Issue 2

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The Hen Hud Hub Science Research Newsletter

Hendrick Hudson High School
2166 Albany Post Road,
Montrose, NY 10548.

Special points of interest:

- Cognitive Psychology
- Neuroscience
- Computer Science
- Educational Research
- Biology and Medicine
- Genetics

Inside this issue:

Exciting Projects for the Science Research Program, by Dr. Christine Rogers

We are finishing the year on very successful notes, as all of our Sophomores are in contact with scientists and will work on their research over the summer. They have defined topics of interest and acquired background knowledge to design research proposals and implement them.
Some of these projects are well underway.
Ben Toll has already written a grant proposal to fund his research with the guidance of his mentor Dr. Higgins at the University of Michigan, where he will be working this summer on designing an in vitro model for the study of Inflammatory Bowel Syndrome, to test treatments and understand pathologies.
Tiffany Porras will be studying breast cancer at the New Jersey Cancer Center under the mentorship of Dr. Wood. One of the projects of interest is to use stem cells to study the molecular mechanisms of breast cancer.
Shivanee Shah, Naimah Hakim and Kayla Plunkett are interested in various aspects of sensory perception.
In collaboration with Dr. Curtis at Oklahoma State and Dr. Keller at Columbia Universities, Shivanee is designing a proposal to evaluate changes of taste perception with hormonal changes in women, which will have tremendous applications for obesity research.
Naimah, a Junior, will pursue synesthesia research, a condition where senses are mixed and confused, with Dr. Marks at Yale School of Public Health.
Kayla will study perception and language acquisition of non-native speakers.
Cassandra Rogers, working at Albert Einstein medical college, will study how the environment generates psychiatric disorders through epigenetic mechanisms with Dr. Lachman.
Alex Alves will evaluate invasive species in the Atlantic ocean to predict the ecological impact of non native species with Dr. Gardner.
Juniors, Shannon Kenny and Zack Struver are pursuing their research and collecting data in the school setting, respectively on the use of technology in the classroom and the implementation of music therapy to reduce test anxiety in schools.
Daniel Briggi will continue studying elbow injuries occurring during pitching in the group of Dr. Ahmad at Columbia University,
Our very talented Seniors have presented their research this year in various local and national competitions.
David Eisenberg competed with a very interesting paper, on corporate communications and its implementation.
Allison Gofman's exceptional paper and research reached the Semi-Finals of the INTEL Science Talent Search competition, the most prestigious scientific competition for students worldwide. Congratulations .
Excerpts of everyone's research are included in this newsletter.

Growth Hormone's Ability to Induce and Sustain Cancer, by Tiffany Porras.

Hormones are secreted by the endocrine glands and are known for their ability to send messages to other parts in a person's body instructing them what it exactly has to do. Growth hormone (GH) has been known to play a certain role that would be beneficial for the human body. Not only does GH transmit messages, but it is significant in the function of a body's metabolism. Growth hormone has the ability to support how the body uses energy. This hormone, along with helping a body's energy use, can repair broken or damaged tissue and can aid a muscle and bones' growth patterns (Campbell & Reece, 2005). Besides assisting the body's functioning skills, GH has the ability to signal the release of insulin like growth factor I (IGF-I) (Campbell & Reece 2005). This growth factor helps the support, growth and development of the body (Campbell & Reece 2005). Certain animal studies have also showed similarities between signaling patterns between rats and humans, with some alterations, suggesting that IGF-I might have the ability to extend how long a human will live (Janssen & Lamberts, 2004). Janssen and Lamberts showed that by disrupting the IGF-I signaling pathways, the lifespan of several animal models was extended. High IGF-I activity also may have the capability to increase the risk of someone to develop cancer (Janssen & Lamberts, 2004).

Sophomores Projects

Mentor: Dr. Teresa Wood, Professor, New Jersey Medical School and Cancer Center.

Growth Hormone's Ability to Induce and Sustain Cancer (Cont.)

Cancer is the result of a hazardous growth of tumor masses that is caused by uncontrollable cell division. Cell division can cause two types of tumors, ones that are benign, and ones that are malignant. Benign tumors are cell masses that aren't cancerous and dangerous to ones health. But malignant tumors are hazardous and the cells from these tumors can break away and spread to other parts of the body (National Cancer Institute [NCS], 2010). Cancer has the ability to spread to other areas in the human body and invade those regions; this process is known as metastasis. As research furthers on a possible connection between GH and cancer, there is still more evidence to be found (Jenkins & Mukherjee, 2005).

Growth hormone (GH) is known to be produced by the pituitary gland, which is located at the base of the hypothalamus in the brain. GH increases protein synthesis in the body and anabolism. It has the ability to enhance the cellular process to build useful proteins and it can also increase muscle growth. Not only does GH acts on proteins, but these hormones are capable of inciting and intensifying the breakdown of fats and fatty acids (Radecki & Kim, 2010). GH plays important role to the body of any human being, and thus its levels are regulated in the blood to maintain homeostasis. The environment has an effect on the body's ability to produce growth hormone. When a person has a certain diet, exercises a particular way, has a specific amount of emotional stress, and gets a certain amount of sleep, the amount of GH in their bloodstream is dependent on these factors (Campbell & Reece, 2005). GH can also control and regulate other factors in the blood. Since GH is a very efficient hormone, it has the capability of regulating blood glucose levels, an essential component of homeostasis (Campbell & Reece). GH can also increases glucose blood levels by acting directly on the production of glucose by the liver. It does this by restraining insulin's abilities, but also stimulates the consumption of glucose in tissues (Campbell & Reece, 2005). Not only does it help glucose production, but it can suppress the secretion of insulin as well.

GH can stimulate the secretion of IGF-I. Insulin-like growth factor (IGF-I) has the ability to aid the body in its growth and development. IGF-I's capability of having an effect on the body has more influence in the muscles and bones region. When GH stimulates the liver to release IGF-I, this growth factor will then stimulate cells in the cartilage, causing the bones of the body to grow (Campbell & Reece, 2005). IGF-I also can trigger the protein synthesis in muscles which can result in an increase in muscle growth (Campbell & Reece, 2005). Although IGF-I may have effect on body growth, the body's status will regulated IGF-I too. It has been demonstrated that a body's nutritional intake has the power to modify IGF- I levels (Cohen & Clemmons, 2000). Along with GH, IGF-I is also shown to have an effect on cancer (Janssen & Lamberts, 2004). GH and IGF-I have a direct relationship, implicating that when there are high levels of growth hormone, there will be high levels of IGF-I. This could mean that if IGF-I has an effect on cancer, then so must GH.

There have been studies, but several years ago, that tries to show a correlation between GH and cancer (Holly & Perks, 2006). What is growth hormone's effect on tumor growth, tumor weight, and the tumors metastasis? One study tried to demonstrate how GH can reduce the metastasis of a tumor (Torosian & Donoway, 1990). The research experiment verified that while providing GH as a supplement, along with a standard protein diet in the rats, there was no new tumor growth, but still there was a small number of pulmonary metastasis in some subjects (Torosian & Donoway, 1990). This experiment not only showed how GH can stimulate some cancer factors, but also how nutrition, along with GH, could induce cancer. Interesting about GH is the type of cancer that it is normally associated with. Animal models show that mice which are transgenic for IGF-I in the prostate will develop prostate tumors (DiGiovanni & Kiguchi, 2000). Also, a commentary done on growth hormone and cancer states that the GH/ IGF-I axis can play a significant part in cancer, especially breast, colorectal, and prostate (Pollak & Schernhammer, 2004). These three cancers are the ones that are mostly associated with GH. This may be because GH and IGF-I bodily processes influence certain patterns in cancer occurrences that can affect all three areas in the body (Pollak & Schernhammer, 2004). These studies are the ones that identify the connection between GH and cancer. But along with these experimental studies, there have been also reviews stating that GH's ability to stimulate cancer is becoming less credible, with fewer correlations between the two in later studies (Jenkins & Mukherjee, 2005).

Some studies have shown a connection on how IGF-I may play a role in cancer development. In Cohen's review, it is mentioned that a person's cancer risk is increased with people who have high levels of IGF-I. Studies have also shown that people who had or developed prostate or breast cancer had increases in IGF-I's blood levels. Although IGF-I may enhance a person's chances of developing

Growth Hormone's Ability to Induce and Sustain Cancer (Cont.)

cancer, it can additionally play a part in the spreading of a tumor cell and more (Cohen & Clemmons, 2000). IGF-I might have effects on the significant stages of cancer's development and its outcome. It has an effect on the cancer cells rapid increase in number and their apoptosis (Laban & Bustin, 2002). Apoptosis is the death of a cell that has already been programmed so there can be development and renewal of tissues (Laban & Bustin, 2002). IGF-I can also trigger cancer's angiogenesis, which is the formation of cancerous blood vessels, and cause cancers resistance to chemotherapeutic agents (Bustin & Jenkins, 2001). IGF-I may aid in tumor growth in the human body (Butler & Blakesley, 1998). It is strongly suggested, therefore, that IGF-I can provoke and sustain the development of cancer.

There has been lots of contradiction as to whether growth hormone itself plays a role in cancer or whether it has no effect on the malignant disease. A study was recorded comparing GH's effect on either cancer or cardiovascular disease in women, and it was shown that more females had a fatal result with cancer than with heart disease with the use of GH/ IGF-I (Hu & Willett, 2004). Another study has stated that with this now available data, the proposition that either GH or insulin-like growth factor (I) can stimulate the growth of neoplastic tissue is supported (Jenkins & Mukherjee, 2005). A contradicting study, based on colorectal cancer, shows that GH does not stimulate the creation of cancer cells in any way (Portera & Shinohara, 2000). With different studies, looking at different types of cancer, and contradicting results, it is difficult to predict which view (GH does induce cancer or GH has nothing to do with carcinogenesis) is more reliable.

GH has not been the only factor in the body that may have a link to cancer, but IGF-I has been strongly suggested to take part in the cancer development process. Not all studies completely show that IGF-I has a direct link to this disease, but it is highly likely that it does have some influence over the illness (Pollak, 2000).

Not only do these endocrine factors alone play a role in the creation and perpetuation of cancer cells, but there is an indication that the aspect of nutrition is significant too (Holly and Perks, 2008). Nutrition is seen as a very important external factor in the outside environment that is known to influence carcinogenesis, along with the internal environment, which includes GH and IGF-I (Holly & Perks 2006).

Cancer itself is a very dangerous and threatening disease. Knowing that a person has cancer is difficult to deal with, but discovering that one's own body may have had something to do with this sickness is even more challenging to bear. Growth hormone has usually been recognized as a hormone in the body to help a person grow and develop to be a mature adult. Now there is more evidence suggesting that GH may contribute to the progression of this life-threatening illness. Yet this evidence is still controversial, (Jenkins & Mukherjee, 2005). Cancer and growth hormone have always been seen as two different opposite aspects of life and of the body, but now it is being seen as two factor who now share a connection and have something in common with each other.

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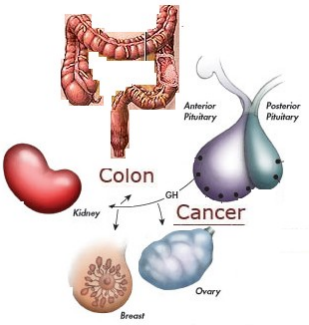

Sophomores Projects

The Role of the Environment on Cancer, Behavior, and Autoimmunity through Epigenetics, by Cassandra Rogers

Mentor: Dr. Herbert Lachman, Albert Einstein College of Medicine

Genetic diseases have been a part of life for ages. Even before the mechanics of genetics and heredity were linked to DNA, it was no secret that some children were born with certain abnormalities, and others seemed to be quite similar to their parents. Now that we know the secrets of the human genome, another more abstruse genome has been discovered and studied. The epigenome is responsible for the effects of environment on DNA. Despite the common root between genetics and epigenetics, the two affect phenotype in two separate fashions. In Latin, the prefix "Epi" connotes extra, outer, and outside. Subsequently, epigenetics affects DNA expression without changing the DNA sequence itself, and it can be heritable (Crews, 2008). It is responsible for the silencing of certain genes, and the amplification of others. This occurs as a result of markers attaching to the DNA. These markers, either methyl groups (-CH_3-) or acetyl groups (-$COCH_3$) attach to DNA and/or histones (DNA coils around groups of four histones), changing DNA expression (van Holde, 1988; Berger, 2002; Shiio and Eisenman, 2003). DNA methylation can occur where a cytosine is immediately followed by a guanine, known as CpG sites (Nakao, 2001). With the enzyme DNA methyltransferase, a methyl group attaches to the cytosine, changing it to 5-methylcytosine (Havliš and Trbušek, 2002). Methylation can also occur on proteins, namely histones. Usually, methylation will occur on lysine or arginine residues, and, when affecting histones, will inhibit or stimulate gene expression (Roloff and Nuber, 2005). Acetylation occurs in proteins, and is either co-translational (occurring during protein synthesis) or post-translational (alteration of a protein after its translation) (Polevoda and Sherman, 2000). Acetylation is primarily studied on histones, because there are more epigenetic implications here than anywhere else. The process is catalyzed by histone acetyltransferases (HAC) or histone deacetylase (HDAC) (Sun et al. 2003).

It was found over twenty years ago that methylation patterns in cancer patients are significantly different than methylation patterns in normal patients (Feinberg and Vogelstein, 1983). In cancer cells, repetitive DNA sequences and CpG sequences in tumor-suppressor gene promoters are hypermethylated. Hypermethylation of these CpG promoters can lead to the silencing of genes and deacetylation of histones, thus promoting tumor formation (Esteller, 2005; Feinberg and Tycko, 2004). In addition, DNA methyltransferases are over-expressed in both tumorous and hematological cancer cells (Ballestar and Esteller, 2005). Similarly, histone acetyltransferases tend to be moved, over-expressed, mutated, or amplified in cancer cells (Zhang and Dent, 2005). These epigenetic abnormalities in cancer cells may in fact occur early in tumorigenesis, affecting alleged "cancer stem cells" (Baylin and Ohm, 2006; Feinberg et al., 2006). These observations could, in the future, lead to the targeting of cancer cells before they become intrusive. The idea behind treatment is to reactivate tumor-suppressing genes that have been epigenetically silenced (Lohrum et al., 2007). Histone deacetylase inhibitors (HDAC inhibitors) are currently being used in clinical trials to stop growth in tumorigenic cells, while normal cells are not affected much (Altucci et al., 2005). While these HDAC inhibitors show many positive results in terms of their outcomes, they also have a wide variety of effects on many HDACs. If HDAC inhibitors that address individual HDACs are used, the treatment may have a more specifically oriented effect (Minucci and Pelicci, 2006). It is common in recurring cancer patients that a resistance to normal chemotherapy is developed by the second occurrence of cancer (Lohrum et al., 2007). This may be the result of epigenetic changes occurring after the first appearance of cancer, as a result of the first round of chemotherapy (Glasspool et al., 2006; Perez-Plascencia and Dueanas-Gonzalez, 2006). As epigenetic treatment becomes more sophisticated and precise, the field of cancer research may see major breakthroughs in success of treatments.

While epigenetic research shows a great deal of potential in the treatment of cancer, it is quite significant in regards to behavior as well. It may be because of epigenetics that differences in care as pups results in different stress responses as adult rats. In fact, based on amount of licking/grooming-arched back nursing (LG-ABN) pups received, scientists have determined that pups cared for with high LG-ABN by their mothers have a more positive response to stress later in life (Caldji et al., 1998). This has led to the deduction that epigenetic factors program adult response to stress (Weaver et al., 2004b). Previous to such research, it was thought that methylation patterns in young animals are plastic, while patterns in adults are static. Rather, it is now known that the mechanisms for methylation and demethylation are present in adults as well as children (Weaver et al., 2005). An experiment done on rats suggests that by injecting an HDAC inhibitor into high LG-ABN rats can change their stress response for the worse (Weaver et al., 2005). This HDAC inhibitor represses histone deacetylase (an enzyme that removes acetyl groups from histones) activity. Furthermore, studies done on humans indicates that neglect and negative parent-child relationships have a tendency to produce children

The Role of the Environment on Cancer, Behavior, … (Cont.)

that have higher chances of depression and chronic illness as adults (Russak and Schwartz, 1997). In fact, there is four times as much chronic illness in people who had distant relationships with their parents (Russak and Schwartz, 1997). In rats, the effects of maternal care on the epigenome are evident in the first week of life; high-care offspring and low-care offspring have markedly different methylation patterns (Szyf et al., 2007). The influence that maternal care has on the epigenome is staggering, but the trigger that creates different methylation and acetylation patterns is still quite obscure.

Epigenetics undoubtedly have major influences on autoimmune disorders as well. Autoimmunity can be described as the body's loss of the ability to recognize its own materials and processes, and is commonly associated with risk factors (Hewagama and Richardson, 2009). It has been noted that most often, autoimmune disorders occur in women, possibly due to the second X chromosome (Herrera et al., 2007; Yin et al., 2007). When epigenetic stability is lost (in other words, methylation and acetylation patterns are irregular), gene expression in certain cells can become abnormal, thus causing the lack of tolerance. In predisposed people, this abnormal gene expression leads to autoimmunity (Strickland and Richardson, 2008). One major autoimmune disease, Systemic Lupus Erythematosus (SLE), has very specific genetic markers, with over 20 loci that contain associated genes (Sestak and O'Neil, 2007; Sestak et al., 2007). T- cells, a type of white blood cell, directly play a role in the immune system. It has been proposed that defective T-cell DNA methylation may be a contributing determinant in Lupus (Hewagama and Richardson, 2009). DNA demethylating drugs have been shown to cause lupus-like disease in genetically predisposed people. The drugs used—Procainamide and Hydralazine—cause Antinuclear Antibodies (ANA) to form in most people, and cause lupus-like disease in the genetically predisposed (Yung and Richardson, 1994).In a study done on rats, hydralazine and procainamide have been indicated to take away methyl groups from cytosines in CpG islands, or regions with high concentrations of CpG sites (Dubroff and Reid, 1980). ANAs cause the body to attack its own tissue as if it were foreign material. Rheumatoid arthritis (RA) is caused by a T-cell response to an environmental trigger, although this trigger remains uncertain (Firestein, 2003). In multiple sclerosis, sun exposure is thought to be advantageous, and Epstein-Barr virus is thought to induce the disease (Kragt et al., 2008; Oksenberg et al., 2008). Of course, these are rather questionable factors, as it is not quite understood if they are merely physical factors, or genetic ones, for that matter. Myelin, a protein and lipid combination, usually acts as a myelin sheath around the axons of neurons. Myelin basic protein (MBP) citrullination (or the conversion of arginine to citrulline), catalyzed by peptide arginine deiminase 2 (PAD2), is a normal process. However, hypomethylated PAD2 promoters may result in low myelin stability in MS brains (Moscarello et al., 2007).

Epigenetics has huge implications for modern-day medicine and treatment, helping to understand the mechanisms responsible for the environment's effect on the body. With development, epigenetic treatment could be used to treat disorders that are currently treated with restrictive diets, psychological therapy, physical therapy, or arduous drugs. Epigenetics has already been linked to autoimmune diseases, cancer, and most psychological conditions, among other such common medical conditions. In fact, epigenetics may eventually be utilized to treat genetic diseases by using methyl and acetyl groups to switch genes on or off. Being that the field of study is relatively new, it is still unknown how exactly the environment affects methylation and acetylation. Inevitably, the epigenome is crucial to the development as people, both physically and psychologically. The genome, previously thought to be the defining aspect of human development, is not the only answer anymore. The field of epigenetics has widened substantially over the past few years, opening the doors to new answers and new possibilities. After all, Lamarck may not have been so wrong.

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Sophomores Projects

The Role of the Environment on Cancer... (Cont.)

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Inflammatory Bowel Disease, by Benjamin Toll

INTRODUCTION/ OVERVIEW:
Imagine that a splinter lodges in your foot and, after a few days, the surrounding area becomes inflamed. What happened? Mast cells secreted histamine to increase blood flow, swelling nearby tissues, and allowing more phagocytes to attack invading pathogens. This is good—it tells you your immune system is working correctly. In a few days, the excess phagocytes will commit apoptosis, histamine will stop being produced, and the inflammation will die down (Sompayrac, 2008). But what if something normal triggers an immune response? In inflammatory bowel disease (IBD), a condition affecting approximately 1.4 million Americans, this is exactly what happens. IBD is defined as "the loss of tolerance of the intestinal immune system towards the intestinal microbiota resulting in constant immune activation ...mucosal tissue damage and chronic inflammation" (Hormannsperger and Haller, 2009). Symptoms include abdominal cramps, bloody diarrhea, and fever, as well as long-term complications ranging from arthritis to colon cancer. In general, victims are diagnosed with either ulcerative colitis (UC), which applies to the large intestine, or Crohn's Disease (CD), which can apply to any portion of the gastrointestinal tract; but the two disorders are so closely related they are sometimes indistinguishable. So how are they treated? (What is IBD)

ACCEPTED TREATMENTS:
A variety of approaches are used in IBD cases. Many doctors place symptomatic patients on low-residue diets. This reduces irritation from fibrous foods, but does not resolve the condition. Doctors also prescribe drugs that help induce and maintain remission. Generally, they follow a step-wise approach, prescribing the most benign drugs first and so on, until the patient becomes asymptomatic. Aminosalicylates and symptomatic drugs, for example, make up step one; they work like aspirin to reduce inflammation. Corticosteroids, faster-acting anti-inflammatory agents, are step two, and immune modifiers that trigger a reduction in the white blood cell count are step three (Shaikh and Rowe, 2005). Step three A drugs, like Infliximab (Remicade) are anti-Tumor necrosis factor (TNF) agents which bind to TNF sites, preventing TNF cytokines from triggering apoptotic cell death or inducing inflammation (Locksley, Killeen, and Lenardo, 2001). These treatments, however, are very expensive and can increase susceptibility to opportunistic diseases. Doctors often advise patients to take supplements like iron if they exhibit anemia from blood loss, or calcium, if they are taking corticosteroids to reduce inflammation (one of the side effects of steroid use is osteoporosis). B-12, multi-vitamins, and other nutrients may also be needed depending on the symptoms. For severe cases, doctors prescribe bowel rest, giving patients intravenous nutrition in the hospital until the flare subsides. Some ulcerative colitis patients also opt to have their colons removed. This, however, is not possible for CD patients who have symptoms spread out across the entire gastrointestinal tract. Moroever, all of the treatments, including colorectomies, may not be successful (Shaikh and Rowe, 2005). This means that improving our understanding and treatment of the illness is vital.

IMPROVING TREATMENTS – GENETIC SUSCEPTIBILITY:

Inflammatory Bowel Disease, (Cont.)

Locating suceptibility genes is necessary for better understanding IBD. In fact, scientists have already noted quite a few, all of which are involved in immune reactivity and early response to bacteria. One can attribute their discoveries to the development of new DNA analysis / sequencing technology and large genetic 'reference' databases.

When naming IBD susceptibility genes, specific conventions must be used. Each gene is given a second name beginning with the prefix IBD. IBD5, for example, represents the SLC22A4 and SLC22A5 gene cluster. And IBD1 represents NOD2/CARD15, the first susceptibility gene in Crohn's (Scaldaferri and Fiocchi, 2007). Discovery of mutations in this gene marked a milestone in inflammatory bowel disease research. NOD2/CARD15 codes for a cytosolic (intracellular fluid) protein that recognizes a major component of the bacterial cell wall, muramyl dipeptide, and sets off the transcription factor, Nuclear Factor-kappa B (NF-kB). Because of its cell-type and stimulus-specific nature, NF-kB affects areas as diverse as cardiovascular growth, stress response, and inflammation (Brasier, 2006). Mutations in NOD2/CARD15 damage its ability to recognize bacterial components and set off NF-kB, ultimately leading to NF-kB misregulation (Scaldaferri and Fiocchi, 2007). This can cause the characteristic overproduction of pro-inflammatory cytokines like TNFa and IL-6 (Interleukin-6) associated with IBD (Atreya, Atreya, and Neurath, 2008).

In 2008, Kaser et al. found that deletion of the protein XBP1 in the small and large intestinal epithelium induced "spontaneous enteritis with histological features of human IBD" (Kaser et al., 2008). XBP1's gene has several roles; it controls the expression of IL-6, a pro-inflammatory cytokine which promotes plasma cell growth and antibody production in B-cells, and activates specific target genes that respond to endoplasmic reticulum (ER) stress caused by misfolded proteins (Iwakoshi et al., 2003; Kaser and Blumberg, 2009). Other studies have also been conducted. In 2004, Stoll et al. reported that genetic variations in DLG5 could lead to IBD susceptibility. DLG5 encodes a scaffolding protein which brings other proteins together so that they can interact, in this case, to help maintain epithelial integrity. STAT3, encoded the the STAT3 gene, was linked to ulcerative colitis. Because it controls the expression of genes in response to cell stimuli, it plays a key role in processes like cell growth and apoptotic death (Reiff and Kelly 2010). Genes like ATG16L1, IRGM, IL23R, and IBD5 (the SLC22A4 and SLC22A5 gene cluster) also affect susceptibility. Inflammatory bowel disease, however, is more than genetics.

IMPROVING TREATMENTS – PSYCHOLOGICAL STRESS:

Psychological stress may also affect IBD. In a study by Paul H. Black from the Department of Microbiology at Boston University School of Medicine, major stress hormones were cited as inducing an acute phase response (APR) "similar to the response elicited when an organism reacts to an invading microorganism or sustains trauma and tissue injury." Stress is defined as threatened homeostasis. Stressors -- characterized as acute, repeated acute, or chronic – are the stimuli that induce the stress response by activating the sympathetic nervous system (SNS). The SNS is the part of the nervous system involved in preparing vertebrates for fighting or fleeing from a threat. And the acute phase response is a series of reactions that occur in response to tissue damage. During an APR, special acute phase proteins (APPs) are produced in the liver, proteins which include up-regulated (positive) APPs, involved in increasing inflammation, and down-regulated (negative) APPs, involved in decreasing inflammation (Black, 2003). Research by Banks et al. (1995) indicates that cytokine IL-6 is closely linked to the acute phase response. In this study, eight cancer patients were injected with IL-6 for seven days at a dose of 1, 3, or 10 µg/kg/day. Scientists found an increase in positive APPs and a decrease in negative APPs, concluding that IL-6 can impact production of most acute phase proteins in vivo. Despite the small sample size of their experiment, this conclusion remains widely accepted. If IL-6 mediates the APR, then any factor that triggers the release of IL-6 will also mediate the APR. An exaggerated response of the SNS to stressors, for example, may lead to chronic elevated blood pressure (or hypertension) which would be a sufficient stimulus for the release of IL-6 (Black, 2003). Nevertheless, the sympathetic nervous system is not the enteric nervous system (ENS) which is most directly associated with the gastrointestinal tract. Research on the stress response in the SNS, however, is still applicable for several reasons. First, the ENS and SNS are closely related-- so closely related that nerve signals are communicated between them on their way to the central nervous system (CNS). Second, IL-6 is an important part of the ENS, as it also functions to promote plasma cell growth and immunoglobin production in B-lymphocytes. And finally, APR can occur in any part of the body. If IL-6 controls this response, then psychological stress affects our entire nervous system.

Both stress and genetic susceptibility are important to understanding IBD. But what are some new treatments that have developed?

Mentor: Dr. Peter Higgins, University of Michigan

Sophomores Projects

Inflammatory Bowel Disease, (Cont.)

IMPROVING TREATMENTS – PROBIOTICS:

Many studies suggest that ingesting certain bacterial strains can be beneficial for IBD patients. These strains, called probiotics, exist natively in the colon and are believed to improve intestinal epithelial cell (IEC) barrier functions. The intestinal epithelium consists of four main cell types: enterocytes which absorb nutrients, Paneth cells which secrete antimicrobial proteins called defensins, enterochromaffin cells which secrete hormones (mainly seratonin) to regulate intestinal movements, and goblet cells which secrete mucus to regulate bacterial attachment. Normally, colonic bacteria carry out important functions like the metabolism of dietary carcinogens; however, in IBD patients, who suffer from a loss of tolerance for their own microbiota, they actually cause additional problems (Hormannsperger and Haller, 2009). This has increased interest in probiotics as they both carry out the functions described and compete with harmful bacteria for epithelial binding sites (Wohlgemuth, Loh, and Blaut, 2009).

Unfortunately, there are only two preparations that have been shown to do this well: the single bacterial strain E. coli Nissle 1917 and VSL#3, a mixture of eight different strains (Hormannsperger and Haller, 2009). Research by Kruis et al. (2004) provides evidence that the former is nearly as effective as the "gold standard" mesalazine (an aminosalicyclate) at maintaining remission. In this study, 327 patients were assigned to receive either 200 mg of the probiotic once daily or 500 mg of mesalazine three times daily. Then, participant health was assessed using the clinical and endoscopic activity indices over the next twelve months. Researchers found that relapses occurred in 36.4% of patients with E. coli Nissle 1917 and 33.9% in patients with mesalazine.

In 2009, Tursi et al. (2009) conducted a double blind, randomized, placebo controlled study, and found that VSL#3 was also effective in treating mild to moderate ulcerative colitis. 144 patients, all under treatment of stable doses of mesalazin, were randomly given the probiotic mixture and, after eight weeks, their improvement on the Ulcerative Colitis Disease Activity Index (UCDAI) was significantly higher than in the control (60.5% vs. 41.4%). Researchers also found that VSL#3 lessened rectal bleeding and induced remission. If probiotics are effective, convenient, and exist natively in the colon, then there is no more natural solution. Still, however, there are problems with probiotic treatment. VSL#3 and E.coli Nissle 1917 are the only two that have been shown effective. In addition, probiotic efficacy was only measured against aminosacyclides, the weakest of the IBD anti-inflammatory medications. And finally, scientists have not located the bacterial components responsible for the beneficial effects of probiotics, nor have they located the bacterial components responsible for triggering IBD (Hormannsperger and Haller, 2009; Shaikh and Rowe, 2005). More research must be done.

CONCLUSION:

There are many fields that have potential to aid victims of IBD. One could study the implications of stress on bowel inflammation. One could study genetic indicators. Or one could study probiotics and work to isolate and increase the efficacy of the chemicals that make them effective. This, however, is certain – that if something is not done, 1.4 million people will continue to suffer.

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Miraculin and Taste Perception, by Shivanee Shah

Imagine being able to drink Tabasco Sauce straight out of the bottle and perceive it as a glazed donut (Farrell & Bracken, 2008).This is possible with miracle fruit. Miracle fruit is a tiny red berry with a large seed covered by a thin layer of pulp that contains Miraculin (Bartoshuk et al., 1969). Miraculin is a taste modifying protein. Miraculin is the cause for the suppression of the sour taste and making it seem sweet. To activate the effect of miracle fruit, one must hold the pulp of the berry in their mouth for a few minutes. After swallowing the pulp, the Miraculin will continue to alter the taste for one to two hours (Bartoshuk et al., 1974). The berry itself has no taste and does not change the taste quality (Kurihara and Beidler 1969) For example, if one consumes lemons with miracle fruit, they may seem sweet but the acids can be harmful if consumed in large quantities.

This plant is native to West Africa and for hundreds of years miracle fruit was used by native Africans to suppress the bitterness and sourness of palm wine and maize dishes. Miracle fruit is difficult to cultivate outside of its natural environment, because it needs to be in a tropical environment with no frost and needs a certain pH level to grow successfully. But, it has been successfully grown in Florida (Sun et al., 2006). The taste alteration made by Miraculin is much sweeter compared to the same amount of sucrose; 0.4 μM of miraculin is three thousand times sweeter than the same amount of sugar (Kurihara and Beidler 1969). The concentration of Miraculin can reach up to 10% of the total soluble protein in miracle fruit (Sun et al., 2006). Gymnema Sylvestre is a herb that is shown to reduce the intensity of sugar. When Gymnema Sylvestre, was used after miracle fruit was eaten, the sour taste returned. This proves that Miraculin does not block taste buds that perceive the sour taste (Bartoshuk et al., 1974). It is unknown how the protein specifically works with the taste buds. Miraculin has a phenomenal property which can be used by many as a benefit to diets.

The need for a natural sweetener with no known side effects is extremely important today with the amount of overweight and obese people. Trying to use Miraculin in a sugar substitute can be beneficial not only obese but people trying to maintain or lose weight because it controls the usage of sugar. Diabetics can get the same taste without worrying about their sugar intake (Sun et al., 2006). Robert Harvey started a company to commercialize Miraculin. The company was called Miralin Company and was directed to the diabetic market. Still in developmental stages, the company generated publicity. The sponsors wanted it not only for diabetic patients but for the general public as well. The FDA was very supportive of the product and Mr. Harvey was confident that the FDA would approve of his product. He tested his product with school children using ice pops made with sugar and ice pops made with Miraculin. The ice pops that were made with Miraculin won every time. This proved that even the children preferred the usage of Miraculin to the sugar-sweetened ice pop. Unfortunately, the FDA rejected the project before the launch of the project. The FDA stated that Miraculin could be used under the classification of "generally recognized as safe". With further research, the FDA claimed Miraculin could be used as an additive. Without any more money for further research, the company shut down with no further explanation of why the FDA did not approve of the product (Fowler, 2008).

Since Miraculin is extremely difficult to grow outside of its natural environment, Miraculin has been genetically modified to fit plants that can be easily cultivated. Miraculin has been successfully inserted into lettuce (Sun et al., 2006), tomatoes (Sun et al., 2007), and strawberries (Sugaya et al., 2008), in which the tomatoes containing the highest concentration of Miraculin (Hirai et al., 2010). This process becomes much easier because the amino acid sequence and gene has been isolated (Theeraslip et al., 1989). This is done by cloning the DNA of Miraculin in a plasmid. The plasmids are injected into the lettuce plant for this experiment. After the injection of plasmids, one must check to see if the DNA is incorporated into the DNA of the lettuce. After, one must ensure if mRNA is being produced and creating functional proteins of Miraculin. Once there was lettuce plants that contained Miraculin, human subjects were used to check if the protein still altered the taste from sour to sweet basing the change on a scale. With this test, one knows if the taste modifying ability can be transferred. From the results, one can conclude that it is possible to genetically modify lettuce to contain the DNA of Miraculin. The concentration of Miraculin is almost the same in two grams of genetically modified lettuce to miracle fruit (Sun et al., 2006). Since Miraculin has been successfully transferred into transgenic plants, Miraculin will become more readily available to study and obtain.

Miraculin has been tested on animals other than humans, such as rhesus monkeys. Monkeys have a strong preference for sweet solutions over acidic tastes. Monkeys consider citric acid unpalatable. Before the consumption of Miraculin, on average, twenty six percent of total intake of food is citric acid. After Miraculin, the average amount of citric acid consumed was seventy five percent. All the acids presented to the monkeys became more acceptable after Miraculin was ingested (Brouwer et al., 1983). Testing how Miraculin works on animals

Mentors: Dr. Kathleen Keller, Columbia University College of Physicians and Surgeons, And Dr. Kathleen Curtis, Oklahoma State University

Sophomores Projects

Miraculin and Taste Perception, (Cont.)

may be useful to find out how Miraculin works with the perceiving taste.
It is fundamental to understand how oral sensation influences our food preferences and food intake. Oral sensation is made up of three parts: true taste, retronasal olfaction, and somatosensation. True taste is the perception of salty, sweet, bitter, and sour. Retronasal olfaction refers to the ability to smell within the oral cavity. And somatosensation is the perception of touch, temperature, and pain. Oral sensation differs genetically and can change over time with exposure to pathogens and difference in hormone levels in women. The genetic difference if one can taste 6-n-propylthiouracil (PROP) and phenylthiocarbamide (PTC) and density of fungiform papillae. Fungiform papillae are located on the tongue and they hold the taste buds. PROP is a tasteless substance to some while tastes extremely bitter to others. Being able to taste PTC and PROP is a result from a dominant allele. Those who cannot taste it must have carry two recessive alleles. An increased number of fungiform papillae and being able to taste PROP and PTC makes a person a supertaster. A supertaster experiences all tastes at an intensified level, many times some substances taste overly bitter such as Brussels sprouts and asparagus. Male and female supertasters tend to have different likes and dislikes. For example, male supertasters tended to have an increased like for fatty foods such as cheese. On the other hand, as PROP intensities increased, the liking for fatty foods decreased in females. Pathological conditions that affect the taste buds are viral infections, head trauma, and consistent middle ear infections. The hormone levels for women change as a young girl, to puberty, menstruation, pregnancy, and menopause (Duffy and Bartoshuk 2000). Oral sensations could be the key understanding for one to follow healthy diet. Miraculin can be used as an aid for those who find it impossible to eat certain healthy foods.
Miraculin and oral sensation can be used hand in hand for to help supertasters follow a healthy diet plan by being able to eat foods that were considered extremely bitter. Also, it is possible to see if the perception of Miraculin changes over changes in women's hormone levels. One could use women form all different age groups including those who are pregnant and test if they perceive Miraculin altering the taste of acidic foods. Another plan for further is testing if Miraculin continues has the affect of altering the sour taste in patients that have frequent central ear infections or head trauma. Understanding how oral sensation can be influenced by external factors is important to for perception of tastes and using Miraculin to benefit the alterations in how one tastes food.

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Effect of the first language on the perceptions of nonnative language sounds, by Kayla Plunkett

Audio perception is the ability to arrange the auditory element of hearing and select the sounds that are instantaneously pertinent to modification (Thomas 1985). There are many aspects that affect the way people perceive sounds and images, which affect the way they 'hear' a language. They are linked when it comes to language, since they are both processed in the brain [visual and auditory cortex]. Given that visual imperfections result in auditive failures, this feature is dependent on your native culture and ethnicity, and the way your culture has become accustomed to speaking. Speech perception can be altered by visual observations of the movements of a speaker's lip and mouth. Two scientists have revealed this in 1976. Scientists Harry McGurk, along with John McDonald discovered an effect, in which it explains that visual articulatory information is automatically and intuitively incorporated in everyone's speech perception. It demonstrates an interaction between hearing and visualizing in speech recognition. This effect eventually earned the name "The McGurk Effect." It also proclaims that a syllable, in which someone perceives, is utterly dependent on the supremacy of audio and visual information. This is due to the fact that our speech function makes use of all the relevant information it can gather, regardless of the modality

Effect of the first language on the perceptions, (Cont.)

(retrieved 1/26/10).
The McGurk effect displays that we all use visual information, and that we cannot help but include visual speech information into whatever we are listening to (Windmann 2004). The Effect does indeed work on perceivers of all language backgrounds, and even on young infants. A person's native language is what they learn from their birth; their first language, which is also called their "mother tongue." The native language also prevents people from learning their second, third at el. language at a fast and productive pace. It is also more difficult to learn than your native language. This is because arterial language familiarity influences auditory–visual of nonnative second language speech perception (Wang 2008). As people develop, they become accustomed to a certain way of hearing, even without knowing. Depending on their native tongue, a person's first language is a foundation for sociolinguistic identity. They may hear the labiodental of the letter f but see a different movement in the structure of the speaker's mouth, which may be ambiguous, so the listener may distinguish it to be an entirely different sounding word or letter, for instance an alveolar of the letter n (Wang 2008). Multiple experiments were conducted to see if a person's native language does indeed affect the way you hear sounds from a second language. The results proved various hypotheses' to be true. Due to the tendency to use visual, audio, audio-visual congruency, or neither audio nor visual information used in a certain language, it makes each person who has that language as his or her birth language, to become acquainted to that precise way of speaking. It makes it slightly more difficult to hear the accurate words or sounds as they listen to a person who is talking to them [in the listeners' second language]. It also prevents people of other languages to hear the correct sounds of their second or third language, because of their own use of information of their primary language.
In a Language and Brain Lab at Simon Fraser University (SFU), three groups of young adults were involved in an experiment related to the influence of speech perception on second language. It shows how audio and visual information play a large role in the way people perceive sounds. Out of the three groups, there were 15 native Canadian English speakers, 15 native Korean and 20 native Mandarin speakers. First, audio and video recordings were made with an adult male speaker, of Canadian English, sitting against a white background in the recording studio at SFU. The speaker was recorded saying six random repetitions of English syllables at a normal speaking pace. In addition, separate audio recordings were simultaneously made with a condenser microphone. These high quality audio recordings were used to replace the audio track from the camcorder recording. This was then presented over loudspeakers, visually on a computer monitor, or both. Participants were tested individually, sitting approximately 1 meter from the monitor and the two loudspeakers.
After this experiment way complete, it was concluded that the nonnative perceivers would not reach native performance (particularly in the audio (A) and/or audio visual congruency (Avc) aspect). However, both nonnative groups performed better in the AVc than the A condition, suggesting an ability to develop visual information in second language speech perception. Also, while second language learners make use of both auditory and visual information in perceiving nonnative speech sounds, their perception is influenced by the interaction the audio-visual (AV) speech categories in their first and second language. The current study indicates that nonnative auditory and visual speech cues may not be acquired simultaneously.
There is in fact a solution to the problem coming from the common question as to why it is better to learn a second language at a young age. The reason is because when you are young, your brain is at its most flexible stages. As a baby, or even a toddler, your brain is more prone to picking up and remembering details that will come even more naturally at a later age. It is most vulnerable to understanding, and holding onto anything he/she has heard as a child. "The young kids learn naturally, absorbing the sounds, structures, intonation patterns and rules of a second language intuitively, as they did their mother tongue. The young brain is inherently flexible, uniquely hard-wired to acquire language naturally" (Why Learn Young?). If your start to learn another language at an older age, you will not only have to train your ears and eyes to focus on the sounds and movements from a speakers mouth, but you will also have to study the grammar rules and all of the many different and complex verb tenses, where as if you learn it as a child, it will come more innately to you.
Native language greatly affects a persons' ability to perceive, learn, understand, and hear the sounds of a nonnative language. This is caused by the information (Audio/Visual) used in your native language, and the differences in information compared to the nonnative language. After a person becomes accustomed to a way of 'hearing,' it is difficult to alter, and therefore difficult to learn, unless a person is raised fluent in many various and diverse languages. The McGurk Effect further explains the theory of needing to see in order to hear the sounds of a nonnative language accurately. This shows

Sophomores Projects

Effect of the first language on the perceptions, (Cont.)

how people unknowingly and mandatorily use their visual strengths and capabilities to hear words and sounds of any and every language they are listening to.

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The invasion of the Pterois Volitans in the waters of the Atlantic Ocean, by Alex Alves.

The Pterois volitans, commonly known as the lionfish, is a magnificent creature. This predator is native to the waters of the Indian and Pacific Ocean; however, recently there have been numerous sightings in the Atlantic Ocean.

The presence of the lionfish in the non-native waters of the Atlantic (Hall 2007) means they are considered to be an invasive species. Invasive species can have devastating affects on the location they newly inhabit (Arthur 2009). And they have no predators in their newly acquired territory thus their numbers can thrive, forcing competition with native species. This can lead to a decrease in native species as prey are eaten by the new species (Arthur 2009). Saltwater fish introductions are extremely rare, thus there are no solid techniques to stop them. Most invasive marine life are crustaceans or algae which are low in the food web. Lionfish, on the other hand, are a vicious predator at the top of the food web and is the first example of a successful invasion by a fish in the Atlantic (Gupta 2009).

How the lionfish got the Atlantic is a bit of a mystery. Some believe that it was caused by ships filling their ballasts in the Atlantic and accidently transporting the larva and eggs through the Panamá Canal and into the Atlantic (Whitfield 2002), (Gardner 2006). This has been the cause of many marine introductions such as the zebra mussel and red algae. Although studies prove that in such cases, the concentration of the invasive species is higher in ports, such is not the case with the lionfish. Another possibility is that a dive operation intentionally introduced lionfish to one of its dive sites to provide a rare tourist trap in the Atlantic (Gardner 2006). Individual lionfish released by independent aquarium owners undoubtedly helped the spread of these fish, but the question is whether or not that was the cause (Hall 2007), (Whitfield 2002). Still, some believe that a resort with an open aquarium accidently released juveniles and eggs into the ocean (Whitfield 2002).

The most likely causes were Hurricane Andrew or aquariums' releases, both purposely and accidental (Whitfield 2002). During Hurricane Andrew, a transport vessel capsized sending three lionfish into the ocean (Gupta 2009) (Gardner 2006). Also during the hurricane numerous aquariums were destroyed and their lionfish were released. This would cause a mass of lionfish to occur in one location that would allow them to breed among themselves (Hall 2007). In the predictions involving individual fish releases, the lionfish would have a miniscule chance of meeting up with another lionfish, and even then, the chance of the meeting ending with a successful mating is virtually impossible.

The lionfish is part of the Scorpaenidae family. All members of this family have large pectoral fins, but none is as stunning as that on a lionfish. The lionfish use these fins to help corral their prey into a corner. What makes them an even more potent invasive species is their venomous dorsal and anal spine that deters predators (Whitfield 2002). The lionfish can eat anything up to ¾ of its overall length (Whitfield 2002).

The native range of the lionfish is the waters of the Pacific and Indian Oceans. (Whitfield 2002) Sightings of the lionfish have been surfacing all over the Atlantic Ocean. The waters of Bermuda and the Caribbean Sea offer warm waters where lionfish can live and thrive year long (Whitfield 2002). The waters of Florida, South Carolina, and North Carolina offer a location were the lionfish can survive all year provided the weather is mild and water temperatures remain high (Whitfield 2002). The eggs from the adults living in these warm water locations can be carried

The invasion of the Pterois Volitans, (Cont.)

farther north by the currents. Due to the Gulf Stream that circulates warm waters farther north; juvenile lionfish have been spotted up and down the East Coast of the United States. Many sighting are as far north as New Jersey, New York, and even Rhode Island (Hall 2007) (Whitfield 2002) (Gardner 2006). Although sightings in these northern locations are relatively rare, sometimes with only a few sightings a year (Gardiner 2007), in southern counterparts, lionfish sightings are common. Many times when teams would go out to collect lionfish specimens, they would leave the dive early because their collection bags were full (Gardiner 2007).

For an invasive species, survival is not always a definite, but such is not the case with the lionfish. The number one killer of invasive species is the environment itself, salinity, water temperatures, and viruses all have an effect on an invasive fish's survival. The salinity content and temperature is perfect for the lionfish in the Caribbean and southern American Atlantic coast. Temperature does limit the lionfish's survival in the Atlantic, but no more then it does in its native waters (Whitfield 2002). In addition, the lionfish is known to be very resilient and parasite resistant. As soon as an invasive species enters a new ecosystem, it instantly becomes part of the food web, both as a predator and a prey. Coming into a new environment invasive species usually have to deal with new predators. Sadly, the lionfish has almost reached the top of the food chain. The first deterrent to would be predators of the lionfish is its appearance. The lionfish's pectoral fins make this fish look like no other. This means that predators commonly do not even consider the lionfish a prey at first glance. The lionfish's red and white stripes are classic colors that mean danger, with good reason (Hall 2007). If a fish does attack the lionfish they would soon regret it as neurotoxins are injected into the predator's blood steam causing extreme pain, or even death (Mark 2007) (Gupta 2009). The combination of all these factors makes the lionfish unsuitable pray to most large predatory fish. The only native Atlantic fish discovered with a lionfish in its stomach in the Atlantic is the grouper. The problem is that this fish is an endangered species due to overfishing, meaning it cannot have much impact in controlling the lionfish population. The only other fish known to eat juvenile lionfish in the Atlantic is mature lionfish.

Another thing that usually limits the survival of invasive species is food source. Once again, this is not the case when it comes to the lionfish, which can eat over 50 different species of fish, and even some crustaceans (Gupta 2009) (Whitfield 2002). To the contrary, the lionfish is an unstoppable predator in these new waters. It's method of using its pectoral fins to corner its prey is unlike any other in the Atlantic, thus the native fish have no way to counteract this (Hall 2007) (Gupta 2009) (Whitfield 2002). This technique is so potent that although lionfish usually eat at night samples collected during the day usually have full stomachs. Accidental, of purposely man's interaction with the environment have released this alien species into the Atlantic (Hall 2007), and now scientists are trying to fight back. The primary way currently for doing so is with divers. Once a lionfish has been spotted a trained group of divers with spear fishing gear can go to the location and eliminate the new threat. (Gupta 2009) (Whitfield 2002). In areas where there is an inadequate amount of trained divers to counter the growing population local dive shops train anyone who is willing to do so. Sometimes the dive shops will even hold rallies and have a prize to whoever kills the most lionfish. Many local restaurants also cook lionfish and are willing to buy lionfish from divers to help motivate them (Gupta 2009).

Although using divers to kill lionfish can help in small locations such as marine preserves, this technique cannot be successful in solving the problem. Lionfish commonly occupy depths between 20 and 50 meters (Whitfield 2002). At 30 meters, a diver only has less than twenty minutes of bottom time, not including decent, ascent and safety stops. Meaning that in such deep areas divers cannot even lower the population. Another method currently researched is to use traps to capture lionfish. The traps would be cheaper, easier to produce and more effective (Whitfield 2002). The downside is that the trap becomes a great problem as they could capture native fish in addition to the lionfish (Gupta 2009).

The invasion of the lionfish is a truly serious issue. Being the first successful fish invasion in the Atlantic Ocean the affects are not known and cannot be accurately predicted (Whitfield 2002). Current research is investigating lionfish, its affect on this new environment and ways to prevent it from causing more damage. The lionfish are in the Atlantic and they are here to stay, the only thing that we can do now is to try to halt their advance and recapture the waters for the native fish of the Atlantic.

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Juniors Projects

Matters of the Mind Reveal Our Identity, by Naimah Hakim

We as individuals and as humanity have always been on a quest to discover our identities. We ask ourselves: Who are we? What are we? And, why are we this way? In order to solve the question of the human identity crisis, we must first seek to understand human nature. However, the key to understanding our nature relies on our ability to understand the purpose and system of functioning within the human mind.
For many years, scientists have realized that the brain is divided into various regions that have specialized functions, but we have not always known exactly how these regions act and interplay during cognition and emotional-processing. The branch of study known as social cognitive neuroscience seeks to explain the neural mechanisms that underlie the brain regions that control the way we think and feel (Ochsner 2004).

In order to study cognition and emotion in the brain, neuroscientists need a means of charting how the brain reacts to stimuli to determine the specialized functions of each brain region. This is where functional Magnetic Resonance Imaging (fMRI) steps in. By mapping areas of increased blood flow in the brain, fMRI signals help to create images that show which brain regions become activated during a wide array of cognitive and emotional processes. As a result, even social phenomena that were previously only regarded on theoretical terms can now find scientific backing through fMRI evidence in brain functioning.

There are many examples of social phenomena that studies in cognitive neuroscience have helped to bring to light in recent years. In particular, fMRI findings have changed the way we have regarded thought-processing for centuries. Appraised French mathematician and philosopher Blaise Pascal once wrote, "The heart has its reasons which reason knows not of" (quoted in Ochsner & Phelps 2007). Essentially, the message Pascal conveys is that emotion and cognition are systems that function independently in the mind. Humanity has related to this concept well, as we all must face situations in which we must decide between what is logically right and what feels right. However, findings in behavioral neuroscience have helped to challenge this view by demonstrating that emotion and cognition actually interact regularly, and that their "integrative operation is necessary for adaptive functioning" (Ochsner & Phelps 2007). Now, many topics that were once regarded as "'cold' cognitive processes" such as memory and perception, are now being restudied for their relationship with emotional systems.

At one point, the regulation of emotion was exclusively credited to the amygdala, a region of the brain located within the medial temporal lobe, but findings at the NYU neuroscience lab under the direction of Elizabeth Phelps have found that the amygdala may also serve as another system that handles memory. Phelps and her research team asked, why is it that "memories for emotional events have a persistence and vividness that other memories seem to lack?" (Phelps 2004). This questions led them to hypothesize that the amygdala must interact with the primary memory center of the brain, a region known as the hippocampal complex, or hippocampus, during memory-processing. Memory-processing is broken up into two main stages, encoding, when the body first encounters a stimulus, and retention, the storage stage. Encoding can be influenced by several factors, including how well a stimulus in initially perceived and attended to (Phelps 2004). A number of studies have shown that a stimulus with emotional attachment tends to capture attention and make the encoding process easier (cited in Phelps 2004). Many people may relate to this concept while they are listening to music on the radio. Often, people listen to the radio idly, and would not be able to recall the last five songs played, since most only hear the music passively. However, the listener will probably be much more likely to pay attention to and remember the songs if they happen to hear a song that had emotional value, such as one they danced to with a loved one, or a song their parents used to sing to them as a child. This situation shows how emotion can drastically influence attention and the encoding process.

Additionally, there is also evidence that emotion can influence the storage of memory during retention. After a memory is encoded, the memory goes through a stage in which it is "prone to disruption" while in the process of becoming 'set' in the mind (Phelps 2004). This process, known as consolidation, may be slow to allow for an emotional reaction to the event. This is because, in survival circumstances, events that also produce emotional responses are more important to survival, and therefore, more likely to be remembered. For example, when walking through the woods, one is more likely to remember the sound of a bear growling because it often creates fear, and emotional response, than remember the sound of a leaf falling to the ground.

Perception is another area of research that has been studied in recent years in terms of its neural mechanisms in relation to emotion and social-cognition. Several research teams have gone about studying this by exploring human reactions and perceptions of faces. Facial perception has often been linked to the fusiform gyrus in the brain (Morris, Pelphrey, &

Matters of the Mind Reveal Our Identity (Cont.)

McCarthy 2007). Kevin N. Ochsner of the Columbia lab for social cognitive neuroscience reports that recent studies have now revealed that this perception is actually processed over a number of brain regions. While the perception of attractive faces activated the medial orbitofrontal regions, known for their role in reward association and processing, the perception of unfamiliar or unfriendly faces activates the amygdala, the center for emotion and fear in particular (Ochsner 2004). This body of knowledge can be used to explain a variety of aspects of human nature. The functioning of the reward center of the brain demonstrates that humans innately see beauty as a positive gain, a concept that justifies why we tend to search for attractive romantic partners or why the cosmetics industry has such influence over our society. It is also interesting that unfamiliar faces trigger the fear-center of the brain. One notable study measured the amygdala response in Caucasian subjects to African American faces, and found evidence that some subjects might perceive foreign ethnicities as a threat (Cunningham et al 2004). Thus, studies in social cognitive neuroscience have the potential to hold vital pieces of evidence that will explain social phenomena that affect our day-to-day lives, like how we judge beauty, and possibly even racism.

When I read about these studies and more, I see a world of opportunity for the future of social cognitive neuroscience. One trend that I have noted in my readings is that the brain regions that tend to interact are those that are physically close to each other. For example, in looking at Phelps's aforementioned study exploring the influence of emotion on memory, I do not think it is coincidence that the amygdala and hippocampus are both located within the greater region of the medial temporal lobe. Thus, I think that researching brain regions that interact along similar or shared neural pathways will lead to many more discoveries about human nature and how the mind works.

Another aspect of neuroscience that I think should be considered in terms of upcoming research is the limits and future trajectory of this branch of science. Now that we are beginning to acquire a knowledge base of the activation of neural mechanisms that control thought-processing, I wonder, do we now have the capabilities to alter the ways in which we think and interpret information? Can we change the way we view beauty? Or, even, stop ourselves from fearing external stimuli, like "foreign" ethnicities? An important part of research is not only to consider the study individually, but to consider what the gained knowledge can do to better our society. While studies as to the possibilities and limits of this research may provide us with interesting information, we must be careful that we always regard the ethics of our methodology.

A concept confirmed by social cognitive neuroscience that I predict will have a major impact on society is the idea that cognition and emotion work together to allow mental functioning (Ochsner & Phelps 2007). In today's world, there is a great emphasis put upon developing our cognitive capabilities, whether it be in terms of education or through our occupations. However, it is evident that not enough time is spent in focusing on healthy regulation of our emotions. As a result, people lose track of how important emotions are in our cognition and how great a role they play for us. Phelps even stated in the conclusion of her study on emotion and memory that "it has become increasingly clear that we can no longer neglect the exploration of emotion, as it is rarely absent from our daily lives" (2004). The discovery that emotion and cognition are integral systems is the first step in us realizing that we must revolutionize our society to one that encourages the development of both, even at school and work. This step may even help us to work to heal those affected by severe mental disorders that seem to be all too common these days, and even ease the negative effects of social-problems that affect thousands of people, such as divorce, drugs, and obesity. With the help of research labs, these findings and more in the field of social cognitive neuroscience may be implemented by centers like the Garrison Institute, which is now working on a program to "Transform Trauma" to aid our society (Rose 2009). The reason I became interested in pursuing studies in social cognitive neuroscience is because I realized that, through reading about unlocking human nature by exploring the mind, I seemed to find a piece of myself and gain an understanding of my own identity. However, I know that this body of knowledge goes beyond myself. I believe that exploring the inner-workings of the mind will bring us all a means of understanding everyone around us. Perhaps if we can find ways to understand each other through cognitive neuroscience, we will achieve a heightened sense of consciousness of human nature, our collective identity, that will even bring us one step closer to peace.

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Mentor: Dr. Lawrence Marks, Professor, Yale School of Public Health

Juniors Projects

Implementation of Technology in the Classroom. Excerpt of Research Proposal, by Shannon Kenny

Mentor: Dr. Brian Reilly, University of California, Riverside

Throughout the country, technological devices are being utilized in schools, bringing a new feature into the world of education (Bransford 2004). It is predicted that the use of technology in the classroom is only going to accelerate in years to come, making research on this topic all the more important in order to prepare for the future (Bransford 2004; Lowther 2008). Although there are factors which remain the same when technology is used in schools, each technological device is different; making it is difficult to find information on the benefits and detriments of each unique machine (Zhao 2002). The right technology for a specific classroom's or school's environment needs to be determined by conducting its own unique study for that particular environment. Some environments require different types of technology than others (Zhao 2002). While there is research that examines the use of technology for educational purposes, individual studies of each device need to commence in order to ensure that the device is beneficial for a specific area (Zhao 2002).

In the Hendrick Hudson School District, the use of a new device, the SENTEO, is being implemented in classrooms. The SENTEO is a hand-held machine that allows students to punch in answers on a remote after viewing questions on a Smart board. These answers are anonymous to the rest of the class, but the teacher is able to observe who sent in which answer, and if they got it correct or not. The SENTEO records how many questions during each lesson were answered incorrectly. After a particular lesson a teacher can go back and analyze the data obtained by the SENTEO to find the strengths and weaknesses of each student, and those of the class as a whole. The SENTEO also allows teachers to get information from the Internet and show it to students, which makes a lesson more interesting and informative. A major benefit of the SENTEO is it allows immediate feedback to a teacher about students' progress, potentially elevating teaching ability and, therefore, greater increasing students' learning.

My proposal to test the validity of the SENTEO in real classrooms would benefit the district as a whole. While the idea of bringing interactive technology to the district has been looked upon with some uncertainty because of the costs involved with the initial expense and the essential ongoing technical support (Baylor 2002; Zhao 2002), formal testing of its use with positive results would allow for a better-educated decision on the part of the district to budget for more widespread use of the SENTEO in the future. Dr. Gottlieb, the Assistant Superintendent for Curriculum, states, "We support use of the SENTEO because teachers who are trained in Smartboard technology believe the two devices complement each other, and provide both increased engagement for children and immediate feedback for teachers. When teachers research tools and have compelling arguments, I feel it's important to support them as best I can" (Gottlieb, 2009). Teacher support of the use of the SENTEO is the single, most important factor in further sustaining my proposal to test SENTEO use in the classroom. While it is essential for students to be improving academically from technology for that technology to be beneficial (Guzman 2009), it is also essential that a teacher be open to a tool's effectiveness to allow for its success. Our district has teachers who are supportive of and skillful with this technology, and who have expressed their enthusiasm in working on such a study (Zucker 2009; Inan 2009).

Additionally, there is a benefit to the use of the SENTEO, because it is standardized. As students who are in the process of taking SAT's and ACT's and visiting colleges know, first-hand, success in a standardized testing environment is important to achieve success in being admitted to college . Technology in the classroom has been proven to improve students' performance on standardized tests. SENTEO technology may better-prepare students for standardized testing, leading to further student success.

Technology in the classroom can help prepare students for the real world, such as their future jobs (Wang 2008; Baylor 2002; Kozma 2003). It brings the outside world into the classroom, which teaches children basic knowledge about technology, its functions, and its uses. If they can carry this information later on in life, then they are going to excel when it comes to working with technology (Wang 2008). Educational technology has also been found to assist students in doing well on standardized tests (Baylor 2002). This is very important in considering the implications of technology and its usage to better student achievement in the classroom. Standardized tests appear everywhere in today's society, such as the SATs, the ERB, the ACTs, the regents, AP tests, etc. If students can be better prepared beforehand for this type of test with the use of technology, then it is an opportunity our school district cannot pass on.

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The Effects of Music Listening on Test Anxiety, by Zack Struver Excerpt of Research Proposal.

Mentor: Dr. Robert Krout, Professor, Southern Methodist University.

Music has broad psychophysiological effects on the body. Music therapy is used to treat individuals with a variety of disorders, disabilities, and illnesses. The American Music Therapy Association (1999) defines music therapy as "the clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship … [with a] qualified music therapist [through] creating, singing, moving to, and/or listening to music." Music therapy benefits individuals because it helps them cope with stressful situations and fosters the exploration of creativity and expression (Hesser, 2001). Music therapists obtain accreditation after graduating from college, and have a wide degree of musical skills and experiences, a vast knowledge of the psychological and physiological effects of music, and familiarity with a variety of cognitive, psychopathological, and therapeutic theories (Bruscia, Hesser, & Boxill 1981).

This study will focus on the application of receptive music therapy, a subset of music therapy, for use on students affected by test anxiety. Test taking requires students to memorize certain facts and master key skills, and often causes individuals stress when striving for a passing grade, or for more ambitious students, a perfect score. Stress causes the release of hormones which have a broad range of adverse affects on the body. Our schools must offer all students a chance to interact with music, as cited by the No Child Left Behind Act (2002), which designates music and the arts as "core academic subjects."

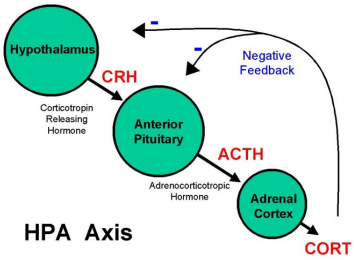
Stress

Stress is a threat, real or implied, to homeostasis (Ley & Yelich, 1998). A stressor is "any situation or thought that makes you feel frustrated, angry, or anxious" (Vorvick & Rogge, 2008). Stressors, or thoughts, ideas, objects, etc., which cause stress vary by individual. What stresses one person may not necessarily stress another (Vorvick & Rogge, 2008). Homeostasis is the maintenance of vital physiological systems necessary for survival, such as the respiratory system and the nervous system. Homeostasis applies to limited systems which are maintained over a narrow range and do not adapt to the environment (Ley & Yelich, 1998). The most common response to stress is the fight or flight reaction. Physiological symptoms of stress include hyperventilation, enhanced anxiety and worrying, and increased heart rate (Ley & Yelich, 1998).

Stress can be identified by behavioral changes - mood swings, out of character actions, changes in sleep patterns, sighing, crying, nail biting, hair twirling, making clicking noises with the mouse, and difficulty completing school work (Hale, 1998). Hyperventilation and blood pressure are often used as physiological indicators of stress. While stress has various negative effects, it can also have positive effects. Eustress is a positive stress which motivates an individual to complete tasks which they would otherwise not complete.

Stress causes in the release of corticotrophin releasing hormone (CRH) by the hypothalamus in the brain, which triggers the release of adrenocorticotrophic hormone (ACTH) by the pituitary, resulting in the release of cortisol by the adrenal gland (McEwen, 2000; Figure 1.1 Illustrates the Process, Figure 1.2 Shows the Structure of Cortisol). Cortisol causes many of the described stress symptoms listed above. Caffeinated drinks, including coffee and popular energy drinks, results in the increased release of cortisol while undergoing mental stress (Lovallo, Farag, Vincent, Thomas, & Wilson, 2006). Cortisol levels follow a specific schedule for well rested individuals (Van Cauter,

Juniors Projects



The Effects of Music Listening on Test Anxiety (Cont.)

Knutson, Leproult, & Spiegel, 2005). When on a sleep restricted schedule, abnormalities become prevalent in the release of cortisol; levels are higher in the early evening (Van Cauter et al., 2005). Cortisol har,s memory performance, a key component of test-taking, increases blood pressure, and has wide biological effects (Newcomer et al., 1999).

Many students perceive test taking as a form of stress, confirmed by Ley and Yelich (1998) from their measurement of increased hyperventilation in students. There is a strong negative relationship between stress and test performance, with students suffering from test anxiety scoring fifteen points lower, on average, on standardized tests (Bradley et al., 2007).

Anxiety

Anxiety is, "a feeling of apprehension or fear". Whereas stress is a reaction to specific stressors, anxiety may not have an identifiable cause. Anxiety is often accompanied by physical symptoms, including: twitching or trembling, muscle tension, headaches, sweating, dry mouth, difficulty swallowing, and abdominal pain. Anxiety can also causes dizziness, an irregular heart rate, rapid breathing, fatigue, irritability, sleeping difficulties and nightmares, and a loss of concentration. Anxiety is often a result of chronic stress, but it is also a result of specific tasks, referred to as performance anxiety. A poor diet and the occurrence of traumatic events can also contribute to anxiety. Further, excessive anxiety may result in a generalized anxiety disorder, phobias, or obsessive-compulsive disorder (Vorvick & Rogge, 2008).

Anxiety can be classified in two general groups: trait anxiety and state anxiety. Trait anxiety describes our overall anxiety. An individual with high trait anxiety experiences a high amount of overall stress, whereas an individual with low trait anxiety experiences less overall stress in general.

State anxiety is the measurement of anxiety in a specific situation. State anxiety is a side effect of the stress caused by a certain situation. The individual perceives the event as a threat. An individual with low trait anxiety can still experience state anxiety in certain situations, such as giving a speech, performing a piece of music, taking a test, or completing a proposal for a research project (Lesiuk, 2000; Bradley et al., 2007). Students undergo a subcategory of state anxiety commonly referred to as test anxiety. The test acts as a stressor which the student perceives as a threat. This heightened stress lasts as long as the student is required to deal with the test (Bradley et al., 2007; Figure 1.3 Illustrates the Process). Surveys of two school districts in California found that sixty-one percent of students experience test anxiety, and twenty-six percent of students experience high levels of test anxiety (Bradley et al., 2007). Students experience this anxiety while studying for the test, before, and during the test.

Receptive Music Therapy

Music is an anxiolytic for the human body. Music acts as a form of communication where the performer makes use of a medium, air, in order to send information, the sonic patterns of music, to the receiver (Cross, 2005). Music is as a "formal eliciting code," whereby music, the sound waves or "acoustic codes" are synthesized by the brain in a highly effective cognitive process into "representational codes," which our brain is consciously aware of, and which elicits psychological and physiological responses (Bharucha, Curtis, & Paroo, 2006). Humans have the cognitive ability to distinguish one sound from another; we can tell the difference between the sound of a car engine starting and the sound of a Mozart violin concerto. Both the melodies of music and the rhythms of music influence individuals. Oftentimes though, music does not emotionally affect individuals. Our daily exposure to music is generally heard by car radio or by walking down the streets, and these experiences comprise a large portion of our overall music experiences. In most of those instances we are not consciously aware of the music as it is merely a background noise with no emotional layers attached (Kone?ni, 2008). Although music does not induce emotion, it may represent emotion, and in certain instances, we may find emotion in the tone, pitch, and timbre.

When using music as a relaxant, the degree of liking has a strong correlation with the degree of relaxation. People react to music in a highly individualized manner. Stratton and Zalanowski (1984) found that "the single factor most closely related to relaxation was degree of liking for the music." Designating music as calming or relaxing does not indicate that it will calm or relax all individuals; in fact, individual stress may increase when an individual does not like the music being played (Stratton & Zalanowski, 1984). Preferred music calms an individual while disliked music causes discomfort (Cooper & Foster, 2008). Their study also found that different types of music do not, on a general principle, reduce stress more than others. More recent studies indicate that the relaxation associated with music occurs due to the numerous ways that music is processed by the brain, and that preferred music helps lower stress and contribute to "wellness" (Krout, 2007). Rather than subjecting individuals to a preferred genre, listening to preferred artists or even songs gives individuals a better control over stress and anxiety, especially when completing stressful tasks in work environments (Lesiuk, 2005b, 2008). While music can help most individuals, people with high-

The Effects of Music Listening on Test Anxiety, (Cont.)

trait anxiety respond worse to music therapy than other individuals (Lesiuk, 2005a). Serious and focused individuals tend to use music to decrease a state of arousal, and are less excited by music (Lesiuk, 2005a). They also suffer more from their stress than individuals who claim to be extroverted and cheerful (Lesiuk, 2005a).
Music helps task completion and helps to facilitate conversation and decrease stress in groups (Ullmann et al., 2008). In a work environment, preferred music helps people complete stressful duties faster. Individuals spend less time on task, increase their quality of work, and have a better more state of mind when listening to music (Lesiuk, 2000, 2005b). This leads to an overall better work environment and happier subjects.
Sedative music, or calming music, usually slow and sad, decreases heart rate and respiration, and is also, generally, both pleasant and calming to the listener (Khalfa, Roy, Rainville, Bella, & Peretz, 2007). In a study by Knight and Rickard (2001), sedative music served as an anxiolytic. When preparing for a difficult speech, subjects exposed to sedative music felt less stress when music was present. The study found that music was "capable of preventing the significant increases in subjective anxiety, systolic blood pressure, and heart rate caused by a cognitive stressor." Slow music relaxes the listener (Khalfa et al., 2007). On the other hand, music with a faster tempo decreases the amount of time necessary to make an informed conclusion when performing difficult and simple "decision-making" tasks (Day, Lin, Huang, & Chuang, 2008). A fast tempo also stimulates physiological response (Khalfa et al., 2007). The perceived "emotion" of the music may also influence the listener. Happy music stimulates a listener, while sad music relaxes (Khalfa et al., 2007).

Receptive music therapy also has many clinical uses. In hospital settings, it is used to decrease the stress and pain of patients. Music decreases the anxiety of patients undergoing a variety of surgical procedures (Mitchell, MacDonald, & Knussen, 2008; Guétin et al., 2009; Agwu & Okoye, 2007; Yu, Liu, Li, & Ma, in press). Other studies indicate that patients in waiting rooms benefit from music as well (Cooper & Foster, 2008). Music is a key factor in an individual's overall wellness and health. After undergoing music therapy, patients of painful procedures have shown reduction in heart rate and respiratory rate (Chan, 2007). Music reduces overall anxiety for patients and helps them cope with illness (Guétin et al., 2009). Music has many key benefits for the human body, specifically for our mental wellness. Music listening is an important mental task which affects our perception of life, and of our own mind and body.

Hypothesis

Three hypotheses will be tested. First, state anxiety posttest scores in the experimental condition will be significantly lower than pretest scores after listening to music (at the $p < .05$ level). Second, subject state anxiety posttest scores for the experimental music listening group will be significantly lower than those in the control group (at the $p < .05$ level). Third, subject posttest test scores will be significantly higher than their pretest test scores in the music listening group (at the $p < .05$ level).

Conclusion

Music listening in an educational environment may help both students and teachers to reduce stress. Although there are many benefits to testing for use in comparing students and measuring learning, test anxiety takes a large toll on students. Schools ought to teach coping methods to deal with stress prior to taking an examination.
The results of this study will function in two ways. First, they will confirm the effects of music listening on adolescents, on which there have been few studies done. Second, they will confirm that music therapy will help reduce mental stress. Music is an important aspect in our lives, not only on an aesthetic level, but on a practical level. Even listening to music at home can help reduce stress in our lives (Krout, 2007).
The findings of this study may also have large applications for studies of education in general. The importance of music courses goes far beyond having a well-rounded education; music therapy can be used beneficially, and with ease, to treat high anxiety students and students with behavioral or physical disabilities (Sausser & Waller, 2006; Beathard & Krout, 2008). Music can also help teachers gain better control over their classrooms by lowering the anxiety of both themselves, their students, and their co-workers, as well as giving students a further reason to become involved in their education (Jackson & Joyce, 2003). Using this paradigm, teachers can use music as a both a reward and a joyous experience for the entire class. When students are able to learn to use a new mechanism to cope with stress, they will be able to use it for the rest of their lives (Hesser, 2001). Music can also help students learn; studies show that training in music boosts verbal memory skills (Donn, 1998). An education system has multiple functions. Its first and most outward function is to provide a basic education for all American citizens and residents in order to have a functioning society. Its second function is to provide students with a moral education and a work ethic so that they may provide for themselves in the future. The final and most important function of an education system is to teach students how to cope with newfound responsibilities and the anxiety of

Stressor → Threat → Anxiety

Juniors Projects

The Effects of Music Listening on Test Anxiety, (Cont.)

maturing to the point of self-dependence. Music possesses the strength to heal and mend the body and mind.

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A Biomechanical Analysis of the Pitching Motion in Relation to Rotator Cuff Pathology, by Daniel Briggi. Excerpt of Research Proposal.

Mentor: Dr. Christopher Ahmad, Columbia University College of Physicians and Surgeons

The overhand throwing motion is one of the most unnatural in all of sports. With every throw, the rotator cuff essentially holds the shoulder together by counteracting extreme forces to keep the humeral head centered on the glenoid. The repeated stress placed on the tissue supporting and surrounding the shoulder can substantiate in the form of several conditions, including bursitis, subacromial impingement, and general degeneration of tissue. Bursitis is defined as swelling of the bursa, a sac of fluid acting as a cushion in the shoulder. Subacromial impingement as contact between the posterosuperior aspect of the glenoid and the undersurface of the rotator cuff that occurs when the arm is in abduction and external rotation, or the "cocking phase" of throwing (Dodson, 2007, p.92). Such injury would typically be treated non-surgically, with injections and therapy. Surgical intervention is the last resort for the attending physician. Full thickness tears (FTT), typically require surgery. However, in the case of a partial thickness tear (PTT), surgery is not always necessary (Björnsson, 2010, p.112). Prior to surgical intervention, the patient will undergo roughly three months of treatment with the goal of restoring range of motion and reducing or eliminating pain. The cessation of throwing, coupled with anti-inflammatory medication, works to reduce pain to the point where physical therapy is tolerable for the patient. Strengthening the rotator cuff, as well as the muscles surrounding it, is essential in the restoration of original function. In addition, to prevent the range of motion limitations that typically accompany this program, emphasis should be placed on stretching, especially of the posterior capsule (Dodson, 2007, p.126). When either the tear is too severe to heal naturally or the physician observes too little improvement, surgery should be considered (Dodson, 2007, p.128). Both arthroscopic and open techniques are commonly practiced, with a general tendency to use arthroscopic meth-

A Biomechanical Analysis of the Pitching Motion … (Cont.)

ods because of a reduction in the formation of scar tissue, reduced deltoid muscle trauma, and overall improvement in function (Ling, 2008, p. 264). By perfecting the techniques used to rebuild the rotator cuff and defining an improved program for rehabilitation, as well as finding new ways to prevent such injury, patients will experience better outcomes and therefore higher quality of life. In addition, professional athletic leagues will be able to keep their best players on the field, maintaining the highest levels of competition and saving teams from losing millions of dollars in investments.

Problem

According to Burns (2008), the number of rotator cuff surgeries is increasing with time. This trend is leaving a greater number of individuals out of work, in pain, and with a general loss of function for the affected limb. Both in the elder population in which joint degeneration is predominant and in the younger, athletic population in which overuse is the leading cause of injury, rotator cuff injuries can be significantly detrimental in aspects financial and regarding quality of life.

Dartfish

Dartfish is motion analysis software that has been implemented across the world of athletics. From U.S.A. soccer and luge to Olympic diving, softball, and Tae Kwon Do, the program has provided an effective means of collecting and analyzing data. Professionals, amateurs, and researchers alike have used the software to break down athletic movement. It has been and can continue to be applied to baseball for all facets of the game, and proves cogent for pitching evaluation. The program's numerous capabilities give it this potential for application. Overlays allow two different pitchers to be compared or provide the opportunity to measure the consistency of delivery for a single pitcher. The ability to draw angles at joints allows for measurements to the tenth of a degree. Stro-MotionTM tracks the motion of an object, in this case a baseball, through the video.
For the purpose of this study, angle measurement and video overlays will be most useful in providing an analysis of the throwing motion.

Questions

Could throwing mechanics dictate the probability of injury?
Is prior injury observable in the mechanics of pitchers over two years post-op?

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Improving Communication Technology in Large Business Environments, by David Eisenberg. Excerpt of INTEL Paper.

Mentor: Erik Rogers, Managing Director, Enterprise Architecture, Bank of New York Mellon.

1. Introduction

Large businesses are often slow moving when it comes to embracing new technologies. Due to the nature and size of these entities, technology acquisition and integration can be a tremendously difficult and costly task. As global markets begin to undergo rapid change, however, multinational and globalized businesses are increasingly dependent on technology in order to increase productivity and communication around the globe (Rycroft 2003).
In order to take advantage of new technologies, companies must be able to identify, select, and integrate the technology into the existing enterprise architecture effectively. Information Technology (IT) members must not only be able to measure the value of the technology within the business to justify its cost, but they must be able to encourage and foster usage in a way that allows employees to incorporate the technology into everyday practices. When technology related purchases can result in millions of dollars of costs for a company, having systems in place to evaluate when a purchase is beneficial or necessary is vital for success. Unfortunately, little attempt at unification has been made to detail how a company ought to complete this process. Finding methods to measure productivity and collaboration are difficult, especially in a large company where it is hard to measure behavior on a small scale. We present three central issues concerning collaborative technology research – (i) the application of laboratory research to real-world conditions; (ii) methods to evaluate whether a collaborative technology results in beneficial impacts; and (iii) ways to predict and encourage technology adoption and integration. Next, we conduct a case study within a large financial services company that is experiencing many of these problems. Finally, we detail the desired approach of future research.

2. Literature Review

2.1 Laboratories and Businesses

It is important to examine how a large business differs from a small scale laboratory or aca-

Seniors Projects

Improving Communication Technology ... (Cont.)

demic environment. As our analysis takes place completely within a large company, the differences between the settings serve as experimental variables that can have significant impacts on results. Much of the research done on collaborative technologies has taken place in a laboratory, and it is important that the impact of those experiments is assessed.

One of the primary differences between the environments is the overall goal of the institutions. While it is clear that a laboratory is interested mainly in the pursuit of scientific knowledge, businesses typically have other priorities. Increasing productivity levels and fulfilling shareholder obligations, for example, are two components that are not shared. This is a functional difference that impacts the way in which data is analyzed – "successful" research would result in the fulfillment of the company's primary goals. To assess how technologies perform within a real world environment, it is therefore essential that we consider the application of technology research to practical and real-world scenarios.

This difference can further be seen with collaborative technologies in particular. Any technology rollout must fulfill business prerequisites before the business value of the technology can be determined. This can include making sure the technology is secure, interoperable with current IT systems, customizable, and tailored to the company's specific needs and goals. High levels of user satisfaction, a quality sought after in a consumer environment, is something that a business may view as secondary to the effectiveness of the product.

Conducting research within a corporation also introduces complex social dynamics that are unique to the environment. Unlike a research organization, the majority of employees within a company have developed relationships with their fellow workers before research takes place. As a result, technology that promotes social behavior takes on a different role. Collaborative technologies would therefore be used more to improve existing employee relationships rather than foster new ones. Further, seeing how technology effects long term work relationships is an important component to consider when examining a collaborative technology that has limited relevance to other settings.

The effect of the environment, however, often delves deeper into the cognitive behavior of the individuals involved. Levitt and List 2007 examined how real-world applications of laboratory studies effect social preferences. Levitt and List compared empirical and experimental data from a variety of different sources and companies, and found that decision making can alter significantly especially when the employees cannot always be observed and monitored. In specific dictator and ultimatum games, where individuals are assigned to bargain over a specific amount of money, more generosity was observed when anonymity was not protected. In addition, significant effects were illustrated depending on the context of the decision; whether the participants were told that they were playing in a "Community" or "Wall Street" game one affected the overall outcome (Ross and Ward, 1996).

While laboratory experiments place a large emphasis on the decision making process, Levitt and List argue, real world decisions are often based on other social factors to create a more dynamic environment. Although such conclusions were drawn pertaining specifically to economic studies, the implication extends towards social preferences in general. List furthered his examination of this dichotomy recently (List 2009) and expanded upon a framework of how decisions with social preferences, as opposed to self-interested motives, are considered and formulated. Five major influences were identified as contributors for decision making along with financial considerations. These include ethical considerations, scrutiny by others, the context of the decision, the pool of individuals involved, and the "stakes of the game." Other research has expressed similar conclusions, but a lack of truly relevant and repeatable data still exists.

In a large business, it is clear that many of these factors play a significant role and can certainly impact decision making. Choice is often heavily defined and limited by ethical considerations, and scrutiny by a fellow employee or manager is definitely a concern. Further, the context of the decision is quite unique and the stakes of the decision can vary greatly depending on the specific circumstances (List 2009). Often, however, the direct financial impact of a decision made by an employee may either be unknown or convoluted to the point where no causal relationship can be established. While employees may be aware that the company or department they are working within may be important or critical for the business, it is unclear how this effects daily decision making. This speculation is unsuitable for a large business where critical applications and processes rely on actionable data. Current research only has limited applications to such an environment, and more research must be done in order to determine how a business with a hierarchal structure affects the way individuals make choices in regards to collaboration technologies. Without the ability to easily analyze and quantify data, business are forced to make technology decisions that may have little empirical basis. As a result, many of these companies may seek to base their technology integrations on information gathered from third parties or vendors. From an objective point of view, however, this does not adequately

Improving Communication Technology … (Cont.)

address the companies' needs as not only is there a financial conflict of interest between the parties, but the information gathered would not specifically pertain to the companies' themselves.

The large business environment also presents other unique challenges that are not reflected in small, laboratory trials. Many of the employees in large businesses can be scattered across the world and can adhere to different cultural and interrelational values. This makes it essential that the technology be usable and physically accessible to all users of a company. Research has shown that technology usage and adoption rates differ between different cultural groups (Rowe et al. 1999). Rowe et al. asked media users to associate different communication mediums with certain cultural values. It was found that cultures that value entrepreneurship and innovation are more apt to choose a newer communication method than an antiquated approach. This has a direct relation to the pool of individuals involved in a social decision and can have widespread impacts depending on the employees within a company.

The lack of available literature in this subject is due to many reasons. The risk of performing an experiment that could possibly result in a loss in revenue for a company without any measureable gains means that businesses will often adhere to standard and established practices even if newer methods may seem more applicable. Furthermore, large companies are often critical about releasing internal information as doing so can expose strategies or weaknesses that can damage the competitive advantage the business has over its peers. Corporations are much more likely to listen to statements and research conducted by vendors as a pragmatic and easy solution. While vendor research can be useful for preliminary examinations, the research is ultimately detached from the company and cannot be assumed to have the same level of relevancy as an internal study.

2.2 Business value of collaboration

In order to determine the success of an integrated technology, companies must have standards by which they can accurately and reliably judge the effectiveness of the integration. However, this is not always a simple task. Without detailed comparative metrics, companies have little way of distinguishing between competing technologies. Furthermore, in situations where comparable quantitative metrics are not available, determining what data to collect and analyze can be extremely difficult. As a result, companies can make costly decisions to pursue new technologies without knowing the full impact of their decision.

Collaboration can be defined simply "…mutual engagement of participants in a coordinated effort to solve [a] problem together" (Dillenbourg et al. 1996). When collaboration is discussed in the context of a business, it often refers to a way of working that rejects traditional organizational hierarchies. Collaboration instead takes on a heterarchical approach in which all participating members of an organization have equal opportunity for input. The benefits of such work seem to be clear – collaboration has been seen as a mechanism for teamwork and efficiency (Hanumantharao & Grabowski 2006). To capitalize on this concept, many hardware and software companies began producing and marketing collaborative technologies to businesses. This has included instant messaging software, Web 2.0 services, and audio and videoconferencing (Denstadli 2004). One of the problems with the concept, however, is to determine the way in which collaboration can most easily be measured. Typically, collaboration is measured through a proxy – most often, this in the form of performance analytics or surveys.

Using a performance metric such as cost reduction or efficiency measurements, while useful, does not measure the intrinsic benefits of collaboration itself. Such methods focus mainly on a limited scope and collect mostly ends-based data. These measurements are often beneficial for testing collaborative learning (Wang 2009) (Prinsen et al. 2009) (Ertl et al. 2006) (Fletcher et al. 2009) to see the overall improvement of the performance of a task before and after using a learning tool, but are not suitable for corporations where a holistic view is needed. Further, these types of measurements make two fundamental assumptions. First, these measurements assume that the technology that has been introduced is inherently collaborative. Second, they also assume that there is a direct correlation between the introduction of the technology and the performance metrics measured (Susman et al. 2003). In addition, in scenarios where this sort of data is not available or easily computable, quantitative analysis is not always feasible. Such is the case often in larger and global organizations. The full consequences of small-scale employee decisions cannot always be determined easily, and the impacts of collaborative software in a large business are more often social than financial.

Using an employee survey also does not adequately measure how well a collaborative technology performs. While surveys may be adequate for controlled laboratory experiments with a small number of participants, administering a survey to employees can be costly and time-consuming. If a survey is forced upon employees, gathered responses may not reflect true opinions. If the survey is left optional, low response rates are

Seniors Projects

Improving Communication Technology… (Cont.)

common. Since no standardized survey to measure collaboration has been established, surveys designed by companies would likely have little statistical significance and inconclusive results. Surveys measuring collaboration have been created, (Lee et al. 2003) (Freidman et al 2007) but they apply mostly to collaboration between different companies and do not address the issue within an organization itself.

Surveys also possess inherent problems that limit their usefulness within a large company. Designing a survey can be a difficult task and cultural boundaries can skew survey results (Rowe et al. 1999). Further, Nowak et al, 2009 demonstrated that surveys can be unreliable as the users themselves may not be able to determine the effectiveness of different mediums. Their study examined various asynchronous and synchronous communication methods, and then compared the end result of their assigned tasks with users' opinions of the communication mediums. When asked if they were satisfied with the technology they used, the users expressed higher levels of satisfaction and perceived usefulness of older, less efficient technologies than newer, ultimately more productive ones. Simply asking how collaboration has been affected by a technology, therefore, is not an effective measurement especially in a work environment where employees are more likely to report positive feedback to please their employers.

2.3 Technology Diffusion

Measuring the success of a collaborative environment is not the only issue large companies face when integrating a new technology. Once a technology is chosen, the product must be adapted, customized, and tailored for the business' specific needs. Especially as new communicative technologies begin to saturate the workplace, IT managers and software integrators within a business are continuing to search for the best ways to introduce and encourage adoption of a collaborative system. Technology rollouts can be extremely costly, and a system that is not adopted by an adequate number of employees may be seen as a waste of valuable resources, time, and money. There is a variety of literature attempting to define and characterize a model for technology adoption.

One of the most widely accepted models, the Technology Acceptance Model (TAM), characterizes technology acceptance as a combination of a user's perceived ease of use and perceived effectiveness of a medium (Davis et al., 1989). There are shortcomings in the model, however, as the model only reflects general concepts that greatly simplify human intent and behavior (Bagozzi, 2007). Furthermore, the model fails to mention specific practices or techniques to implement in order to have high levels of these constructs. In this manner, TAM serves more as a goal rather than a guideline and cannot be used as a predictor for future success. When working within a corporation, having clear procedures is a necessity for technology integration and adoption to run smoothly. In addition, while frameworks such as TAM attempt to show how users adopt technology, the framework does not examine the actual effectiveness of the technology itself, which is more important to a corporation than what users feel about the medium.

Since the introduction of TAM, a variety of different diffusion models have been produced and studied. The Unified Theory of Acceptance and Use of Technology attempted to expand upon TAM and other early adoption models by including the users' age, gender, experience, and other social factors as variables for adoption (Venkatesh et al. 2003). The Technology-Task Fit model is a performance based model which designates how well the technology fulfills a specific need as the main variable for usage. Nine factors are specified: quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability, and the relationship the technology has with the users (Goodhue and Thompson 1995). One of the newest adoption models, the Lazy User Model, takes a new approach. Instead of focusing on functionality or social factors as primary variables, the Lazy User Theory contends that users will gravitate towards methods that require the least effort as long as the possible solutions are functional (Tetard, & Collan 2009). The technology user is therefore defined by his or her need and limited by the user's current state. The user then selects the easiest solution from the options available. While the model was first drafted to explain trends in e-business and commerce, the theory has applications to information systems.

Studies of diffusion observe and analyze the factors that accelerate or hinder the speed at which new users begin to accept a particular system. While it is easy to assume that diffusion will occur quickly in situations where user perceptions are high, often the diffusion occurs at slow rates and the technology loses a portion of its potential value. There is a wealth of literature on how factors affect the speed of inter-firm diffusion, but there is a lack of empirical research of how intra-firm diffusion occurs and what factors are at play. Studies such as (Fuentelsaz et al. 2003), (Battisti & Stoneman 2005), and (Hollenstein and Woerter 2007) have begun to illustrate how different types of diffusion act independently. Variables such as firm size and the level of training available affect the rates of intra-firm diffusion more so than inter-firm. Regardless, the study of

Improving Communication Technology… (Cont.)

how diffusion occurs within a company "has largely been neglected" (Battisti and Stoneman 2005) and more research should be conducted.
(…)

4. Conclusion

Collaborative technologies are becoming important and integral components of global businesses. The level of scientific data available, however, has yet to catch up with the fast pace of growth. It has been demonstrated that this lack of knowledge effects collaboration at all stages throughout the integration and adoption process. The unique setting and dynamic of a large business indicates that separate and comprehensive research must be conducted within such an environment in order to develop a unique framework for experimentation.

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Preference for Goal-Directed Action in Infancy and at 4 years old , by Allison Gofman. Semi-Finalist INTEL Paper Excerpt.

Just like the baby who gleefully watches a bird fly while ignoring the toy in front of him, people must distinguish through the multitudes of objects in their sight, and decide which are worth attention. The decision often takes into account agency, defined as the assumed possession of mental states such as thoughts, emotions, or will (Johnson 2000). The mental states that agents are assumed to possess can be described as a "mind" analyzing its surroundings. While objects remain constant in composition and action, human beings and other agents constantly change goals and personality, making recognition theoretically difficult. However, many characteristics have been attributed to characterization as an agent, including the action's effects (Biro & Leslie 2007), appearance of rationality (Gergely *et al.* 2002), self propulsion (Baron-Cohen 1995) or by the existence of goal-directed action, regardless of the actor (Csibra *et al*. 1999).

Generally, past experiments have quantified recognition of agents by measuring the degree to which infants track them, typically though looking time. Tracking is the physical and mental process of following or monitoring, but as physical tracking implies that there is a reason for the item to be tracked, for experimental purposes, physical tracking implies the existence of mental tracking as well. Much research on infant expectations of causality and agency are predicated on the discovery that infants tend to look longer at novel or unexpected situations then at familiar and anticipated events.

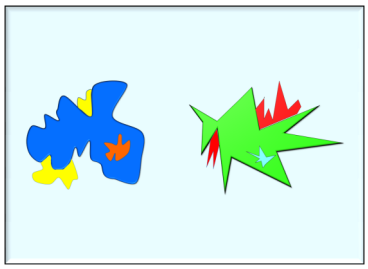
Studies have shown that infants do not interpret all motions as intentional, but can distinguish between purposeful and accidental actions as early as five months, although not necessarily drawing conclusions about the nature of the actor at such a young age (Woodward 1999). By 6 or 7 months, however, infants are able to recognize self-moving and intentional agents from inert objects in more complex situations and with more sophisticated analysis and extrapolation (Leslie & Keeble, 1987; Kotovsky & Baillargeon, 2000; Pauen & Trauble, 2006; Woodward, 1998; Woodward, Sommerville, & Guajardo, 2001).

The present experiment hopes to connect two well-established sets of research in a novel way. The first is that discussed above, regarding the various cues that infants use to deter-

Mentor: Dr. Rebecca Saxe, Massachusetts Institute of Technology.

Seniors Projects

Preference for Goal-Directed Action...(Cont.)



mine and attribute agency (Biro & Leslie 2007, etc.). The second is that of early preferences. The primary recent field of research on infant preferences has focused on face preference: infants have been found to be preferential to human faces over non-human faces from immediately after birth (Johnson et al 1991). This research is typically highly controlled, offering infants a choice between two stimuli, one face-like and the other not, either through reversal of feature organization or lack of polar contrast (Farroni et al 2005, Morton & Johnson 1991). A recent unpublished study, however, attempted to determine the practical functionality of this face preference: infants were presented with a naturalistic scenario (clips from Baby Einstein videos, which have been shown to keep infant attention) to establish whether the face-preference could override competing preferences present in real life, such as color, motion, etc. Preliminary analysis has shown that face preference does seem to be an overriding preference in many cases from an early age. Faces are a prime example of an agent, as they represent humans. The present experiment aims to identify whether infants have a similar preference for non-human agents.

Many recent agency-recognition studies have focused on infant reactions to non-human agents, typically "morphologically ambiguous objects" (or novel objects) that the infant will have never seen before (Johnson 2003). These objects eliminate the innate predisposition to humans, and thus achieve results that are more functional. While most objects used in the experiments are of odd shapes, experiments with different sets of characteristics have found that faces and eyes, self propulsion (Baron-Cohen 1995) and interaction, either physical or verbal interactions are important factors in identification as agents (Spelke *et al.* 1995). S.C. Johnson found that 15-month-old infants can reenact inferred and unseen goals of non-human agents (in the study, a stuffed orangutan) (2001). Not only did the majority (52%) of infants imitate the action that the orangutan completed, but a large part (37%) completed an action that the orangutan had attempted but failed to do. To compare the effects of physical characteristics, the same procedure was done with an object lacking a face or limbs: a common lamp. While it appeared to interact with the actor similarly to the orangutan, infants had significantly lower rates of return interaction and imitation (Johnson 2001). Another recent study focused on whether infants attributed goal-directedness to an interaction or to a specific being (Saxe *et al.* 2007). Experiment Three of the study presented infants with a beanbag being thrown from behind a box. 10 and 7-month-old infants were able to use the motion of the beanbag being thrown to infer the position of a hand, not of a toy block, suggesting that preverbal infants expect a causal agent as the source of motion of an inert object. However, the experiment allowed numerous extraneous factors to influence the results: by using agents well known to infants (a hand and train), preconceived assumptions of agency could easily have factored into the determined infant attribution of agency to the possible agents (the toy block and the hand). The results of the study confirm the ability of infants to attribute agency to a specific actor – key to the methodology of the current research – and also reinforce the necessity of using novel objects to avoid the effects of extraneous factors.
(...)

Discussion

Combined, the two experiments contribute to a growing body of literature examining infant cognitive development. The fundamental benefit of using novel objects is that we are essentially giving infants a "blank slate" by using unique objects, eliminating the effects of previous experience. Thus, infant looking time represented only preferences that were developed during the course of the experiment.

The looking time throughout the various analyses showed very little change, and very little preference. As it is established ealier that infants are able to differentiate agent from non-agent at the ages tested, there are several potential explanations for the results.
The first is a possible fault of the stimuli. Informal survey of adults found that while many did consciously recognize that one of the characters was goal-directed while the other is a physical object, a significant number did not make that connection. Thus, while the data does support the hypothesis, further research with more representative stimuli would strengthen the results. The motion of the stimuli could be altered to provide stronger implications of agency, for example by having slightly longer and more complex stimuli that allow the agent more opportunity to show a "mind". The toddlers interviews do, however, seem to indicate that at four years old the subjects were able to see a difference.
It is also possible that the hypothesis is false, and that infants do not exhibit a preference for agents even if they distinguish them.

The toddlers analysis was less robust due to the smaller sample size. The results, however, demonstrated a very strong trend towards a verbal (conscious) preference toward the agent, and accurate extrapolations of an agent's actions. This to some degree solves one of the problems of the eye-track data; namely, that it is impossible to evaluate why that preference exists. Motion,

Preference for Goal-Directed Action...(Cont.)

or answers that discussed the way in which the character moved (for example, "That one always get to that star") was the most common answer. Statistical analysis showed that despite the small sample size, there was a less then 5% chance that the overall preference for agents was by chance. While a larger sample size would help validate the data, there is at least preliminary support for the hypothesis that by four years old, toddlers are not only able to differentiate agent and non-agent (already well documented) but have a conscious and unconscious preference for them.

Future Research

With several statistically significant results and several neutral results, many possibilities for future research are suggested. There are several ways in which the stimuli could have been the cause of the neutral results. Although the sample size is insufficient to draw decisive conclusions, the interviews with toddlers strongly suggest that color and shape play significant roles in the subjects' perception of the stimuli. As such, altering these characteristics to be more similar would minimize the extraneous differences. The two stimuli each had a 'cool' color as their base (green and blue); however, one had red accents while the other was orange. It is well documented that infants are attracted to bright red colors, so it is possible that this choice affect the results. Further, one stimulus was significantly angled, while the other had smoother, more rounded edges. Several toddlers indicated the shape as reasoning for their preference and agent extrapolation, making it more possible that this difference was important. However, fewer differences between the stimuli could make it more difficult for infants to distinguish between the two characters, and remember them, thus possibly skewing results further.

Another direction for further research could be the method of comparison. Older children tend not to be as interested in stationary images on an eyetracker, and are moderately less likely to exhibit a preference in such a situation. It may be possible, along with the stationary pre- and posttrials, to show the two characters in motion in the same environment on a split screen and compare the amount of time spent looking at the two scenarios. While this is more difficult, it could potentially garner interesting results.

Finally, extending the research into larger and more clearly defined age cohorts, as well as creating an adult group for a control could determine whether the results indicate that no preference exists or if it has simply not developed yet at the ages tested.

Implications

The research looks at infants development, how they think and see the world, providing educators and parents with important information on how to interact with them and best ensure their overall welfare. Especially in the second experiment, if infants are more interested in what they consider agents, then such things would make interesting toys, as well as more relevant educational examples and stimuli.

Combined with other research over the course of many years, developmental milestones in this area could eventually be used as a diagnostic tool for developmental delays and possibly autism. While this would require follow up research and confirmation, previous research has shown that "theory of mind" and agent recognition is strongly impaired in autistic children. Agent tracking has a significant place not only in infant development, but in autism research as well. Baron-Cohen et al. (1985) have hypothesized that autism is the failure to detect the goals of other agents, and specifically to fail to attribute mental states to them. One of the common signs of autism is the failure to follow other people's gaze, which can easily be interpreted as failing to understand the goal-oriented nature of the motion given patients' typical difficulty in assigning mental states. However, studies have found that autistic patients are able to interpret agency in situations modeled after those used for other studies, as modeled above. These results imply that mere distinction between agents and non-agents is not sufficient for a normal "theory of mind" and agent tracking, but that additional mechanisms must be in place (Johnson 2003). Depending on how strong the ability is at various ages, individual infants could be tested to compare their ability to the average. The ability to distinguish agents is an ability crucial in life, and a preference towards them provides illumination into the mind of the child and human.

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