and seminars.

Opportunities for independent laboratory research are available through multiple departments in the Colleges of Arts and Sciences and Engineering, and at Boston University School of Medicine, including Anatomy and Neurobiology, Biochemistry, Neurology, Pathology, Pharmacology & Experimental Therapeutics, Physiology and Biophysics, and Psychiatry. Undergraduate research opportunities in neuroscience laboratories expand throughout the university across both the Charles River and Medical campuses.

The Mind and Brain Society (MBS; formerly known as the BU Organization for the Mind and Brain Sciences) was founded in the fall of 2008 in concert with BU’s new undergraduate program in Neuroscience. The group aims to create a network for undergraduate students who wish to take an active role in current issues and research. MBS serves as a hub for not only Neuroscience majors, but all students interested in Psychology, Biology, Philosophy, Computer Science, etc. Our goal is to support an eager multidisciplinary undergraduate community with the conversations and resources fundamental to Neuroscience today.

Throughout the academic year, MBS hosts events spotlighting many different facets of Neuroscience. We hold discussion sessions during which we informally discuss a topic of interest over coffee; previous topics include “The Neuroscience of Religion” and “NeuroEthics.” The group also hosts research presentations by BU professors and screenings of thought-provoking films pertaining to neuroscience.
We are looking for three types of papers:

1. ARTICLES

These are light reading, requiring the reader to have little background knowledge. Typical length is around 2,000 words.

2. REVIEWS

These are analogous to reviews that appear in professional journals. They explore the chosen topic in depth and are based on serious research of the literature. Typical length is around 4,000 words.

3. OPINIONS

These are perspectives on current trends. Authors are encouraged to submit works that touch on any topic in the Mind and Brain Sciences. This includes, but is not limited to, psychology, anthropology, philosophy, biology and computer science.

Learn more at bu.edu/thenerve/submissions
BU Undergraduate Program in Neuroscience
www.bu.edu/neuro/undergraduate

BU Mind and Brain Society
www.bu.edu/thenerve

The Nerve Blog
www.blogs.bu.edu/ombs