the Berkeley Carroll School

Proceedings of the Berkeley Carroll

2ND INDEPENDENT RESEARCH CONFERENCE

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Welcome from the Editor

The "Sophomore Slump" is a well-known phenomenon in many of the creative arts. The reasons are easy to work out: the first movie, or novel, or play is a labor of love that has been written and rewritten dozens of times over decades and the result is something original and honest. A second production, in contrast, can be a rushed attempt to cash in on initial success.

Scientific literature, although somewhat resistant to this kind of slump due to the peer review process, is not entirely immune. It is very easy for a once novel idea to become entrenched as a school of thought, and a second scientific publication can become just as derivative as a rushed sequel. If you don't believe me just try to find current papers about the expanding Earth model for geological spreading centers, or the planetary model of the atom.

Although this is the second issue of the Berkeley Carroll Journal of Independent Research, I'm happy to say that in these pages, you will see no such slump. Quite the contrary — you will see a broad range of innovative, coherent, and readable pieces of scientific writing.

These papers are excellent. The authors are exploring and experimenting with the frontiers of science. In "General Biodiversity in the Hudson River Estuary", for example, Ariel Dineen writes about the interactions between fluvial fauna and an artificial reef she built, and she considers the future of the coral reefs of New York. Olivia Scott, in "Using Enrichment to Reduce Stereotypic Behavior in Coatis", tackles the somewhat baffling phenomenon of "stereotypies", in which captive animals acquire behavior that is unusual, abnormal, or just plain harmful, and she lays out a plan for reducing these behaviors in at least some situations.

Several other papers explore different aspects of the magnificent human brain. Anya Katz and Haley Gillia use the case study as a method to explore individual responses to Post Traumatic Stress Disorder and music therapy for autism, respectively, and Sophia Timko examines the causes of microscopic iron accumulation in injured brains. August Rosenthal looks at the effect of mobile phones on the health of the entire human body. Finally, in "Inflationary Cosmology", Jaya Sahihi unpacks a new theory that takes us to a region of space that is impossibly large and impossibly small at the same time; just before the Big Bang when space itself was "jittery".

There is no Sophomore slump in these pages, and there won't be a Junior slump next year. That's because every year is a labor of love for these authors; they have worked on their topics for three years and have really produced some exceptional work. I have no doubt that you will enjoy their work greatly.

Until next year
Scott W. Rubin
Upper School Chair of Science

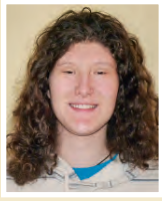
The Berkeley Carroll School

Anya Katz is a senior at Berkeley Carroll who began her Science Research project looking at Post Traumatic Stress Disorder in victims of the 1994 Rwandan genocide. During the summer after her sophomore year she went to Rwanda to study the healthcare system. She then turned her attention to PTSD in veterans as well as people who have experienced other traumatic events such as heart transplants and physical abuse.

Jaya Sahihi is a senior in the Science Research and Design program who decided to focus on quantum physics and time. As she dove deeper into her research she found herself drawn into cosmology and how quantum physics helped create the universe we see today. Aside from this, after studying at a laboratory in Georgia that specified in bacteriophage therapy, she became fascinated in the option of using phages as alternatives to antibiotics.

Ariel Dineen is a senior at Berkeley Carroll. She began the Science Research and Design Program in sophomore year, intent on researching gene therapy. By her junior year, Ariel's focus shifted to encompass Marine Biology. She interned at the river project from February-October 2012 and conducted a biodiversity study in September.

August Rosenthal is a senior at Berkeley Carroll who was first drawn to cell phone radiation and its potential hazards to our bodies in the spring of 2011. As he delved deeper into the field, he focused on cell phone radiation's effects on the male reproductive system, specifically sperm cycles. His paper serves as both an introduction into the field of cell phone radiation as well as a detailed review of the current research going on.



Olivia Scott was drawn to her topic of stereotypies after reading Temple Grandin's book *Animals Make Us Human*. By her senior year, she had expanded her topic and knowledge of the abnormal behavior, stereotypies, to include the different ways humans combat these behaviors called enrichment. Over this past summer, she worked with the Trevor Zoo to develop an experiment using the zoo's two White-Nosed Coati.

Sophia Timko is a senior who was drawn to the field of traumatic brain injury after reading an article about consciousness her sophomore year in the Science Research and Design Program. Since then, after visiting a few scientists doing research in the field, she has mainly focused on minor traumatic brain injury (concussions) and the role of iron accumulation in the brain after head injury. Sophia hopes to continue studying biological sciences and neurology throughout college.

Haley Gillia is a senior who studied Music Therapy and the benefits it can have on adolescents with Autism Spectrum Disorder. Haley is a violinist and has always loved science, so she was immediately drawn to this fascinating, up-and-coming and important science. Over the past summer, Haley spent time at NYU's Nordoff Robbins Center for Music Therapy. In addition, she also interviewed music therapist Holly Mentzer in creating her final Literature Review.

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Post Traumatic Stress Disorder

by Anya Katz

Introduction: What is PTSD?

As stated in the Diagnostic and Statistical Manual of Mental Health Disorders IV in order for Post Traumatic Stress Disorder (PTSD) to be diagnosed, one must have been exposed to a traumatic event that satisfies two requirements out of three "symptom clusters," known as "intrusive recollections, avoidant/numbing symptoms, and hyperarousal symptoms" (American Psychiatric Association, 2000). The diagnosis also assesses both the duration of symptoms and the reaction of the patient towards the trauma, such as how they were functioning in their daily lives.

The criteria for being diagnosed include the following. One must have been exposed to a traumatic event that has either threatened one's or someone else's life or has responded to a traumatic event with intense emotions such as fear, terror, and helplessness. The person who experienced this event must also express symptoms of either recurring dreams or nightmares about the traumatic event, recurring thoughts or images of the event, hallucinations that make one feel like they are reliving the event, or strong reactions (both emotional and physical) to situations and cues that remind one of the event. Other symptoms include avoidance and numbing. In order to be diagnosed, a patient has to meet three of the next seven indicators. The patient will make an effort to avoid certain thoughts or emotions that link to or remind them of the event; they will avoid specific activities, people, or places that remind them of the incident; they have trouble remembering parts of the traumatic event; they lose interest in completing important activities; they feel detached or isolated from the world around them and from other people; they feel that their lives lack potential and they have trouble seeing successful and happy futures for themselves. Additionally, the patient must meet two of the next criteria. They have difficulty falling asleep; they are irritable and aggressive; they have trouble focusing and getting work done; they are hyper-aware and hyper-vigilant, and they are startled easily and have extreme reactions to loud noises, sudden movements, and other startling situations.

PTSD can be defined as either acute or chronic. If acute, the symptoms must have been occurring for less than three months. If it is chronic, the symptoms must have been occurring for three months or longer.

The purpose of this paper is to give readers a better understanding of what Post Traumatic Stress Disorder is, and to provide an insight into people's lives who are suffering from the disorder. In addition to two interviews, I wrote a review of the literature, which discusses and compares five articles and studies that concern PTSD.

Review of the Literature: Treatment of PTSD

Post traumatic stress disorder can develop from an array of circumstances. Because of this diversification, treatment for PTSD may vary from case to case. While scientists recognize the non-black and white nature of the disorder, they have developed certain techniques, some more effective than others, to combat it. Below are the five studies and articles that I have reviewed.

A Meta Analysis on Comparative Efficacy of Treatment for Post Traumatic Stress Disorder discusses the most common forms of medical care for the condition and contrasts them, looking for the most successful outcomes. This analysis was done on 61 trials, and includes the use of certain drugs as therapies (TCAs, carbamazepine, MAOIs, SSRIs, and BDZs). It also incorporates psychological therapies such as behavior therapy, Eye-Movement Desensitization and Reprocessing (EMDR), relaxation training, hypnotherapy, dynamic therapy, and, lastly, control therapies (Van Etten & Taylor, 1998). The results may get mired in the technical terms, so I'll interject with a brief description of the treatments listed above. **TCAs** are Tricyclic and Tetracyclic antidepressants. They are commonly used to reduce depression. **Carbamazepine** is frequently used to treat seizures, but it can also be used in instances of Bipolar Disorder. **MAOIs** are Monoamine Oxidase Inhibitors, which are antidepressants that can be used to treat depression as well as numerous anxiety disorders. **SSRIs** are Selective Serotonin Reuptake Inhibitors, and they work in a way that makes it easier for nerves to obtain more serotonin. They are classified as antidepressants. BDZs are tranquilizers that handle anxiety disorders.

In terms of Behavioral therapies, **EMDR** is performed in eight phases. The actual treatment doesn't begin until phase three when a patient is supposed to think of images, thoughts, and sensations that remind them of the traumatic event that they experienced while moving their eyes quickly back and forth, following a therapist's finger that moves across their frame of vision.

Before the meta-analysis surveyed the efficacy of the distinct treatments, it proposed certain cognitive hypotheses. It discussed a certain "fear structure" that was the origin of the symptoms that people with PTSD suffer from. This fear structure can be found in long-term memory, and it is comprised of reactions to stimuli that remind people of their traumatic events (Van Etten & Taylor, 1998). Certain events that cause sensory reactions such as smell, sound, and sight set the fear structure in motion, which causes the symptoms that people with the disorder then experience. Some scientists are saying that the only way to "treat" and tackle this structure is to provide exposure to situations and sensory inducing circumstances that generate fear and flashbacks, without actually harming the subject in the long run.

After performing numerous tests, the scientists running this experiment concluded that drug therapies and psychological therapies generally have the same effect and are equal in terms of success rates. It also noted that EMDR appeared to have better outcomes than relaxation and dynamic therapies, which teach one how to loosen up, moderate temper, and eliminate certain areas of stress in their lives, including the stress that comes with relationships. SSRIs tend to be more effective in treating avoidance than most psychological therapies aside from EMDR and behavior therapy, which were the most effective. 36% of the patients that were on SSRIs in the study terminated their treatments. This could have been the result of a multitude of issues, but it probably occurred due to the likelihood of agitation as a side effect of the medication. Overall, SSRIs were the most effective of drug therapies, and EMDR and behavior therapies were the most effective in psychological therapies.

The next study, *Psychological Treatments for Chronic PTSD: Systematic Review and Meta Analysis,* focused on 38 controlled trials that were synthesized in an attempt to reveal the efficacy of current therapies and medications. In order for the studies to meet the requirements for the analysis, all of the subjects had to be suffering from PTSD symptoms for at least three months after whatever traumatic event they experienced. The larger study didn't detail each individual review, but the results described two therapies that were found to be the most effective in treating the disorder. Trauma-Focused Cognitive Behavioral Therapy **(T-FCBT),** one of the two therapies, is commonly used in situations of childhood abuse. It teaches people to control their emotions as well as to help people talk about the traumatic events that they experienced in a healthy way. It tackles both behavioral and emotional issues. EMDR was the other effective form of treatment. Both of these therapies target memories.

Another study, *Treatment of Victims of Trauma,* broke down the multifaceted nature of PTSD and described effective ways to treat a variety of symptoms. It started by presenting the uncertainty as to whether PTSD is an anxiety or a mood disorder. As stated earlier, PTSD treatment is very circumstantial. Doctors will only treat patients based on the symptoms that they are expressing. However, this article argues that all people suffering from PTSD should be treated with exposure therapy and antidepressants. It then breaks down certain therapeutic methods, stating that there need to be three focuses: behavioral and cognitive strategies,, short and long-term psychological therapies, and medication (Adshead & Ferris, 1995). Behavioral and cognitive therapies are described in this study as methods of exposure that show images and bring up memories of the trauma that the subject has experienced. This exposure allows patients to control both their avoidance obstacles as well as their intrusive thoughts. Long-term therapy, what most people what most people refer to when they say they are "seeing a therapist", typically reflect on a more comprehensive summary of one's entire life and looks to find the root of multiple issues. Short term therapy is more focused on understanding a specific situation in one's life. It teaches one how to cope with that situation and how to deal with their emotions in that situation. It usually lasts for 10-20 weeks, depending on one's situation. This study also discusses how different types of PTSD require varying forms of treatment. For acute PTSD, exposure therapy, cognitive therapy, psychodynamic therapy, commonly referred to as traditional therapy in which people are supposed to

bring underlying issues to the surface, and antidepressants are recommended. For chronic PTSD, the study suggests that one should undergo exposure therapy if the traumatic event has never been talked about or cognitive-behavioral therapies, long-term therapy, and antidepressants (lithium and carbamazepine).

The results of this study were that psychological therapies seemed to have a greater effect than psychotropic medications, which are medications prescribed for behavior. In terms of medications, SSRIs appeared to be the most effective. Behavioral therapy also showed signs of being extremely effective. The study also noted that when treating acute stress disorder and PTSD, it is important to keep in mind that debriefing, immediate help, and support after the traumatic event can hinder the development of the disorder. Benzodiazepines were successful in controlling arousal problems in PTSD and exposure therapy is not useful when treating fear-based reactions. Lastly, the study states that psychodynamic therapies, which center on eliminating subconscious issues, should not be used in treating PTSD.

Another article about treatment was called ***Embattled Childhood: The Real Trauma in PTSD.*** This account discusses the lives of Danish Soldiers in the Guard Hussers regiment. They were deployed for 6 months in Afghanistan, and were tested for PTSD and indications of PTSD that would develop in the future. Most studies about soldiers being tested for PTSD have taken place *after* combat. This study differed in that it tested the soldiers after they were recruited, during the war, and a few weeks after they had returned from the war. 746 subjects had psychological tests performed on them before they were deployed. The soldiers completed a test for depression and a questionnaire in which they had to list any traumatic events that had happened in their lives. After they were deployed, they had to complete a number of other tests such as a war zone stress test, discussions about life threatening experiences that they had encountered, a listing of the wounds that they had incurred, and they had to talk about the experience of killing (Wray, 2012, p.1). This study not only shed new light on PTSD diagnoses, but also exposed a whole new facet of treatment.It is generally assumed that most people develop PTSD due to war experiences and exposure to the kind of things that people see when they are in combat. It is also assumed that someone who has experienced a great amount of trauma in their life is more susceptible to developing PTSD and that symptoms present themselves immediately after the traumatic event and last for a long time. The scientists in this study found very different information. The majority of the soldiers in this analysis that developed PTSD recovered very quickly. The soldiers that took longer to recover didn't experience PTSD indicators until much later than the rest. 13% of the people in this study also developed symptoms before they were sent into combat, but these symptoms relaxed once they were in Afghanistan. It appeared to be that the majority of the soldiers who developed PTSD had experienced some form of trauma in their childhood. This led the scientists to believe that it wasn't war that caused the symptoms, but rather years of suffering from another traumatic event. Being in combat and experiencing the camaraderie in their regiment took their mind off of residential struggles and bad memories back at home.

Lastly, a New York Times article called ***Warrior Voices*** described a new type of therapy: bibliotherapy. Veterans come home from war experiencing extreme feelings of isolation. The intensity that war brings forces soldiers to form intimate bonds. When people experience

trauma together, there will always be a special camaraderie among the group that can't be matched by anyone else. Coming home to a society where people keep to themselves, don't understand what the veterans have gone through, and don't know how to talk about their experiences can be extremely unsettling for soldiers and other army personnel. This article introduces the idea that the military is now considering writing, music, and other forms of art as the key to helping soldiers recover from PTSD. Travis L. Martin, an Iraq Veteran, says "My experience is that traumatic memories are fragmented. They appear in flashes of intensity, but not always in order. If you can put those emotions and the traumatic events in a narrative that makes sense to you, it makes the trauma tangible. If it is tangible, it is malleable. And if it is malleable, you can do something with it" (pp.2). Writing not only allows veterans the opportunity to express and piece together their feelings, but allows them to share their experiences with other people. Reading other veterans' writing also helps them when trying to understand what they are going through themselves. Talking about one's experience at war may be more emotionally distressing than writing about it. Today there are numerous groups devoted to helping soldiers through writing such as the Veterans Writing Project, Warrior Voices, the Syracuse Veterans' Writing Group, as well as countless others.

Interviews

As stated above, stories can be one of the most effective ways for people to discuss their PTSD. It not only helps the people who are suffering to sort out their memories and piece together what they are feeling, but allows others to get a better sense of what they are going through. Sharing experiences can not only be a form of healing but can serve as a tool for education as well. Often times peoples' lives are consumed by their diagnoses. Once a doctor has told them that they are sick, they become a reflection of that conclusion. Sharing peoples' stories and having people share their own stories adds a new dimension to their lives. It allows them to express themselves and to move past the medications and alternative therapies and give their own personal insight to what they are experiencing.

Instead of conducting original research or simply a review of the literature, I decided to share peoples' stories. A few weeks ago I interviewed a man named Todd who had a heart transplant about his life post-PTSD diagnosis. I then spoke with a veteran, Dave, about his experience returning from Iraq. Below are the results.

Note – all names are changed to protect the privacy of the subjects

TODD

1. Were you diagnosed with PTSD and, if so, when? What was the cause?

Yes, I was diagnosed in 2009. I had a heart transplant in Feb., 2009 following 5 years of significant and invasive cardiac issues (familial cardiomyopathy, a genetic unraveling of the heart muscle). I had a defibrillator implanted in 2004 and it began firing continuously in 2007. I had a left ventricular assist device implanted in Jan., 2008 (basically an artificial heart), and I was "battery operated" for 13 months while I waited for a donor. The period of time from 2007-2009, when the defibrillator fired constantly, and then the year on the LVAD, would be considered "the cause".

2. What were your symptoms?

My symptoms include: being easily startled and jumpy from loud or unexpected noises, cars honking, thunder, bright lights flashing (driving at night), room lights getting turned on and off by someone else, getting ragged and more easily frustrated or prone to anger in situations where I never did — very frayed nerve endings when I am tired. I jump from cold to hot emotionally, I have less of a middle range. There are also certain activities that I simply cannot get myself to do, such as going in the pool. I grew up in South Florida, was around water my whole life: but I had a year when I could NOT get wet (no showers, etc.) while I was on the pump waiting for a heart (would have gotten a systemic infection and died). Now I understand logically that this is no longer an issue for me, but I am hugely spooked by it and have a hard time getting past my panic. I have a very hard time falling asleep (losing control) and staying asleep, and I often have bad dreams or nightmares, including flashbacks to weeks and weeks in the ICU. I get irritable easily and have problems with my anger out of proportion to the situation. I work hard to keep that at bay, which is exhausting in and of itself.

3. Did you know that you had PTSD before the diagnosis or was it surprising?

I was very aware of what was happening. Two concerns post-transplant (aside from all the issues of the surgery and recovery) were my executive functioning, and my "emotional" well-being. You're on very high doses of steroids following any transplant to prevent rejection of the organ so for a few months, one's entire mood is out of whack. As the steroid doses were lowered (and are still being lowered), you feel better and more like yourself, less jumpy and irritable, but still quick to emote.

4. Has your diagnosis had an impact on your relationships, and if yes, how so? If not, why not?

Yes it has. I am easily frustrated, I am more emotional, I am quick to anger, I am much more jumpy and difficult. I can put on a show for outsiders and you might not know anything is different, but i can't keep it up 24/7, so my family gets the real me. Everyone is very under-

standing, but it definitely impacts relationships. My kids (24, 26, 28, 30) can come and go when they have enough of me, but my wife is stuck. She does the best she can. Most of the time things are fine, and we have ways to avoid trigger situations, for sure, but the fact that it never goes away is pretty exhausting. She can also be very helpful to ease me out of a tough situation.

5. What has been most helpful in terms of coping with your PTSD? Did you receive professional treatment? If so, what type? (medication, therapy, group therapy etc.)

If I were in a position to cut back my work life and keep my days simple, that would make a big impact. I can see it when I go on vacation. Staying out of NYC would help. Getting more sleep would help. Fewer phone calls and people coming at me would help. The less haggard/ragged I am, the better able I am to stay calm and handle the bumps. That's pretty common across all problems in life! But neurologically for me, it is a fact. I've also stopped driving at night altogether (the bright lights coming at me are too jarring), and I have a driver by day in NYC and I sit in the back seat of the car, so I'm much less impacted by all the noise and craziness and honking and cars swooping in and out. Of course all of that is much easier in the suburbs. When you have a transplant, there is a psychiatrist on the team, and I also saw a neuropsychologist for a lot of testing. They both steered me to a cognitive behavioral psychologist who worked with me on dealing with specific scenarios and building up some protective barriers. If I had more time, it would have been great to continue, but I really don't have that kind of time to spare, and if I did, I'd rather spend it relaxing, so it becomes a catch-22. If I get into trouble with sleep, Ambien makes a big difference because the way I handle a day is very much affected by how exhausted I am. They also prescribe anti-anxiety medication throughout the transplant process (also as a heart sedative, pre-transplant, to keep the arrhythmias quiet), so that also helps with the PTSD.

6. Is your PTSD apparent in your day to day life?

Yes

7. Does having PTSD affect the way you live your day to day life? Are you more anxious about the safety of yourself and others?

I don't think I'm more anxious about the safety of others. I have always been a "fixer", I take responsibility for a lot of people and situations, and that includes safety, but I think my PTSD on a gut level is about myself. The instinctual panic when a light bulb pops is that I think I'm going to blow up because my defibrillator is going to fire. It's probably like being blown up in a war — you see a light flashing, you hear the noise, you feel the strike, you get blown to the floor. You can't do anything to stop it, you never know when it's going to happen. And it happened 400 times that year, in the middle of a deep sleep, and when I was out jogging, or at a work meeting. No control. Then I'd have to go into the hospital, get weaned off a medication, start a new one, get up to a therapeutic dose, lots of time, always scared it would fire again.

8. Are there triggers for your flashbacks? If so, what are they?

As I've said, bright lights, cars honking, people yelling, thunder, random noises, lights being turned on and off, getting overtired and stressed.

9. Do you ever have any physical reactions when reminded of the event?

Yes, I feel like it's happening again. It feels real.

10. Is there anything else of significance that you would like to say about PTSD in general, or specifically about yourself?

Incredibly, after all we've been through, the ongoing issue doesn't have to do with the heart transplant itself, which was actually a piece of a cake compared with everything that came before it. The PTSD is the debilitating left-over part of what was otherwise a very stressful 5 years which yielded an amazingly good outcome.

DAVE

The first question that I asked Dave was if he thought he had PTSD. He said that he didn't think so, even though a doctor and an ex-girlfriend had diagnosed him with the disorder. He said that he often had nightmares of being back in the military, but that in his day to day life he has no difficulty functioning. He believes that the nightmares are a product of him being stressed because when he works at removing certain stressful things in his life, the nightmares subside. One of the things that causes his nightmares seems to be heavy drinking. When he stops drinking, the nightmares come less frequently. Additionally, drinking causes paranoia. When he's drunk, he constantly thinks of the worst possible scenarios and is not able to rationalize his thoughts. Drinking brings up unfiltered feelings and he continuously proposes "what ifs."

Dave also said that in the period of time during which he is barely awake but not yet asleep he is very easily startled. If his girlfriend lightly taps him or if a loud noise goes off on the TV, he jumps up and paces around the room, sweating, and not able to collect himself. He thinks that much like inebriation, in that specific period of time between consciousness and unconsciousness, he lacks the ability to filter his thoughts. During his day to day life, Dave has the ability to control his speculations. He can differentiate between realistic and irrational, but this power is not always available for him.

Dave has a different theory about PTSD than most people. He thinks that doctors and individuals think that combat-related PTSD stems from experiencing a singular traumatic event. People assume that once a soldier sees one person being killed, they automatically develop the disorder. Dave thinks that PTSD comes from something different. When in the army, soldiers and all of the other people working on the ground have to be constantly aware of their surroundings. The moment they let down their guard, something terrible could hap-

pen. Dave said that whenever he would use a Port-A-John, he would tilt his head to the side so a sniper would misjudge his location if trying to shoot him. It is this hyper-vigilance and constant fear of being harmed that brings on the PTSD. It is less of a single traumatic event but more of a consistent psychological debilitation. Not only does this mentality cause PTSD, but it also causes desensitization, or numbing, a symptom of PTSD. Being in the army leads to a constant state of adrenaline pumping. You constantly expect death, but eventually you become okay with death--you become desensitized to it.

Almost all soldiers and people taking part in the war have experienced some form of psychological change when they return home. Dave said that he was completely different when he got home, but he was slowly able to return to "normal." I asked Dave if he would return to Iraq if he had the option to. Without hesitation he said yes. He misses the excitement of Iraq. He feels that he will never be as important as he was when he was in the marines. He also misses being surrounded by his favorite people in the world. Not only do you experience an unprecedented form of camaraderie, but you have job security and no financial or relationship problems. Some of the war-related dreams that Dave experiences have to do with going back. War is addictive.

I asked Dave how he felt about killing people. He said that he wanted to kill people. At no point in time did he have the desire to kill innocent people, but he felt no guilt about killing someone who was doing something wrong or who had ill intentions. Serving as a marine has made death more manageable for Dave. When his grandfather passed away, Dave felt nothing. He didn't cry and he felt numb. He described it as a non-traditional grief response that he was shocked by. He wasn't aware of how desensitized to death he had become.

Conclusion

While I didn't necessarily find hard and conclusive evidence from my research, I am now sure that stories are one of the most effective ways to communicate trauma. Whether these stories are conveyed verbally, through text, art, or any other media, there is no doubt in my mind that improvement would be shown. There is no one form of PTSD. It will manifest itself differently in different people. The illness is not black and white, but rather complex and perplexing. Not everyone will exhibit the same symptoms and not everyone will require identical treatment. It is important to evaluate all indications of the disorder before planting someone in one form of therapy or another.

My work in PTSD over the last three years has taught me that the most successful form of care comes through exposure. The only way to relieve symptoms and eliminate the fear of reliving the traumatic event comes from discussing and revealing aspects of the event that have been buried within ones' mind.

Going further with my research, I would love to look more deeply into bibliotherapy and conduct more interviews. I would like to meet people with varying degrees of PTSD. I am interested in hearing the stories of people suffering from all different types of traumatic events. Stories not only suppress suffering, but also provide an unprecedented insight into the lives and minds of people with the disorder.

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Inflationary Cosmology

by Jaya Sahihi

Our universe is 13.77 billion years old but I want to take you to a period of time only 10^{-36} seconds long. Although this is only a tiny bit of time, it is the period responsible for creating the universe as we know it today. According to theory of inflationary expansion, during the initial stages of our universe it grew by a magnitude of at least 10^{78} in contrast to the present day slow expansion (Fabric of the Cosmos). When proposed, this new theory promised answers to questions about time, where our mass comes from, entropy, more details on what the universe was like after the big bang, as well as other important questions. But before we go any deeper into what the inflationary period was and what it explains about the workings of our universe, I want to show you why scientists believe that it could have happened.

If you are having trouble wrapping your mind around an ever-expanding universe, you aren't alone. Many scientists in the late 1800's were skeptical. Sure, people thought, it does answer previously asked questions that would be nice to have answered but how do we know that it isn't just something we have created *in order* to answer those questions? They needed proof that there was a strong likelihood that this inflationary period might have occurred and it wasn't just something dreamed up by wishful scientists. In showing you the answers to these questions and explaining what ended up convincing the skeptics, I hope to start you off with a better understanding of what the inflationary period was as well as a belief that this is a viable, concrete theory. Then we will dive even deeper into the implications inflationary cosmology has on our universe and daily lives.

Let's start by looking at the questions the scientists started with such as: what conditions would have been necessary for inflation? And what would have needed to happen for these conditions to be fulfilled? If the answers to these questions require an extremely unlikely situation, then scientists are merely trading big bang special conditions for those of inflation and the theory can be disregarded (Fabric of the Cosmos).

The first change that needed to be made was rather than thinking of the inflationary burst (aka the big bang) as the creation of our universe, it is more accurately thought of as the result of an event occurring in a preexisting

universe (Hidden Reality). This pre-inflationary space would have been warped and bumpy, and overall, extremely chaotic. Now let's zoom in on one inflation field. Let me first define a field. In its most basic form, a field occurs when, at any point in space, a quantity has a measurable value as well as an energy density that relies on that value (Felder). This is still very difficult to understand so just think of a magnetic field. Magnetic fields can be measured at any point in space; we do this using a compass most of the time. Back to our inflationary fields, let's look at the one that created our universe. This inflation field would have been extremely disordered with its rate of change jumping all over the place. As the inflation field fluctuates at all different levels, eventually the amount of energy would have hit a value that then would have initiated an outward burst of inflationary expansion — creating our universe (Fabric of the Cosmos).

Next, scientists wanted to know what the probability of this occurring was. Austrian physicist Ludwig Boltzmann suggested that our universe arose from a rare, but completely feasible fluctuation of total disorder. Since the only universe that needs to be accounted for is our own, we only needed this value to be hit *once,* and out of the entire disordered pre-inflationary space, this seems completely achievable (Fabric of the Cosmos). To help you visualize this, imagine you are holding an entire deck of cards and shuffling them over and over again. The chances of you shuffling them into the order they came in is *extremely* unlikely. But, if every point in space is filled with people shuffling their own decks, the chances of someone getting this special order suddenly increases quite a bit.

Okay, so we have figured out what would have been necessary for inflation. But another question has arisen from this answer. Scientists wondered why this fluctuation produced such a giant, complicated universe, hugely more ordered than what is necessary even just to support life as we know it. It would have made much more sense statistically if there were just a few, or even one galaxy, much more modest than that with which we are familiar.

Once again, Boltzmann held the answer. He said that everything we see today could have come from another rare (but once again possible) statistical jump to lower energy (Fabric of the Cosmos). As I will explain later, the stretching of this tiny nugget of space can easily explain how our universe got to be the way it is from its shape, to its large scale uniformity, to even the slightest variations. The inflationary theory not only promises answers, but, as we have seen, it is very plausible that it occurred. And now it is no longer possible to dismiss inflationary cosmology as a dream of scientists. It is, as far as we can tell, the true beginning of our universe.

Now that we know inflationary cosmology is a viable theory, we can ask questions about how it created the universe we know today. One of the most pressing questions of how our universe works arises from the problem of time. As accepted as it is in everyday life, scientifically, scientists cannot figure out where the arrow of time comes from. The idea that "this" happens before "that" is one we take for granted but cannot be mathematically proven. There is no reason why, under the right (but practically impossible) conditions, an egg shouldn't be able to unbreak, a fire unburn, or even ice unmelt in your glass. Concepts so routine to humans such as past, present, and future, don't stand up to experiments. They can't

be explained by equations (Fabric of the Cosmos). The one concept that has supplied at least a partial explanation to this question of where time comes from is entropy. Entropy is the measure of disorder. If a system has high entropy it is considered very disordered; if it has low entropy it is very ordered. It is thought that the movement of time can be thought of as the movement from low entropy to high entropy (Fabric of the Cosmos). That is why an egg can break and not un-break. Our universe is constantly moving towards a state of less order. However, the only reason this works as an explanation for time is because our universe began as a very low entropy, highly ordered entity. The universe moves forward in time as entropy increases.

For this, we have the period of inflation to thank. At the start of our universe, matter was spread uniformly throughout space. If you were to look at a map of the entire universe, although there would be vast areas of empty space, the mass that was present, was present in equal amounts throughout this space. Imagine you are a tiny water molecule in a bottle of seltzer. Although you only come across a bubble after traveling long distances, if you recorded the amount of empty space between bubbles, you would find it to be practically uniform throughout. This uniform distribution makes sense when one is talking about the distribution of bubbles in seltzer, but when gravity plays a role, this is far from the normal. One would expect areas that have just a slight amount more mass than other areas to continue to pull in more and more mass until becoming a black hole. At first glance, it doesn't make any sense that our universe isn't just empty space pockmarked with massive black holes. The fact that our universe is so highly ordered, with such low entropy, seems counter intuitive. Why did the universe end up with uniform distribution of space as well as a uniform spatial curvature?

To figure this out, one must realize that the reasoning that points towards a universe of black holes relies on the assumption of the attractive nature of gravity. I'm not telling you this isn't true. The gravity we are familiar with is absolutely attractive. But, during the inflationary phase of the universe, gravity was *repulsive* (Fabric of the Cosmos). That changes everything. The gigantic outward push of gravity caused space to grow to such extents so swiftly that any clumps of matter that had previously been present, were completely diluted, basically wiped away. In terms of creating uniformity within the curvature of spacetime, the universe had grown by such a fantastic amount that any wrinkles that had been previously present were stretched out until they no longer existed (Fabric of the Cosmos).

But how can gravity be repulsive? Well, it wasn't exactly the gravity that was causing the repulsion, it was a byproduct of the gravity. When the universe was first coming into existence, the only energy present was uniform vacuum energy. And walking hand in hand with uniform vacuum energy is always a high vacuum pressure, the kind of pressure that resists gravitational collapse. Here is where the idea of a repulsive gravity comes from. The pressure of the vacuum energy could destroy any bumps or lumps, making an incredibly flat, uniform space. This all occurred before mass and radiation were present so the vacuum energy was so strong enough to create a universe so flat that it remains so for billions of years to follow (Fabric of the Cosmos).

Back to the question of time. We now see that the outcome of inflation was a uni-

verse that was uniform in its distribution of matter and in its spacetime curvature, with extremely low entropy — just what scientists were waiting for to explain our movement towards higher entropy; just what they needed to insert an arrow to time. Inflation set the stage for the gravitational formation of galaxies and stars that created our universe. The future became defined as the direction in which entropy grows.

Whenever a new theory is tested it must hold up to all the other laws of physics we have previously discovered or state a very convincing argument as to why what we had thought before was somehow off. At first it seemed as though the inflationary burst violated the second law of thermodynamics. This law states that the entropy of a system never decreases because systems are always moving towards states of maximum entropy (Second Law of Thermodynamics). The idea that the inflationary burst smoothed things out, and therefore lowered entropy, would go against this law.

Luckily, scientists did not have to go through the process of rewriting inflationary cosmology or the laws of entropy. As they looked into it they found that during this period the total amount of entropy did go up overall. The reason it disguised itself as going down was because it went up by *much* less than it could have. The entropy resulting from the creation of so many particles caused an overall increase in entropy. However, in respect to the order of the universe, there was much less entropy created than could have been (Fabric of the Cosmos). When you hear scientists mention the low entropy state of the universe they are referring to how ordered our universe was created compared to how disordered it could have been. Although there was an overall rise in entropy, there was still a very large discrepancy between how much entropy could have been created and how much there was. Since inflation, every clump of matter that has been formed out of our otherwise uniform universe has been entropy trying to bring itself one step closer to realizing its entropy potential (Fabric of the Cosmos).

So now that we have a uniform, low entropy universe, where did all the matter that makes up our earth, the countless stars in the sky, and even humans come from? The answer to this lies in particle movement and energy transfer. To understand this better we must look at the concept of *redshift.* Redshift can be defined as the difference between the observed wavelengths of light and the wavelengths of light emitted from an object (Red Shift). To measure redshift, one must know the wavelength of the emitted light when the source it comes from is at rest (meaning the wavelength that would be measured by an observer located adjacent to, and moving with, the source). To do this, scientists often look at features in the spectrum of the emitted light such as absorption lines, emission lines, and other variations in light intensity in order to compare those with the features of known chemical compounds found on earth (Red Shift). Once they figure out what is emitting the light, they will know what wavelength the light must have been emitted at. They can then compare this to the wavelength that has reached the observer. The reason redshift has its name is due to the fact that, as the wavelength of light gets longer, it moves down the spectrum towards the last color on the visible light scale, red. There are three types of redshift, each with a different cause. For our purposes, we will examine cosmological redshift. Cosmological redshift is

the redshift caused by the expansion of space. As space expands, the wavelength of light increases as it moves from its point of emission to its point of detection by the same amount that space has expanded during its trip (Red Shift). As methods of measuring distance to stars and galaxies continued to mature, Astronomer Edwin Hubble came to the realization that redshift, which can be thought of as recession speed, is proportional to distance. This means the proportion can be used as a tool on its own for measuring distance (Red Shift). Since then, this method has become a common application of redshift and has enabled scientists to discover many new things about our universe. For example, it has become clear that the further a galaxy is from earth, the faster it is moving away from us.

As for what this tells us about the creation of matter, we can see through redshift that as space expands, these fast moving particles are constantly working against the inward pull of gravity. Because of this, the particles are constantly slowing down as they are pulled back by a gravitational field, resulting in a decrease in the particle's energy and radiation. This is the decrease of energy we see in cosmological redshift. The longer a particle has been traveling, the redder the light it emits is (Fabric of the Cosmos).

When you add a uniform inflation field to the equation, such as the one present in our universe, it exerts a negative pressure gravity and in the same way gravity took energy from the particles, an inflation field takes energy from gravity. The inflation field feeds on gravity and as space expands, the total energy carried by the inflation field continues to increase (Fabric of the Cosmos).

During the inflationary phase of expansion the energy density of the inflation field remained constant. This is interesting because it means that the total energy it contained increased in proportion to the volume of the space it filled. If the universe increased by a factor of 10^{30} during inflation, the volume of the universe must have increased by at least 10^{90} (Fabric of the Cosmos). The energy held in the inflationary field must have increased by this same, giant number. It is thought that, at the end of the inflation phase, the inflation field had a bunch of energy pent up from the massive expansion that it had to release. This release of energy is where our mass came from (Fabric of the Cosmos). It is suddenly clear that the inflation field did not need to have an extreme amount of energy as was previously thought in order to create all we see today. As the universe expanded, the energy increased by massive amounts even though not a lot of beginning energy was present. In fact, it has been calculated that all the pre-inflationary universe needed was an area of space that was 10^{-26} centimeters across, filled with a uniform inflation field and with a weight exceeding twenty pounds (Fabric of the Cosmos). After inflation, this tiny amount of space had grown so large it can account for the energy needed to create the universe we see today.

The last question relating to this brief but fascinating period of inflation that I want to leave you with asks how, out of this uniform distribution of space, our galaxies came to be? This requires you to think on both an extremely small and extremely large scale. One must look at the inflationary expansion of space as well as the quantum uncertainty principle. To start with, the uncertainty principle states that the more certainly one knows a particle's position, the less they can know about the particle's velocity and vice versa. It prohibits

simultaneous knowledge of both position and velocity. It suggests that before any observations are carried out, the particle remains in the realm of quantum uncertainty, or probabilities. Before a particle is measured, it could be anywhere (The Uncertainty Principle). Although this is very counterintuitive to the way we think of life around us (as Einstein argued: even if we don't look at the moon, its still there), things work very differently when you get to the scale of particles. This uncertainty principle also applies to fields: the more one knows about the value of a field determined at one location in space, the less they know about the rate of change at that location (The Uncertainty Principle).

Out of this uncertainty, suddenly everything becomes *jittery.* If it is impossible to know the velocity of a particle with absolute precision, it is also impossible to know where the particle might be even the slightest fraction of a second later. The particle can be thought of as taking on many velocities in a jittery, frantic movement. The same goes for fields; they will undulate up and down with a mixture of rates of change, taking turbulent values and random changes (The Fabric of the Cosmos).

Turning to the beginning of our universe, after inflation, the infinitesimally small became the unbelievably big. As space swelled, these tiny variations within the particles and fields would have been stretched out to scales larger than the quantum domain, creating a sort of minor lumpiness within our otherwise extraordinarily uniform universe. These slight inhomogeneities were the beginning of large astrophysical bodies. Every galaxy in our universe sprouted from one of these lumps (Fabric of the Cosmos). Our uniform distribution of galaxies is all thanks to quantum mechanics.

Evidence for this comes from observations of the microwave background radiation temperature throughout our universe. Take the temperature in one part of our sky and it will agree with any other part to very, very high accuracy. It is only the fourth digit after the decimal point where temperatures start to vary (The Fabric of the Cosmos). It is this tiny variation though that explains the quantum fluctuations smeared throughout our universe by inflation. When these quantum jitters were spread out, the result was that some areas were slightly hotter or cooler than others. As said before, the differences are miniscule but physicists have predicted how the microwave radiation temperature should vary around our sky based on this idea of quantum jitters. They found that these predictions, when compared to satellite observations, were almost completely correct (Fabric of the Cosmos).

This means that the temperature of photons that have been traveling for close to 14 billion years from all directions have almost exactly the same temperature and the differences stay true to a pattern determined by inflationary cosmology and quantum jitters.

Inflationary cosmology has managed to answer some very important questions but with these answers come at least three times as many questions. For me, there are a few specific ones I want to look into as I continue my research. First of all, inflationary cosmology implies that it is very possible for there to be many other universes out there, completely invisible to us, resulting from other nuggets of space hitting the fluctuation value exactly right to achieve inflationary expansion (The Hidden Reality). It is hard to imagine how we would ever prove if this is true or not but I would like to look more into this "multiverse" the-

ory and explore its implications as well as the possibility of it being true. Next, I would like to look into string theory, which answers even more questions about the secret workings of our universe. I would learn more about how it overcomes one of the greatest obstacles in theoretical physics, the rift between general relativity and quantum mechanics.

Although it may feel like we covered quite a bit, inflationary expansion took up barely any time at all. However, as you have now seen, it is most likely the reason our universe has become the way it is today. From a chaotic, wild primordial universe there was a microscopic fluctuation in an inflation field weighing less than twenty pounds. And from that fluctuation every thing began to expand, creating a uniform, low entropy universe, and since then, we continue to move further and further into disorder. There are many questions left to ask, but inflationary cosmology gets us off to a pretty good start.

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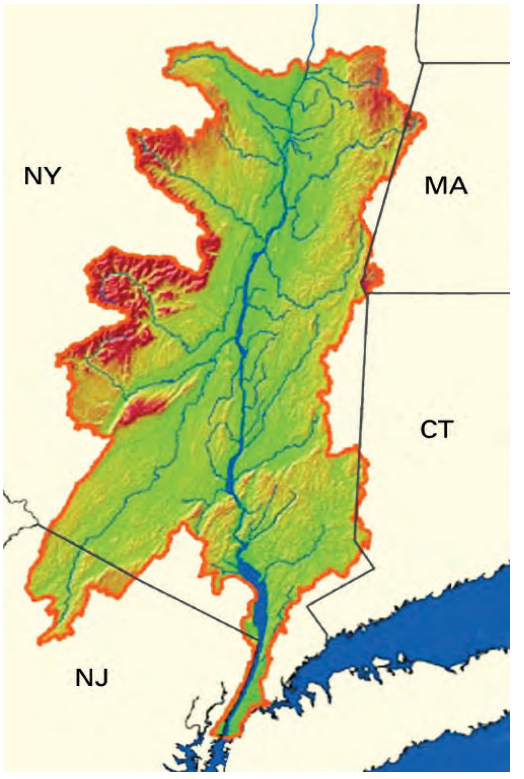
General Biodiversity in the Hudson River Estuary

by Ariel Dineen

Introduction

The Hudson River is a fiercely vibrant and diverse estuary — a swath of sea where salty ocean collides with fresh water from the land. Estuaries host a great variety of organisms because of their dual-nature: freshwater, saltwater, and estuarine species shape this ecosystem. However, most freshwater and saltwater species are merely visitors. Some have to travel through an estuary due to their migratory route, such as anadromous organisms (originating in freshwater and living at sea) or catadromous organisms (originating in the ocean and living in freshwater environments). With a scarcity of marine predators and an abundantly rich food supply, estuaries are ideal locations for spawning and nursery grounds.



Topography of the Hudson River Estuary and its watershed.

Green and Red Represents the water shed, the region draining into the Hudson River. Blue represents the estuary.

But the permanent residents, the true estuarine species, are intriguing because they can complete their whole life cycle in these transitional waters. These organisms must be robust and have a high tolerance for stress: capable of surviving shifts in salinity and other water-quality fluctuations. Therefore, only select species can endure this turbid environment. The Hudson River is populated by a whole host of these true estuarine species — including primary consumers like the American Eel, Black Fish, and Toadfish, secondary consumers such as Atlantic Silversides and Lined Seahorses, and tertiary consumers such as isopods and amphipods.

What better way to observe this incredible ecosystem than by providing the habitat, an oyster reef? Oyster reefs — once prominent in the Hudson River — are typically inhabited by this

vast array of organisms. Individuals flock to oyster reefs for protection against predators and also for food. We can see the abundance of these estuarine species and the correlation between that profusion and the fluctuating water quality by observing the biodiversity of an artificial oyster reef.

In collaboration with the River Project (a non-for-profit based off of Pier 40, NYC), I conducted a biodiversity and fish ecology study assessing the correlation between water quality and the organism pool. By creating an oyster reef, I was able to observe the fluctuating water quality and its impact on marine life.

Materials and Methods

To create an artificial oyster reef, I had to mimic the natural structure of northeastern reefs. Oyster larvae, more commonly known as spat, are sessile organisms that will latch on to a calcareous exoskeleton (often an oyster shell) in order to complete the duration of their life. The repetitive attachment of juvenile oysters to adult oyster shells leads to a densely packed mound of living oysters and shells — or rather, an oyster reef.

Nina Zain, James Sarmiento and I immersed a PVC pipe in cement to make the base of the reef. We then chipped off some cement segments to allow for more surface area. The reef was about 22 inches tall and the base had a 10-inch diameter. To imitate their natural structure, I affixed oyster shells in specific patterns to provide both surface area for barnacles and oyster spat, and alcoves for larger organisms.

After the reef was constructed and safely tethered to a cleat off of Pier 40, our study commenced. The reef was removed from the water 2-3 times per week and data was collected for both biodiversity and water quality. I submerged the reef in a bucket of Hudson River water, counted, measured, and gathered the organisms, and then transported them to the River Project's wet lab. Then the reef went back into the Hudson.

With that same water sample, we then performed a series of water quality tests in order to contextualize our results. We assayed the turbidity, salinity, dissolved oxygen (DO), temperature, pH and tidal patterns through water samples for each day. Turbidity measures the murkiness of water induced by the abundance of suspended particles. As you can imagine, the Hudson is not like the clear and pristine waters of the Caribbean, so we measured its turbidity with a Secchi Disk by the centimeter.

In addition, salinity was measured with an oceanic hydrometer in parts per thousand.

Our artificial oyster reef before experiment commenced

Dissolved oxygen (in parts per million) shows us the oxygen levels in the water. As in the case of terrestrial animals, aquatic animals need oxygen in order to live. As water filters through their gills, tiny bubbles of dissolved oxygen get transferred from the water into their bloodstream. *(Water on the Web)*

To quantify the dissolved oxygen of a water sample (retrieved from the benthic layer), we generated specific chemical reactions using the LaMotte Dissolved Oxygen test. First, ensure that there are no air bubbles trapped in your sample. The second step is to add the reagents: 8 drops of Manganous Sulfate solution immediately followed by 8 drops of Alkaline Potassium Iodide Azide. We mixed the solution by inverting it multiple times and then allowed the precipitate to settle below the shoulder of the bottle.

After it settled, we added 8 drops of Sulfuric Acid and inverted the bottle until the precipitate and reagent had completely dissolved. The solution turned a yellowish orange hue. This color-change indicated that there was a presence of the constituent, dissolved oxygen.

LaMotte Dissolved Oxygen Test Kit

The third and final component of the LaMotte Dissolved Oxygen test was titration. We filled a syringe with Sodium Thiosulfate titration solution and carefully added it — drop by drop — until the sample turned a very pale yellow. From there we were able to get a reading of dissolved oxygen levels by measuring the volume of Sodium Thiosulfate used. Assessing water quality through turbidity, salinity, and dissolved oxygen levels is so important because biodiversity of the Hudson River Estuary depends greatly on these abiotic factors.

Individual Isopod

Results

The Hudson River is full of life during the summer months; the River Project's wet lab (an aquarium using water from the river) was full of Blue Crabs, Black Fish, Atlantic Silversides, Toadfish, White Perch, and Lined Seahorses. But as the season turned from fall to winter, we observed the decline in our pool of organisms. This could have been due to many factors, such as the decline in temperature, or the gradual deconstruction of the artificial oyster reef (shells began to break off due to the turbulent waters). However, we were still able to gather data on many different species.

Isopoda is an order of crustaceans. They can range anywhere from 300 micrometers to 50 centimeters in size. Their seven pairs of legs are very similar in shape and size. Among the aquatic isopods in the Hudson, ***Edotea Triloba*** and ***Cyathura Polita*** are by far the most common ***(52, Stanne and Panetta).*** Sea pill bugs, or ***Sphaeroma Quadridentatus,*** another estuarine species under Isopoda, are also commonly found. We collected 142 isopod individuals over the course of the study.

Lined Seahorse

Individual Isopod

Amphipods comprise another order of crustaceans. They are more like shrimp than isopods, but hardly ever grow to more than 3 centimeters. As one of the most copious species in the Hudson River, they can surpass 20,000 individuals per meter squared ***(53, Stanne and Panetta).*** As a vital part of the food chain, they eat animal and plant matter (such as algae or deceased animals) and are also a crucial food-source for many primary and secondary consumers (such as the lined seahorse).

The Hudson's species of **grass shrimp** are segmented and have nearly transparent bodies. Grass shrimp are yet another important food source for small fish, but they are not so easy to catch. Along with their impeccable ability to dart away, they also have a very pointy helmet over their eyes for self-defense. I have actually observed multiple grass shrimp *attacking* a seahorse.

But despite all this, grass shrimp are very essential estuarine crus-

Individual Grass Shrimp

taceans. Their decline reflects harmful human influence, such as pollution or global warming, on an ecosystem rtand can really threaten the estuarine food chain *(NOAA News Online).* We were able to collect three grass shrimp.

Toadfish

Toadfish (fish found in the *batrachoididae* family) are widespread benthic predators in the Hudson. The name, toadfish, was coined because of their toad like appearance. They can reach up to 38 centimeters in size and display a parental protectiveness that is unusual for fish (defending their "nest" even after their eggs hatch and the juveniles are growing). They feed on crustaceans and occasionally other small fish. Two juvenile toadfish were found on the reef.

Skillet fish are another benthic predatory species. They are similar to toadfish in behavior and diet. Skillet fish occupy oyster reefs and also eelgrass beds (a kind of SAV — sub aquatic vegetation). The suction disk on the belly of the fish is used to cling to rocks or shells for security. One skillet fish (measuring at about 5 cm) was found on the reef.

Skillet Fish

Our objective was to collect data all the way from September to December. Unfortunately our experiment was terminated due to the devastation caused by Hurricane Sandy.

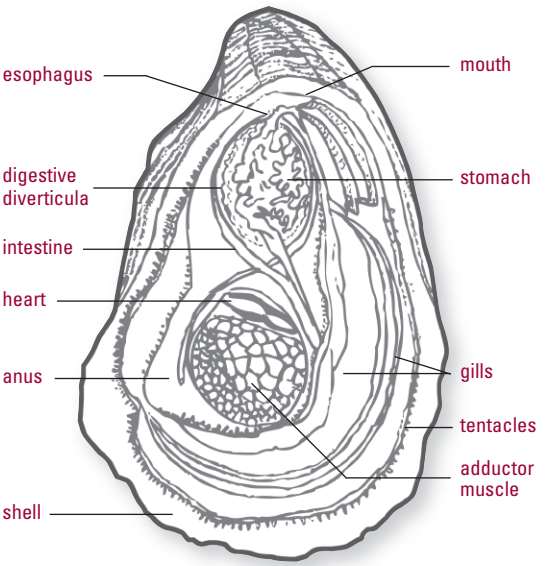
Discussion

So why were all the water quality assays so important? They could hold the answer to why we acquired specific organisms on any given day. Highly turbid and saline environments can be uninhabitable by certain organisms. Similarly, fluctuating dissolved oxygen levels, temperature, and pH can lower many organisms' chances for surviving in those conditions. One very interesting variable in water quality is actually the tide. Many organisms that inhabit oyster reefs are bottom seeking; they can sense when the water level is subsiding, leading them to swim down. Depending on the tide, there might be an absence or abundance of these benthic-seeking creatures. From the limited data we gathered, we were able to see a gradual decrease (ending with a dramatic decrease on the last day) in organism count — going from dozens to zero.

This was hardly surprising to me; in the summer months the wet lab is populated by hundreds of fish and crustaceans and by winter the numbers dwindle down. So why is that? Many marine animals are exothermic, meaning that their internal body temperature constantly matches the surrounding environment. However, many of these fish dive down to deeper and warmer waters to survive the cold winters. One reason might be temperature — we observed a scarcity of marine animals towards late October (when temperatures dropped down to 14°C).

However, this decline could also be attributed to many other things besides temperature, such as tide. Benthic tertiary consumers like isopods and amphipods have the ability to sense shifts in tide, causing them to swim down. Towards the end of our study, we were actually checking the reef at low tide (as we later discovered), which could account for the dramatic drop in isopod count. Once the isopods sensed the water surface nearing, they swam down and into the protection of deeper waters. Without this bountiful food source inhabiting the oyster reef, there was nothing to draw fish. Hence, we saw fewer species and fewer individuals per species.

Crassostrea virginica, American oyster



Furthermore, aside from temperature and tide, there were some uncontrol-

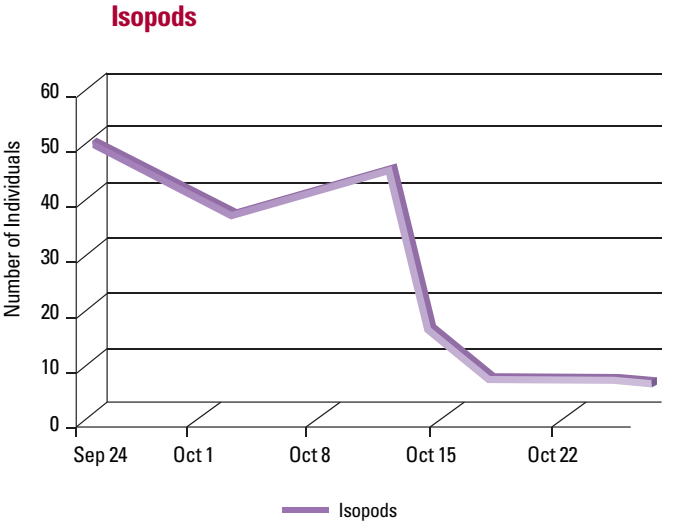


Figure 1
This line graph represents the individual isopod count on the allotted dates of this study. On Oct 3, 2012 no data was

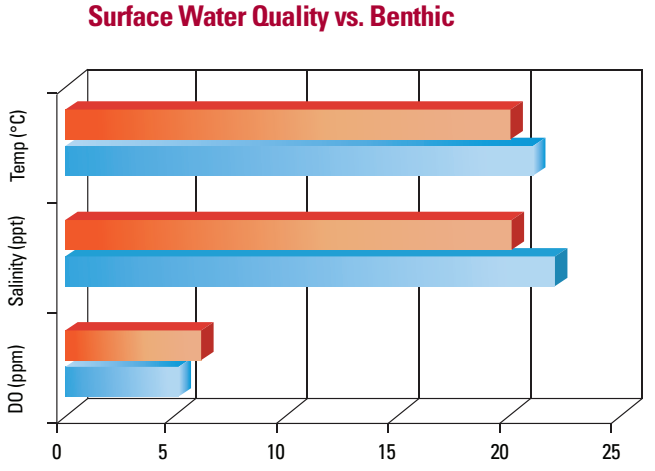


Figure 2
Surface water quality vs. Benthic water quality. Collected on Oct 15, 2012

lable factors that destroyed the physical reef. Each day more and more shells fell off, though the adhesive was strong, because the reef was continuously tousled and battered in the water. Sadly, with fewer shells come fewer organisms.

What are the differences between benthic water quality and surface water quality? The benthic temperature measured 20°C and surface measured 21°C. The surface had 5.0 ppm dissolved oxygen where the benthic had 6.0 ppm. Water quality testing also showed that salinity was at 20 parts per thousand at the benthic level and 22 ppt at the surface. In simpler terms, the surface had a higher temperature, lower DO levels, and a higher salinity. Temperature is the easy one to explain; surface water interacts with the air and sun, thereby warming it up (only by 1 or 2 degrees Celsius).

By this logic, you would also believe that surface water would have higher levels of dissolved oxygen because of constant interactions with the air. Surprisingly, our results didn't

General Biodiversity

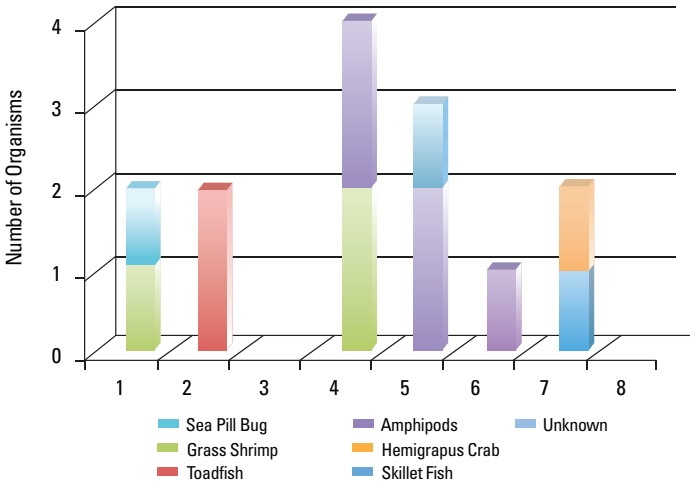


Figure 3
Represents general biodiversity excluding isopods. The days we collected data spanned from Sep 24 (day 1) – Oct 24, 2012 (day 8)

Relationship between Salinity, Temperature, Turbidity, and Dissolved Oxygen

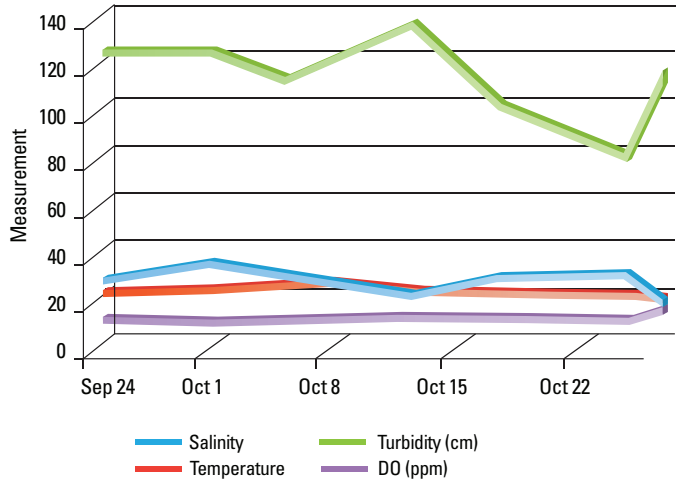


Figure 4
Relationship between salinity (ppt), dissolved oxygen (ppm), turbidity (cm), and temperature (°C).

show that: dissolved oxygen (DO) on the surface was at 5 ppm (parts per million) and at the benthic level 6 ppm. Because cold water can hold more of any gas, it has higher levels of dissolved oxygen *(Water on the Web)*. That is partly why when we saw temperatures drop to 14°C, we also recorded a dramatic increase in DO levels to 7.1 ppm. For the same reason, dissolved oxygen concentrations are usually higher in the winter than in the summer.

Surface salinity is also subject to fluctuations based on evaporation and precipitation. In this case the surface had a higher salinity (22 ppt) than the estuary floor (20 ppt). As water evaporates from the surface, there is a higher concentration of salt particles. This highly saline surface will then sink below the less- dense benthic water and the whole process will

Oyster Bed off the coast of South Carolina

repeat itself. Our findings were merely a moment in time, showing the constant fluctuations of this salinity cycle. One really curious finding is when the salinity levels dropped suddenly to 8 ppt on October 24th, 2012, only one day before the peak of Hurricane Sandy. What caused this sudden decline? During any hurricane, the different levels of water begin to mix and churn. The cool and deep waters on the ocean floor will suddenly be whirled to the top, and vice versa. This phenomenon also throws salinity completely out of whack. Our findings only reflect the drastic changes in water quality before the storm surge.

This study was like a pilot study. We had to experiment all throughout August and September to create the list of protocols, water quality tests, and to determine essential factors like location and adhesives for the reef. And once Sandy blew over New York City, the experiment had to end. Interestingly enough, New Yorkers began to recognize the value of oyster reefs as our natural protection against tidal surges like those from Hurricane Sandy.

Oysters were once incredibly widespread along New York Harbor and the Hudson River. The working class ordered oysters on the half shell at the Grand Central Oyster Bar almost as much as they ordered pizza — it was safe to say that the Oyster was New York's favorite mollusk. Oyster reefs were our version of coral reefs, but just like the coral reefs of the modern world, they all but disappeared. Approximately 85% of the world's oyster reefs have vanished since the late 1800s. What caused that exorbitant decline? The answer is over harvesting, pollution, and destructive dredging by fishermen (John Collins Rudolph).

But now, there is a movement to restore the Atlantic oyster reefs. In 2010, The Hudson River Foundation constructed six experimental reefs and established them throughout the estuary (HRF). These restored reefs will provide organisms with a richer habitat (causing a flourishing ecosystem), help clean and filter water, and be used as coastal protection.

Oyster beds contour, dip, and swell to break up the pounding waves of hurricanes and other storms. This was our natural protection, but as New York developed, the harbor adopted a smooth bottom. The oyster reefs leveled and as a result became incapable of buffering our coast *(Paul Greenberg, An Oyster in the Storm).* These organizations that are working to reinstate oyster reefs have their work cut out for them. It took as much as 7,000 years for New York to naturally build this barrier *(Megan Schuknecht, Oysters in a Storm).*

I believe that New York Harbor and all of its respective rivers will be seeing big changes. The water is getting cleaner every year and people are beginning to realize that we have to uphold New York City's natural defenses. Oyster reefs are more than just vibrant ecosystems; they are our buffer against a raging (and rising) Atlantic Ocean.

Acknowledgements:
James Sarmiento, Nina Zain
The River Project

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Negative Effects of Cell Phone Radiation

by August Rosenthal

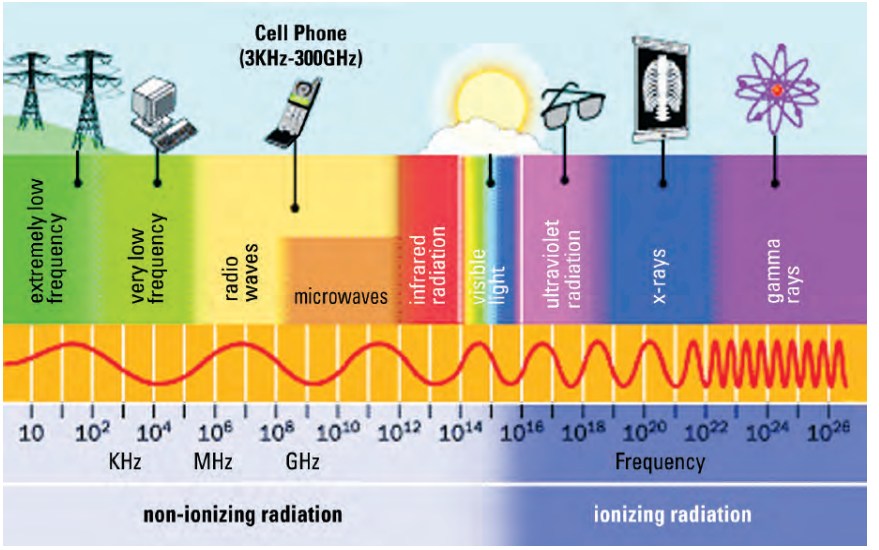
Introduction

Before addressing cell phone radiation and its different forms, it is important to understand what radiation is. Merriam-Webster's dictionary defines radiation as "the emission of energy as electromagnetic waves or as moving subatomic particles," but what does that really mean? Basically, it means that certain entities give off energy, in the form of sound, light, heat, or energy forms that we can't physically detect.

Ionizing vs. Non-Ionizing

Ionizing radiation is made from short electromagnetic waves of very high frequencies. It breaks the union of electrons to certain atoms, giving that atom a charge, thus creating an ion. The high frequency and short length allow it to break bonds that longer waves or waves with lower frequencies could not. Ionizing radiation is naturally occurring — the Sun, cosmic rays, radioactive elements in the earth, and gamma rays all emit ionizing radiation. Despite its natural roots, ionizing radiation is unequivocally understood to be harmful to the human body.

Non-Ionizing radiation is made from long electromagnetic waves of low frequency. It cannot break the union of electrons to atoms. These waves reside on the lower end of the



Non-Ionizing Radiation and Ionizing Radiation

electromagnetic spectrum because they do not carry as high energy as ionizing radiation. They span from radio waves to television signals to microwave radiation — with microwave radiation being the highest energy non-ionizing form of radiation. This section of the electromagnetic spectrum is referred to as radiofrequency microwave (RF/MW) and encompasses cell phone radiation.

So, if cell phone radiation is within the spectrum of non-ionizing radiation, how could it be dangerous?

Cell Phone Radiation

Controversy over cell phone health effects have been all over the media in recent years. Searching for higher ratings and catchier headlines, the news doesn't always provide an understanding of how cell phone radiation even works, what kind of radiation we should be nervous about, and whether or not there is any conclusive evidence in the world suggesting cell phones are legitimately harmful. Illnesses that have been linked to cell phone radiation include cancer, brain tumors, Alzheimer's, Parkinson's, fatigue, and headaches. These illnesses, though widely publicized, are not the main concern of my science research.

There are two main types of radiation that scientists have been interested in, in regard to cell phones: thermal and electromagnetic.

Thermal Radiation

I am aware that cell phones don't look like this anymore. However, besides the aesthetic design, their composition is unchanged. The transmitter processes the sound of your voice and translates it onto a sine wave. This sine wave radiates out from the antenna and travels, evenly, in all directions through space. These waves can heat your skin, especially if you are in direct contact with your phone.

The department of Otorhinolaryngology (study of diseases of ear, nose, and mouth) from the Goztepe Research Hospital in Istanbul investigated the thermal effects from cell phones on facial nerves (FN) and surrounding soft tissue area.

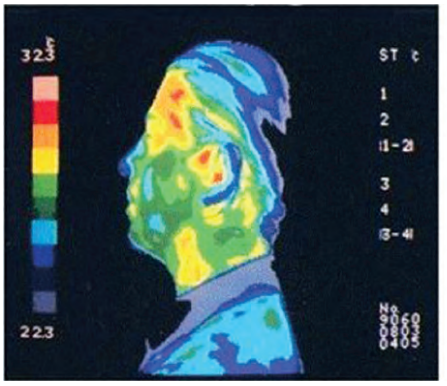
They carried out a prospective study on 12 male rabbits, studying the FN conduction rates and the compound muscle action potentials (CMAP) — basically muscle performance capacity — before exposing the rabbits to radiofrequency radiation (RFR) emitted from a cell phone. A Luxtron fiber optic system also measured temperature levels of the rabbits' faces during the experiment. The cell phone had a frequency of 1900MHz, which is typical for a modern cell phone, and the rabbits were exposed for twenty-five minutes. In essence, the Otorhinolaryngologists were measuring the effects of a half-hour phone conversation. Their results were astounding. Directly after the exposure, the average temperature of the ipsilateral tissues — tissues on the same side of the cell phone — was .39 K higher than the pre-exposure temperature values. Normal temperatures were not reached until twenty-five minutes after the cell phone was powered down, which is more than just statistically significant. It meant that the amplitudes of FN CMAP after RFR were notably smaller than they were pre-exposure and during exposure. Having smaller amplitudes means that the muscles could not preform the same tasks with the same ease or strength that they were able to do previous to exposure. With that in mind, consistent, high levels of thermal radiation could have serious, adverse affects on human facial tissues.

Takeaway: Radiofrequency radiation emitted from a cell phone can, and does, cause temporary FN dysfunction partly due to temporary temperature increases in the ipsilateral soft tissue around the FN.

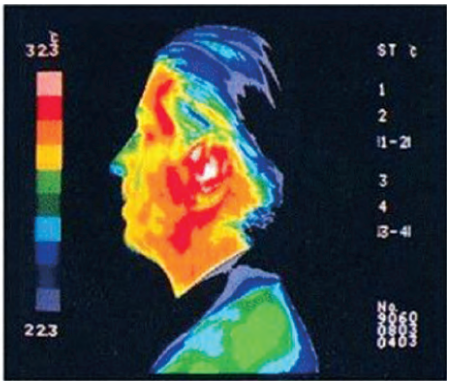
How to attenuate the effects of thermal radiation: The main trick behind limiting thermal radiation is changing basic cell phone habits. Try and hold the cell phone a few inches from your head, or even tilt the top part of the phone (containing the antenna, which releases

Thermal Effects

Heat generated on the face by 15 minutes of cell phone use due to their electromagnetic radiation



Before using mobile phone



After using mobile phone for 15 minutes

TIPS FOR SAFER CELL PHONE USE

• Hold it at the bottom

By covering large areas of the phone with your hand, you reduce its ability to send and receive signals. The phone then increases its power and transmits stronger radiation to compensate this. So hold the phone as far down as possible, so it can operate at low power.

• Get in the best position

When reception is good, the phone reduces power and radiation. If reception is poor, the phone uses maximum power and radiation

the radiation heating you up in the first place, away from your head. Other ways to limit heat are by using Bluetooth headsets or simply talking on the phone for shorter periods of time. Another excellent idea, although slightly different than the others proposed, is turning your phone onto airplane mode during long-distance car trips. As your phone passes through different cell spaces (different cell tower areas), it links with the strongest signal. If you are on the road for a long time, your cell phone will continue to switch cell tower connection. Each time it switches, it releases more radiation, as it needs to send out a new signal to a different cell tower. That's why your phone sometimes gets extremely hot in your pockets on car trips. If you put your phone on airplane mode, however, it will not send signals to cell towers, thus mitigating the heat. This solution, although simple, should actually minimize the damage the previous study discovered. Until cell phones can insulate thermal radiation more effectively without impeding cell phone connection, our physical utilization of phones is the best means to combating this issue.

Electromagnetic radiation

Mobile phones communicate by transmitting RF/MW, which are electromagnetic fields and, unlike ionizing radiation (e.g., X-rays and gamma rays) cannot break chemical bonds or cause ionization in the human body. Since microwaves have the highest frequency of non-ionizing rays, whether or not they have detrimental health effects is still debated.

As of 2013, 87% of the world's population has a cell phone. Given the massive number of cell phone users, finding any potential public health impacts of cell phone use is important. There are many ongoing studies all over the world investigating long-term effects of cell phone use, but because of modernity of this issue, the mechanism of the EMF interactions is not well understood. A number of studies have concluded an increase in levels of lipid peroxidation, free

radical formation, and biochemically induced oxidative stresses result from RF/MW — basically, an atom with an open valence shell stealing electrons from fatty membrane causing cellular damage — while other studies run completely opposite conclusions.

A recent article — July 2012 — from the Sao Paulo Clinics noted, however, that there are definite effects of electromagnetic cell phone radiation on rats, particularly their testicles, which leads us to the meat of my research: cell phone radiation and its affect on male genitals.

The objective behind this study was to understand the effects of RF/MW stemming from conventional cell phone use on the oxidant and antioxidant status in rat testicular tissue and to test whether vitamins C and E could mitigate the negative effects of said electromagnetic radiation on the testes.

The biologists split the rats into six groups: control (no radiation), control plus vitamin C, control plus vitamin E, exposed to an electromagnetic field, electromagnetic field plus vitamin C (40/mg/kg/day), and electromagnetic field plus vitamin E (2.7/mg/kg/day).

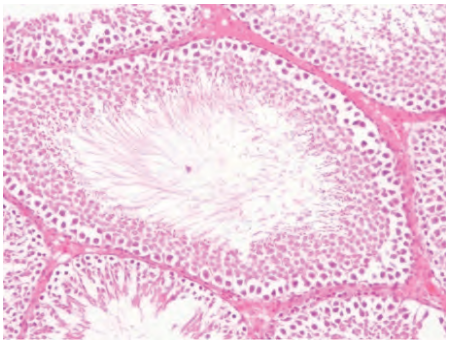
The rats exposed to an electromagnetic field were placed in a cage 50 centimeters away from a standard cell phone, while the control groups were placed in cages in a different room for the same period of time. The distance from the phone was decided to ensure that the radiation effects would not be thermal, but only RF/MW. The scientists were attempting to determine the threshold for radiation causing damage and if that damage could be repaired. In both rooms scientists removed any other device that produced electromagnetic waves (except for light fixtures).

The results certainly matched the concern before the experiment. There is a growing trend toward deterioration of the male germline (both spermatogenesis and sperm maturation). The germline is the sequence of genetic material that can be passed to offspring. This is an environmental toxicant that compromises male fertility through inducing an oxidative stress in the testes.

There are necessary vocabulary words to understand before reading the detailed results.

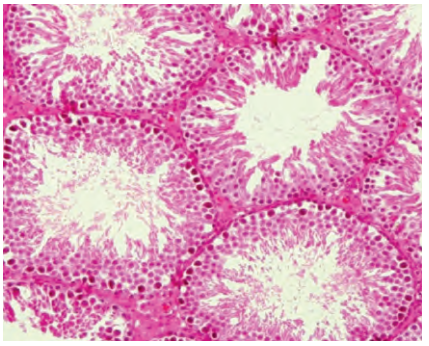
Gamete: male or female germ cell that is able to unite with another of the opposite sex in sexual reproduction
Spermatozoa: the male reproductive cell; the male gamete
Seminiferous tubules: any of the numerous long convoluted tubules in the testis which are the sites where spermatozoa mature.
Spermatids: an immature gamete produced by a spermatocyte; develops into a spermatozoa
Spermatogenic: development of spermatozoa
Spermatocytes: A cell produced at the second stage in the formation of spermatozoa, formed from a spermatogonium and dividing by meiosis into spermatids.
Lumen: The central cavity of a tubular or other hollow structure in an organism or cell.
Interstitium: of or relating to interstices (intervening space especially a small one)

What this article ultimately demonstrates is that cell phone electromagnetic radiation is a legitimate threat to our bodies. Even though this study was carried out on rats, similar experiments have been done with humans, although none showed results so extreme. There



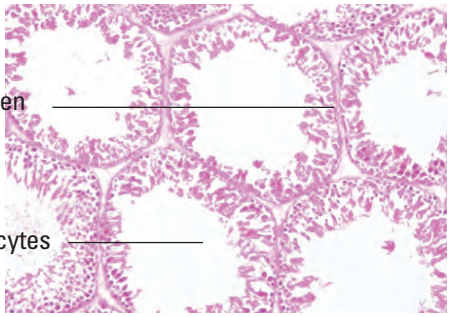
Section 1

Here is a section of rat testis from the control group. These are healthy, normal seminiferous tubules. Depicted as well, are spermatids and spermatogenic cells at different stages of development.



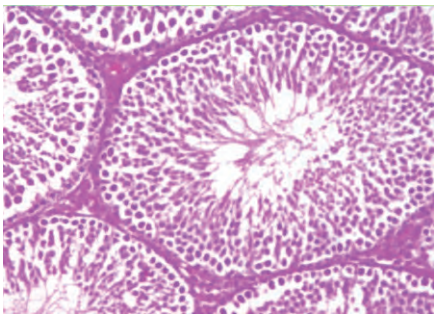
Section 3

Here is a section of rat testis after the regenerative effect of vitamin C. Here there are almost normal seminiferous tubules, spermatocytes and spermatids. However, there are barely any spermatozoa.



Section 2

Here is a section of rat testis exposed to EMR for 60 minutes. Notice the damage to the spermatocytes and the previously mentioned spermatids. There is a clear widening of the seminiferous tubular lumen. And, most importantly, ***an absence of spermatozoa!*** *Notice the entire lack of mature gametes; you can see this by the holes in the middle of the tubules where the tails of the mature gametes would be.*



Section 4

Here is a section of rat testis after the protective treatment with vitamin E after two weeks. The seminiferous tubules, the interstitium, the spermatogenic cells, and the spermatozoa are all good as new. Vitamin E, in this case, had remarkable regenerative features!

haven't been any studies showing whether or not vitamin C or E have regenerative effects on human sperm production. The article also did not explain the reasoning behind testing vitamin C or E's healing effects. Despite the positive results, further testing is definitely needed. Since this article is so new, however, there are no studies confirming or denying this discovery. There have been observational studies at infertility clinics finding similar results with human men, but no experimental studies have been done as of yet. Recent studies on human male sperm production have shown an increase in oxidative stress levels, a significant change in sperm cell cycles, and a increase in the generation of free radicals, which are clear indications of an infertility pattern that is initiated due to an overproduction of reactive oxygen species — or

oxidative stresses. They also concluded that RF/MW waves from commercially available cell phones could affect the fertilizing potential of spermatozoa. This field is still in its nascent form, however, and still requires much more research.

Cell phone radiation should be a concern of ours; thankfully — like with thermal radiation — there are ways to combat receiving such high quantities of radiation.

1. **Use your phone less**.
   By limiting phone calls and texts and phone-to-phone games, your phone emits less radiation.
2. **Don't sleep with your phone right next to your head.**
   You can still hear it ring from a few feet away!
3. **When making a phone call, speak in areas of good reception.**
   With low signal, cell phones emit more radiation, and expend more power — which also heats up the phone!
4. **Buy a low radiation phone!**

Here is a chart of the twenty highest radiation-emitting phones as of October 2012. Keep in mind, not all companies released their levels.

SAR Cell Phone Ratings

RANK	MODEL	SAR (Digital)	CARRIER
1	RIM BlackBerry Curve 9310	1.58	Boost Mobile
2	Motorola Razr HD	1.56	Verizon Wireless
2a	Motorola Droid Razr Maxx HD	1.56	Verizon Wireless
4	Nokia Astound	1.53	T-Mobile
5	RIM BlackBerry Curve 9350	1.5	Sprint Nextel
6	Nokia Lumia 900	1.49	AT&T
7	Motorola Defy XT	1.48	US Cellular
7a	HTC Trophy	1.48	Verizon Wireless
9	Motorola Atrix 4G	1.47	AT&T
9a	RIM BlackBerry Curve 9360	1.47	T-Mobile
11	ZTE Score M	1.45	MetroPCS
11a	ZTE Score	1.45	Cricket Wireless
11b	Motorola Droid Razr	1.45	Verizon Wireless
11c	Motorola Droid Razr Maxx	1.45	Verizon Wireless
15	RIM BlackBerry Torch 9810	1.44	AT&T
16	Samsung Rugby Pro	1.42	AT&T
17	ZTE T-Mobile Concord	1.38	T-Mobile
17a	RIM BlackBerry Bold 9930	1.38	Verizon Wireless
19	Motorola Atrix HD	1.34	AT&T
20	Motorola Droid Razr M	1.3	Verizon Wireless

Ultimately, scientists still are not sure whether or not cell phone radiation has an adverse affect on our bodies. This new field will be scrutinized for decades. There's one thing we know for sure, though, cell phones are here to stay. The question is: how can we make them safer?

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Using Enrichment to Reduce Stereotypic Behavior in Coatis

by Olivia Scott

This pilot study used sensory enrichment with two white-nosed coati, a South American relative to the raccoon. The hypothesis was that by introducing the coatis to different scents they will increase the amount of time they spend active in their cage and decrease the amount of time they spend either inactive or doing a stereotypic behavior. A stereotypic behavior is a type of repetitive behavior that does not have a direct purpose. In this particular study, there were some results that could indicate that the scents increased the amount of activity in the coatis, but a future experiment with changes to the experimental design will help support and yield more accurate data.

Introduction

Animal's habitats are constantly being destroyed due to human development. Consequently, many species are becoming endangered. Zoos are stepping up to keep these different species alive (Swaisgood & Shepherdson, 2005). Besides being institutions to breed species, zoos have taken an active role in educating the public about the lives of the animals in the wild. Zoos have ceased focusing on entertainment for their visitors. They strive now to show their visitors an accurate glimpse of an animal's life in the wild. Their goal is to educate and inform visitors of the natural history and life of the animals at the zoo. (Hermesh, Szechtman, Zor & Eilam, 2006).

Captive animals frequently display abnormal repetitive behaviors. An abnormal repetitive behavior constitutes a behavior that is inappropriate for the species or situation and has a repetitive goal or motor pattern (Garner, J. P., 2005). Under the category of repetitive behaviors falls a stereotypic behavior, which is a behavior that has no goal or purpose (Hermesh, Szechtman, Zor & Eilam, 2006). Zoos are at the forefront in researching abnormal behaviors and stereotypies (Swaisgood & Shepherdson, 2005). They are also leaders in enrichment. The Association of Zoos and Aquariums' (AZA) Behavioral Scientific Advisory Group defines enrichment as "a dynamic process for enhancing animal environments within the context of the animals' behavioral biology and natural history. Environmental changes are made with the goal of increasing the animal's behavioral choices and drawing out their species-appropriate behaviors, thus enhancing animal welfare" (AZA, 2009). Enrichment is the way in which stereotypies are combated. But they are not effective all of the time. Shepherdson found that

"enrichment reduces stereotypies 50-60%" and that the "stereotypy [was] not eliminated." (Shepherdson, N.d.).

So far scientists have not managed to reduce stereotypies from animals that have developed them, but stereotypies do not indicate that the current environment the animal is in is poor. As Shepherdson states, "Performance of stereotypies may not correspond to current wellbeing because stereotypies may be a ''scar'' from previous suboptimal environments" (Swaisgood & Shepherdson, 2005). Mason and Latham's survey states that around 68% of the time stereotypies an indicator of decreased welfare (2004). Stereotypies are an indicator for poor welfare, but there needs to be further investigation into the animal's environment to determine if their environment is causing the stereotypy.

Zoos are constantly learning about the most effective enrichments to use per animal species and sharing that knowledge with each other. Finding the best enrichment tools that stimulate the individual animal or the animal species will hopefully increase the welfare of the animal as well. Beneficial and appropriate enrichment will either prevent abnormal behaviors from occurring or decrease the amount of time the individual is performing an abnormal behavior. Positive welfare in animals will mean that the animal has a higher likelihood of reproducing so the species remains for future generations of zoo visitors. Reproduction of zoo animals can help

reestablish populations of that species in the wild depending on how they are bred (Shepherdson, N.d.). Positive welfare is also a better education tool for zoo visitors when understanding the natural behaviors of animals in the wild. When the public observes the appropriate behaviors of the species they see at the zoo, they will hopefully have a positive experience with the animal to then help the survival of the animal species in the wild in the future.

Background

Stereotypies can take many different forms and can stem from many different aspects of an animal's life. Animals, like humans, have a plethora of different behaviors they are programmed to do. A particular stimulus can activate a particular behavior. For instance if a puma is in the forest and it registers an internal stimulus for hunger, it will start to search for prey. If that same puma then smells its prey it will begin to stalk. The behavior of stalking only occurs when the puma smells prey. In captivity, the ratio of stimuli to behaviors gets altered. Zoos are like a gourmet hotel for life. All the amenities of life are present, all the survival components are available: food, water and shelter. What happens to all the animals' behaviors that involve getting food? They never get stimulated. In the wild an animal is always trying to stay alive, and in a zoo none of those behaviors to stay alive are being stimulated simply because there is no danger. The animal needs some behavior to fill its days, so they develop stereotypies. These behaviors are similar to routines (Hermesh, Szechtman, Zor & Eilam, 2006). The rocking of an elephant, the pacing of a polar bear, or cage hopping in mice all fall under large category of stereotypies because all these behaviors do not have a goal or purpose.

Enrichment is what humans do either to prevent or help decrease the amount of time animals spend stereotyping. Palm tree leaves floating in a polar bear exhibition, a radio for monkeys' to listen to, or a canvas for elephants to create paintings on are all ideas humans have had to entertain animals when in captivity. Enrichment encourages species-specific behaviors. For example, hiding treats around an exhibition will allow the animal to perform a seeking or foraging behavior. Enrichment is categorized as follows according to the AZA: Environmental Enrichment Devices (EEDs), Habitat Enrichment, Sensory Enrichment, Food Enrichment, Social Groupings, and Behavioral. EEDs are objects that can be handled and "manipulated by the animal". There are both manmade and natural EEDs. Manmade EEDs include tires or car wash roller brushes or piñatas, while natural EEDs could be anything from branches, wool, or flowers. Habitat Enrichment is the architectural design of the animal's space. The cage does not need to look like the environment the animal is naturally in. Instead, the space should be versatile and allow for the animal to move about freely and have stimuli for its different behaviors. For example, animals that live in the trees could have moving platforms or ropes. Sensory Enrichment is enrichment that activates one or more of

the senses. Natural or artificial smells (perfumes or phermones), unusual textured materials (burlap, straw or soft blanket), sounds of different animals or a radio station, or visuals like seeing animals in other exhibits or having a mirror so the animal sees itself are all types of Sensory Enrichment because they arouse a response from the sense. A common type of sensory enrichment is in the form of a gustatory stimuli, for taste. This could be flavored water or food enrichment. Food enrichment are different challenges that stimulate the animals seeking behavior in terms of hiding food, or can be the different textures of food such as a frozen banana for a chimpanzee. Social enrichment is usually attained by housing animals together, but this can be grooming, courtship or territorial behaviors. The last form of enrichment according to the AZA is behavioral conditioning which are mental challenges to animals: training sessions. All the categories of enrichment can be effective depending on the animal, and by using a variety of different enrichments no enrichment will become routine and would mirror the novelty of the wild.

Background on Coatis

The characteristics and background on the animal in captivity are sections of knowledge pertinent to understanding what types of enrichment would best encourage natural behaviors. In particular, facts pertaining to the animals' social life and what the majority of their time consists of will help find the most accurate enrichment options to fit the animals' needs. My pilot study used white-nosed coati or *Narsua narica*. The coati is a relative of the raccoon that lives in South America. It is known for its long nose and long striped tail. Researching the natural history of the white-nosed coati helped in deciding the best type of enrichment that fits them.

The majority of the coati's day consists of foraging. They have an enlarged sensory region that can be externally noted (Gompper, M. E., 1995). They can cover up to one kilometer in a day foraging (Gompper, M. E., 1995). The majority of their time is spent on the forest floor, but occasionally the coati climbs up trees to escape predators or to continue foraging (New Hampshire Public Television, 2013). A unique characteristic of this mammal is that its hind legs have evolved to allow it to descend trees face forward (Gompper, M. E., 1995). The social conditions of the coati are different depending on the gender. The female coatis spend their days in large groups of up to twenty females with their young offspring, while the male coatis travel independently (Zoological Wildlife Foundation. (n.d.)). These were the highlights of the natural history of the coati that contributed to decisions made about their enrichment.

The two coatis housed together in the Trevor Zoo at the Millbrook School in Millbrook, New York were of opposite genders. They arrived at the zoo in a pair displaying an "odd" or stereotypic behavior.

Both animals had a form of stereotypic behaviors, but the female's was more obvious for the zoo and the visitors. Her behavior would be a walk or run from one side of the exhibit

to the other, her forepaws would climb the pole as she stood on her hind legs then a quick spin of her head and she would be off the pole back to the starting location to repeat *(Figure 1-3).* She had a few paths she would walk in to get to a pole, but the forepaws and the twist of her head were consistent with each routine. The stereotypic behavior itself could be exacerbated and repeated faster when visitors or unknown stimuli triggered it. The male on the other hand had a simple stereotypic behavior of walking back and forth for a very short distance in the same spot every time, in the back of the exhibition *(Figure 4).*

The size of the exhibition was rather small for an animal that spends its days foraging up to a kilometer. They received food on a pretty regular routine and the food was scattered into different piles around the exhibition. In between the food there was not much going on in their cage: resting *(Figure 5),* stereotyping or an occasional alert behavior. The male entertained himself quite a bit by foraging around in the front of the cage in a patch of grass and litter. In the end, stimulating an olfactory behavior was the best fit for them.

Figure 4

The male on the other hand had a simple stereotypic behavior of walking back and forth for a very short distance in the same spot every time, in the back of the exhibition

Figures 1-3

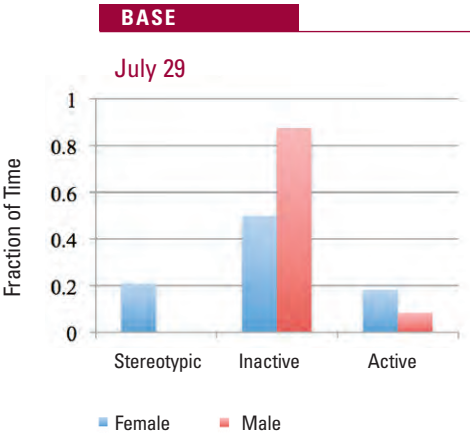
Her behavior would be a walk or run from one side of the exhibit to the other, her forepaws would climb the pole as she stood on her hind legs then a quick spin of her head and she would be off the pole back to the starting location to repeat

Procedure

The goal of the pilot study and the future experiment is to increase the amount of time the coatis spend being active. This would mean decreasing the amount of time they spent either inactive or stereotyping. I observed the coatis for two weeks in order to get a sense of how they spent their day. For three days, each day for two hours I sat at their exhibit recording their behavior. I decided to do a sampling of the total behavior they spend their time doing, called instantaneous sampling. This sampling method means that at the same second of every minute, you note what behavior each coati is doing. This method seemed like the best fit because I could see the correlation between the coati and their behavior. I made a list of the different behaviors I was going to look for, and had to place the behavior I noticed under one of those behaviors. In total, the behaviors I recorded included, Foraging, Sniffing, Alert, Pacing 1, Pacing 2, In Box, Resting, Other and Not Visible. I left the option of "Other" if there was a behavior I was not recording and "Not Visible" to allow for behaviors not seen due to visual barriers in the exhibition. Active behaviors include Foraging, Sniffing and Alert. Foraging behavior is defined

Figure 5

In between the food there was not much going on in their cage: resting, stereotyping or an occasional alert behavior.



Figures 7-11

These graphs illustrate results and actual data and results from the experiments conducted.

as an active searching behavior with the coati's nose to the ground with paws actively rummaging around. Sniffing behavior is more stationary, but still the coati's nose is to the ground actively following a smell and there is no paw movement besides walking. Alert is a still behavior where the coati's head is up, ears are cocked, and eyes are up and searching. All former activity is stopped. Stereotypic behaviors include pacing 1 and Pacing 2. Pacing 1 is a slower relaxed stereotypic repetitive pacing behavior. This was what the male's behavior was because it was not anxious or rapid in any way. The female's behavior was primarily Pacing 1, but sometimes her stereotypic behavior would become Pacing 2. Pacing 2 is a rapid, anxious repetitive pacing stereotypic behavior. Not Active behaviors include both In Box and Resting. In Box is when the coati is in his or her own box or nest in the exhibition. Either the head is out sleeping or looking around, or is not visible, but is known to be in the box in active. Resting is when the coati somewhere else in the exhibition is lying down eyes either shut or open. I spent three days noting the coatis' behavior between one and three o'clock in the afternoon. These three days were my control or baseline days because there was no enrichment in their exhibition, and I used the baseline of their behavior in relationship to the future experimental days. After that I moved onto the experimental part of my pilot study. I spent two days spraying three different scents around their exhibition. The scents were applied both low and high on trees and the rocks and the dirt throughout their exhibition. They included peppermint, orange and almond *(Figure 6).* I picked these scents because they were the scents the zoo had on hand. They were scents and flavorings you could buy from a grocery store, but they were then heavily watered down each in a different spray bottle. Each scent covered a specific section of the exhibition.

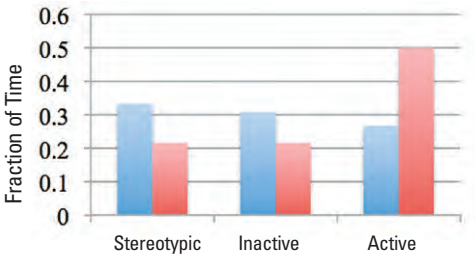
Results

These graphs *(Figures 7-11)* illustrate kind of results that the future experiment will yield. The graphs do show that

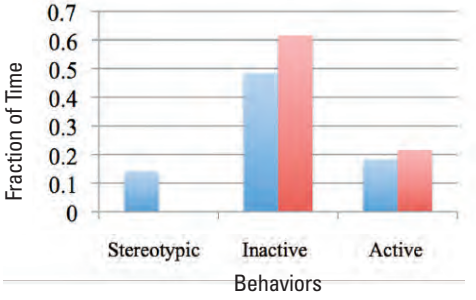
Figure 6

Scents were applied both low and high on trees and the rocks and the dirt throughout their exhibition. They included peppermint, orange and almond

August 2

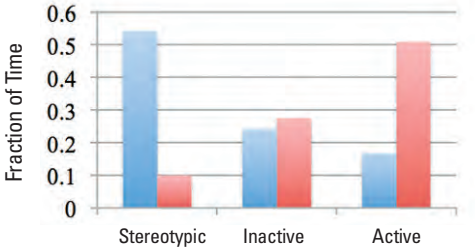


August 3

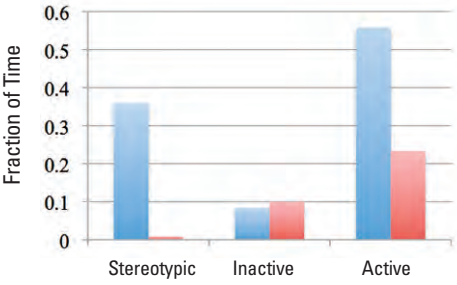


EXPERIMENTAL

August 9



August 11



the enrichment could have been a factor in decreasing the inactivity seen in the experimental days. It is still unclear as to the relationship between the scent enrichment and the coatis' time spent doing a stereotypic behavior. I can not draw any conclusions because the experiment needs to last longer. There needs to be more control and experimental days in order to have enough data to have reasonable results. The instantaneous sampling interval I picked also needs to be smaller, so I can collect more data points and eliminate the amount of behaviors I do not record because they are not happenings on the time interval. No conclusions can be drawn because this study only involved two coatis and the data cannot be extrapolated to the larger coatis in zoos population. The data suggests that the amount of time the animal spent active increased during the experimental days. On August 9th, the first day of placing the scents in the coatis cage shows a large increase in stereotypic behavior from the female. Her behavior could be because this was the first time I entered their cage, inducing both stress upon her because of the change in routine. The stereotypic behavior could have been a coping mechanism for me entering the cage, and not be at all related to the scents. The second day of the placing the olfactory enrichment in the exhibition the levels of stereotypic behavior drops in both male and female. This could be them getting used to my entrance into their exhibition. A longer experimental time will allow for a definitive answer on the subject.

Discussion on Future Works

By completing this pilot study I have paved the way for a more accurate and ideal experiment using coatis at a collection of different zoos. A cross zoo study will take place, which means that some changes will be made to account for the increase in variables among coatis participating in the experiment and their background history as well as the differences in the environmental factors that go into behavioral experiments. After concluding the pilot study, changes would need to be made in order to achieve accurate results in the actual experiment.

1. There needs to be more observational control or baseline days and the experimental days. Two weeks for both would be an adequate time to see the differences in visitors that attend the exhibition as well as making sure all behaviors are normal for the individual animal.
2. Although it was not a part of the experimental plan, I sat observing the individual coatis before I decided on a form of enrichment to use. I think this pre-experiment observation time should be included and required as a part of the experimental design. This change would allow the coatis to get used to the experimenter before the baseline days occur. By having the experimenter around before the actual experiment begins, the animals will get used to the experimenter's presence so they will not be stressed during the baseline days of the experiment. The experimenter should enter the cage and take notes every minute as if doing the experiment, so no stress is felt when the actual experiment begins. This pre-experiment procedure would happen for one week.
3. A placebo scent would be administered for the pre-experiment and baseline days. This would factor out the stress of a person entering the exhibition into the experimental days. Water would be an adequate placebo because it has a neutral scent and it can be administered like the scents through a spray bottle. The action of spraying the water around the exhibition needs to mirror that of the actual scents being administered. A set time needs to be universal across the zoos and a decision before needs to be established based on the activity level seen around given times. The time of day when the pilot study was done from one to three in the afternoon was when the coatis would spend most of their time resting. The experiment should be in the morning or in the late afternoon, not at the heat of the day.
4. The time interval on which to record the behaviors of the individual coatis needs to be shorter than the time in the pilot study. During the pilot study, the time was recorded every minute. I felt that a lot of different behaviors were happening in-between this interval, so I would suggest lowering the interval to fifteen seconds. A preprinted chart of the different behaviors would make it easier on the experimenter, so the time interval can be met.

5. The pilot study was a two-hour observation of the coatis and their activities. I think that two hours should be adequate in terms of observation time, but I propose for the future experiment the time be increased to twelve hours starting at seven in the morning and concluding at seven at night. This would allow adequate time to make sure the enrichment is playing an effect on the coatis behavior throughout a day of zoo visitors and to make sure the overall health of the animal increases.
6. During the pilot study, I noticed that after some visitors left the exhibition or while they were at the exhibition the coatis performed their stereotypy differently than without the visitors around. In the actual experiment, the experimenter should mark when visitors are at the exhibition to see if there is a correlation between the stereotypies and the visitors.
7. In the pilot study both coatis already have a form of a stereotypic behavior. According to the Trevor Zoo it is common for coatis to develop stereotypies. All of the coatis in the experiment should have a type of stereotypic behavior because it is a common issue in zoos.

The number of coatis the Trevor Zoo has and that the pilot study was conducted on seems like the most common number of coatis found in zoos currently. The following zoos could be apart of the future experiment: Phoenix Zoo, Philadelphia Zoo, Belfast Zoo, and The London Zoo. Each zoo listed has at least two coatis and has at least one male and female. Although the low number does not satisfy the normal social interactions these animals experience in the wild, they will help determine what zookeepers can do to provide stimulus. The lack of female companions for the female in the study and the increase in female companions for the male in the study are the common housing of coatis in zoos, so this experiment will help determine how to reduce the stereotypies in this abnormal social situation. All the zoos in the experiment should have an exhibit size that is constant to what most zoos use to house coatis. This will enable the most useful results for other zoos. The knowledge gained from this experiment will help with the welfare of coatis in zoos currently as well as future coati zoo residents.

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The Reasons Behind the Repercussions of Traumatic Brain Injury

by Sophia Timko

Introduction

Humans live by social interactions. It is communication that allows us, as well as any animal, to coexist and help one another and experience joy when in each other's presence. We meet each other, we talk together, we cry together, we smile at one another, we laugh together, we embrace, we make eye contact and we enjoy each other's company. We base what we will say and do in relation to others on emotions, most of the time their emotions. If someone is sad or crying, we console him and grieve with him. If someone is frustrated, we ask how we can help. We take comfort in knowing that others can sense our emotions and are willing to help. But how do people sense emotions? What would happen if humans, or any animals for that matter, couldn't sense others' emotions?

Many times victims of traumatic brain injury (TBI), who have endured a blow to the head, experience many difficulties along those lines. Some of these difficulties affect their social interactions by impairing their facial affect recognition abilities, which allow people to recognize emotions written on others' faces. Patients with TBI cannot sense emotions the way that a person who has never experienced a head injury before can. Their injury prevents them from fully communicating with the people in their lives. So why does this difficulty with social interaction and facial affect recognition occur? What is happening within the brain that leads to this symptom? Let's take a look at the inner workings of the brain and various findings on TBI.

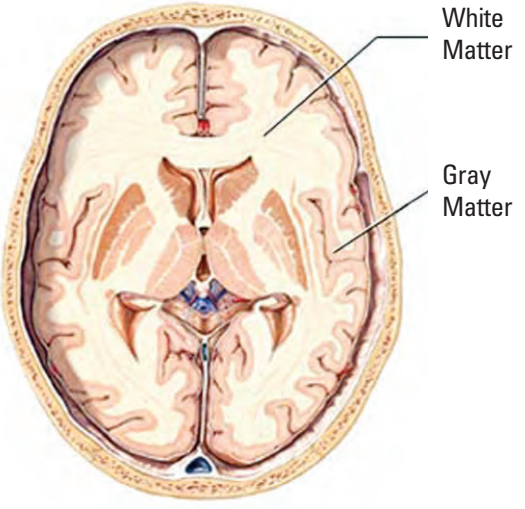
Background

Neurons are crucial parts of the central nervous system (CNS). They transmit signals that tell us what to think, what to move, what to feel, and how to react to various stimuli. When these electrical signals are interrupted or prevented from ever occurring, we can suffer seriously. There are two forms of matter in the brain that contain different types of neurons: grey matter and white matter. The grey matter regions of the brain are the elements of the CNS containing neurons with unmyelinated axons (axons that lack the myelin sheath protective covering) and capillary blood vessels. The grey matter regions mainly control movement, sensory perceptions, memory, emotions, and speech. White matter regions, on the other hand, are the parts of the CNS with myelinated axon tracts that transmit signals received from the grey matter regions. *(Figure 1)* The grey matter regions, because they are located near the outside of the brain, are more likely to get damaged from a hit to the head and because the

grey matter regions control so many functions, damage to this area can be devastating, resulting in speech problems, motor control issues, and memory loss (Conidi).

Figure 1

The grey matter regions are near the outside of the brain, and the white matter regions are the in-between area containing myelinated neurotransmitters.



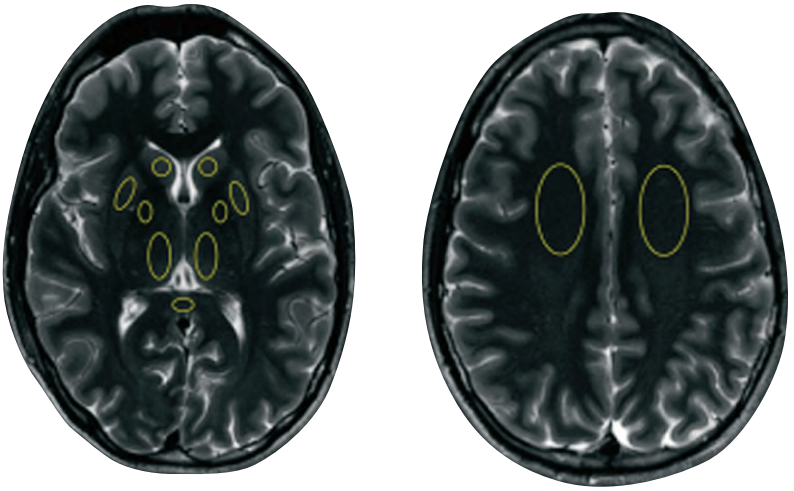
There are two types of traumatic brain injury (TBI): severe traumatic brain injury, which involves a patient who is in a vegetative, unconscious, or minimally conscious state, and mild traumatic brain injury (mTBI). Also known as a concussion, mTBI, which typically results from a hard hit to the head, is much more common than severe TBI, but because of its mildness it can often go unnoticed, which could be harmful down the road. Because mTBI can lead to the degeneration of neurons in the brain, the repercussions can get progressively more severe when left unnoticed, especially when the inner regions of the brain degenerate. Since the grey matter regions are located on the outside, they are typically affected by mTBI. Damage to the grey matter in the brain can impair motor, sensory, emotional, memory, or speech functions, and it can also cause oxidative stress injury, which results in the presence of reactive oxygen species that prevent tissue repair by impairing cell signaling and hemoglobin degradation products. (Raz E. et al.)

Multiple experimental studies, including one done by E. Raz et al, have shown that in addition to impairing functions, mTBI can cause an increase in iron accumulation in certain regions of the brain (mainly the globus pallidus and thalamus). *(Figure 2)* Using MRIs, which work by aligning the nuclei of hydrogen atoms to create a picture, scientists can detect the presence of iron because of its paramagnetic influence on proton behavior in tissue water. The nuclear magnetic relaxation rates of water protons are increased when more iron is present. The globus pallidus and thalamus are both located at the center of the brain and are grey matter regions. An increase in iron accumulation can lead to degeneration of the neurons in these two major control centers, which has been proven to have serious effects on behavioral and cognitive tasks. (Raz, E. et al.)

Because all of these noxious effects that occur after mTBI happen within the brain, mTBI is very difficult to diagnose. Most diagnoses are based on one's own self-assessment. New techniques, including an eye-tracking device, are being developed in order to diagnose mTBI. If scientists are able to locate exactly where iron accumulates after mTBI, quantify the amounts of iron that have accumulated, and figure out why iron would accumulate, they could potentially diagnose mTBI by detecting increased amounts of iron.

Figure 2

The circled areas are those where iron accumulation was found: the thalamus on the left and the globus pallidus on the right.



Review

MTBI can typically lead to deficits in information processing speed and attention and memory, as well as various neurodegenerative diseases like Chronic Traumatic Encephalopathy, a degeneration of brain tissue leading to serious memory loss. In previous studies, it was proven that there was a correlation between iron accumulation in certain regions of the brain and mTBI. Iron plays a critical role in the CNS; it aids in oxidative metabolism and it helps synthesize neurotransmitters and myelin. However, a surplus of iron can be toxic and lead to neurodegeneration. For this reason, in an unpublished study, researchers at NYU Medical Center wanted to find a better way to quantify and characterize iron in the thalamus, a central part of the brain that controls sensory perception, motor control, and consciousness. They were interested in how to quantify it and find the difference between microscopic and macroscopic magnetic field correlation (MFC) values. The microscopic MFC component is sensitive to field inhomogeneities (dissimilarities) relating to volume, which is likely to be affected by brain iron on a cellular level; the macroscopic MFC component is sensitive to field inhomogeneities on a length scale, most likely resulting from tissue interfaces and larger areas of iron accumulation.

In order to perform this experiment, 23 patients were tested along with 23 controls. The patients had all undergone closed head injury with less than 24 hours of concussive amnesia, had a Glasgow Coma Scale score of 13-15 (the scale ranges from 3-15, 3 being the most severe head injury) and had had less than 30 minutes of loss of consciousness. Imaging was then done on each of the patients and controls and MFC was calculated in the thalami. One method of MFC imaging measured field inhomogeneities that resulted from iron effects,

and then both microscopic and macroscopic MFC values were calculated.

Patients had a much higher total MFC *(p=.02)* in the thalamus than the controls did. This increase in total MFC was most likely attributed to microscopic MFC because there were no differences between the macroscopic MFC values of patients and of controls in any regions of the brain. There was only a significant increase in microscopic MFC in the thalamus, and not in other regions. Total MFC did not correlate with neuropsychological tests, but microscopic MFC had a negative correlation with performance on a verbal learning and memory test and an attention, concentration, working memory and information processing ability test. Because microscopic MFC was more statistically significant, there must be differences in intravoxel field inhomogeneity, suggesting that mTBI is more related to iron accumulation in local tissue and not in a specific area, which is to be expected on a cellular level. These results correspond with other studies performed on rodent brains showing accumulation of iron on a cellular level after brain injury.

Because MFC is a non-invasive way to quantify and characterize brain tissue iron, it could be useful in diagnosing mTBI early on. More knowledge about iron metabolism in the brain could lead to better methods of therapy.

One of the regions directly affected by traumatic brain injury (TBI), as shown in the study above, is the thalamus. Thalamic relay nuclei transmit messages between the basal ganglia and frontal cortex regions of the brain. Previously, corticobasal ganglia loops were considered one-way circuits: the message would go to the frontal cortex through the basal ganglia to the thalamic relay nuclei. To test this theory, Nikolaus R. McFarland and Suzanne N. Haber examined the connections from the thalamus to the basal ganglia by tracing thalamic relay nuclei. A test was performed on twenty adult macaque monkeys in order to trace the connections. Tracers, chemicals that allow visualization of projections of the axons, were injected into the ventral anterior (VA), ventral lateral (VL), and mediodorsal (MD) thalamic nuclei. Another set involved injecting tracers into regions of the frontal cortex that receive messages from the basal ganglia through these thalamic relay nuclei. A craniotomy, a dissection of the brain, was made over the regions of interest and incisions were made at injection sites. To track the neuronal signaling patterns, electrode penetrations were performed. Immunocytochemistry, the usage of antibodies to target specific antigens allowing for examination of cellular components, was used on these sections of the thalamus to visualize certain tracers. Lastly, the sections, which had surrounded the injection sites, were laid on eight different slides to allow visualization of the tracers. Using a microscope, McFarland and Haber were able to chart the cell and fiber distributions in the cortex and thalamus. They were then able to distinguish the anatomical borders of the different thalamic nuclei for the different areas in the prefrontal cortical areas by examining the stained images.

It was revealed that the VL projects to regions associated with motor execution and preparation of movement. The VA projects to rostral premotor areas and the prefrontal cortex. The MD projects to the dorsolateral and to the orbital prefrontal cortex. This indicates that VA-VL and MD nuclei perform by relaying basal ganglia output within a certain cortical unit and mediate information flow between cortical circuits. Contrary to the previous belief

that basal ganglia loops were one-way circuits, this experiment shows that there is a pathway back to the cortex consisting of two components: one that reinforces each ganglia circuit and one that relays information between circuits. (McFarland & Haber).

A crucial job of relay nuclei of any kind is to transmit signals. Whenever we smile, pick something up or walk, relay nuclei are sending signals allowing us to perform these actions. After suffering TBI, victims often have difficulties, possibly resulting from damage to relay nuclei, in communication and basic social functioning. One aspect of social relationships that was examined in this study is facial affect recognition, which is the ability of a person to recognize another's facial expressions and the emotions they are feeling. Previous information showed evidence of difficulties with facial affect recognition after TBI, but researchers Duncan R. Babbage et al. were the first to actually investigate how greatly this affected TBI patients.

Background information showed that children and adults with TBI, who had trouble recognizing facial expressions also, according to their parents, showed less socially appropriate behavior. For example: smiling when someone is clearly upset or crying. Previous studies also identified the prefrontal, temporal, and parietal lobes, and amygdala, as areas of the brain required for facial affect recognition. These areas tend to be commonly damaged in TBI patients, so it would make sense that patients would have trouble with facial affect recognition after a head injury.

In order to figure out the magnitude of the effect of TBI on facial affect recognition, a meta-analysis, a study of previous experiments that studied facial affect recognition difficulties after TBI, was conducted. Thirteen studies were examined that compared adults with moderate to severe TBI to control groups. There were 296 TBI patients and 296 members of the control group.

The average effect size (strength of correlation between the findings of the various studies) for the meta-analysis was -1.11 with a 95% confidence interval that the hypothesis that facial affect recognition and TBI were completely unrelated. On average, TBI patients performed worse on facial affect recognition tasks by approximately 1.1 standard deviations. From this meta-analysis, an estimation of the frequency of difficulties with facial affect recognition for TBI patients was made. It was estimated that between 13% and 39% of moderate to severe TBI patients might have serious difficulties with facial affect recognition. This study tells us that difficulties with facial affect recognition for TBI patients is clearly an issue, and should receive attention for rehabilitation for these difficulties.

Discussion

Currently, what is indisputable is that mTBI has a serious effect on the thalamus, a grey matter region located at the center of the brain. The first study showed a serious increase in MFC values in the thalamus due to iron accumulation. The evidence from this study corroborated findings in other studies like E. Raz's (mentioned in the Background section), which found increased iron accumulation in the globus pallidus and the thalamus. Iron accumulation in these areas makes sense because these areas are composed of grey matter and grey mat-

ter nuclei are composed of long fibers that begin in or pass through them, making the nuclei more susceptible to strain damage or shear in those regions. Since the globus pallidus is in the basal ganglia region, using the full circuits found in the second study, it could be a possibility that iron deposition in these regions could be interfering with the transmission of signals by the thalamic relay nuclei. This interference could be preventing signals from being passed, thus impairing the motor functions performed by the thalamus and basal ganglia. In the NYU Medical Center study, there were high MFC values not only for the specific thalamus, but also for the surrounding region suggesting iron accumulation throughout the surrounding tissue. This would mean that the iron accumulation is widespread and not concentrated and could interfere with even more relay nuclei circuits.

In conjunction with this theory, although the regions aren't the same, an increase in iron accumulation in the central grey matter tissue of the brain could also result in the facial affect recognition difficulties present in Babbage's study. Although the NYU Medical Center study didn't identify any MFC values for the frontal cortex, the thalamic relay nuclei delineated by McFarland and Haber are sending signals directly into the cortical regions. The parts of the brain located in the frontal cortex are the ones that directly control social relationships and emotions and play a major role in facial affect recognition. We know that if these regions are damaged or hit, the victim will have difficulty with facial affect recognition, but this could result because of damage to the thalamic relay nuclei, preventing certain circuits to the cortical regions from being completed. However, because there were no MFC values found for these cortical regions (meaning no iron accumulation in these regions), it is difficult to say whether iron accumulation has an effect on facial affect recognition. Perhaps the iron could have interfered with the thalamic relay nuclei earlier on when the signal was in the basal ganglia region, preventing a full signal from reaching the cortical regions.

Although it is unknown why iron accumulation would occur and why it would occur in these specific regions, we could only conclude that a high concentration of iron can be detrimental. Whether its harmful effect comes from an interference with thalamic relay nuclei circuits or not requires further experimentation but it is a possibility that the iron is precluding some signals from getting transmitted. Perhaps, in the future, scientific researchers could perform an experiment that would entail having mTBI patients whose brain scans showed iron accumulation in the cortical regions take a series of facial affect recognition tests in order to examine the relationship between iron accumulation, thalamic relay nuclei in the cortical regions and basal ganglia, and difficulties with facial affect recognition. If this connection is proven correct, it would help doctors and therapists better serve mTBI patients by working to improve the patients' impaired communication skills and social interactions that are crucial to our everyday lives.

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Music as Medicine: Music Therapy and Autism Spectrum Disorder

by Haley Gillia

What is Music Therapy?

Much more than a well-meaning pianist banging out Broadway standards in a nursing home, music therapy is a rapidly evolving health profession whose credentialed practitioners are trained in music performance, psychology, group interaction, and a wide variety of "physical, emotional, cognitive, and social needs of individuals of all ages," as defined by the American Music Therapy Association. (www.musictherapy.org) According to the Nordoff-Robbins Center for Music Therapy, "interventions can be designed to promote wellness, manage stress, alleviate pain, express feelings, enhance memory, improve communication, promote physical rehabilitation," as well as address the needs of children and adults with various neurological disorders and illnesses — including autism, Parkinson's disease, and Alzheimer's disease, among others (http://steinhardt.nyu.edu/music/nordoff).

Treatment methods include carefully designed and administered programs for creating, singing, moving to, and/or listening to music. "There are so many techniques," according to Holly Mentzer, a practicing music therapist I interviewed as part of my research. "This is why we have degree programs to educate music therapists, and they [the programs] are all different depending on the population." She described a number of techniques — including song writing, song choice/lyric discussion, vocal toning (which can involve mirroring and matching musical pitches between the patient and music therapist) — that can be used with adults or adolescents, individuals or groups, with a variety of needs ranging from trauma, depression/anxiety, eating disorders, substance abuse, HIV/AIDS, cancer, and palliative care, to name a few.

My particular area of focus has been on the use of music therapy in the treatment of autism spectrum disorder in children. I began my work by studying the impact of playing music on musicians themselves, and more specifically, on brain plasticity and the process of learning and playing music. As a classical musician myself, this starting point was particularly relevant and interesting to me. Over time, however, my studies evolved and my focus shifted to music therapy, how playing music in a clinical setting can be employed to help people with various disorders. Eventually, my focus narrowed to the use of music therapy to treat autism spectrum disorder in children. More specifically, my work included a review of the available literature on music therapy and autism; several visits to volunteer at the New York University Nordoff Robbins Center for Music therapy, where I had the opportunity to video tape a number of music therapy sessions; and a one-on-one interview with Holly Mentzer, a

practicing music therapist at Memorial Sloan-Kettering Cancer Center. In this paper, I review the specific characteristics of autism spectrum disorder (ASD) and the evolving methods of treating ASD with music therapy.

What is Autism Spectrum Disorder?

According to the National Institute of Mental Health, "[a]utism is a group of developmental brain disorders, collectively called autism spectrum disorder (ASD). The term "spectrum" refers to the wide range of symptoms, skills, and levels of impairment, or disability, that children with ASD can have. Some children are mildly impaired by their symptoms, but others are severely disabled."

ASD affects roughly 1 in 88 children in the U.S. currently, but it has seen a tenfold increase in prevalence in the last 40 years, and is currently growing at a rate of 10%-17% annually. (Biao, 2012) According to a study by Mike Brownell, summarized in a *Journal of Music Therapy* article based upon his Master's thesis, however, it is not clear to what extent (if any) the increase in prevalence is a result of higher/more sensitive awareness of ASD by health professionals. (Brownell, 2002)

Individuals with autism tend to have difficulty communicating with others, often involving a delay in language development or a complete lack of language skills entirely, difficulty starting or maintaining conversations, "and/or a lack of developmentally appropriate make-believe or imitative play skills. Behaviors, interests, and activities may also be limited or repetitive." (Brownell, p.114) At the same time, children with ASD also find it difficult to communicate without using words; eye contact and physical gestures are particularly challenging. They can be distracted by and become fixated on objects or subjects of discussion, and any changes to their established routines can be extremely upsetting for them. Establishing and maintaining relationships with others can be particularly difficult for children with ASD, as they tend to have a great deal of trouble with "emotional reciprocity." They don't readily understand what other people may be thinking or feeling; they fail to recognize and respond to common verbal or visual signals (a smile of greeting, an outstretched hand for shaking) that accompany social interaction. (Brownell 2002)

Treating ASD with Music Therapy

Music therapy can help to improve communication, interaction and engagement in autistic children, since music has "a complex range of expressive qualities, dynamic form and dialogue" (Wigram and Christian Gold, 2006) and can effectively function as an alternative form of communication. Wigram and Gold (2006) note the importance of "mother-infant babble and preverbal engagement" in developing human communication skills. Much of this relies on shared, or joint, attention, which is essentially when two people are both paying attention (or "sharing" attention) to something together, or jointly. Often it involves one observer noting and then following the gaze (or pointed finger) of the other. This basic ability is thought to be the critical foundation for more complex communication and interaction between people (Wigram and Gold, 2006). Children with autism tend to have difficulty with joint attention, and it can be measured accurately in autistic children as young as six months old. (Wigram and Gold, 2006) Music therapy, usually in the form of improvisational music making, is used to improve joint attention in autistic children. (Wigram and Gold, 2006)

Juliet Alvin, Paul Nordoff and Clive Robbins — pioneers in the development of music therapy — described the process of music therapy as the music therapist "meeting the child" in music, "where musical attunement is achieved and the child's expressive or non-expressive production can be matched and reflected in the therapist's music". Essentially, the music therapist improvises music that reflects something that the child is doing — translating actions into music rather than words. To help understand this in an admittedly non-scientific way, one might think of the way that pianists in old movie theaters used to improvise an appropriate musical accompaniment to the actions occurring in silent movies. When autistic children realize that the therapist's music is mirroring something they are doing, they tend to respond positively, and, according to Wigram and Gold (2006), these basic wordless interactions, with the therapist mirroring the child's reactions with changes in pitch, rhythm and dynamics (louds and softs) can be compared to the way a mother interacts and responds to her infant child.

At the same time, autistic children often require a solid structure to communicate and respond effectively. Music helps here as well, since it is both highly structured but also varied and flexible enough to break down the rigidity that often characterizes the musical behavior of autistic children, at least initially. Techniques employed here include "dialoguing" (where therapist and child communicate with each other through their musical activities), and "frame-working" (in which the therapist creates a reliable, "safe" musical structure for the autistic child to play in freely). In short, carefully designed musical improvisation utilizing these techniques helps to improve engagement and interaction with others (including the ability to take turns), and joint attention. (Wigram and Gold, 2006) I observed this process first hand at the Nordoff Robbins Center for Music Therapy, when I videotaped several music therapy sessions behind a one-way mirror in a room adjacent to the session. These were intense interactions (for the music therapist at least), involving close observation of the child by the therapist and immediate responses by the therapist to the changing behavior of the child.

An Effective Tool for Diagnostic and Clinical Assessment

According to Wigram and Gold (2006), the standard assessment tests used in cognitive psychology to measure intelligence are extremely rigid and as a result cannot really measure a child's creativity, and this limitation is particularly pronounced in children with ASD, where creative development is especially limited.

Music making, as it is practiced in a course of music therapy, on the other hand, promotes creativity, can be much more effective in assessing children with ASD — particularly when it comes to social engagement and non-verbal communication. Examining a child's musical behavior in detail — aspects of tempo, dynamics, phrasing, rhythm and repetition, ability to lead and/or follow, non-functional use of instruments (children with ASD often don't typically play instruments in a traditional way, but may become fascinated with aspects of the instrument that don't actually involve making music, such as becoming fixated with the peg of a guitar or the parts of a flute) — can provide a great deal of useful quantitative and qualitative information that can be used to assess strengths and weaknesses of a child with ASD, obtain important information about a child's personality and the specific nature of their particular ASD (or even if the child has ASD at all), and then develop effective therapeutic approaches. This is one of the reasons that music therapy sessions are videotaped — to measure changes in behavior over the course of treatment and often modify approaches as a result. The assessment process is sophisticated, rigorous, and extremely detail oriented, and can be used to track changes in a child over time. I videotaped several music therapy sessions at the Nordoff Robins Center for Music Therapy, and I was able to observe both the complex nature of the music therapy sessions themselves, and also the large number of quantitative assessment tools — which measure frequency and duration of musical events, specific responses to music, such as changes in tempo, rhythm, style and intensity, and many others –that are used afterward with the videotapes to assess progress. Two of the tools used with children with ASD are the autonomy profile and the variability profile. The autonomy profile measures the degree to which the child is able to lead and or follow the musical therapist in a musical context (children with ASD typically have difficulty following). The variability profile measures the extent to which children are able to vary the music that they make (children with ASD tend to be more rigid in their musical play).

Evolving Therapeutic Approaches

As mentioned above, children with autism often experience delays in language acquisition, and some 30%-50% of individuals with autism lack language completely. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010) For those who do develop language, it's often severely restricted and basic. The prevailing wisdom has been that a child without language at age five or six would be unlikely to ever develop it, but there is new evidence emerging that language acquisition after this time may indeed be possible. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

Why do autistic children face such challenges with verbal communication? Some scientists believe it is related to the theory of mind, or a "lack of understanding of the mind." (Wan, Demaine, Zipse, Norton, and Schlaug, p.161) In other words, autistic children are not able to understand that other people — what they're thinking, what they want, what they believe in, why they do what they do — are separate from themselves and their own thinking. This is closely related to the joint attention deficits that I mentioned above, and in fact, studies have discovered a correlation between joint attention and language acquisition in autistic children. This ability — that is, joint attention — usually begins to develop in most children by about one year old, and it leads to the development of critical social interaction skills. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

In addition to joint attention deficits, "the communication deficits in autism may be related to imitation difficulties." (Wan, Demaine, Zipse, Norton, and Schlaug, 2010) Imitation is exactly as it sounds — that is, the ability to copy another person's actions accurately, and this ability has also been linked to the ability to speak. Individuals with autism are commonly found to have imitation deficits.

In the past decade, scientists have gradually come to suspect that these two deficits (imitation and theory of mind) are so common to autism that it may be the result of a dysfunction with one shared neural mechanism — the mirror neuron system. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

The Mirror Neuron System

The mirror neuron system (MNS) has been discovered at various locations in the human brain, including one particular one area, called the Broca's area, that has been linked to language: Wan and coworkers state that "[m]irror neurons are involved not only in the perception and comprehension of motor actions in humans, but also in higher-order cognitive processes such as imitation and language, which are often impaired in individuals with autism." (Wan, Demaine, Zipse, Norton, and Schlaug, p. 162)

The scientific evidence has been mounting that there is a link between autism and abnormalities in the mirror neuron system. Even before this was discovered, scientists believed that understanding speech required in the listener a certain understanding of human physical gestures (mouth, eyes, hands, etc.) in addition to just the spoken sounds:

The discovery of mirror neurons provided support for the involvement of the motor system in auditory speech perception. The shared representations of observed and executed actions in these neurons may serve as a foundation for our capacity to understand the experiences of other people, which is crucial to effective communication and social interaction. Accordingly, it has been hypothesized that an intact mirror neuron system might underlie normal language functions in humans, and that language comprehension may be achieved through action understanding and mental simulations of sensory-motor structures. ((Wan, Demaine, Zipse, Norton, and Schlaug, p. 162)

Being able to speak and being able to understand someone else speaking, is about more than just the words spoken — it is part visual, part auditory, and it requires a mutual

understanding between speaker and listener. The Mirror neuron seems to help in this process. Much of this has been discovered from neuroimaging studies that showed that when individuals (without autism) read sentences that refer, for example, to actions with the hand or the leg, the areas of the brain that are normally involved in those actions become activated. The same thing occurs when it comes to listening to speech; the Broca's area (associated with speaking) becomes activated. This link may be especially critical when individuals are first learning a language. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

A similar auditory-motor mapping brain activity, but even more pronounced, is observed in musicians: "Listening to music, reading musical notation, watching musical performances of pieces that one knows how to play, and actually playing that music, all appear to engage a network of brain regions related to the putative human mirror neuron system." (Wan, Demaine, Zipse, Norton, and Schlaug, p. 163)

Various imaging studies, using techniques such magnetoencephalography (MEG) and electromyograms (EMG), of autistic individuals have revealed less activation in the Broca's area and other areas associated with the MNS, and the more severe the autism and language deficit, the less activation there was. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010) It was also discovered that those with autism had reduced cortical thickness (decreased gray matter) in the MNS parts of the brain. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

Music Therapy to Activate and Strengthen the Broken Mirror Neuron System

According to a 2010 study in the Brain Research Bulletin, "given the important role that the MNS might play in the understanding of actions and processing of language, and the MNS abnormalities and communication deficits associated with autism, a treatment approach designed to engage the putative human MNS may have significant clinical potential." (Wan, Demaine, Zipse, Norton, and Schlaug, p. 163)

This is encouraging news. While certain aspects of autism — engagement and flexible, reciprocal interaction — have proven to be treatable through music therapy (and other treatments), as we discussed above, until now, there has been no effective method of dealing with the language problems experienced by individuals with autism. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

Studies have shown that the MNS can be changed through training; a recent study "found that a relatively short period of incongruent sensorimotor training (performing index-finger movements while observing little-finger movements, rather than performing movements with the same finger observed) was sufficient to alter the expected pattern of mirror neuron responses during observation of the trained actions." (Wan, Demaine, Zipse, Norton, and Schlaug, p.163) In other words, the plasticity of the brain that many scientists are currently exploring (that is, the ability of the brain to create new neural pathways and change itself) appears to exist within the MNS. This is significant.

And, particularly promising, music therapy can activate the MNS: "Music is a unique,

multi-modal stimulus that involves the processing of simultaneous visual, auditory, somatosensory, and motoric information; in music making, this information is used to execute and control motor actions." (Wan, Demaine, Zipse, Norton, and Schlaug, p.`163) Scientists now suspect that since making music involves imitation and synchronization, it may well involve the MNS. In fact, neuroimaging research has shown similar responses to music and language, specifically the Broca's area, during a variety of music listening and music making activities. So, targeted music therapy — in particular, singing, imitation and motor activity — that emphasizes the auditory and motor systems may be helpful in treating autism, particularly when it comes to language development. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010)

Moreover, children with autism enjoy making music and often show above-average music skills (pitch memory and discrimination), *and* listening to music can inspire strong emotions (autistic individuals tend to have trouble processing emotions). (Wan, Demaine, Zipse, Norton, and Schlaug, 2010) Also, many children with autism who cannot speak at al, are able to sing sometimes complex songs. So, in addition to the potential language development benefits, the simple love of music shared by autistic individuals can help with engagement and social interaction and forms of nonverbal communication, and there is evidence emerging that these improvements can persist beyond the music therapy sessions and in non-musical contexts. (Wan, Demaine, Zipse, Norton, and Schlaug, 2010).

Is Music Therapy Beneficial for Individuals with Autism?

Establishing the efficacy of music therapy in treating ASD is problematic, simply because the disorder (though increasingly prevalent) is relatively rare, and so large scale studies are difficult to mount. (Wigram and Gold, 2006) At the same time, the individual cases — and their specific treatments — are often quite different, so finding a large enough and homogenous sample to conduct viable outcomes research is challenging to say the least. (Wigram and Gold, 2006) That said, given the handful of (admittedly not perfect) studies of music therapy intervention, and the many clinical reports, music therapy does seem to be beneficial for those with autism. Structured, flexible improvisational "attracts the attention and provokes engagement in children with ASD, and promotes the development of reciprocal, interactive communication and play." (Wigram and Gold, p.542) Moreover, as discussed, recent and ongoing advances in neuroscience hold the promise of more effective treatments for autism — particularly with regard to language — in years to come.

Music Therapy: Much More than Feel-Good Soft Science

In general, my topic connects to a lot of what I do outside the Science Research Program. I am a classical musician, and I work with other musicians every day. I assist with teaching and even have one young student of my own. I actually attended a specialized music school in elementary and middle school, so growing up around musicians was just natural for me. I did not, however, have much of an understanding of music therapy. Like a lot of people I've

spoken with in the past few years, I saw music therapy as a soft science, or not even as a science at all, and imagined people singing random folk songs with an autoharp and banging on tambourines to feel good and maybe relieve stress. Music therapy is clearly much, much more than that. Visiting the Nordoff Robbins Center for Music Therapy, speaking with a practicing music therapist, and reading about the development and future of musical therapy has changed my opinion completely. Music therapy is an incredibly interesting, challenging and valuable discipline. In short, music therapy is a demanding discipline that truly helps people with a wide variety of sometimes quite serious disorders and medical issues; when it comes to autism spectrum disorder, my area of special focus, current techniques are having a measurable impact and recent scientific advances — particularly, the growing use of new neural imaging techniques and creation of new, more rigorous therapies for the treatment of ASD — hold significant promise for the future.

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Bacteriophage Therapy

To the Editor:

In order to combat some of the most modern challenges to human health, it is increasingly necessary to turn back to the old ways, searching nature for a response to our maladies. I would suggest that one example of such a current threat is that of antibiotic resistant bacteria, and that the solution may be bacteriophage therapy.

If patients take only enough medicine to feel better, rather than to be cured, and as diverse bacteria become increasingly resilient and evolve to attack us in increasingly diverse ways, our current treatments for them become less and less effective. Furthermore, even when antibiotics do work, these medications are not working in a productive way. Think of it like using an atomic bomb on a small village. The atomic bomb cannot specifically target the problem; instead it annihilates everything in the area. Antibiotics do the same sort of thing in your body. They do not know exactly what to target so they wipe out both good and bad bacteria. This is the cause for many of the side effects listed under "warning". For these reasons, the future of infectious disease treatment may just lie in bacteriophage therapy.

The name bacteriophage, also referred to simply as phages, comes from the word bacteria and the Greek word Phagein, which means, "to devour". They are simply viruses that infect bacteria. After attaching to the bacteria the phage injects its genetic material into the cell. After it has reproduced everything it needs, it destroys the cell and releases a new phage that then goes out to repeat the process There are thousands of types of phages but each one only infects a specific type of bacteria, or at most, a few different types. Thus, bacteriophages are no atom bomb – they are more of a surgical strike.

What is so amazing about phages is how easily they can be found and how that has contributed to their value in medicine. Phages can be found almost anywhere their bacterial hosts can be found, and the best places to look for them may be the most counterintuitive.

The idea of looking to nature for answers to our illnesses and diseases, although not a new concept, is one that in many ways has been forgotten, overshadowed by the looming pharmaceutical business. However, in a quiet courtyard outside of the town of Tbilisi scientists are doing just that. The Eliava Institute, a large building built by the Soviets during their occupation of Georgia, is dedicated to the pursuit of scientific discoveries. It is on the second floor, in a hall filled with the smell of dead bacteria that Nina Chanishvili and her team continue to work on the bacteriophage therapy breakthroughs made by their predecessors years ago. Because of the high concentration of bacteria, one of the major places they are looking is in sewer water. By looking in places that harbor dangerous bacteria that cause illnesses such as streptococcus and Escherichia coli, scientists can find the phage that fights it, isolate

it from its surroundings, and turn it into a product that can to be given patients suffering from these bacteria instead of the usual antibiotic approach.

This demonstrates just how incredible nature is. Nature has supplied a cure to these bacteria in the same place the bacteria itself is found. Along with sewer water, soil and animal intestines are place examined for phage presence.

So how can phages supply an answer to this? As said above, phages are very specific in their targets. One strain of phage can only reproduce in (and hence, destroy) a specific type of bacteria.

Although there are pros and cons to this type of treatment, most of the cons arise from how recent these discoveries are. Bacteriophages are extremely specific in what they target. While this makes them very efficient and limits the amount of damage done to only the harmful bacteria it also means one strain of phage is so specific it won't even work on all strains of the same type of bacteria. Meaning two people with strep might need two totally different phages. To overcome this problem, rather than having to identify the specific strain of strep each patient has (which is not cost or time efficient at the moment), the doctors give the patient a "phage cocktail" composed of many different phages all meant to attack different strep bacteria. Another aspect of phages that must be kept in mind is that they only attack bacteria, meaning that they do not do anything against viruses, the flu, or anything else that isn't caused by bacteria.

Phages hold a lot of potential in what they have to offer the medical world. They are a safe, cheap way to attack harmful bacteria within the body. They have already replaced many antibiotics in the veterinary world. So why don't we see more of them? Although we have already discussed many of their shortcomings they are still extremely effective and cheap. The reason they aren't more popular, in my opinion, lies in the politics behind the pharmaceutical companies. Phages hold so much potential that major antibiotic companies fear the effects phage production will have on their businesses and sale of their products. Although this is a completely justifiable fear it should not impede research. Politics aside, phages need to continue to be looked at until humans better understand just what they have to offer.

Sincerely,
Jaya Sahihi

We look with favor on all
forms of learning, but with particular grace
we encourage philosophical studies,
especially those which by actual experiments
attempt either to shape out a new philosophy
or to perfect the old."

KING CHARLES

from the 1661
Charter for the formation
of the Royal Academy of Science;
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are the oldest journal in existence

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