Hendrick Hudson
High School

Science Research

May 2016

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Science Research

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Dr, Christine Rogers received a 2015 INTEL STS Badge and a Teacher of Merit Award.

Jane Milcetic entered the INTEL STS competition.

Jane Milcetic received the Research Report Badge for well-written, college-level, journal-style research report

This year we had great success with our students, who both competed at the Westchester Science and Engineering Fair (WESEF), the largest regional fair with over 500 projects from Westchester schools and at the Tri-County competition. Jane Milcetic, a senior, placed Third in the animal science category for her project. She also competed at the Westchester-Rockland Junior Science and Humanities Symposium (JSHS), where she placed 5th as a speaker in the Biology category. Her project, "The Preference of Female Zebra Finches for Zebra Finch Males Based on Song and Proximity", was conducted under the mentorship of Erich Jarvis, at Duke University in his world-renowned laboratory studying bird song. In zebra finches, bird song is extensively studied as it reflects some very specific mechanisms of learning and can be associated with regions of the brain. Males are the only ones singing and their song is part of the mating behavior of the birds. Jane chose to study the behavior of the female, a significantly different approach, to see if only the song was critical to her response, or if the physical proximity was also an important factor. She found that females are very individualized in their choice of males based on various individual factors such as song and physical proximity. Her project opens the door to another aspect of the zebra finches mating preferences: the receptivity of the female. Jane entered the INTEL-Science Talent Search competition, where she received a Badge for a very well written college-level journal-style scientific paper.

Isabella Brizzi, a junior, won two awards at WESEF for her work on chemical dispersants: the American Meteorological Society Award and the Stockholm Junior Water Prize Regional Award. The American Meteorological Society Awards recognizes projects, showing a "creative and scientific endeavor in atmospheric and related oceanic and hydrologic sciences". The Stockholm Junior Water Prize Regional Award, recognizing top water projects, allows Isabella to proceed forward and enter the state competition with her research paper. Additionally Isabella placed Second at the Tri-County Science fair in the Environmental category. Isabella studied the best conditions to remove oil from oil spills in oceanic water, using a chemical dispersant. Her work is very important in optimizing the use of dispersants with minimal impact on the oceanic environment. She worked under the direction of Dr. Zhong Pan at the New Jersey Institute of Technology. She will continue her research this summer, expanding it and testing more conditions leading to the best use of chemical dispersants. Her work is extremely important and practical for environmental clean-up of oil spills.

WESEF is sponsored by Regeneron and Acorda pharmaceuticals.

The Preference of Female Zebra Finches (Taeniopygia guttata) for Zebra Finch Males Based on Song and Proximity

Jane A. Milcetic (INTEL STS Paper -excerpt-)

Abstract

Male zebra finches have been the primary subject of songbird study because of their individually distinct songs, leaving the females of the species largely disregarded. This study focuses on the role of females in mate preference based on the male's song and familiarity. The hypothesis predicts that females would consistently pick one male due to his familiarity and song frequency, no matter the amount of physical interaction. Females were tested using the two-way choice chamber and a new experimental setup that allows physical contact with one male and prevents contact with the other. Results showed that the majority of females did not show consistent strong choices between males, and that physical interaction had a variable effect. Song analysis focuses on the appealing characteristics behind certain males, and the motivation behind the females' preference. Consistent with previous studies, the data hints that female zebra finches prefer familiar males over novel males. This study aims to encourage the exploration of the female zebra finch's neurological processes when confronted with various mating scenarios that deal with varying degrees of male familiarity and contact.

Introduction/Review of Literature

Though love at first sight as yet to be proven, sound has a heavy impact on mate selection, as songbirds can attest to. The zebra finch (Taeniopygia guttata) has already been studied extensively for its song, which differs in each male (Woolley & Doupe, 2008). The majority of songbird experimentation has focused on the males due to the sexual dimorphism within the species (Hara et al., 2009; Whitney et al., 2014; Simonyan et al., 2012; Tchernichovski & Marcus, 2014; Tchernichovski et al., 2001). Yet, some studies in the last twenty years have begun to investigate how female zebra finches influence song by exhibiting receptive behavior and thus reinforcing the male behavior and song frequency (Tchernichovski et al., 1998; Campbell et al., 2008; Campbell & Hauber, 2009; Forstmeier, 2004; Forstmeier & Birkhead, 2004; Neubauer, 2000; Woolley & Doupe, 2008; Lauay, 2003). These recent studies have found that, generally, zebra finch females share a set of preferences across the species (Campbell, 2008; Neubauer, 2000; Lauay, 2003; Hauber, 2010; Forstmeier & Birkhead, 2004). They prefer songs of their own species (conspecific songs), stereotyped songs with little variability and faster tempo, and songs they have heard before (familiar) (Campbell et al., 2008; Neubauer, 2000; Lauay et al., 2003; Hauber et al., 2010; Forstmeier & Birkhead, 2004; Kao & Brainard, 2006; Sossinka & Bohner, 1980). Females must be raised around a male tutor until they are at least 35 days old in order to solidify her recognition of her species' song (Hauber et al., 2010).

Many studies have developed different experimental designs in order to assess the response of females to male song (Rutstein et al., 2007; Forstmeier & Birkhead, 2004). Some of these experiments have measured the attraction of the female through behavioral and spatial responses, but did so while preventing physical contact between male and female zebra finches in setups similar to the two-way mate choice chamber (Campbell et al., 2008; Neubauer, 2000; Campbell & Hauber, 2009; Hauber et al., 2010; Rutstein et al., 2007; Forstmeier & Birkhead, 2004). The two-way mate choice chamber prevents the female from physically interacting with the male, but still allows her to hear and see him, and ultimately lets her make a choice by remaining on one side or the other. Rutstein, Brazill-Boast and Griffith (2007) perceive cages - such as the two-way mate choice chamber – unnatural, as mate choice behaviors supposedly require a physical connection before copulation (Rutstein et al., 2007). Yet, Rutstein, Brazill-Boast and Griffith (2007) only compared the two-way mate choice chamber to dissimilar structures. In one experiment ("no-choice trials"), they placed a male and a female zebra finch in a cage for 5 minutes and measured the birds' interactions; in another ("aviary mate choice trials"), a group consisting of 4 females and 4 males were placed inside an aviary for approximately 24 hours, and observed for 140 minutes per group (Rutstein et al., 2007). Though the no-choice trials are most similar to the two-way mate choice chamber out of all their experimental setups, Rutstein, Brazill-Boast and Griffith

(2007) measured the effect of physical contact with three birds, while the two-way mate choice chamber utilizes only two birds. So, in using an unequal number of subjects, their comparisons have more than one important variable that differs, and thus the various aspects like dynamics between males (dominance and fighting) and female receptivity are lost within the experimental design (Rutstein et al., 2007).

Despite the number of studies that have tried to understand the attractive qualities of zebra finch song, most of their results suffer from natural inconsistencies (Forstmeier & Birkhead, 2004; Neubauer, 2000). Forstmeier & Birkhead's (2004) study tested for trends related to female zebra finch preferences of beak color, song rate, male aggressiveness, and found very little agreement in the tested females, except for song rate. There was an indication that females prefer males who sing more frequently. More importantly, only 45 of the 96 females showed a preference for one male, and only 22 of those 45 chose the same male in a second trial. As trials continued, less and less females continued to choose the same male, showing that very few females consistently pick the same male. Forstmeier & Birkhead (2004) attribute these results to the invariability of male appearance, the female's acceptance of various males, and lack of sexual motivation. While Forstmeier & Birkhead (2004) utilize a four way choice-chamber similar to the one Rutstein, Brazill-Boast & Griffith (2007) criticized, their realistic data demonstrate the nuances of working with animals and that results exhibit natural inconsistencies that nevertheless provide an indication of preference.

Considering that investigation of the female zebra finch's perspective has only become popular within the last twenty years, the results of all these experiments provide great insight into the bird's mind. Yet, the studies that seek to investigate reaction to song alone forget about a vital part of mating: physical contact (Campbell et al., 2008; Neubauer, 2000; Campbell & Hauber, 2009; Lauay et al., 2003; Forstmeier & Birkhead, 2004). Even though physical interactions may enhance the female's receptiveness to a male, no studies have measured if physical contact can be powerful enough to distract a female from a male she has already developed a preference for. Of course, many of the aforementioned experiments do possess a level where females may touch the males, but none have investigated if the male zebra finch's song is powerful enough to hold a female's attention while she is distracted by a physical interaction with another male (Rutstein et al., 2007; Forstmeier, 2004). Our study seeks to understand if the male's song alone, an important sexually selected trait of the zebra finch, can be more influential than a tangible mate with a physical interaction.

Goals of the Study and Hypothesis

This study uses the two-way mate choice-chamber (Figure 1) and a new arrangement (Figure 2) to understand how song without physical contact and song with physical contact affects females' preference for a male. The comparison of these two methods will allow insight into which factors influence a female's decision more.

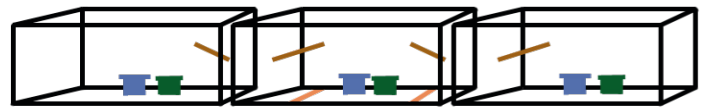


Figure 1: Experiment 1

Since previous experiments have shown that female zebra finches can choose between males based on their songs, the following hypothesis was formulated: females will consistently choose one male regardless of the amount of physical contact (Lauay et al., 2003; Campbell & Hauber, 2009; Hauber et al., 2010). The predictions below aim to test the hypothesis.

Predictions:

A. Individual females will consistently choose one male based on his amount of singing, and the familiarity of his song.

B. Females with the same father will consistently choose the same male based on the familiarity of his song.

C. Regardless of the amount of physical contact, females will pay more attention to the familiar male over the unfamiliar male.

(...)

Experiment 1: Choice Chamber

Parameters

All trials took place in metal cages approximately 20x20x40 centimeters situated with food and water placed in the center of each cage (Figure 1). The cages were situated so that each 20x20 cm side was around 2 cm from one another. The leftmost and rightmost cages contained one perch oriented towards the center cage. The center cage had two perches to face the left and right sides. In the center cage, two strips of orange tape, 10 cm from 20x20 cm side were placed to gauge the female's position. A white curtain visually isolated all cages from the surrounding environment, but the test subjects could still hear some calls from other zebra finches. An Apple iPhone 6S on HDR settings was used to record all trials.

Procedure

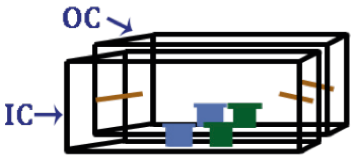
Starting around 11 AM, 2 males were transported from their housing cage to the testing cages. One male was placed in the leftmost cage, and the other in the rightmost cage. At the beginning of the day, males were given around 5 minutes to acclimate while visually isolated from one another by dividers. One female was then transported into the middle cage, and the trial began as soon as the barriers between the birds were raised. Five 15-minute trials were conducted per day using 2-4 males, depending on which female was being tested. Food and water were available at all times.

Experiment 2: Familiarity

Parameters

All trials took place in metal cages approximately 20x20x40 centimeters situated with food and water placed in the center of each cage. Two cages were placed so that each 20x40 side were approximately 1 cm from one another. The cage containing two birds had two perches on each 20x20 side, and the cage containing one bird had one

Figure 2: Experiment 2



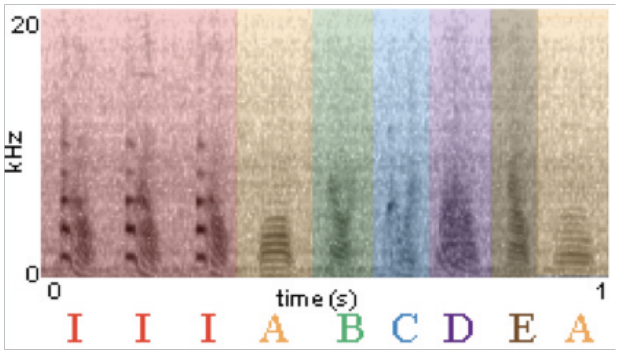


Figure 3. Color-mapped song of Black 441. Each letter and color corresponds to the syllables of Black 441's song, "I" meaning "introductory" and "A-E" meaning the following syllables of the stereotyped song.

perch on the right 20x20 side. A white curtain visually isolated all cages, but the test subjects could still hear each other's vocalizations. An Apple iPhone 6S on HDR settings was used to record all trials.

Procedure

Starting around 11 AM, 2 males were transported from their housing cage to the testing cages. One male was placed in the "In Cage," deeming him the In Cage Male (ICM) and the other male in the "Out Cage," deeming him the Out of Cage Male (OCM) for that trial. At the beginning of the day, males are given approximately 5 minutes to acclimate while in view of each other.

Females were separated into two groups: Delayed Contact (DC) or Instant Contact (IC) (Table 2). Females in the IC group were placed in the cage with one of the four familiar males they had seen in Experiment 1, and the unfamiliar male they had never seen before was placed in the adjacent cage for the first trial. Females in the DC group were placed in the cage with the unfamiliar male, and a familiar male was placed in the adjacent cage for the first trial. One female was transported into the middle cage, and the trial began as soon as the female entered the "In Cage." Five 15 minute trials were conducted per day using 2-3 males, depending on which female was being tested. Food and water were available at all times.

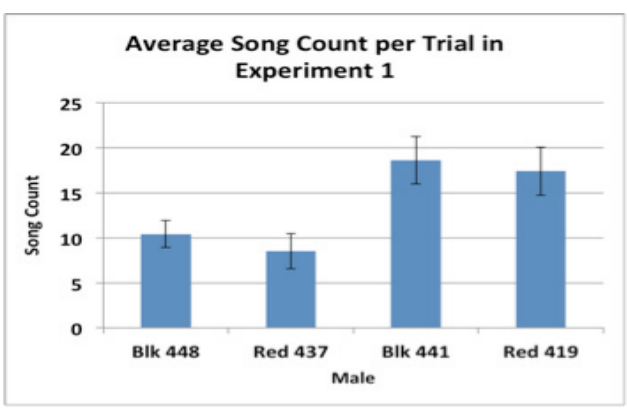


Figure 4. Average song count for each male of Experiment 1

Results

Preliminary

Songs of each male were extracted from the 30-minute recordings using RavenLite (Cornell Lab of Ornithology). Songs were analyzed using Sound Analysis Pro 2011 (Tchernichovski, 2012). By comparing each male's song to his own, it was found that all males sang a very consistent directed song with a syllable self-similarity percentage of 98.93 (SEM=.2321). All 5 males were compared to one another, and had a wide range of 61% to 92% similarity. Similarity scores were calculated by comparing the global and local aspects of two songs. In comparing two different birds, the overall percentage is based on global characteristics like the length of the song, the spacing between segments of the song. When comparing the same bird, the finer percentage, focusing on the accuracy and consistency within smaller segments of the song, matters most.

Figure 3 shows a sonogram of directed song of male Black 441, using RavenLite (Cornell Lab of Ornithology). The highlighted portions represent the different syllables that make up Black 441's average song.

Experiment 1

Over the entire group of females, results were highly varied depending on each female's motivation (Table 1). Half of the females tested positive for side bias, spending around 60% or more of their time on one side (Figure 5). Other females did not show a significant preference. These females either remained in the neutral zone, or spent increments ≤ 5 seconds on either side, which was too little time to be considered a significant choice. Even though males had highly variable song count per trial, all females heard at least one song from every male, thus giving them a chance to express their preferences (Figure 4). Some males naturally sang more than others, but an encouraging female response (such as hopping along with his song or chirping for him to continue) will usually make the male sing more.

Experiment 2

Most females spent more time with the in cage male (ICM) than the out cage male (OCM) (Figure 6). Unlike the birds from the delayed contact (DC) group, some birds from the instant contact (IC) group like D-JL049 and S-JL042 spent more time with the OCM. Even so, these results must consider that the majority of birds from the IC group hardly spent time with either male. Most members of the IC group also had much closer ratings based on the familiar and unfamiliar male (Figure 7).

Discussion and Conclusion

Overall, the results show little evidence for the predicted trends, but show unexpected patterns within the ten tested females. Testing for a longer period of time with a larger sample size of both males and females would have provided stronger data, but lack of an overarching trend through Experiments 1 or 2 does not render the results useless. Each experiment leaves room for comprehension of this sample's view of males. The variance within the total data shows that there are highly individual behavioral elements in mate preference for zebra finches.

Experiment 1 demonstrated that the majority of females could not consistently choose a male. As shown in Table 1 and Figure 5, the majority of

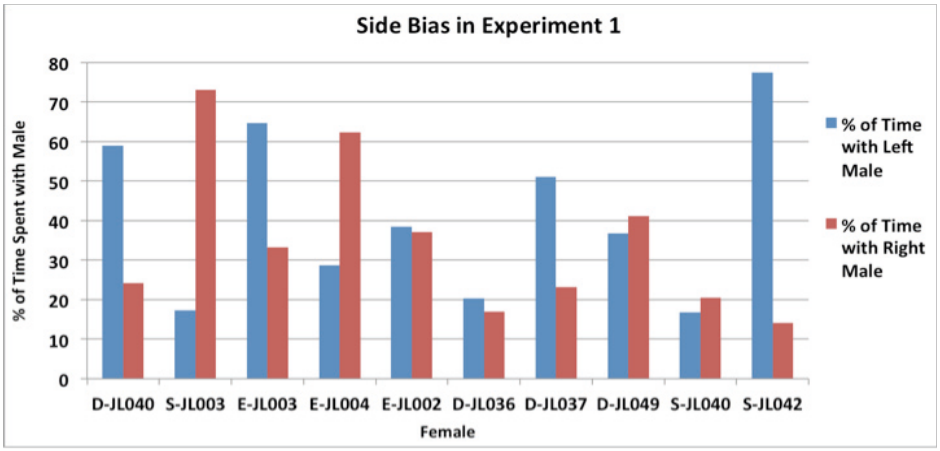


Figure 5. Side Bias in Experiment 1. Birds spending around 60% or more of their time on one side of the cage had a side bias.

females did not show a significant choice due to side bias or low amount of time with any male in Experiment 1. It appeared that only D-JL049 could make a clear decision, exemplified by her active signals (hopping and chirping) and time spent by Red 419 and Black 448. Compared with the consistency results from Forstmeier and Birkhead's study (2004), a 10% consistency rate was lucky considering their much larger sample size produced a 20% consistency rate. The unresponsive females in this study probably felt sexually unmotivated, seeing as the number of birds with side biases outweighed those who simply could not make a significant choice.

Somewhat in line with Prediction C, Experiment 2 shows that nearly all birds spent more time with the familiar male. Yet, most members of the IC group had rather close measurements when comparing the familiar and unfamiliar male (Figure 7). Though physical contact does seem to influence the amount of time females spend with each male, all females showed a higher preference for the familiar male. The data indicate that contact has a great effect on female responsiveness. While the males sometimes coerced females by perching next to them or invading their space, many females of the DC group did not attempt to rebut them, essentially choosing that male. With future research and more time, I would control their responses by habituating the animals to the setup of Experiment 2 to diminish the effects of the novel environment.

Due to the lack of consistency and responsiveness throughout the majority of the birds in Experiment 1, Prediction B holds no ground in relation to the data. Table 1 focuses on the father of each female, as the genetic background and hatchling environment shapes the basis for which song females prefer (Miller, 1979). In particular, one female, D-JL049, did have the highest amount of consistency throughout Experiment 1. Yet, Prediction B cannot be applied to D-JL049, as her sisters, S-JL040 and S-JL042, were irresponsive or had a side bias. Despite the overall lack of evidence for consistency from the females, D-JL049's results provide an interesting source of insight into the mind of a female zebra finch with high standards. D-JL049 seemed to prefer both Red 419 and Black 448 in Experiment 1, and was tested with Red 419 in Experiment 2 due to the slight difference in the time she spent with the two males in Experiment 1 (Table 2). Even if D-JL049 did not make a significant enough choice between Black 448 and Red 419, her inability to pick only one male shows that female zebra finches will choose a variety of males, though some females are more accepting than others (Forstmeier & Birkhead, 2004). Interestingly enough, Black 448 and Red 419's songs were only 77% (SE=.93) similar, while a few other sets of males had much more similar songs, 90% and up. Black 448 and Red 419 also had very different average song counts for Experiment 1 (Figure 6). Thus, Experiment 1 refutes the song frequency component of Prediction A. D-JL049's choice between unfamiliar and familiar males in Experiment 2 raises many questions concerning validity of data in respect to her performance, the other female's performance, and the male's performance.

Experiment 2 in itself was peculiar across the majority of trials, as males barely sung in comparison to the high song production rate in

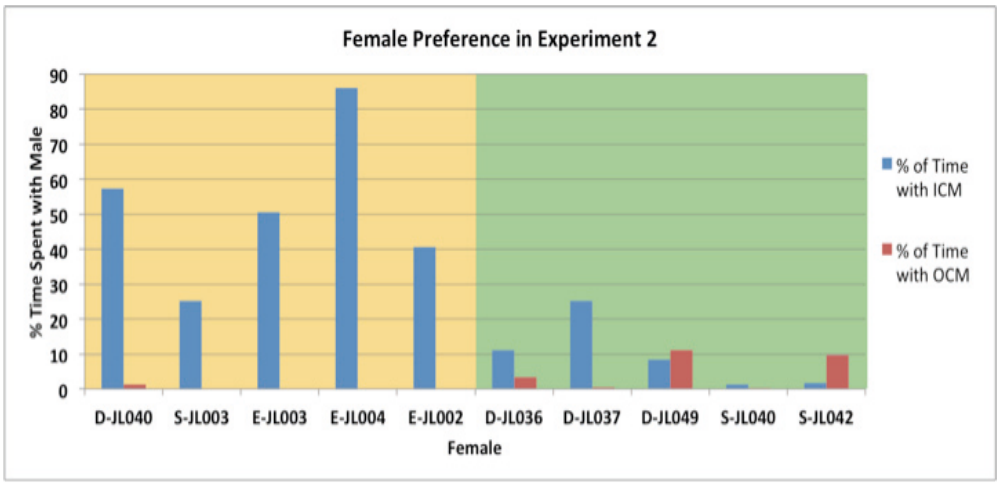


Figure 6. Female preference in Experiment 2. The orange includes the DC group, and the green includes the IC group

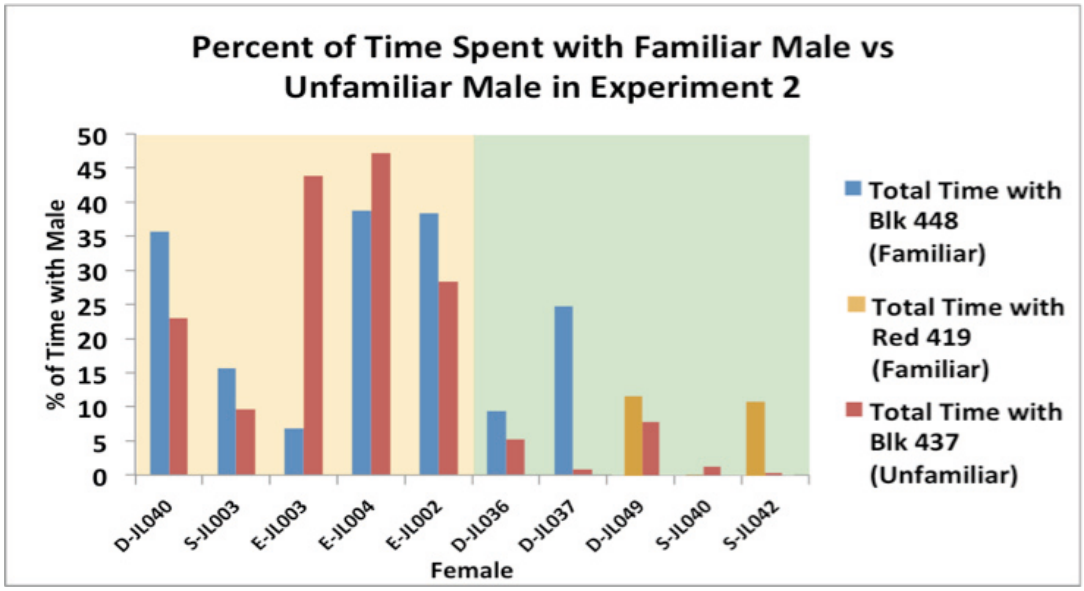


Figure 7. The orange includes the DC group, and the green includes the IC group.

Experiment 1. D-JL049 had only a somewhat significant difference between her time with the unfamiliar male, Black 437, and the familiar male, Red 419, which seems odd when acknowledging that Black 437 did not sing in either of D-JL049's trials. Despite D-JL049's exceptional performance in Experiment 1, her less than exceptional results of Experiment 2 indicate that context also could have an effect on the female's behavior.

Female	Father
D-JL040	B-JL279
S-JL003	B-JL279
E-JL003	R-JL08
E-JL004	R-JL08
E-JL002	R-JL08
D-JL036	B-JL279
D-JL037	B-JL279
D-JL049	B-JL317
S-JL040	B-JL317
S-JL042	B-JL317

Table 1. Family relationships of the female zebra finches.

Past studies have made clear that females prefer familiar songs, and our data, though inhibited by time constraints can conclude that female zebra finches prefer familiar over unfamiliar songs (Campbell et al., 2008; Neubauer, 2000; Lauay et al., 2003; Hauber et al., 2010; Forstmeier & Birkhead, 2004).

Future Research and Implications

These results expand a still relatively new body of literature investigating the dynamics of females in a sexually dimorphic species and how they interact as the recipient of the male song. By increasing the understanding of the variance of individuals within a population, the finer details of mate selection can begin to be uncovered. Even though this study provides a fresh perspective on the interaction between males and females, subject individuality and limited number of trials and subjects cause high variability of results. Enlarging the sample size and number of trials would not necessarily increase the individual consistency – females with side biases will probably maintain them, and nonresponsive females would probably continue to ignore the males – but these changes would provide more reliable data, and leave less to inference.

Research on the female perspective in mating could also lead to further investigation in the visual system's role in mate receptivity. Hara et al. (2008) found that seeing females while singing can influence the singing regulated gene expression of song nuclei in the male's brain. This study could be extended to identify some of the specific cues females give males to indicate if they like or dislike his courtship display. In refining our understanding of such signals, quantification of female preference could entice more researchers to pay attention to the important role of females in song production.

Several studies have already identified which regions of the female songbird brain activate when hearing a male's song (Bailey et al., 2002; LeBlanc et al., 2007; Svec & Wade, 2009). Bailey, Rosebush, and Wade's study (2002) identified that the caudomedial neostriatum, caudal hyperstriatum ventrale, hippocampus, and adjacent paraphippocampal area activate greatly when a female zebra finch hears the conspecific song, and the caudomedial noestriatum, hippocampus, and adjacent parahippocampal area show a lesser degree of activation when she hears the heterospecific song, one of another species'. They suggested that the all areas coordinate with one another to respond to a "biologically relevant auditory stimuli." (Bailey et al., 2002) Interestingly enough, these same areas activated in the male zebra finch brain when the same conspecific versus heterospecific test was administered (Bailey et al., 2002). This experimental design has revealed which areas of a female zebra finch's brain process song input, and could possibly be extended to measure their preferences. Bailey, Rosebush, and Wade (2002) measured the amount of activation using immunohistochemistry to determine the female's degree of reactivity to conspecific and heterospecific songs. This method could be applied to females who indicate a clear preference for one male, and a clear dislike or ignorance of another male. Females could be separated into groups where they would be exposed to their preferred male or disliked male, and then sacrificed to examine the degrees of activation in the areas of the brain that react to song. Svec and Wade (2009) have already done a similar experiment in which they examined the induction of the immediate early gene, ZENK, of females exposed to untutored or tutored males. They formed a control group of hormonally untreated birds, and another experimental group by giving female zebra finches doses of estradiol, a sexual steroid that likely causes

Mentor: Dr. Erich Jarvis, Ph.D.

ASSOCIATE PROFESSOR, Howard Hughes Medical Institute, Dept. of Neurobiology,

Duke University Medical Center.

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the brain to generate a reproductive response (Svec & Wade, 2009). Svec and Wade's results showed that the density of ZENK expression was much higher when listening to the tutored song. Gene expression studies can be further applied to female zebra finch's preferences by gathering birds with more scrupulous criteria, like D-JL049, and exposing them to males that fit or do not fit their preferences (Bailey et al., 2002; LeBlanc et al., 2007; Svec & Wade, 2009).

Much more can be done to understand both the behavioral and cognitive processes behind the complex activity of songbird courtship. Even though males have already been greatly studied across multiple species, the nuances of mate preferences are still being uncovered as the investigation of female perspective continues. By comparing unique and dimorphic species like the zebra finch, the nature of mate selection will become more apparent.

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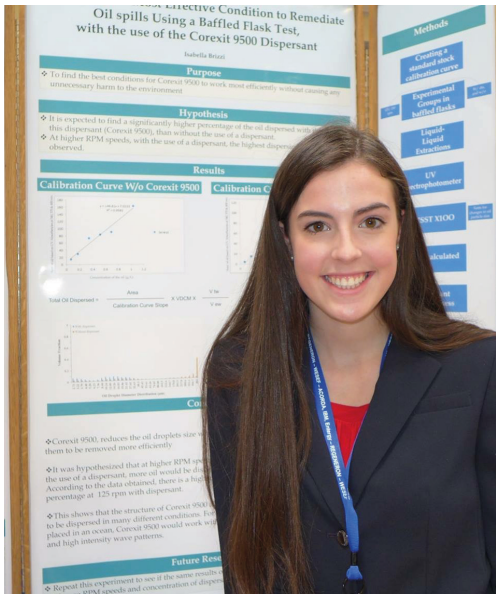
Testing for the Most Effective Condition to Remediate Oil spills Using a Baffled Flask Test, with the use of the Corexit 9500 Dispersant

Isabella Brizzi, WESEF Paper Excerpt (Junior)



Abstract

Corexit 9500, a dispersant for accidental oceanic oil spills, was studied to determine the best and most efficient parameters for its use, while reducing environmental impact. Four different series of sub-experiments, with and without the use of a dispersant, were conducted and data was obtained at different RPM speeds (125 rpm and 250 rpm, mimicking wave energy). For each sub-experiment, different time lengths were tested in five different samples. Once the oil-water mixture was removed from the shaker in the controlled temperature setting, liquid-liquid extractions were performed. The volume of the oil-water solution retrieved from the liquid-liquid extractions was adjusted and then tested in a UV spectrophotometer. The data obtained was compared to a 6-point calibration curve that helped to determine the Total Oil Dispersed. It was hypothesized that at higher RPM speeds and in the presence of a dispersant more oil would be dispersed. The idea that with the use of dispersant, more oil would be dispersed, proved to be true as seen in both the 125 rpm sub-experiments, as well as the 250 rpm experimental group. The data showed that the 125 rpm sample with dispersant had 21.6% of oil dispersed, while the 250 rpm sample with dispersant only had 15.2% of the oil dispersed. A higher efficiency at 125 rpm is surprising, and goes against our expectations. More studies have to be conducted to confirm that this effect is consistent and replicable, thus the need for more trials to be completed.

Introduction

Oils spills have been a prevalent issue in society since The Deepwater Oil Spill in April of 2010. Oil spills like the Deepwater Horizon Oil spill, often are responsible for causing a population of species to become drastically affected, resulting in death within the population. In consequence, such disasters may cause a significant decrease in a species population (7). The Deepwater Horizon Oil Spill caused thousands of gallons of oil to be leaked into the Gulf of Mexico, which affected many aquatic species of wildlife (1). An example of a similar situation would be the increase of deaths in the Dolphin species following Hurricane Sandy. Many of the dolphins who washed up on beaches after Hurricane Sandy were seen to have died of the Dolphin Morbillivirus, a virus belonging to the measles family (Watson, 2013). Recently in the spring of 2015, another oil spill occurred off the coast of California releasing an approximate 105,000 gallons of oil released, due to a pipeline rupture (2). In order to attempt to remediate the damage caused by these disasters, the use of a dispersant is needed. A dispersant is a liquid or gas that is commonly used to help clean up oil spills. Dispersants are able to break down larger particles of oil into smaller particles. This allows the particles to be able to broken down further and consumed by microorganisms (3).Exposure to deadly toxins or chemicals can weaken an organism's immune system and make that organism more susceptible to various diseases (1). Although many of the effects of dispersants are still unknown, modern day dispersants are less toxic than those previously used (6).If the correct dispersant is used at the found optimal condition, it can be expected that the effect on both the environment and the wildlife can be less severe.

Goals and Hypothesis

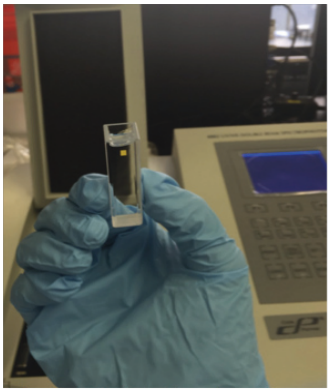
The purpose of this would be to find the most effective condition for a dispersant to work most efficiently without causing any unnecessary harm to the environment. To do so, we would test for the best possible conditions for the dispersant, Corexit 9500, working with a baffled flask at various RPMs. At RPM speeds with the use of a dispersant, more oil would be dispersed, facilitating its removal. The different RPM speed would be used to stimulate different wave patterns, creating an ocean like situation. It is expected to find a significantly higher percentage of the oil dispersed with the use of this dispersant in the best possible conditions. Without the use of a dispersant, there would not be a percentage of oil dispersed at the RPMs tested. (...)

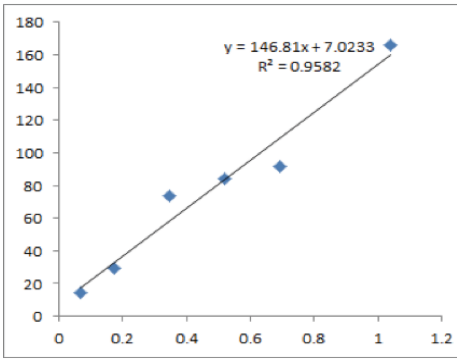
Procedure:

All procedures were constructed under the instruction and teaching of Dr. Zhong Pan, but were completed independently.

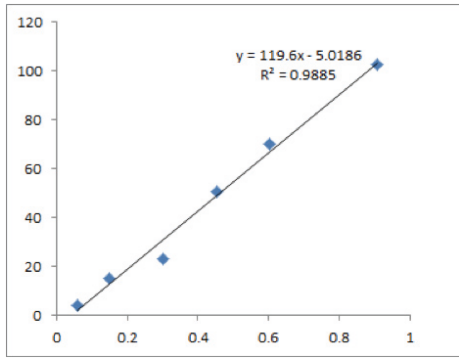
1. Finding the most effective and ideal condition for the dispersant.

There were four series of experiments. These experiments consisted of, a solution with a dispersant at an RPM speed of 125, a solution without a dispersant at an RPM speed of 125, a solution with a dispersant with an RPM speed of 250, and a solution without a dispersant at an RPM speed of 250. Each of these experiments would be made up of 5 tests, which would be testing the





Standard Curve with Dispersant



Standard Curve without Dispersant

effect of time on a sample. The different samples have times of 5 minutes, 10 minutes, 30 minutes, 1 hour, and 2 hours. These experiments would be conducted in a baffled flask, which would be specifically used for this experiment. Before any sample is to be started, there would need to be a standard stock solution created (control). This standard stock solution would serve as a base line, and would be compared to all of the samples obtained from the four sets of experiments. This standard stock solution would be created using 80µL of Corexit 9500, 1 or 2 ml of the obtained California oil (depending on the thickness of the oil), and 18 ml of dichloromethane.

2. Creating a calibration curve

From this solution, liquid-liquid extractions with specific volumes would then be conducted. To perform these liquid-liquid extractions, samples of 20, 50, 100, 150, 200 and 300µL would each be added to 30 mL of synthetic seawater and be placed into 125 mL separatory funnels. The data obtained from these liquid liquid extractions would then be test in the UV spectrophotometer. Two different calibration curves would be made to act as the control. One of these standard stock solutions would be made with the use of a dispersant, and one of the standard stock solutions would be made without the use of a dispersant. Then this data would be used to create a 6 point calibration curve which would become essential to the project.

3. Experimental group using the baffled flask test:

Each individual sample solution would be made up of the same components. Each sample required a baffled flask to be filled with 120 mL of synthetic seawater. To add the oil, it would have to extracted properly from its container with a syringe and then weighed on a scale. It would then be added to the center of the baffled flask, close to the solution but not touching it to ensure that it would not contaminate the solution. The syringe would then be weighed to determine the mass of the oil, which would later be used to calculate the concentration of oil within the solution. If dispersant was needed for a particular sample, using a 1-10 µl micropipette, 4µl of Corexit 9500 would be added to the center of the oil-water mixture without touching the surface of the mixture. The samples would then be placed into a flask shaker inside a temperature regulated area for their predetermined amount of time (5 minutes, 10 minutes, 30 minutes, 1 hour, 2 hours).

4. Liquid - liquid extraction

After the samples would be taken out of the shaker, samples would be taken from them and liquid-liquid extractions would be performed with 30 mL of the degraded and dispersed oil/ synthetic seawater mixture. The 30 mL would be placed into a 125 mL separatory funnel. 5 mL of Dichloromethane would be added to the funnel and then shaken. The extract from the liquid liquid extraction would be collected in a beaker. This process would be repeated 3 times and then the extract would be poured over a funnel filled with glass wool and Sodium Sulfate Anhydrous. The extract would then be adjusted to a volume of 20 mL and would be stored in a 25 mL glass test tube.

5. UV Spectrophotometer

Vials would then tested at different wavelengths in a UV spectrophotometer (340, 370, and 400 nm). The cuvettes would be first rinsed with Dichloromethane to rid of remaining oil left, which could result in incorrect data. The cuvettes used would have to be made out of quartz. If any other material was to be used, there is a very high chance that the Dichloromethane would state to dissolve the materials that the cuvette is composed of. The purpose of the UV spectrophotometer would be to find the quantity of oil that has been absorbed and dispersed into the water column (4).

6. LISSTX100 Test.

Part of the sample from the shaker, would be removed and placed inside a LISSTX100 to test for a change in the oils particle size. (...)

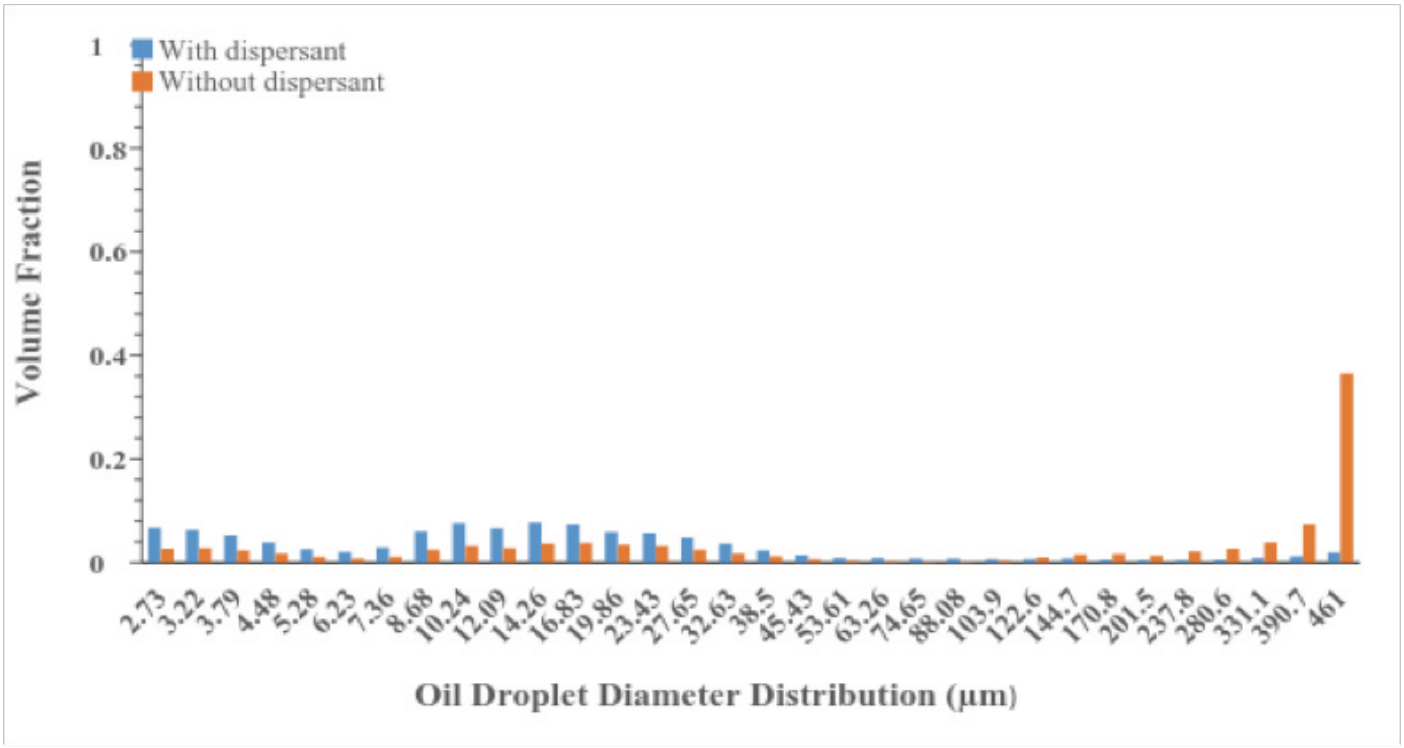
Results

Data Analysis

To analyze the data obtained from this experiment, it would be compared to the 6 point calibration curve. Also, some of the data would be put into a Dispersant Effectiveness Equation which would determine the amount of oil dispersed with the use of Corexit 9500. (...)

Discussion of Results and

RPM speed and if disp. is present	Total Oil Dispersed	% of Oil Dispersed
125 rpm w/ disp.	1.29	21.6%
125 rpm w/o disp.	.307	5.11%
250 rpm w/ disp.	.576	15.2%
250 rpm w/o disp.	.797	8.85%



Conclusion:

The results from this experiment will be able to determine the best condition for the dispersant Corexit 9500 to work. Based off of the data obtained, from the four different sub-experiments (150 rpm with and without dispersant, and 250 rpm with and without dispersant), it is evident that more oil is dispersed in the presence of a dispersant based off of the total oil dispersed and percentage of oil dispersed equations. The data received from the LISST machine showed that in presence of a dispersant, the diameter of the oil droplets become smaller. These results are compared to the diameter of the oil droplets that are not in contact with the dispersant have larger diameters. This shows that the dispersant, Corexit 9500, reduces the oil droplets size which allowed them to be removed more efficiently. The results obtained for the Total Oil Dispersed and Percentage of Oil dispersed are seen to be different than what was expected. It was hypothesized that at higher RPM speeds and with the use of a dispersant, more oil would be dispersed. According to the data obtained, there is a higher dispersion percentage at 125 rpm with dispersant. Although this data was unexpected, it shows that the structure of Corexit 9500 allows for oil to be dispersed in many different conditions. For example, if placed in an ocean, Corexit 9500 would work with both low and high intensity wave patterns. The original variance can be due to a variety of factors. One such possibility can be human error. Since this was a first run of this particular experiment, several more trials will be repeated the next summer to receive more conclusive data.

Mentor:
Dr. Zhong Pan, Ph.D.

Post Doctoral Research Associate.

Center for Natural Resources Development and Protection, New Jersey Institute of Technology

We are very grateful to Dr. Pan for his dedication and help.

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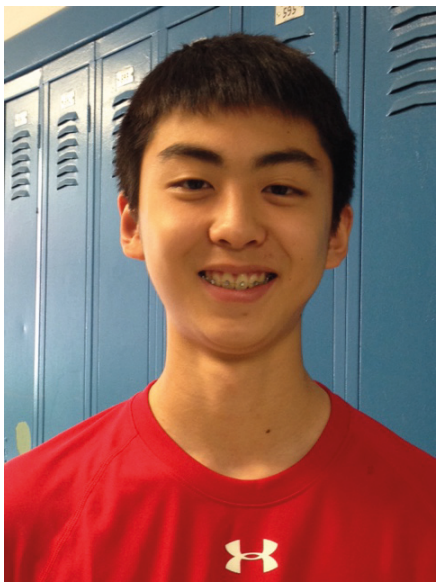
Role of the Microbiota and Probiotics in Brain Function: Potential Antidepressant Effects and Function, Jonathan Chung (Junior)

Many neurological diseases such as Autism, Rett syndrome, Cerebral Palsy, and major depression report gastrointestinal issues as a prevalent comorbidity (Hsiao et al, 2013). These findings support the concept of a gut-mirobiome-brain axis that influences neurological diseases. In support of the gut-brain axis, it has been shown that commensal bacteria affect a variety of complex behaviors, including social, emotional, and anxiety-like behaviors, and contribute to brain development and function in mice and humans (Cryan and Dinan, 2012). Despite the substantial evidence for gut-brain communication, a definitive answer as to how the gut and brain communicate, whether through neural, endocrine, metabolic or immune pathways, does not exist.

The implications of the gut-brain axis in Autism Spectrum Disorder (ASD) have gained considerable attention with promising reason. With a startling incidence rate of 1 in 88 births in the US as of 2008, ASD represents a significant medical and social problem (Hsiao et al, 2013). Further, among ASD children, 7 out of 11, a substantial portion, suffer from gastrointestinal abnormalities (Hsiao et al, 2013). These abnormalities, potentially caused by an altered composition of intestinal microbiota, correlate with symptom severity. Studies have demonstrated the significance of microbiota composition through presenting promising results with probiotics. For example, the probiotic Lactobacillus rhamnosus decreased anxiety and despair-like behavior and reduced stress-induced increase of plasma corticosterone levels in mice (Cryan and Dinan, 2012). In addition, the probiotic agent Lactobacillus farciminis, prevented intestinal barrier leakiness and reversed psychological stress (Cryan and Dinan, 2012). Aside from anxiolytic properties, probiotic treatment appears to possess antidepressant properties as well. These properties have been shown by Bifidobacteria treatment reducing the level of 5-hydroxyindoleacetic acid (5-HIAA) in the frontal cortex and decreasing the level of 3,4-dihydroxyphenylacetic acid (DOPAC) in the amygdaloid cortex (Desbonnet et al, 2008). Similarly, a study published results that demonstrated chronic L. helveticus NS8 supplementation, with the efficacy of many antidepressants, such as citalopram, can counteract chronic stress-induced behavioral, cognitive, and biochemical aberrations (Liang et al, 2015). Live Lactobacillus plantarum PS128 (PS128) treatment significantly increased the levels of dopamine and serotonin in the brain (Liang et al, 2015). This enhancement in striatal dopamine neurotransmission may cause the enhanced locomotor activity observed. It has been hypothesized that the elevation in dopamine transmission is mediated by vagus nerve activity rather than increased dopamine production in the gut because dopamine, like serotonin, cannot freely pass the blood brain barrier (Liang et al, 2015). These successes with probiotics validate the gut-brain axis. But more importantly, the efficacy of probiotics in normalizing both the microbiota and behavior reveals the potential role of bacteria in regulating gut-brain communication.



A potential mechanism of action in gut-brain communication involves metabolites, which are the intermediates and end points of biological processes (Hsiao et al, 2013). In the maternal immune activation (MIA) model, a model that emulates autistic like behavior in mice, mice exhibit increased gut permeability, tight junction defects, and dysbiosis. These conditions were hypothesized to affect the metabolome of mice and significantly altered eight percent of all serum metabolites. The metabolite 4-ethylphenylsulfate (4EPS) was of particular interest due to a staggering 46-fold increase in serum levels of MIA offspring that was completely restored by B. fragilis treatment. However, p-cresol (4-methylphenol), a possible urinary biomarker for autism that is structurally similar to 4EPS, was not elevated enough for statistical significance. On the other hand, indolepyruvate, a key molecule of the tryptophan metabolism pathway, had elevated levels in serum. Notably, the commensal bacteria such as B. fragilis directly produced or at least modulated both indolepyruvate and 4-ethylphenylsulfate. Given its potential role in behaviors relevant to ASD, 4-EPS was tested separately on naive mice. Mice treated with 4EPS potassium salt from 3 weeks of age to 6 weeks of age displayed anxiety-like behavior similar to that observed in MIA offspring. This outcome suggests that specific symptoms relevant to ASD and other neurodevelopmental disorders may be connected to molecular connections between the gut and the brain. Combinations of metabolites, however, may control more complex behaviors. Regardless, the effects that these changes in metabolites have on ASD or GI dysfunction are currently unknown (Hsiao et al, 2013).

Metabolites, such as α-tocopherol, tyramine, and 4-aminobenzoic acid (PABA), upregulated by spore forming bacteria have been shown to promote 5-hydroxytryptamine (5-HT), or serotonin, biosynthesis both in vivo and in vitro (Yano et al; 2015). For in vivo, the elevated luminal concentrations of particular microbial metabolites in germ free mice increased colonic and blood

Mentor: Dr. Matthias Quick, Ph.D.

ASSISTANT PROFESSOR of Clinical Neurobiology, Department of Psychiatry and Center for Molecular Recognition,

Columbia University and College of Physicians and Surgeons.

We are very grateful for the dedication and help of Dr. Quick.

5-HT levels. Accordingly, germ free mice injected with the metabolite deoxycholate had sufficiently increased colon and serum 5-HT compared to vehicle injected controls. Corroborating the finding that spore forming microbes, primarily composed of Clostridia, increase deoxycholate levels, particular Clostridium species are known to possess the high 7a-dehydroxylation activity needed for the production of deoxycholate from cholate. For in vitro, the metabolites such as tyramine and PABA were tested on chromaffin cell cultures. These metabolites also increased tryptophan hydroxylase 1 (TPH1) expression, suggesting colonic enterochromaffin cells receive signals from these particular metabolites to enhance 5-HT biosynthesis. The indigenous microbiota, which produces many of these metabolites, can even modulate hippocampal levels of 5-HT, indicated by disruptions in the serotonergic system in the absence of a normal gut microbiota (Yano et al; 2015).

Aside from signaling to cells in the gut, metabolites also signal to the brain. Propionic acid (PPA), an enteric bacterial metabolite, reaches the brain by crossing the gut-blood and blood-brain barriers, gaining access to the brain (Thomas et al, 2012). Concentrating intracellularly in the brain, propionic acid deleteriously affects various neurophysiological processes, including neurotransmitter release, gene expression, mitochondrial function, immune modulation, gap junction gating, and behavior. The increased intracellular neuronal, glial acidification and calcium proportions altered neurotransmitter release, which included glutamate, dopamine, norepinephrine, and serotonin (El-Ensary et al, 2012). These observations following PPA infusions, such as increased glutamatergic transmissions, align with the theory of ASD as a disruption of excitatory and inhibitory neuronal activity.

Given the ability of various metabolites to signal to enterochromaffin cells and directly contact and influence brain function, the effect of metabolites on transporters in the brain should be explored to validate the hypothesis that metabolites signal to the brain at a molecular level. Metabolites such as 4-EPS, propionic acid, and indolepyruvate, which have already been proven to be relevant to particular behaviors, may affect neurotransmitter systems in individuals with ASD. Propionic acid, for instance, has properties that affect neural function through inhibiting Na+/K+ ATPase, increasing N-methyl-D-aspartate (NMDA) receptor sensitivity, promoting intracellular calcium release, and elevating nitric oxide, all of which can affect synaptic transmission or neuronal activity. Meanwhile, probiotics, such as L. helveticus NS8, incited the recovery of 5-HT content in the hippocampus and produced results similar to those of selective serotonin reuptake inhibitor therapy, elucidating potential antidepressant effects (Liang et al, 2015). Thus, while the effects on behavior modulation have been well documented, the physiological and biochemical mechanisms remain unclear. Many studies mention alterations in monoaminergic signaling, production of neurotransmitters, and levels of monoaminergic metabolites and even note the antidepressant properties through recording the similar effects of probiotics and antidepressants but have not focused on the potential role of monoamine transporters.

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A New System for Capturing Solar Energy: Artificial Photosynthesis; and Investigating How the Structure of Porphyrins Affects Chlorophyll Absorption, Melanie Porras (Junior)

Whenever people think about solar capturing systems, what typically comes to mind is the average solar panels. Solar panels take solar energy, which is simply energy that comes from the sun, and convert it to electricity with the help of photovoltaic (PV) cells ("Energy the Solar Prospect", 2014). For many years solar energy has been captured through these photovoltaic cells. But recently there has been results of some success with a system capturing solar energy through artificial photosynthesis.

In the past, the focus has been on specifically on solar panels and photovoltaic cells. These photovoltaic cells concentrate on the production of electrical current at the junction of two substances exposed to light (Marsden, 2001). To produce electricity from solar energy an electric field must be created, through the separation of opposite poles; and metal conductive plates must be placed on the sides of the PV cell to collect electrons and transfer them to wires (Marsden, A. T. 2001). The PV cells then take the sun's photons, particles of light, to knock electrons free from the atoms of the semiconducting material, thus generating a flow of electricity. Several PV cells when put together are then able to create a solar panel or solar concentrator ("Energy the Solar Prospect", 2014). Other solar energy systems have been recently created besides PV cells.

An offspring of PV cells are transparent luminescent solar concentrators, TLSCs (Zhao, 2014). TLSCs, recently developed at Michigan State University by graduate student Yimu Zhao, offer a new improvement in the field of solar energy. TLSCs, which absorb near-infrared radiation, can decrease the production cost for solar materials while also eliminating solar panel's visual impact, by harvesting NIR photons rather than visible light (Zhao, 2014). Specifically, TLSCs can one day offer us the ability to power buildings through windows, power a car through a windshield, or even help power a cell phone. Contrary to typical solar panels, these TLSCs are highly transparent to the naked eye because TLSCS are not limited by the absorption or emission of a chromophore, an atom whose presence is responsible for the tinting of a compound (Zhao, 2014). In order to not be limited by chromophore absorption or emission the TLSCs have to absorb and emit near-infrared radiation (NIR), which is done by waveguiding deeper-NIR luminophor. Overall TLSCs display a 87% non-tinted transparency while having an efficiency of 0.4%, however it is said that they have the potential to reach a whopping 10% efficiency in the future (Zhao, 2014). TLSCs provide an opportunity to harvest light in a different way by using new technology of the future, but still fail to answer the question of a system with a high efficiency.

On the other hand there are Gratzel cells, Dye-Sensitized Solar Cells (DSSCs), which also present a path to solar power. Although the Dye-Sensitized Solar Cells are cost-effect, because of their feasibility to be manufactured, efficiency receives a hit in the process (Klinger, et al., 2012). DSSCs can be produced as such ease because they do not require the expensive and rare materials that some other solar cells require today (Klinger, et al., 2012). Compared to PV cells these carbon nanotubes propose a cost-effective and easier solution to the materials required to harvest solar power. However, overall the lack of a high efficiency sets a drawback in the future of DSSCs.

Although a variety of solar energy systems have been created and adapted, efficiency continues to be an issue. The lack of a high efficient system is something that needs to be solved quickly as humans are turning away from fossil fuels and turning toward alternative energy sources. Fossil fuels have supplied humans for decades and have powered their homes, but the exploitation of source has led to the continual deterioration of the environment. Thus, the search for a more environmentally friendly, and effective system has quickened.

This is why many scientists have considered a different approach to capturing solar energy, the approach of artificial photosynthesis. Plants have created the most efficient power supply, with an energy source that is abundant, cheap, and clean. Photosynthesis supplies plants with the energy they need while only absorbing about 3 percent, or less, of the sun's photons (Boyd, 2003). Thus, humans are trying to recreate the photosynthesis process, but with a different output. Instead of plant's food scientist are trying to create a system that produces liquid hydrogen, or methanol, for fuel to power cars and electricity (Boyd, 2003).

Artificial Photosynthesis is the replication of natural photosynthesis used in plants. A plant's structure is what enables the organism to undergo photosynthesis. The most crucial part for photosynthesis, in regards to the plant's structure, is the chloroplasts (Campbell, 2005). The chloroplasts are located in mesophyll cells and are responsible for feeding plants. Within chloroplasts exists a green pigment, a compound that absorbs a particular wavelength of visible light, called chlorophyll. Chlorophyll is a big proponent in photosynthesis because the synthesis of molecules occurring in this organic process is powered by the light energy that the chlorophyll

absorbs. Thus, it is crucial that the chlorophyll absorbs the necessary light needed to spark these reactions (Campbell, 2005).

During photosynthesis plants take photons, carbon dioxide, oxygen, and water to create glucose (Campbell, 2005). This process can be broken up into two different phases: light harvesting which is then followed by charge separation (McConnell, 2010).

To trigger light harvesting chlorophyll has to absorb a photon. The absorption of the photon leads to the excitation of a chlorophyll's electron, when an electron moves from its stable ground state to an excited state. However, the electron can not stay in the excited state for too long, thus the electron must descend back to its ground state. If a fitting electron acceptor is close by, the excited electron can leave its current molecule and go to the acceptor. The whole process mentioned above, is a chain reaction that leads to the split of water into hydrogen and oxygen in photosystem II. During the process of splitting water, hydrogen ions, as well as electrons, are moved from a water molecule to carbon dioxide, which is then turned into glucose (Campbell, 2005).

What enables the chlorophyll to absorb light energy is its structure. Part of the chlorophyll has a hydrophobic tail like structure that connects the chlorophyll molecule to the thylakoid membrane. The unique part of the chlorophyll is its head which is composed of a porphyrin ring. At the center of the porphyrin ring is a Magnesium (II) atom; this particular atom enables the absorption of light energy (Campbell, 2005).

Since chlorophyll is a pigment that absorbs certain wavelengths of light, there are different types of chlorophyll. While chlorophyll a is the main chlorophyll in organisms such as: algae, terrestrial plants, and cyanobacteria; chlorophyll b has also been recorded in some plants (Kobayashi, 2013). What differs is that chlorophyll a absorbs photons from the blue-violet and red section of visible light, and chlorophyll b absorbs photons from the blue and orange section. However, in natural photosynthesis, chlorophyll a plays a direct role during the light reactions (Campbell, 2005). Another type of chlorophyll, chlorophyll d, has been found in local ascidians, a spineless marine organism that serves as a bottom filter (Kobayashi, 2013). The variety of chlorophylls enables scientists to work with an abundance of diverse chlorophylls in their search for an effective artificial photosynthesis system.

In terms of Artificial Photosynthesis, the same exploitation of pigments to harvest energy is needed (McConnell, 2010). Thus it is typically seen that scientists use the Magnesium (II) ion, which enables the light absorption process, in their projects. (Gust, 2009). As previously mentioned, porphyrin type and structure is critical in the light harvesting stage. Without the proper arrangement, full absorption may not be reached.

Thus, it is the intent of my project to test different types of varying porphyrins to see which would produce the highest absorption rates during the light harvesting process. It would then be part of my future studies to focus on the charge separation stage.

To test the absorption of the porphyrins many tests can be conducted. One way is to use a spectrophotometer to measure the amount of light that is absorbed. Spectrophotometry refers to two different types of spectrums, the absorption spectrum and emission spectrum (Chang, 2003). When a substance absorbs photons the particles become excited and move from a lower energy state to a higher energy state. Through the atom's abortion spectrum, one can see at which wavelengths particles are excited. One the other hand an atom's emission spectrum depicts at what wavelengths excited photons are emitted and fall back down to lower energy states. The different types of spectrometry include Ultraviolet and Visible (UV-Vis) Spectrometry, Infrared Spectrometry, and Nuclear Magnetic Spectrometry (Chang, 2003). In each case, the porphyrins would be tested to react with different types of light. The results of each test would then be compared to a control group to see the major effects of the different porphyrin. This can help recognize how at what certain wavelengths photons are absorbed and emitted. Also, helping characterize the porphyrin even further. Subsequently, if another substance was synthesized accidently while metallizing the porphyrin with magnesium, then it can be seen here.

These metallated porphyrins, if success in the artificial photosynthesis process, can lead to the production of artificial leaves (Nocera, 2012). Research at MIT, lead by professor Daniel Nocera, has produced an artificial leaf that can harvest sunlight, and the energy it stores, and turn it into a chemical fuel. The end result of chemical energy is beneficial because the fuel can be stored for a later time and utilized as a source for energy. The artificial leaf's two byproducts are oxygen and hydrogen. These two byproducts could then be used in a fuel cell, a system that combines hydrogen and oxygen into water while also producing an electric current (Nocera, 2012). This is one of the "different outputs" that scientists are looking to achieve with artificial photosynthesis. With these outputs of artificial photosynthesis humans can obtain efficient renewable solar energy.

The new advancements offer us a new and cleaner way to use energy in an eco-friendly way. And since solar energy is renewable we will never have to worry about there

Mentor:
Dr. K. V. Lakshmi, Ph.D.

ASSOCIATE PROFESSOR Chemistry and Chemical Biology.

SCIENTIFIC DIRECTOR of the Baruch '60 Center for Biochemical Solar Energy Research

Rensselaer Polytechnic Institute.

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not being enough or running out anytime soon.

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Synergy of T Helper Cells TH22 and TH17 with TH2 as possible factors in the onset and development of Atopic Dermatitis, Deepa Mistry (Junior)

Atopic Dermatitis is the most common inflammatory skin disease in which 10% of children and 5% of adults are affected (Gittler et al., 2012). It is an autoimmune disorder that is more colloquially known as eczema (Gittler et al., 2012). There are two important stages in atopic dermatitis that show the progression of the disease. The acute stage is the initial irritation of the skin where it looks bright red, "wet", and flat (Gittler et al., 2012). The chronic stage is the dull, red, dry, and thick aftermath from the acute stage (Gittler et al., 2012). This skin disorder is known to be closely linked to both immune and barrier abnormalities (Gittler et al., 2012). About 85% of cases begin in childhood where early onset is common and there are more pediatric cases of atopic dermatitis that adult cases (Noda et al., 2014). In order to be diagnosed with atopic dermatitis, a lesion must appear on the skin for three days or longer (Hamilton et al., 2014).

Current treatments of atopic dermatitis are highly ineffective (Noda et al., 2014). Oral steroids are often paired with UVA1/NB-UVB phototherapy treatment because both act as immunosuppressants which would reduce the autoimmune symptoms associated with atopic dermatitis (Noda et al., 2014). In addition, cyclosporine, a common immunosuppressant is also a popular treatment for this disease (Noda et al., 2014). However, due to toxicity issues from the oral steroids and other immunosuppressants, there are limitations for long term use (Noda et al., 2014). UVA1/NB-UVB phototherapy is given with a 308 nm excimer laser at a dermatologist's office and is usually administered 2-3 times a week with a 48 hour break in between treatments, making UVA1/NB-UVB phototherapy a highly inconvenient method of treatment (Noda et al., 2014).

While treatments may be ineffective, there are ways to help manage atopic dermatitis. Some symptom reducing treatments include antihistamines and antibiotics (Noda et al., 2014). With the highly inflamed skin, antihistamines work to reduce the irritation and reduce swelling (Noda et al., 2014). The antibiotics are effective in cases where infections have developed on the irritated lesions (Noda et al., 2014). The root of the autoimmune pathways in atopic dermatitis lies in the T Helper cells which are cells that help to activate cytotoxic T cells to terminate abnormal cells or foreign bodies (Gittler et al., 2012). The current model for this pathway shows that the hallmark of T helper cells in atopic dermatitis is the TH2 cell which produces specific keratinocytes responsible for the onset and development of atopic dermatitis (Gittler et al., 2012). Keratinocytes work to form a barrier against foreign invaders of the skin. In atopic dermatitis, these keratinocytes overreact, cause the skin to be highly inflamed, forming lesions of eczema (Werfel et al., 2009).

Research has shown that treatments that block the TH2 axis can help atopic dermatitis patients because it reduces the severity of the disease (Janeway et al., 2001). Since it does not completely treat atopic dermatitis, it suggests however, there may be other cytokines involved (Janeway et al., 2001). There has also been research that shows TH22, TH1, and TH17 cytokines like ILl-22, ILl-17, are also involved in immune activation in atopic dermatitis (Gittler et al., 2012).

In this project we will be testing the mRNA expression of inflammatory mediators of each immune pathway

Mentor:
Dr. Emma Guttman , Ph.D.

PROFESSOR Dermatology; ASSOCIATE PROFESSOR Medicine, Clinical Immunology.

Mount Sinai Medical School, ICahn Medical Institute.

We are grateful to Dr. Guttman for her help.

produced by keratinocytes with stimulation of different combinations of cytokines. Specifically we will be testing terminal differentiation genes (LOR, FLG, INV), a Th2 chemokine (CCL26), a Th1 chemokine (CXCL10), and Th17 markers (IL-19, CXCL1, CAMP, S100A7, LCN2, PI3, DEFB4B, and CXCL20). To dissect the complicated cytokine network, we will perform an in vitro study using cultured keratinocytes. We will stimulate the cells with recombinant cytokines representing each immune pathway, such as IL-4 and IL-13 (Th2), IL-17 (Th17), IL-22 (Th22), and IFN-gamma (Th1), and assess the gene expression of important inflammatory mediators in AD (CCL26, CXCL10, IL19, CXCL1, CAMP, S100A7, LCN2, PI3, DEFB4B, and CCL20) and terminal differentiation molecules (filaggrin, loricrin, and involcrin). We hope to find that the cytokines often have a synergistic effect on key regulators of AD. This notion will help further understand the complex immune status of AD.

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An Epidemiological Study of Aphantasia, Research Proposal, Melody Munitz (Sophomore)

Introduction

One great human ability is that of visualisation, or being able to conceive an image in one's mind's eye. Believed to be the product of fronto-parietal and posterior brain processes (Bartolomeo, 2008), this skill has numerous practical implications, such as its assistance in learning, the formation of relationships, and creativity, as well as mental state and other psychological processes. The formation of mental imagery is also linked to memory, as supported by Marks' 1973 experiment in which male and female subjects who claimed to have varying visual imagery capabilities were shown an image and then asked to recall it. The results showed that the subjects who claimed to have higher visual imagery capabilities were more accurate in their recall of the images they had seen, allowing for the conclusion that "images have an important role in memory" (Marks, 1973). In another experiment relating to the correlation between eye movements and visualization, there was "no evidence that vivid visualizers showed more scanning activity than a group of Ss [patients] operationally defined to be poor at visualizing", proving that visual imagery is more than simply eye movements (Marks, 1973)

Some of the first documented research regarding visual imagery was conducted in England in 1880 by Sir Francis Galton, and was geared towards determining how different people's visual imagery skills compare. In order to assess where each patient lay on the scale of visualization, Galton developed the Vividness of Visual Imagery Questionnaire, which has since become a standard of scientifically quantifying visualization skills. This survey describes several situations and then asks the participant to rate the vividness of their mental imagery on a scale of 1-5. Through the use of the VVIQ and other similar tools and questionnaires, Galton found that not everyone is equipped with comparable visual imagery capabilities. While most people fall somewhere on the high end of the spectrum, having good or even superb visual imagery skills, there is a small percentage of people that possess very poor visualization abilities

(Galton, 1880). In similar research conducted by Faw in 2009, assessing such capabilities of 2,500 participants, it was found that 2.1-2.7% of them fell in this small group, claiming extremely poor or absent visual imagination (Faw, 2009)

Until recently, aside from Faw's limited work, this phenomenon has not received much scientific exploitation. Just recently, however, Professor Adam Zeman at the University of Exeter has begun conducting research on this topic. Since named 'aphantasia' (Zeman, 2015), this condition is believed to be the result of two different types of neurogenic visual imagery impairments: i) visual memory disorders, and ii) 'imagery generation' deprivation (Farah, 1984). To explore further features of Aphantasia, Zeman and his team distributed a shortened version of the aforementioned VVIQ as well as a supplemental questionnaire addressing additional personal information to 21 participants who suspected that they had the condition, 19 of whom were male. This testing generated various statistics; 5/21 reported having relatives who experience similar symptoms, "10/21 claimed that all modalities of imagery [hearing, touch, smell, sight, taste] were affected", and that most participants claimed having realized their visualizing deficit during their teens or early twenties through conversation with 'normal' visualizers. Interestingly, despite the 21 participants' VVIQ scores being tremendously lower than those of the 121 control patients, the majority of subjects claimed involuntary imagery, 10/21 during wakefulness and 17/21 while dreaming. These statistics have helped to begin to quantify the condition of aphantasia, and are a good basis for further research, such as that I am planning to conduct (Zeman, 2015).

I will create a questionnaire that will be distributed via the internet to self-proclaimed aphantasia patients whose answers, upon undergoing statistical analysis, will aid in determining additional etiological statistics of the condition, including age of onset, how it is presented in both genders, and progression, as well as demographics of the condition such as any potential environmental risk factors, socioeconomic factors, or cultural correlations. Additionally, I will be considering the effects of aphantasia on learning ability/disability, personality, creativity, and chosen career path, as well as hypothesized comorbidity between aphantasia and other conditions such as autism and dyslexia, in order to establish further understanding in the scientific community of the condition of aphantasia and its factors.

Goal Of Study:
Develop a survey to be administered to self-proclaimed Aphantasia patients in order to verify their condition, as well as gage additional statistics about Aphantasia that will facilitate further scientific discoveries.

Hypothesis:
This will serve as the first epidemiological study of this condition, providing useful information regarding: Age; Gender; Education; Social and economic correlations; Cultural correlations; Comorbidity

Materials and Methods
a.) Adam Zeman's original survey and questionnaire as reference materials.
b.) Message to be distributed on social media in conjunction with my survey:

'Hello, my name is Melody Munitz and I am a highschool student conducting Aphantasia research in association with the team of Dr. Adam Zeman at the University of Exeter. I am conducting experiments in an effort to gather further statistics about this recently surfacing condition, and have created a survey with more in depth and wide-range questions to learn more about this condition. My hope is that the results from this survey will provide information that will aid in further classification of this condition that will facilitate scientific advances in the field of Aphantasia. Anyone who claims to have a severely weakened or nonexistent mind's eye who would be willing to take part in this scientific study should click on the link below to be directed to the questionnaire. Please note: All survey responses are de-identified. You must be 18 years or older to participate in this study.'

c.) Please see attached survey.
d.) Distribution of survey:
Facebook groups for Aphantasia patients
"Aphantasia (Non-Imager / Mental Blindness) Awareness Group"
"Aphantasia - Non-Imager/ Mental Blindness Awareness"
Aphantasia forum: http://

Dr. Adam Zeman, MD

PROFESSOR of Cognitive and Behavioral Neurology

University of Exeter, Medical School, Exeter, UK.

We are very grateful to Dr. Zeman for his dedication and help

aphantasia/Twitter

Additionally, I will be considering the effects of aphantasia on learning ability/disability, personality, creativity, and chosen career path, as well as hypothesized comorbidity between aphantasia and other conditions such as autism and dyslexia. This data will facilitate an improved understanding of Aphantasia within the scientific community, and depending on the results of this study, further studies can be carried out in the hopes of understanding the cause of Aphantasia and possible preventative and therapeutic measures.

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An Exploration of Autonomic Computing, Matthew Gofman (Junior)

Due to the progression in computing and software, the intricacies of systems and their functions have risen to the point they inundate the abilities of current methods and tools. The human nervous system within humans, consistently deals with various problems of different intensities. Based on the human nervous system, autonomic computing intends to create systems that are autonomic, or self-managing. With the directions given by humans, such systems can resolve decisions autonomously. Autonomic systems can adjust to altering conditions, and consistently scan and enhance their statuses (Sterritt et al., 2005). The functions within a self-managing system can be broken up into self-configuration, self-healing, self-optimization, and self-protection (Jacob et al., 2004). In order to meet these standards, an anticipatory approach to the computing system is necessary.

The autonomic nervous system within the human body oversees the heartbeat, upholds standard body temperature, and monitors blood sugar levels without any deliberate work from the human. Autonomic computing systems are modeled on the this system. However, while the nervous system makes decisions unconscious to the human, autonomic computing systems will make decisions based upon provided tasks by the human (IBM White Paper, 2003). The four universal properties provide the framework for the entire system. Self-configuration entails that an autonomic system autonomously configures itself based on the specific objectives provided by the human. For a system to have self-optimization capabilities, it must be able to independently optimize resource use by preemptively changing the system. Self-healing systems are able to identify and diagnose complications, such as software and hardware failure. When it is achievable, the system attempts to solve the dilemma by autonomously performing tasks such as updating the software. Self-protection necessitates that the system is able to autonomously alter itself to attain data projection and security, in the case of cyber attacks, or just humans who incidentally change the software (Huebscher & McCann, 2008). Along with the four universal properties, researchers have described several more nuanced attributes to the autonomic system (Sterritt et al., 2005).

An autonomic manager and managed elements are necessary for any autonomic system. The self-monitor takes the forms of control loops with sensors, while the self-adjuster takes the form of effectors. The control loops and the effectors, in conjunction with the information the system has and the adaptive procedures, enables the system to self-manage (Bustard & Sterritt, 2003). Each part of the system is self-managing under this arrangement, which goes beyond low-level tasks of self-management. A human will provide the system with a success factor, and the system will understand the task, self-configure, and self-optimize. The system will also self-heal and self-protect to ensure that the policies are preserved despite changing conditions. In the human nervous system, our bodies unconsciously perform low-level tasks, allowing us to exert our effort performing high-level tasks. Likewise, in order for computing systems to be able to perform high-level tasks, there must be a framework in place that enables them to unconsciously perform low-level tasks (Sterritt et al., 2005).

The nature of the Autonomic Environment necessitates that the autonomic managers are able to communicate amongst one another. The autonomic systems contain pulse monitors that release pulses that signify health or urgency signals. This pulse monitor protects the essential processes of the system, by signaling to the other systems that they are healthy (Sterritt et al., 2003). The pulse monitors, in concurrence with the autonomic communications channel and event messages, allow autonomic systems to communicate with one another (Sterritt et al., 2004).

Autonomic systems have many real world applications that researches have been developing. The IBM Storage Tank is a system for managing storage that utilizes self-healing, self-optimization, and a storage system based on policy (Menon et al., 2003). OceanStore is a worldwide system for data storage that utilizes self-configuration, self-optimization, self-protection, and incessant monitoring, analyzing, and healing (Hildrum, 2002). Sabio autonomously cat-

egorizes documents through self-awareness and self-organization, by grouping documents based on the word and usage of phrases (Pool, 2002). Autonomic computing is applied in the engineering fields, such as in autonomic building, traffic, and manufacturing systems (Kaiser et al., 2003). Researchers are even developing autonomous economically motivated software agents. These agents are given an algorithm by a human to maximize profit, and then will practically become their own business. Entirely autonomously, the agents will buy information from other agents, refine the information, and then sell it to other agents or humans. Thus, an economic web of information and services is created among the autonomic systems. A study comparing the economic gains of autonomic software agents versus humans found that the agents earned an average surplus of 20% higher than that of humans. The study also found that 35-45% of all the trades occurred between humans and agents. From this information is can be expected that agent performance will move even farther ahead of human performance, and that agents and humans can work together (Kephart, 2002).

Further investigation into how autonomic systems can be applied to areas such as the engineering or economic fields, will provide me with the ability to test how these systems can make an impact in the real world.

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Dr. Ryan Baker, Ph.D.

ASSOCIATE PROFESSOR of Cognitive Studies in Education

Teachers College, Columbia University, NY

Bioinformatics, Peter Manthey (Sophomore)

Bioinformatics is an emerging discipline that uses computer technology, statistics, mathematics, and engineering to analyze and translate biological and genetic data, as well as healthcare information. Although bioinformatics has been around since the 1960, it is now being widely used. In the simplest form, bioinformatics is data that is collected from specific sources, run through unique code and organized by the associated biological macromolecules.

The amount of data being collected today throughout the world is enormous. One of the largest databases being used for bioinformatics is the GenBank, which is part of the International Nucleotide Sequence Database Collaboration. As of December 2015 this database contained over 203 billion nucleotide bases in more than 189 million sequences, collected from daily exchanges of data with the DNA DataBank of Japan (DDBJ), the European Molecular Biology Laboratory (EMBL), and GenBank at NCBI.

"This database is produced and maintained by the National Center for Biotechnology Information (NCBI) as part of the International Nucleotide Sequence Database Collaboration (INSDC). The National Center for Biotechnology Information is a part of the National Institutes of Health in the United States. GenBank and its collaborators receive sequences produced in laboratories throughout the world from more than 100,000 distinct organisms." (1)

As a result, there has been an increase in the application of bioinformatics tools to help medical researchers not only analyze larger quantities of data in shorter period of time, but to also become more precise in diagnosis and determining treatments. One breakthrough is using DNA sequencing to break apart a DNA strand which is made up of four nucleotide bases. By doing this scientists can determine variations for genetic diseases. Collecting all of this data and using bioinformatics will now allow doctors to break down a person's entire human genome in one day and provide personal-

ized treatment and medication. One bioinformatics software tool currently being tested, will automate the interpretation of the genome data by accessing any medical journal, research and articles applicable to the data and allow the treating doctor to reference those sources for potential treatment.

Many relevant research papers have been written over the last 12 years. It is evident that today bioinformatics is being used for everything from trying to determine a cure for the common cold, to using biomarker data to better diagnose certain forms of cancer. A summary of some of the more relevant research is below.

In 2003, researchers from several esteemed universities in the United States leveraged CompuCell, a multi-model framework for the simulation of morphogenesis, to simulate the formation of limbs in multicellular organisms during their embryonic stages of development. The program was designed to help researchers better understand the processes of morphogenesis. The program simulation models the interactions between the gene regulatory network and genetic cellular mechanisms. This new technology for modeling morphogenesis could help us to better understand defects that occur during limb development (2). In 2005 additional research was performed presenting CompuCell3D, a three-dimensional , cell-centered, multiscale framework (3).

Today CompuCell3D is being used to in an open source environment that allows for "virtual tissue simulations of development, homeostasis, toxicity and disease in tissues, organs and organisms, covering subcellular, multi-cell and continuum tissue scales." (4)

As of 2014, approximately 1% of the world's population is considered to be on the Autism Spectrum and this is on the rise. 5 Autisms is a disease with no known cause or cure. In 2015, The Hartwell Foundation formed a central repository for information regarding children who have been diagnosed with autism named iHART. The database will allow researchers to examine phenotypes, proteomics, metabolomics, genomics, brain activity data, information on the gut microbiome, blood-based biomarkers, physician narratives, diagnostic test results and treatment protocols (6). iHART will be an open portal so that the information is available worldwide. This is just one example of how enormous amounts of data is being used to help scientist find biomarkers that may be future indicators of autism.

In October of 2015, a group of scientists in Italy developed a bioinformatics program that is capable of identifying potential biomarkers for diseases and disorders know was SANIST. In this study, researchers used SANIST to identify a biomarker for prostate cancer known as carnitine, an ammonium compound involved in fatty acid metabolism. The research found that carnitine was expressed at lower levels in the plasma of prostate cancer patients and concluded that SANIST was able to accurately identify and separate individuals with prostate cancer from those with benign conditions at a rapid rate (7).

In late October of 2015 several databases have were created to provide doctors with access to allergen lists, protein classifications and sequence information to be used to determine potential risk of allergenic cross-reactivity. Over 55% of the US population has tested positive for some type of allergy (8). Allergies are caused by a person's immune system which mistakes an allergen, a foreign body, as a threat and launches and attacks to neutralize it. The researchers used bioinformatics to predict which proteins in parasitic worms would cause a reaction similar to an allergic reaction in humans. They were able to isolate in a parasitic worm one of the most common proteins in pollen. This protein was similar to a protein only known previously in the genomes of plants. Pollen is one of the most prevalent allergens. This bioinformatics tool will allow scientists to predict proteins that cause allergies, and to design protein molecules for treating them (9).

Right now research is occurring to find a more accurate detection for ovarian cancer in women. Currently fifty percent of women who have been diagnosed with ovarian cancer do not survive more than 5 years. The reason this cancer is so deadly is because ovarian cancer is very hard to detect, with signs only presenting themselves normally during later stages of development. In 2012, there were over 200,000 documented cases and 125,000 deaths worldwide. Researchers have found that NSC 319726, a small-molecule anticancer, could be used to effectively treat ovarian cancer. This study used bioinformatics to analyze and map the interactions between differentially expressed genes across a network. This allows researchers to find potential targets for NSC 319726. The result suggested that these genes and pathways may be candidate agents for NSC 319726. This is because NSC 319726 has been found to reduce levels of RPS6KA6, a chemical that is found to be over expressed in patients with cancer due to it influencing the growth of cancer cells (10).

It is evident that bioinformatics is a powerful tool in the evolution of predicting and treating diseases. In this research we will focus on using bioinformatics and the CompuCell3D simulation to

Mentor: Dr. Stuart A. Newman, Ph.D.

PROFESSOR of Cell Biology and Anatomy

New York Medical College, Valhalla, NY.

We are grateful to Dr. Newman for his help

more accurately model limb development during early stages of fetal development.

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Treatment of Alzheimer's Disease with Gamma-Secretase Targeting Antibodies, Margaret Gruber (Sophomore)

Dementia is a common disease elderly people face in America, characterized by memory loss, decline in cognitive function, and worsened motor function. (Alzheimer's Association, 2015). The most prevalent type of dementia is Alzheimer's Disease (AD), primarily affecting those ages 65 and older in late-set (LS) AD, while rarer cases of early-onset (ES) AD occur in the middle-aged and younger. A slowly-progressing disease, AD prevents sufferers from retaining information, causes disorientation and confusion, memory issues, loss of motor control, unfounded suspicion of others, and eventually results in death. On average, AD patients live for eight years after AD symptoms are identified. The overall Medicaid cost of AD treatments each year $113 billion dollars, a cost which would be greatly cut if an AD cure is found. (Alzheimer's Association, 2015).

AD is primarily caused by the formation of plaques of amyloid-beta protein in the brain. Amyloid-beta (Aβ) is the result of the cleavage of the amyloid precursor protein (APP) by the gamma-secretase protease. While Aβ's normal function is thought to be linked to neural plasticity, cleavage results in buildup of clumps of Aβ, blocking cell signaling. (Genetics Home Reference, 2014) (Alzheimer's Association, 2015). After Aβ accumulation commences, the tau protein, which normally keeps transport systems parallel in the brain, begins to tangle and the transports fall apart, preventing deliverance of nutrients. However, because tau neurofibrillary tangles are a result of Aβ plaque formation, preventing the creation of Aβ plaques would also eradicate tau tangles. (Alzheimer's Association, 2015)

The gamma-secretase protease which cleaves APP is activated by a gamma-secretase activating protein (GSAP). Reduction and knockdown of GSAP levels in the brain resulted in lowered Aβ-levels, a promising sign for an AD cure. In the paper "Gamma-secretase activating protein, a therapeutic target for Alzheimer's disease," by Dr. He, GSAP was found to be directly correlated to levels of Aβ in the brain. Blocking function of GSAP resulted in less plaque buildup in the brain. (He, 2010) Treatments utilizing gamma-secretases' function have been attempted before. However, since gamma-secretase has multiple functions outside of working with Aβ, utilization of the protease or blocking it without interfering with other functions is difficult. A cancer drug, imatinib, has been found to block GSAP function in vitro without interfering with other functions of gamma-secretase, including the Notch substrate. The Notch substrate is involved in digestion and other essential bodily functions, making any interference with it unstable for the body. However, Imatinib was not found to interfere with Notch function, a boon that supports use of GSAP inhibitors for treatment of AD. (He, 2010).

A giant challenge to discovery of an AD cure and many other neurological diseases is the passing of the blood-brain barrier, (BBB). The BBB is a diffusion barrier made of brain capillary endothelial cells, linked by tight junctions. Luminal, or blood-facing, and abluminal, brain-facing, poles separate the blood and the brain and carefully manage what passes through. (Ballabh, 2006). Since the brain is such an important organ, the body has developed an extremely selective layer in order to ensure dangerous materials stay out of the brain. However, this also serves as an obstacle to modern medicine

because it is so difficult to permeate. Through use of a bispecific antibody, the BBB can be passed.

The "Boosting Brain Uptake of a Therapeutic Target by Reducing Its Affinity for a Transcytosis Target," paper by Ryan Watts utilized an antibody with a transferrin (TfR) receptor and a BACE-1 inhibitor in order to treat AD. The BACE-1 inhibitor blocked the function of of the beta-secretase enzyme in order to reduce appearance of Aβ plaques in the brain. The TfR receptor was utilized by attaching to the BBB and passing the BACE-1 inhibitor through the membrane under the guise of performing its normal TfR function, which is to transport iron nutrients. The bispecific antibody, with a TfR receptor on one end and a BACE-1 inhibitor on the other to form a Y shape, was able to pass through the BBB and enter the brain. A TfR receptor with a low affinity, meaning that it held on loosely to the membrane when crossing the BBB, had the most uptake in the brain due to the ease of letting go to transporters in the BBB. Therefore, if a similar antibody was created but with using a GSAP inhibitor and a transferrin receptor, the AD treatment could theoretically have a higher uptake in the brain.

To get the benefits of both the GSAP inhibitor and the transferrin receptor, the bispecific antibody model could be modified to fit a GSAP inhibitor and a low-affinity transferrin receptor. While an GSAP-inhibiting antibody would have a lower uptake in the brain due to the impassibility of the BBB, utilization of the transferrin receptor would make the treatment more effective. Although the transferrin receptor showed success, its role with iron transport may pose an issue with the treatment, as introduction of new transferrin receptors without iron to the brain may affect iron uptake. (Goodsell, 2002). Further study of the effect of utilizing this transferrin receptor is required in order to determine whether another method of crossing the BBB is needed to be found. (Watts, 2011).

Transferrin is not the only option for crossing the BBB, however. Utilization of ultrasound therapy has been found to "open" the BBB for a brief period, allowing for treatment of various neurological diseases. When used on an AD mouse model, Aβ levels were reduced in their brains, and memory and cognition was restored. Utilizing low-power ultrasounds would allow antibodies to enter the brain without causing damage, stimulating microglia function, removing the Aβ plaques. (Burgess, 2014). The difficulty of treating AD is not only due to the impassibility of the BBB, but the genetic differences between mice and humans may affect the effectiveness of a treatment. One antibody that prevents formation of Aβ plaques in a mouse model could be less effective in humans. All of these challenges, although daunting, can be surmounted through innovation and continued research.

AD is a disease difficult to surmount due to its complex nature as a disease, but a GSAP-inhibitor and TfR receptor antibody may serve as a possible treatment. In order to increase uptake, a bispecific antibody with a low-affinity transferrin receptor and a GSAP inhibitor would be created. In order to test the efficiency of the antibody, an AD mouse model would have to receive therapeutic treatment. If the antibody proves able to reduce Aβ levels in the brain, clinical trials would be sought in order to see effectiveness of the antibody on human AD. Thanks to the GSAP inhibitor's reduction of Aβ levels in the brain and a lack of interference with Notch, it shows a promising treatment for AD.

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Mentor: Dr. Patric K. Stanton, Ph.D.

PROFESSOR of Cell Biology and Anatomy
New York Medical College, Valhalla, NY

We are grateful to Dr. Stanton for his help.

The Effect of Music on Emotions in the Human Body, Research Proposal, Kathryn Kenny (Junior)

Have you ever listened to a song and immediately felt a certain way because of it? Maybe, you listened to a slow song, in a minor key, and that caused a damper on your mood; possibly, you could have listened to an upbeat song, in a major key, and immediately felt happy and excited. That is all due to the correlation between human emotion and music. Many, like myself, have theorized this concept of a connection between music and emotion.

The hypothesis of music and emotions being linked has been exemplified in such experiments having to do with music therapy. According to the American Music Therapy Association, Inc., "music therapy is the clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program" (American Music Therapy Association, 2014). Music therapy was first used during World War I in Veterans hospitals to help soldiers who were suffering from shell shock. Just like many other therapies, music therapy has not been confirmed to completely heal a patient of any diseases. However, it is an efficient treatment because it has the ability to enhance the quality of life for a subject. This certain type of therapy has the capability to promote healing, encourage emotional expression, relieve symptoms, and provide an overall sense of well-being ("Music Therapy", 2015). That is due to the idea that music can add to your emotional state. It has shown to be beneficial for sick children in hospitals because it makes them happier and my goal, with this project, is to figure out why that is.

It has been demonstrated that both hemispheres of the brain process music. Music has been shown to stimulate cognitive function and build other necessary operations. It has also been known to trigger communication, mood, social skills, and behavioral outcomes from patients (Wu D, 2009). While listening to music, motor actions, emotions, and creativity are stimulated. Listening to a favorite song has the ability to connect the auditory brain areas and the hippocampus, a region in the brain, which is accountable for memory and social emotion consolidation (Wilkins, 2015). Music therapy can assist people who have physical, psychological, emotional, social, behavioral, cognitive, communicative, and or spiritual requirements or challenges. The parts of the brain that are associated with memory, attention, planning, and movement are shown to be stimulated while subjects are listening to music (Pereira, 2011).

In the long run, listening to music greatly affects the superior temporal gyrus, which is located on the lateral side of the brain. It contributes in predicting whether someone likes a song or not. Throughout your life, the different genres one listens to will affect the way in which their superior temporal gyrus is formed. The more of a specific genre one listens to, the more they will cherish music of that genre (Landau, 2013). When dealing with auditory music therapy, you have to consider patients' music interest. A study was done with fourteen unpleasant, rebellious teenagers to see if listening to their preferred genre of music, which was rap, would improve their behavior in the foster homes in which they were living. They listened to music of their preferred genre throughout the week and one day each week there would be a meeting where the children would discuss the music and how it made them feel. Only rap music with positive lyrics was distributed among the children. The conclusion of the study showed that the participants were interested in the music (Dolgui, 2013). They each picked a certain line from a rap song that they liked best and their behavior tended to become better over the time of the experiment. This goes to show the effect of the genre of music used in music therapy (Tyson, 2002). A questionnaire would have been a good addition to this experiment's results because it would have explained why the children appreciated the music more than other genres; it also could have helped to explain their emotional state during the process.

Another study was done with 60 healthy females, where scientists were able to see the relationship between music therapy, stress and anxiety. These women, ages averaging at 25, were given a standardized psychosocial laboratory procedure and questionnaires to determine their stress and anxiety levels as well as their heart rate. The subjects were put in a comfortable chair with headphones and their choice of preferred genre of music. Although pop was the most popular genre chosen, classical was also very prominent as a chosen genre. The results of the experiment showed that stress and anxiety levels changed overtime. Cardiac measures also changed over the time of the experiment. Music has been shown to affect cognitive, emotional, and physiological processes for the better. Listening to music does positive things, like decrease sympathetic activity and trigger positive emotion. Through this, it's clear that music can be beneficial to stress and anxiety (Thoma et al., 2013).

People experience their emotions as a single affective state, rather than specific, well-separated affective states. In our minds, we as humans, can associate people and events with different emotions. These feelings can determine different energy levels and dictate decisions. They are felt directly in different parts of the body and different ways-sadness, happiness, anger, etc. A

study in Finland was done in which participants were shown different images and were asked to record what emotions they were feeling and where on their body they were feeling them, using a blank body shape. After doing so, results showed that when pertaining to emotions, there were increases and decreases in strength to those areas due to the emotions that participants felt in those areas (Nummenmaa, 2013). I am proposing to do a very similar project, but instead of using pictures, I want to see the effects of music.

Hypothesis

Music and Emotions are connected, in that, when a patient is exposed to a certain piece of music, for example- a song in the key of C major- it could possibly increase the quality of their mood. However, if you were to show someone in a good state of mind a song in the key of A minor, it could potentially generate a decrease in the quality of their mood. On the other hand, if you had a depressed patient experiencing negative emotions, exposing them to a song in a minor key may make them feel better and the piece in a major key could make them feel even worse. This could be explained using the validation theory of cognitive psychology, explaining that if you are sad, and you listen to sad music, it validates your feelings, and thus making you feel better (Brinol & Petty, 2003).

Methods/Materials

I will attempt to illustrate this hypothesis by composing four songs in both major and minor keys (at different tempos) using Garageband on a mac computer. One of each of the major and minor pieces will be upbeat/ at a faster tempo while the other will be played at a slow speed. The difference between major and minor scale is the difference of two notes – the third and the sixth. Each major scale has eight notes, Do Re Mi Fa Sol La Ti Do, while (harmonic) minor scales have a solfege of Do Re Me Fa Sol Le Ti Do. The different solfege syllables in the minor scales represent a difference of one semitone, instead of- in a major scale- a whole step between the second and third, and fifth and sixth notes. Out of the three different types of minor scales- natural, harmonic, and melodic- I have decided to use harmonic minor chords in the compositions because of the fact that their sound differs the most from major chords. This helps to emphasize the difference of the third and sixth notes in both major and minor scale. A major chord is a group of musical notes having intervals of a a whole step, between the second and third degrees, and in most cases, the fifth and sixth, and the seventh and eighth. A minor chord is a chord based on a minor scale, and is defined by the root note, the note in which the chord is based, the minor third, a note only three half steps above the root note, and the perfect fifth, the fifth note in a chord that is seven half steps above the root note and four half steps about the minor third.

For the neutral experiment, Participants will record how they feel that day by answering a series of pretest questions. In a random order, the participant will listen to one piece of music at a time. Lastly, they will record their emotional state after hearing each individual song.

For the opposite action experiment, participants will record how they feel (ex. sad, upset) on a scale from 0 to 100 and locate where they are feeling such emotion on a body map. They will next listen to music of the OPPOSITE emotion (ex. happy). Following, participants will then record how they feel (on a scale from 0 to 100) and on a body map.

Secondly, for the concurrent action experiment, participants will record how they feel (ex. sad) on a scale from 0 to 100 and on a body map, listen to the music piece found to have the SAME emotional connotation (ex. sad), then record how they feel on a scale from 0 to 100 and on a body map. These experiments will help us to understand which emotions are felt due to which kinds of music and why.

Participants will be able to access the study, featuring these compositions and survey questions, by going on the internet and find a website that I will create. (...)

Expected Results

For the neutral experiment, I believe that subjects listening to the fast paced, major scales will feel happier emotions (ex. happiness, joy) and subjects listening to the slow, minor scales will feel more depressing emotions (ex. sadness, shame). For the concurrent experiment, depending on the patient's emotional state at the time, if we were to name major as "happy" and minor as "sad", the opposite emotional music would create a decrease in the quality of the participants mood, while the same emotional music would improve their mood. The validation theory will show positive in explaining participants feelings, having a positive effect: "individuals are more inclined to feel confident in their thoughts-and hence these thoughts are more likely to affect attitudes" (Brinol & Petty, 2003). No matter which experiment they're involved in, I expect that the subjects emotions will change throughout the experiment. Participants initial emotion will differ from their final recorded emotion.

Discussion/Conclusion

Music and Emotions both interact with similar parts of the brain. Because of these interactions, they are most likely have a strong correlation between each other. To take my study beyond this, I would eventually like to try and test how different pieces of music affect kids with emotional disorders or anxiety problems.

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Solving the Diagnosis Problem in Mitochondrial Diseases, Brian Gershgorn (Sophomore)

Mitochondrial diseases are a group of diseases caused by genetic mutations in both mtDNA, which is located in cytoplasm, and nDNA, which are certain genes in the nucleus that can control mitochondrial function (Chinnery, 2014). About 1,500 nDNA genes play important roles in mitochondrial function (Kohda, 2016). In fact, only about 15-30% of reported cases on mitochondrial disorders are credited to mtDNA, the rest being caused by mutations in nuclear DNA (Kohda, 2016). Mitochondrial diseases often cause the most damage to the brain, heart, liver, muscle system, kidney, and endocrine/respiratory systems ("What is Mitochondrial Disease - The United Mitochondrial ...", 2012). Mitochondrial disorders have an occurrence of approximately 1 in every 5,000 births (Kohda, 2016).

The purpose for researching mitochondrial diseases is to ultimately treat mitochondrial diseases more efficiently. This includes finding more useful diagnostic tools or treatments. Researchers have already found chemicals that point to the possibility of mitochondrial diseases, such as lactate/pyruvate ratios.

The problem with the diagnosis of mitochondrial diseases is the lack of research. Scientists still don't know all of the genes that cause mitochondrial disorders or are even linked to disease (Kohda, 2016). Also, diagnostic tools include simple blood lab tests, imaging studies such as MRI and MRS, muscle biopsies, and genetic testing (Chi, 2015). Possibly the most reliable diagnostic tool that doctors have are muscle biopsies. While muscle biopsies are the most definitive form of diagnosis, they are also expensive and invasive (ElBeheiry, Omar, Etaby & Abougabal, 2013). Also, muscle biopsies have false positives and false negatives, and while a positive result usually confirms a mitochondrial disease, a negative result does not necessarily exclude the possibility. This occurs because the piece of muscle being tested may not be affected by the mitochondrial disease (Balcells, 2010). Even though muscle biopsies are usually correct, it is a flawed tool, and factoring in its price and invasive nature, it should not be regarded as a "gold standard" for diagnosing mitochondrial diseases ("Mitochondrial Disease - Cleveland Clinic", 2015).

Blood tests are common, and a common marker used for possible diagnosis is blood lactate levels. The problem with this is that blood lactate levels are inconsistent, and not always high. Pyruvate, CSF lactate, and lactic acidosis are also commonly looked at. Also, genetic tests are a common diagnostic tool for mitochondrial disorders. Genetic testing is difficult because there are so many genes that can cause a defect in mitochondrion. Scientists often test for common genes that cause the specific symptoms of the patient, but it still remains a challenge. Genetic testing will probably become more relevant and reliable as more causative genes are discovered (Chi, 2015).

Another major reason why mitochondrial diseases are so hard to diagnose is because different diseases present different symptoms, possess different levels of severity, and affect different areas of the body (Chi, 2015). Many mitochondrial diseases, such as MELAS, have a very inconsistent prognosis. The prognosis for MELAS is typically from ages 10 to 35, a very wide window. For example, MELAS is a progressive neurodegenerative disease. Symptoms typically occur between the age of 2 and 15. MELAS can cause muscle weakness, seizures, migraines, vomiting, stroke-like episodes, and neurodegenerative abnormalities. It affects multiple organs and muscles throughout the body, including the kidneys and heart ("MELAS - Genetics Home Reference.", 2010). Kearns-Sayre syndrome, on the other hand, primarily affects the eyes and muscular system. It also causes muscle weakness and heart problems, but the heart symptoms present in a different way. Deafness and ataxia are also common. ("Kearns-Sayre syndrome - Genetics Home Reference.", 2011). While the two mitochondrial diseases have multiple similarities, they are also very different, and very hard to diagnose.

Lactate/pyruvate is usually abnormally high in mitochondrial diseases. Thus, it provides a possible sign for the detection of mitochondrial diseases. Lactate is commonly high because anaerobic metabolism, which is mitochondrial respiration without oxygen, occurs by fermentation. During lactate acid fermentation, pyruvate is reduced by NADH, and it forms into lactate. This causes an increase in lactate in the body, while pyruvate is decreased (Campbell & Reece, 2005)

Magnetic Resonance Spectroscopy is a noninvasive form of neuroimaging that looks at chemical information in the brain (Gujar, 2005). It seems to be a

promising diagnostic tool for mitochondrial diseases in the future. MRS makes it possible to look at different chemical levels in the brain during different stages of development (Vagal, 2010). It looks at certain molecules in the brain and, from the resonance vibrations, it is able to detect certain chemicals and their concentration (Gujar, 2005). These chemicals include amino acids, lipids, lactate, alanine, n-acetyl aspartate, choline, creatine, and myoinositol (Vagal, 2010).

One study, "Role of brain magnetic resonance spectroscopy in the evaluation of suspected mitochondrial diseases in children: Experience in 30 pediatric cases", examines the efficiency of MRS as a diagnostic tool. In this study, 30 children with suspected mitochondrial diseases were examined. After tests through MRS, these kids were divided into three groups. Group 1 (15 patients) had highly suggestive features, Group 2 (11 patients) had non-specific features, and Group 3 (4 patients) had a normal appearing brain. In Group 1, two patients were diagnosed with "definite" mitochondrial disease, eleven were diagnosed with "probable" mitochondrial disease, and two patients were diagnosed with "possible" mitochondrial disease. In Group 2, all eleven patients were diagnosed with "probable" mitochondrial disease. Lastly, in Group 3, three patients were diagnosed as "probable", while one was diagnosed as "possible". This study found that MRS is a reliable, noninvasive, and inexpensive tool for pediatric diagnosis of mitochondrial diseases. MRS testing would also help to decide if more, definite and expensive tests are necessary. (ElBeheiry, Omar, Etaby & Abougabal, 2013).

Another study, "Proton MR Spectroscopy in leukodystrophies", aimed to analyze MR spectroscopic findings and ratios of chemicals in abnormal brain. Patients tested were those with leukodystrophies, including mitochondrial diseases. Leukodystrophies are a group of rare genetic disorders that affect the central nervous system. The nervous system is disrupted by disrupting the myelin sheath that insulate nerve cells. Of the 26 patients (17 males and 9 females), 7 patients had a mitochondrial disease. During the study, conventional MR and MRI imaging was used. MRI showed white matter abnormalities in all 26 patients. MRS was able to show abnormal ratios in the patients. 23 of the 26 subjects presented with elevated Cho/Cr ratio, decreased NAA/Cr, and an elevated Cho/NAA. The study found MRS to be a valuable tool to diagnose MDs. MRS also proved to be able to diagnose other white matter diseases. (Abdelsalam, Lateef, Fathy & Ashamallah, 2015)

The precise goal of my research is to discover possible diagnostic tools for mitochondrial diseases. Ideally, these tests or items would be cheap, reliable, noninvasive, and available to the population regardless of their class or wealth. Also, my research aims to confirm the diagnostic efficiency of Magnetic Resonance Spectroscopy, which could prove to be a noninvasive and reliable diagnostic tool for mitochondrial diseases. In addition, since MRS measures chemicals in the brain, and a diagnosis is made from the results of the test, there are possibly other chemicals that could be seen through MRS and could prove to be a useful sign.

Through study of mitochondrial diseases, methods will be found that are reliable for treatment or diagnosis, and prove to be more efficient (when costs and comfort of patient are taken into account) than current methods. There are already possible treatments and diagnostic tools being researched and developed.

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Analyzing the Properties of KIC8462852, Amelia Bisaccia (Sophomore)

In the field of astronomy, an important area of research involves the analyzing of distant stars in the search for exoplanets. Several types of astronomical objects may surround a certain star being studied, so identifying the different effects created by orbiting objects is essential to characterize them. The Kepler mission is dedicated to identifying possible exoplanets in outer space, and time is spent analyzing the factors that determine the transiting object. In order to do this, light curves from stars are measured and studied in order to confirm the presence of an object around the star. A mysterious case that has arisen from the Kepler mission is that of the star KIC8462852, since the star's flux was measured to have dropped drastically during the time of study, and these drops are highly unusual in light curves of different stars (Boyajian, 2015). Scientists have attempted to characterize the object surrounding KIC8462852. If the large drops in flux that are seen from KIC8462852's light curve are unparalleled by other light curves found during the Kepler mission, then KIC8462852 is not being orbited by exoplanets or a megastructure, but rather a swarm of exocomet fragments.

The goal of the Kepler mission is to identify any earth-like exoplanets in outer space by measuring the brightness of distant stars, and the mission has been going on for over four years. Nearly one hundred possible exoplanet candidates have been discovered as part of the Kepler mission (Rein 2014). A division of the Kepler mission known as the Planet Hunters work on discovering these exoplanets and work on viewing thirty day segments of light curves from stars that are then used to identify transiting planets. Transits occur when an orbiting object passes in front of its star, which changes the total brightness of the star. Recently, the main topic of discussion surrounds the mysterious objects that are orbiting KIC846852, for the star's drastic drops in flux suggest something different than exoplanets. Flux is defined as the total amount of energy per unit area and depends on the luminosity and distance of the object, and the flux of KIC8462852 has been measured to drop irregularly. The transits of the objects orbiting this star were also aperiodic, differing greatly from the transits of regular orbiting exoplanets, which are usually repeated and regular (Boyajian, 2015). Planet Hunters attempted to find stars in the Kepler field that had similar drops in flux to those of KIC8462, so the algorithm used to search the database was used, looking for stars that had drops that reached 10%, but when nothing was found, this was lowered to 5%, and still no stars seemed to match the dramatic 20% drop in flux that KIC8462852 had shown (Boyajian, 2015). A series of graphs from the Kepler database show the light curves from the stars being studied as part of the Kepler mission, including stars of study such as KIC8462852,KIC12557548, and KIC11904151 (Barbara, 2015). KIC1255, which had been studied due to an evaporating object orbiting it, has a light curve that has been noted to be the result of average transits, with periodic flux drops (Wright, 2015). KIC11904151 has two exoplanets surrounding it, and has a stable light curve as well (Wright 2015). KIC8462852 has a light curve that drops in short amounts of time, an unusual characteristic of the flux of a distant star (King, 2015).

It was speculated that KIC8462852 had an artificially-made megastructure orbiting it, due to the unusual flux drops, but evidence suggests that this is not the case (King, 2015). It is true that transits of megastructures would cause the dramatic drop in flux, not unlike the objects surrounding KIC8462. However, a megastructure's transit would be periodic, and create a light curve that reflects this, and the transits of the objects orbiting KIC8462852 were aperiodic and irregular instead. Megastructures can also be detected by the mid-infrared radiation that they emit after absorbing the light from the star they orbit and then reprocessing it (Wright, 2015). This was not detected while the Planet Hunters worked on characterizing KIC8462852, so the characteristics of megastructures were not displayed during the process. It was concluded that the most likely explanation for the mysterious light curve is simply that there is a swarm of exocomet fragments orbiting the star.

The Planet Hunters were able to characterize the properties of KIC8462852 by using different methods, including Kepler photometry, spectroscopic analysis, and adaptive optics (AO) imaging. Kepler Photometry involves measuring light from an object in terms of brightness to a human eye. KIC8462852 was observed yielding an ultra-precise light curve in the thirty-day segments, and its drops in flux were measured to be very large and irregular. Spectroscopy is the analysis of the spectrum of electromagnetic radiation, and while measuring this, the research team found nothing out of the ordinary, as KIC8462's electromagnetic radiation seems similar to that of other stars. Adaptive Optics (AO) Imaging involves telescopes and laser communication systems that helps to remove distortion of images. The images of KIC8462852 reveal a small companion star not far from

the original star, and this star was thought to have been affecting the drops in flux from KIC8462. It was concluded, however, that the companion star is too faint and cannot be physically interfering with the behavior of KIC8462852. Another source of error was thought to be attributed to the instruments used to characterize KIC8462, but this was quickly disproven since the same instruments had been used to view other stars, and yet no star showed any peculiar data that could have matched that of this star. The theory arose that the reason for the mysterious drops in flux were caused by comet fragments for a series of reasons. Unevenly distributed dust around a star has been an explanation for flux drops in other observed young stars, and these possible clumps of dust and comet fragments may be going undetected as they may lie in a very thin belt around the star. Fragments of comets are also known to have highly eccentric orbits, which may explain some of the irregularity in transits (Boyajian, 2015).

The idea that exocomets were surrounding became the most accepted theory, and while research is still being done, the evidence holds true. While it was concluded that there were some areas in which KIC8462852 is similar to other others, the strange drops in flux are what makes this star unparalleled by any other in the Kepler field. Discovering and analyzing the causes of the flux drops in KIC8462852 may lead to new new discoveries within the Kepler field, for analyzing anomalous situations may improve the way astronomers go about researching exoplanets and distant stars. Future studies on this topic may come with the improvement of instruments and methods used to characterize the properties of stars and the objects orbiting them. The studies invoving the analyzing of distant stars and exoplanets are an essential part of astronomy.

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For more information on the Science Research Program,
Contact Dr. Christine Rogers, Ph.D.
christine.rogers@henhudschools.org