

— YOUNG — RESEARCHERS' CONFERENCE T O K Y O ● 東 京

CONFERENCE PROCEEDINGS 2018

The 1st Young Researchers' Conference
November 23rd - 24th, 2018
Tokyo, Japan



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WELCOME SPEECH

Dear Students, Teachers and Parents,

Welcome to the inaugural Young Researchers' Conference!

The Young Researchers' Conference was formed by a group of concerned mentors and tutors at Tokyo Academics and Tokyo Techies to **provide school students with a head start on scientific research and publishing**. Our team has observed that seemingly only a handful of students worldwide have been able to publish and share their research in academic circles. Let us share some example of students across the globe who have made scholarly contributions:

- Japanese school students hatched chicks outside of eggshells¹
- US teen makes scientific discovery about the number of bonds carbon can form²
- Three US teenagers devise method of filtering lead from drinking water³
- 16 year old teen's research on electric honeycomb was touted as a scientific first⁴

Thus, with this event, we intend to democratize research. It is intended to help foster the spirit of research in high schools. Our goal is to provide a dedicated event and platform for **high school students to conduct proper scientific research, publish and share their results with their peers from all over the world and the larger public** as with any other academic conference.

Why is a conference for school-aged students important? To answer this, we can use sports as an analogy. If you read the profiles and backgrounds of all great athletes and sportsmen and sportswomen, whether it's the soccer superstar Messi or 8 Olympic gold-medal swimmer Michael Phelps or current US Open Women's Singles tennis champion Naomi Osaka, you will note a common trend: all these sporting heros made their foray into sports at very young ages. We therefore believe the same applies to our future academics and researchers: early opportunities

¹ <https://www.bbc.com/news/world-asia-41548203>

² <https://www.inverse.com/article/44254-high-school-student-george-wang-carbon-7-bonds>

³ <https://edition.cnn.com/2018/05/03/us/black-teens-nasa-science-competition-4chan-hackers-trnd/index.html>

⁴ <https://www.bbc.com/news/world-asia-41548203>

Now let us answer another question: Why should we encourage research in high schools?

- We firmly believe that research conducted by school students enriches and complements the education process
- It gives an opportunity to apply school-learned knowledge to solving real world problems
- Provides an opportunity to learn outside of the school curriculum
- Finally, depending on the level of success, it can make tangible and concrete contributions to knowledge or society. We have given you some examples already

To provide an intellectually stimulating experience to the young minds present here today, we have carefully selected a number of keynote speakers from academia for this event. We urge all students to carefully listen to these speakers over these two days.

Let us now give you a brief overview of submissions details. We received 24 submissions from 7 different schools in 3 countries. Papers were submitted from Japan, UK, and Vietnam. These are respectable numbers for a conference in its first year and it gives us adequate reason to now declare this the *International Young Researchers' Conference*. We intend to organize this conference on an annual basis and to keep it nonpartisan we will invite teachers who are present here today to join the technical committee of this conference. Interested teachers may contact us by email.

We acknowledge the management and staff of Tokyo Academics and Tokyo Techies for their sponsorship and support for this event. They have kindly provided us with the use of their premises to host this event. We are grateful to our keynote speakers: Mr. Yutaka Tahara, Dr. Nguyen Duc Quang, Dr. Sarah K. Abe and Mr. Paul M. Lewis for kindly accepting our invitation to speak to you and taking out their time to attend this conference.

Finally, we hope that many future great researchers and scientists will be born here today. It will give us the greatest satisfaction were to find out in the future that one of you present here today grow into a famous academic, scientist or researcher.

With this, let us officially open the 2018 Young Researchers' Conference!

CONFERENCE PROGRAM

	Friday, 23 Nov	Saturday, 24 Nov
9:00 - 9:45	Registration	Registration
9:45 - 10:00	Opening Speech	Registration
10:00 - 10:45	Keynote speech 1	Keynote speech 3
10:45 - 11:00	Break	Break
11:00 - 13:00	Student presentations (see pp. 8 for details)	Student presentations (see pp. 9 for details)
13:00 - 14:00	Lunch	Lunch
14:00 - 14:45	Keynote speech 2	Keynote Speech 4
14:45 - 16:45	Student presentations (see pp. 8 for details)	Student presentations (see pp. 9 for details)
16:45 - 17:00	Free time	Awards Ceremony/Closing
17:00 - 18:00	Free time	
18:00 - 20:00	Dinner	

KEYNOTE SPEAKERS



田原豊 **YUTAKA TAHARA**

Oihama High School, Chiba, Japan

Yutaka Tahara is a Lecturer of Biology at Oihama High School in Chiba, Japan. He graduated from Kouchi University majoring in Biology and has worked as a high school teacher and lecturer in several Japanese high schools from 1977. For his work on Avian shell-less hatching technology development and implementation for education, Mr Tahara has been the recipient of several awards and medals from the Minister of Science and the Japan Biological Education Association.

Nguyen Duc Quang is the Founder and Owner of Spring Hill Academy in Vietnam where he mentors students on research projects related to movie making, plant science, environment, psychology and animal science. He has a Bachelor of Science degree from the Vietnam National University of Education Hanoi, specializing in Life Science and Technology Education. He also has a Masters degree in Science, again specializing in Life Science and Technology Education. Dr Quang also has a Masters and PhD from Ehime University, Japan specializing in Population Genetics of forest trees.



NGUYEN DUC QUANG

Spring Hill School, Vietnam



SARAH K. ABE

National Cancer Center, Japan

Sarah K. Abe is a Researcher at the National Cancer Center Japan specializing in diet and cancer epidemiology. Previously, she worked as Assistant Professor in the Department of Global Health Policy (GHP) at The University of Tokyo where she co-coordinated the Global Health Entrepreneurship Program, a hands-on, workshop-based program for university students. Dr Abe holds a Bachelor of Science degree from Suffolk University, Boston, a Master of Science from the Charité – Universitätsmedizin Berlin and a PhD in International Health from The University of Tokyo.

Paul M. Lewis is the Founder of Harvard College VISION: Global Health Society, a group that empowers youth to become civically minded leaders for the future. Each year, VISION hosts a Global Health and Leadership Conference that pairs high school students to Harvard students to create projects that impact their communities. Mr. Lewis holds a Bachelor of Arts degree from Harvard College, where he concentrated in Neurobiology with a secondary in Global Health and Health Policy. He received a postgraduate fellowship to travel to Japan and learn about caregiving.



PAUL M. LEWIS

Harvard College VISION

STUDENT PRESENTATION SCHEDULE

Friday, 23 Nov

Page
Number

11:00 - 13:00

Difference in Color Sensitivity of <i>Poecilia reticulata</i> based on different light environments Karin Kase , <i>Ritsumeikan Uji Junior and Senior High School</i>	10
How do Different Brands of Natto with Various Amounts of Protein and Lipid Affect the Growth of Human Saliva? Sahana Natarajan , <i>Seisen International School</i>	15
Whether Unkind Words/Kind Words Affect Plants? Nguyen Hoang Minh Khue, Vu Minh , <i>Spring Hill Academy, Vietnam</i>	21
Effects of Molar Ratio and Hardness of Glyptal, the Value-Added Product of the Production of Biofuels Momoka Kobayashi , <i>Ritsumeikan Uji Junior and Senior High School</i>	24
The Comparison of Microwave-Assisted Organic Synthesis and the Conventional Heating Method Qinrou Zhang , <i>Ritsumeikan Uji Junior and Senior High School</i>	29
Change in Sleeping Pattern Between Pre-Adults and Adults Shiho Inagaki , <i>Tokyo Gakugei University International Secondary School</i>	35

13:00 - 14:00

Lunch

14:45 - 16:45

SAT Reading Analysis Using Eye-Gaze Tracking Technology and Machine Learning Andrew Howe , <i>The American School in Japan</i>	40
Tennis Stroke Classification Using Myo Armband Lisa Bailly , <i>The American School in Japan</i>	44
Investigation of sleep quality parameters to improve cognitive performance in classroom tests Alisa Fukuda , <i>The American School in Japan</i>	47
A Machine Learning Based Approach for Automated Used-Car Price Evaluation Jongpyeong Lee, Hiep Nguyen, Konrad Lykowski, Thien Phan <i>Tokyo Techies</i>	54
Flower classifications using AI model Nguyen Kieu Khanh, Le Bao Dan, Nguyen Huu Hoang Minh, Nguyen Quoc Khoa, Nguyen Xuan Phong, Nguyen Duc Quang <i>Spring Hill Academy, Vietnam</i>	59
Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players Tyler Cross , <i>The American School in Japan</i>	62

Saturday, 24 Nov

		Page Number
11:00 - 13:00	Classification of Ballroom Dancing Music Using Machine Learning Noemie Voss , <i>Sevenoaks School, Sevenoaks, UK</i>	68
	An Exploration of the Effects of Alternate Realities on One's Identity Stefan Mead , <i>Ritsumeikan Uji Junior and Senior High School</i>	72
	Change in Japanese Economy and How Prime Minister Abe's Word Choice is Influenced by the Economy Ryunosuke Saito , <i>St. Mary's International School</i>	77
	Adidas And The Evolving United States Footwear Market Andrew Ammar , <i>Ritsumeikan Uji Junior and Senior High School</i>	82
	TPP11 and The Economic Revitalization of Rural Japan: The Effect of Culture and Consumer Preferences on Demand for Domestic Food Products Masao Kawasaki , <i>The American School in Japan</i>	89
	The Acquisition of Formal and Informal Political Power in the United States and Japan Kai Kurosu , <i>The American School in Japan</i>	99
13:00 - 14:00	Lunch	
14:45 - 16:45	A Study on Muong Language Nguyen Thanh Tra, Truong Vu Khanh Chi , <i>Spring Hill Academy, Vietnam</i>	106
	The role of moral education in the modernization of Meiji Japan until 1894 Yoshimaro Kamikubo , <i>Ritsumeikan Uji Junior and Senior High School</i>	110
	Investigation on the Time Taken per Cycle and 100m Breaststroke Record Reika Shimomura , <i>Ritsumeikan Uji Junior and Senior High School</i>	116
	Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability Sayaka Nagano , <i>Ritsumeikan Uji Junior and Senior High School</i>	121
	What Is The Relationship Between Keystroke And Timbre In Piano? Yuki Akizuki , <i>Ritsumeikan Uji Junior and Senior High School</i>	127
	Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere So Amano , <i>Ritsumeikan Uji Junior and Senior High School</i>	133

Difference in Color Sensitivity of *Poecilia reticulata* raised in different light environments

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Abstract – *Poecilia reticulata* has been a very common species of fish to investigate their vision and how they are able to sense color, which became an influence to this paper. From the experiment of raising them in two different groups, the question to how different environments of light can change sensitivity to color will be explored, based on data interpretations using the chi-squared method. Two schools of fish were put in two different light environments, one being orange and the other being green. The experiment made it possible to explore how little differences in the environment can hugely influence vision, as the results were able to prove that color can be an influencing factor on the sensitivity to color, where the fish raised under orange light was more sensitive to color compared to the other school of fish raised under green light.

Key Words – *Poecilia reticulata*, chi-squared, rods, cones, wave length

INTRODUCTION

Research question- By exposing *Poecilia reticulata* under orange or green light from an early growth stage, how does their sensitivity towards seeing the difference in different shades of color change?

The topic I have chosen in order to write my extended essay is from my interest in fish. I was interested in what is inside, where I was very interested in Anisakis, a roundworm living in the stomach of fish. This was risky in terms of the safety and ethical terms but has led to research of how fish live. Based on this, I have decided to investigate the topic of vision in fish, based on different light environments they are grown in. In this experiment, I exposed a total of 24 individuals of *Poecilia reticulata* to either green or orange light, to see how their much their sensitivity to color will change based on the light environment raised in.

Advantages of using *Poecilia reticulata* as the studies species is because they have been commonly used amongst scientists in experiments along with cichlids, based on topics such as vision, along with how this influences other living behaviors such as mating or searching for food. [1] As well as that, species similar to them have also been studies, based on the studies made on the *Poecilia reticulata*.

LITERATURE REVIEW

I. Sensitivity to color

Light environment has been considered important amongst scientists from the discovery that individual *Poecilia reticulata* had different sensitivity to color, based on the different environment they develop in. [2] Because of light environment during the growth stage, it has been stated in a research that the sensitivity to 600nm waves (orange) were higher when the *Poecilia reticulata* were grown under orange light compared to green light. [2] Light environment has influenced the expression of opsin gene sequence of the opsin protein, which changes the sensitivity. [2] The reason fish became so sensitive to color can be explained from the environment fish belong in. [3] Light intensity can change based on the depth of water environment, as the light intensity would change based on it. [3] Just like how we see color, we see the color which are not absorbed by other things. [3] In this case, the water is able to let colors through, and creates a range of colors to observe. [3] Therefore, the physics of how color absorption in water is what influences their sensitivity to color.

II. Vision of *Poecilia reticulata*

The way fish are able to see color is the same as how we humans see color. Color is detected as the light wave enters the eye, where it will hit the back of the eye, where the photoreceptors are located. [4] There are two types of photoreceptor cells called cones and rods, where rods have one opsin protein and cones have three opsin proteins.[4] Of these two photoreceptor cells, cones are responsible for color vision. [4] The cones are able to sense the primary colors that we see, which creates the base of color vision. [4] The opsin protein becomes stimulated when it is hit by light, and activates the retinal, a chromophore molecule, which includes vitamin A. [4] After this happens, the retinal attached to the opsin protein will change its structure arrangement.[4] When the retinal changes its structural arrangement based on the light detected, a signal will be sent out to the brain from the cone cell, notifying that light waves have been detected. [4] Based on different colors, there will be a difference in the light wavelength, presented by short wavelength (SWS), mid wavelength

Sensitivity to color of *Poecilia reticulata* by raising at different light environments

(MWS) and long wave length (LWS). [4] Because this, the opsin protein sequence created by the light intensity will be different. Along with that, the retinal will also have a difference in its structure based on the different lights detected, which makes it possible for the brain to receive the signal what color is being observed, based on the retinal sequence formed. [4]

As well as that, there has been research that shows that fish in general see a wider range of colors compared to us humans, which is based on the spectral sensitivity. [3] The way we see color is defined by whether certain light waves can possibly to sense by the eye and into the brain. [3]

TABLE I

COLOR DETECTED BASED ON DIFFERENT LIGHT WAVES

Light wave type	Color detected
MWS/LWS	Red
RH2	Green
SWS2	Blue
SWS1	Purple
RH1	Rod, sensing light

Fish are the only animals that are able to sense primary colors other animals do not see, based on research. [3] Non-primary colors are being detected as we see the blue, green or red light waves individually, but at the same time (eg. purple: red and blue waves being sent) as well have more than two subtypes of genes, due to gene duplication or alleles, because of the evolution of throughout time in environments fish were raised at. [3] By having two subtypes of genes, this makes it possible for fish to have a greater sensitivity to color, since the genes can have a slight difference and have a wider range of colors to see the difference. [3] Therefore, by having multiple numbers of genes to sense color, this made it possible for the fish to develop their color sensors to become more accurate, giving them a huge range of colors to explore to sense the difference of. [3]

Poecilia reticulata belong in a superorder group of fish called Acanthopterygii, which includes species of fish such as Japanese Rice Fish (Medaka), also known as *Oryzias latipes*. [3] The Acanthopterygii are said to be very sensitive to color, and further research was done with *Poecilia reticulata*. [2] This showed that the *Poecilia reticulata* have a total of five types of LWS opsin genes, and two of those LWS opsin genes showed that there are more than two types of alleles found. [2] Figure 1 shows based on the different light wavelengths, what color can be seen based on it.

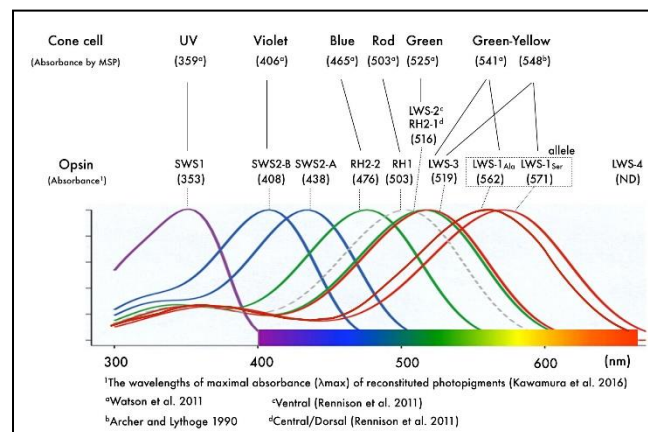


FIGURE 1

CONE ACTION SPECTRA

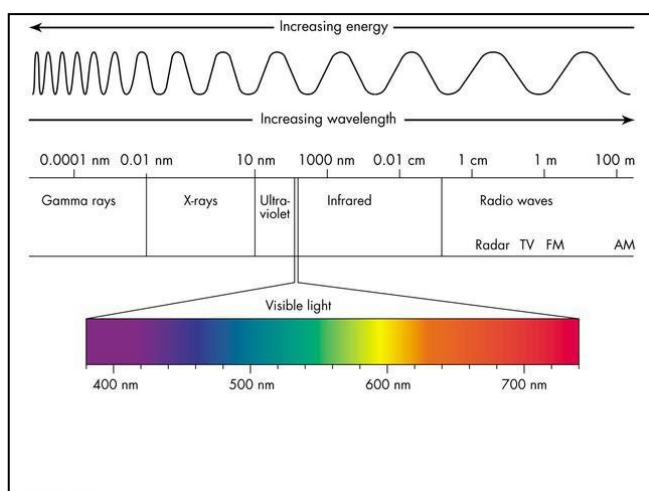
Source: The wavelength of maximal absorbance of reconstituted photopigments, Tohoku University, <http://memo.biology.tohoku.ac.jp/klabowiki/index.php?%A5%B0%A5%C3%A5%D4%A1%BC%BF%A7%B3%D0%8E%A5%A5%AA%A5%D7%A5%B7%A5%F3%8E%A5%C8%AF%B8%BD>

As it can be seen here, the LWS, which is the light wave for the color red, shows that the LWS opsin is the best to see the color orange. This means there is a range of difference in what kind of wavelength can be observed, based on the different alleles. Therefore, the more LWS genes present, makes it possible for the *Poecilia reticulata* to sense the color red accurately, therefore they are sensitive to the colors which can be seen from LWS opsin genes.

The two environments I will be comparing between will be under two different light colors, which is what causes the *Poecilia reticulata* to have different sensitivity to color. [2] The two lights I will be using in this experiment will be orange and green, since this shows a huge difference hence makes it easy for myself to observe the experiment. The reason these colors are chosen are because light environment is what influences the expression level of the opsin genes. [2] This means that the sensitivity to color is hugely influenced since the expression level is different. The experiment has been conducted in the past, with the conclusion that the *Poecilia reticulata* grown under orange light had a higher color sensitivity level compared to the green. This experiment was able to also show that the *Poecilia reticulata* grown under orange light had a higher sensitivity to 600nm light, based on investigating the gene sequence later on, [1] which is the orange light as referred to the electromagnetic spectrum chart below.

Sensitivity to color of *Poecilia reticulata* by raising at different light environments

FIGURE 2
ELECTROMAGNETIC SPECTRUM



Source: "Electromagnetic Spectrum." *The Electromagnetic Spectrum: The Family of Light*, cyberphysics.co.uk, www.cyberphysics.co.uk / topics/light/emspect.htm

III. Color preference of *Poecilia reticulata*

Orange is a very important color for *Poecilia reticulata* when it comes to mating, especially for the female *Poecilia reticulata*. Female *Poecilia reticulata* have been showing that their partner is chosen based on the orange color of the male *Poecilia reticulata*, where they prefer a bright orange, or even better orange with black spots on it.[5] Along with that, there has been data shown that *Poecilia reticulata* follow an orange colored fruit called *Sloanea laurifolia*, which is a color very similar to the orange color of the *Poecilia reticulata*. [3] There has also been research found about the genes in the *Poecilia reticulata*, which gives the reason to why they prefer the color orange, based on the explanation over sensitivity to the color orange.[3] Therefore, it has been able to support how *Poecilia reticulata* prefer the color orange and are very sensitive to them, being an important factor to influence mate choice behaviors.

METHODOLOGY

For this experiment, an equal amount of *Poecilia reticulata* was raised under two different light environments.

I. Independent variable

Environment the fish will be raised under, which I will raise the fish under orange or green light.

II. Dependent variables

The color the *Poecilia reticulata* will choose out of the pair of color. (either the original trained orange color, or another shade of orange) This will be measured by using another shade of orange shown to the *Poecilia reticulata* with the original color.

III. Controlled variables

-Fish tank and water environment the *Poecilia reticulata* will be raised at

The *Poecilia reticulata* will have to be raised in a water environment with oxygen, 26 degrees water, with the

calcium in normal tap water removed by heating it up slowly.

-Light intensity, light type

The color of light used will be different, but in order to keep the light intensity and brightness of the tank the same with each other, the same type of desk light will be used with the same type of light bulb.

-Age of fish

All fish tested in this experiment are born from the same fish on the same day (2018/03/21), grown under white light for the first 2 weeks

IV. Training and experiment

The methodology used in order to conduct this experiment will be based on a color vision experiment on cichlids.[6] The main aim of the certain experiment was to be able to test out how much Cichlids were able to see the difference in color, difference in shades, and difference between the trained color which was blue by lining up with different shades of gray.[6] I have applied this methodology on the *Poecilia Reticulata* I will be testing them.

1. Every time when giving food to the fish, a certain color that the fish will be trained with was shown. Once the fish realized that showing the color card is feeding time, the fish started tapping on the color cards.
2. Once the fish was fully trained enough to the point they are able to tap on the color card the experiment was conducted. Two colors were used in order to judge whether or not the fish sample is able to see the difference between the color. When the fish tapped on the color it was trained with, feed the fish. The fish will normally be raised at the light environment assigned, but during the showing of the color cards, the light was changed back to the white light.

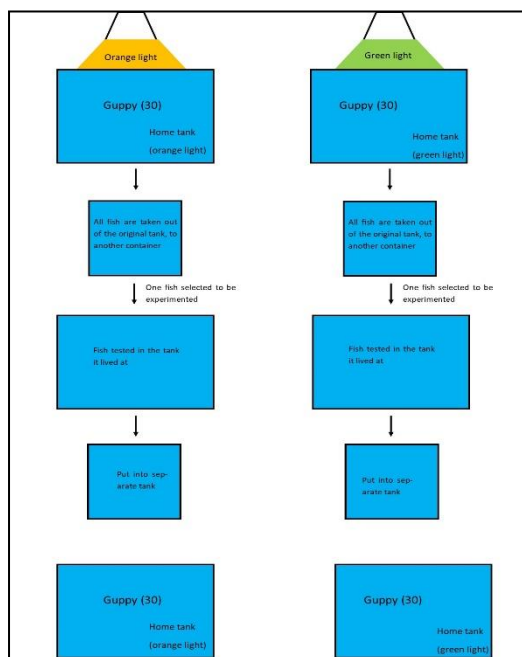
This certain methodology was used in order to test out whether the experiment conducted on Cichlids will be applicable to the *Poecilia reticulata*. This way, it was possible to test out whether the *Poecilia reticulata* are trainable, so that it would become possible to use this certain methodology. The orange color chosen in order to conduct this experiment was the orange color close to the color of the *Sloanea laurifolia*.

Nov 23-24, Tokyo

Sensitivity to color of *Poecilia reticulata* by raising at different light environments

VI. Data collection

FIGURE 3
PROCEDURE METHOD



The data collection was done in a total of two days, twice a day during feeding time.

1. Print out and laminate three lighter shades and darker shades of orange compared to the orange color the *Poecilia reticulata* were trained with.
2. A different random shade of orange along with the orange it was always trained with will be shown to the *Poecilia reticulata*. The *Poecilia reticulata* should tap on the orange color card it was trained with, if it sees the difference in the colors. If the *Poecilia reticulata* taps on the right color, food was given.
3. The *Poecilia reticulata* will be move to another container, with the same water in the tank it lives in. This container marks down which fish was already conducted the experiment.
4. Another random fish from the tank will be selected. This time, another color pair will be tested, which will not be the same as the previous one. The total color pairs tested were six. For each feeding time, each color pair was tested two times with different fish, since there are 12 fish per environment
5. Steps 3-5 repeated with a different *Poecilia reticulata* and random color pairs. This way the experiment was fair since the samples and color pairs chosen are all random.
6. After all the 12 *Poecilia reticulata* are tested, they were taken back to the tank they belonged at. the same thing will be repeated for the other light environment fish.

VII. Statistical analysis

In order to analyze this data, the chi squared method was used, where it showing the significance in the data, whether or not when the experiment was conducted, the *Poecilia reticulata* weren't choosing randomly. If the *Poecilia reticulata* were choosing randomly, the p-value will become more than 0.05, showing that the data is not significant enough to show that the *Poecilia reticulata* were choosing the color based on the training and vision they have.

In every experiment trial, a pair of colors were placed in the tank, where one will be the original color tested, and the other one will be a random shade selected to see which color will be selected by tapping. Since the *Poecilia reticulata* will have two colors to choose from, the probability of choosing the original color or the other shades will each have the probability of a half if they cannot distinguish between colors. Since there are 24 trials conducted for each shade under one color, the probability over all of choosing one either the color trained with, or another shade will be 12 out of 24, therefore showing the expected value if the fish cannot distinguish between colors is 12. Based on this, the p-value will be calculated, where when the p-value is less than 0.05, this means the *Poecilia reticulata* are nor choosing any color randomly, but they are selecting on the color based on their own vision and knowledge or habit from the training.

ANALYSIS

TABLE II
COMPARISON OF PROBABILITY OF ALTERNATE SHADE SELECTED, ORANGE LIGHT VS GREEN LIGHT

Probability of alternate color selected	Light shade		Dark shade	
	Orange light	Green light	Orange light	Green light
	0/24	7/24	6/24	16/24
	Orange < Green		Orange < Green	

	O	E	O-E	(O-E) ²	(O-E) ² /E
Original	18	12	6	36	3
Dark	6	12	-6	36	3
				Chi-square= 6	
				P-value= 0.01	

TABLE III
CHI SQUARE OF POECILIA RETICULATA EXPOSED UNDER ORANGE LIGHT, SELECTION OF ORIGINAL VS DARK SHADES

	O	E	O-E	(O-E) ²	(O-E) ² /E
Original	24	12	12	121	12
Light	0	12	-12	121	12
				Chi-square= 24	
				P-value=0.000001	

TABLE IV
CHI SQUARE OF POECILIA RETICULATA EXPOSED UNDER ORANGE LIGHT, SELECTION OF ORIGINAL VS LIGHT SHADES

	O	E	O-E	(O-E) ²	(O-E) ² /E
Original	8	12	-4	16	1.3
Dark	1	12	4	16	1.3
				Chi-square= 2.667	
				P-value=0.1	

TABLE V
CHI SQUARE OF POECILIA RETICULATA EXPOSED UNDER GREEN LIGHT, SELECTION OF ORIGINAL VS DARK SHADES

Nov 23-24, Tokyo

Sensitivity to color of *Poecilia reticulata* by raising at different light environments

	O	E	O-E	(O-E) ²	(O-E) ² /E
Original	17	12	5	25	2.083
Light	7	12	-5	25	2.083
				Chi-square= 4.167	
				P-value= 0.04	

TABLE V1

CHI SQUARE OF *POECILIA RETICULATA* EXPOSED UNDER GREEN LIGHT, SELECTION OF ORIGINAL VS LIGHT SHADES T

Based on the data collected, the data from the *Poecilia reticulata* es exposed under orange showed a p-value less than 0.05, showing it is significant to support that the *Poecilia reticulata* do not select the colors randomly. However, for the results of the darker shades of *Poecilia reticulata* exposed under green light, the P-value is higher than 0.05.

As well as that, based off the results it shows the p-value of the results are either closer or more than 0.05, which shows that the colors were selected randomly. Through this, it can be seen how the *Poecilia reticulata* which were raised under orange light have selected the color based off what they see, showing how they were choosing accurately, while the ones raised under green light showed either they were randomly choosing, based on the p-value collected from the experiment.

Because of this, this makes it able to point out the fact not just that the *Poecilia reticulata* raised under orange light had a more sensitive color vision, but it also makes it possible to point out that the ones that were raised under the green lights had a higher chance of choosing the colors randomly. This way, this shows how the *Poecilia reticulata* raised under the green lights were not able to see the differences in the color, which shows how they were probably choosing randomly. Therefore, the result of getting 0.1 for the p-value on Table 5 is a valid way to also show the accuracy of colors being chosen was far more inaccurate compared to the ones raised under the orange light.

CONCLUSION

From the result, it shows that the hypothesis can be supported by this evidence, since it is showing that the *Poecilia reticulata* under orange light is selecting more different shades compared to green, therefore it is able to support the fact the *Poecilia reticulata* exposed under orange light will most definitely have more sensitivity towards color compared to the ones under green light. This means just by looking at the data, it is showing that the sensitivity of color is higher in the *Poecilia reticulata* grown under orange light, which makes it possible to support my hypothesis.

ACKNOWLEDGMENTS

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How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

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Abstract- This research paper will be discussing on how different protein and lipid levels in natto inhibit the growth of bacteria in human saliva. Different brands of natto will be chosen as they contain various protein and lipid levels.

INTRODUCTION

Japan has the highest life expectancy, 83.98 years (2016), in the world [1]. Their main source of food is fish, rice, and probiotics such as miso, yogurt, and natto. I was intrigued by this fact as I have been raised in Japan all my life, and I had never stopped to think closely about the Japanese diet. I decided to research and understand how probiotic-rich foods', in this case, natto, antibacterial properties.

Probiotics are microorganisms or live bacteria that have several health benefits. They are said to improve immune functions including digestions and absorption of food and nutrients, as well as protect against the activity of pathogens [2]. Most of these probiotics contain bacteria from the genus *Lactobacillus* or *Bifidobacterium* and these are commonly seen in many of the different examples of probiotics [3]. For a probiotic to have beneficial qualities, it must include one or more of these: immuno-modulation, inhibition against pathogenic bacteria, metabolism, and resistance to low pH and acids [4]. Research has shown that probiotics have reduced the risk of antibiotic diarrhea by 42% and can also boost measures of immune response that inhibits against colds/flu [5]. Probiotic-rich foods contain about 5 to 10 billion colony-forming units (CFU) per serving and natto contains between one million to one billion colony forming bacteria per gram- meaning it is a highly rich probiotic food [6]. However, while probiotic bacteria has shown promising effects, it is still a widely researched topic. These natural products of probiotic bacteria will be the face of research in biology and food sciences.

One example of a probiotic is Natto: a traditional food in Japan that is made by fermenting

soybeans. Soybeans are soaked, steamed or boiled, and the bacteria *Bacillus subtilis* is added to it. When these soybeans ferment over time, natto is created and is a highly effective probiotic. Furthermore, this bacteria in natto creates a specific enzyme called Nattokinase which creates vitamin K2 [7]. Vitamin K2 has the potential to prevent heart disease as it stops the blood from clotting and also helps prevent calcium from depositing in the arteries [8]. Additionally, as natto is fermented, the proteins are easily digested and absorbed and gives massive gastrointestinal benefits [9]. This is because the fermentation process reduces antinutrients and increases the plant compounds and enzymes [10]. Natto also contains pyrazine which is a carbon molecule that is found in folic acid in the form of pterin [11]. Pyrazine works with nattokinase to prevent blood clotting and also gives the strong smell that natto is characterized to have[12]. Furthermore, natto has several antibacterial properties to it.

This experiment will be focused on finding how varying protein and lipid levels in different nattos affect the growth of bacteria in human saliva. Human saliva is used in this experiment because it is readily available and also it is safe to use. The bacteria that will be used in this experiment is taken from human saliva and the genus *Streptococcus* is one of the more abundant bacteria in saliva. There are several different types of *Streptococcus* such as *Streptococcus mutans*, *Streptococcus mitis*, *Streptococcus salivarius*, *Streptococcus pneumoniae*, and *Streptococcus pyogenes* [13]. According to the NCBI Resource page, *Streptococci* are Gram-positive, nonmotile, nonspore forming, catalase-negative cocci that occur in pairs or chains [14]. *Streptococcus salivarius* is the most common species of *Streptococcus* that is found in the saliva, and it grows at an optimum temperature of 37°C and at the pH level of 4.0-4.4.

METHODOLOGY

1. Measure 1 mL of spit in a 10mL measuring cylinder by spitting into it. Pour this into a test tube.

How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

- Measure 9 mL of distilled water in a 10mL measuring cylinder and pour this into the test tube with the spit.
- Measure 1 mL of the diluted spit from the test tube in a 10mL measuring cylinder using a pipette and pour this into a new test tube.
- Measure 9 mL of distilled water in a 10mL measuring cylinder and pour this into the new test tube.
- Repeat steps three and four 5 times, each time taking the sample from the diluted test tube.
- On an agar plate, place one drop of this new solution from the fifth test tube and using a cotton swab, spread the solution across the agar plate.
- Place the petri dish in the incubator
- Repeat steps 6-7 five more times for each of the natto solutions
- Repeat steps 1-8 for the three different brands of natto
- Measure using a two-decimal scale and crush natto beans using chopsticks until 1.00 gram of natto paste is formed
- Place natto paste in a 50 mL beaker
- Repeat steps 10 and 11 five times for each brand of natto resulting in 20 agar plates.
- Add distilled water based off of desired serial dilution
- Repeat steps 7-11 five times for each brand of natto resulting in 20 replated agar plates
- Take a pipette and squeeze once from the desired natto paste solution
- Open petri dish and add one drop of the solution into the agar
- Take a cotton swab and gently spread the solution evenly across the agar
- Place lid on the petri dish immediately

RESEARCHED DATA

Four different brands of natto were used for the varying levels of protein and lipid contents. The four brands will be renamed as Sample A, B, C, D:

- くめ納豆秘伝金印ミニ3 (Kume Natto Secret Money Seal) = Sample A
- くめ納豆 北海道納豆ミニ3 (Kume Natto Hokkaido) = Sample B
- 味わい小粒 (Small Grain Flavor) = Sample C
- プロ仕様 ひきわり納豆 (Professional Hikiriku Natto) = Sample D

	Protein (g)	Lipids (g)
Sample A	15.5	9.0
Sample B	16.2	8.5
Sample C	7.1	4.2
Sample D	8.8	5.0

RAW DATA

Table 1: The raw data collected about number of salival bacterial colonies visible after adding natto solution

# of Colonies Visible	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5
Sample A	63	19	0	0	1
Sample C	27	43	46	24	1
Sample D	17	15	22	56	20
Sample B	50	29	5	59	58

Processed Data

Table 2: Processed Data of Average Number of Salival Bacterial Colonies visible and Standard Deviation of number of colonies

	Average Number of Salival Bacterial Colonies Visible	Standard Deviation
Sample A	16.6	24.3
Sample C	28.2	16.1
Sample D	26.4	15.2
Sample B	40.2	20.6

How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

Table 3: Comparison between Sample A and Sample C of number of salival bacteria colonies visible

	Sample A	Sample C
Trial #1	63.0	27.0
Trial #2	19.0	43.0
Trial #3	0.0	46.0
Trial #4	0.0	24.0
Trial #5	1.0	1.0
Average	16.6	28.2
Standard Deviation	24.3	16.1
T-test	0.796	

Table 4: Comparison between Sample A and Sample D of number of salival bacteria colonies visible

	Sample A	Sample D
Trial #1	63.0	17.0
Trial #2	19.0	15.0
Trial #3	0.0	22.0
Trial #4	0.0	56.0
Trial #5	1.0	20.0
Average	16.6	26.4
Standard Deviation	24.3	15.2
T-test	0.69	

Table 5: Visible colonies of human saliva after natto bacteria added. Comparison between Sample A and Sample B

	Sample A	Sample B
Trial #1	63.0	50.0
Trial #2	19.0	29.0
Trial #3	0.0	5.0
Trial #4	0.0	59.0
Trial #5	1.0	58.0
Average	16.6	40.2
Standard Deviation	24.3	20.6
T-test	1.48	

Table 6: Visible colonies of human saliva after natto bacteria added. Comparison between Sample C and Sample B

	Sample C	Sample B
Trial #1	27.0	50.0
Trial #2	43.0	29.0
Trial #3	46.0	5.0
Trial #4	24.0	59.0
Trial #5	1.0	58.0
Average	28.2	40.2
Standard Deviation	16.1	20.6
T-test	0.916	

How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

Table 7: Visible colonies of human saliva after natto bacteria added. Comparison between Sample C and Sample D

	Sample C	Sample D
Trial #1	27.0	17.0
Trial #2	43.0	15.0
Trial #3	46.0	22.0
Trial #4	24.0	56.0
Trial #5	1.0	20.0
Average	28.2	26.4
Standard Deviation	16.1	15.2
T-test	0.199	

Table 8: Visible colonies of human saliva after natto bacteria added. Comparison between Sample B and Sample D

	Sample B	Sample D
Trial #1	50.0	17.0
Trial #2	29.0	15.0
Trial #3	5.0	22.0
Trial #4	59.0	56.0
Trial #5	58.0	20.0
Average	40.2	26.4
Standard Deviation	20.6	15.2
T-test	1.108	

From **Table 3**, **Table 4**, **Table 5**, **Table 6**, **Table 7**, and **Table 8**, it is apparent that the t-values are all less than the c-value of 2.228 at 10df. To achieve 95% confidence level for 10 df, the number must be greater than 2.228. This shows that the results obtained in this experiment is not statistically significant, and therefore the null hypothesis cannot be rejected. There is therefore no significant data that proves the effectiveness of different brands of natto on the growth of human saliva.

Table 9: Processed data table for number of salival bacteria colonies as a percentage in regards to the petri dish

	Sample A	Sample C	Sample D	Sample B
Percentage occupied on grid (%)	23.4	10.0	6.3	18.6
	7.1	16.0	5.6	10.8
	0.0	17.1	8.2	1.9
	0.0	8.9	20.8	21.9
	0.4	0.4	7.4	21.6

Table 10: Processed Data of Average Percentages Number of Salival Bacterial Colonies

	Average # of Colonies	Average % covered (area covered)	Average % of colonies divided by control	Average % growth of salival bacteria inhibited by natty
Sample A	16.60	6.18	15.26	84.74
Sample C	28.20	10.48	25.88	74.12
Sample D	26.00	9.66	23.85	76.15
Sample B	40.20	15.00	37.04	62.96

ANALYSIS OF RESEARCHED DATA

The main cause for the changes in protein levels behind natto is due to the time the beans have been fermented for. Fermentation is used to “increase the bioavailability of nutrients” and also “reduce the levels of anti-nutritional factors” [15]. Since protein increases when the fermentation time increases, it can be inferred that nattos with lower protein levels were not fermented as long as the nattos with higher protein levels were. It can also be inferred that natto with low protein content has higher anti-nutritional factors than natto with high protein and will be able to inhibit the growth of certain bacteria. In an experiment done by Kajikawa H., Mitsumori M., and Ohmomo S., different types of proteins were used to see the growth of ruminal bacteria. In the experiment, the growth rate of the ruminal bacteria was inhibited by the amino acids Cys, Leu, Lys, Phe, and Val [17]. This can be correlated back to the experiment as protein has a positive effect in inhibiting the growth of bacteria. Furthermore, Table B shows the different levels of

Nov 23-24, Tokyo

How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

essential amino acids in unfermented and fermented soybean. There is an increase in protein levels after increased fermentation time, and according to the table, fermented natto contains highest amounts of Lys (12.13), Lys (8.25), Val (6.91), and Phe (9.18). It can be hypothesized that the natto with the highest weight of protein will have increased amounts of these amino acids, and therefore have an increased inhibitory effect on the growth of human saliva.

Additionally, natto has various lipid content as well, and different fatty acids are said to have inhibiting effects on the growth of bacteria. In an experiment done by Rene J. Dubos on the effect of lipids and albumin on bacterial growth, it was founded that increasing the concentration of Oleic Acid had inhibited the growth of tubercle bacillus and micrococcus greatly (See Appendix Table C). Natto contains Oleic Acid and can be hypothesized that increased amounts of lipid content in natto has higher levels of Oleic Acid so there will be greater inhibition of human saliva.

Therefore, the higher the protein and lipid level, the more nutritional it is for humans as it has the ability to inhibit the growth of these bacterias.

CONCLUSION

The results obtained from Table 10 has shown that natto has the ability to inhibit the growth of human saliva. The brands "Sample A", "Sample B", "Sample C, and "Sample D", all inhibited the growth of human saliva by 84.74%, 62.96%, 74.12%, 76.15%and respectively, which shows that natto inhibits the growth of bacteria from human saliva. As apparent, all four brands of natto were able to inhibit more than 50% of the growth of human saliva. Sample B had the highest protein level compared to the other four brands. Interestingly, however, it had the smallest inhibiting percentage on the growth of saliva. Theoretically, high-protein natto is said to have the greatest amount of health benefits, and should, therefore, have the highest percentage in inhibiting the growth of human saliva. While Sample C had the lowest amount of protein content of 7.100 grams, it had a low amount for the growth of human saliva. Furthermore, when looking at the lipid content of the different natto brands, it is apparent that Sample A has the most amount of lipid content. This is hypothesized to decrease the growth of bacteria due to the presence of Oleic Acid. The hypothesis has been proven to be significant as Sample A had the highest percentage of

inhibiting the growth of human saliva, at 84.74%. However, there is inconsistency within this hypothesis as the second highest lipid content brand was Sample B. As discussed before, it is apparent that Sample B had the lowest potential to inhibit the growth of human saliva although it had the second highest amount of lipid content.

However, there is no statistically significant data that shows that a certain brand of natto inhibits the growth of human saliva better than another. The experiment has failed to reject the null hypothesis. This is apparent when looking at the t-test values in [Table 3]~[Table 8] as the t-value in all of those tables are less than the c-value at 8 df of 2.306. There is subsequently no brand of natto that has a better inhibiting effect on the growth of human saliva compared to other brands at 95% confidence level.

The compared between Sample B and the other three brands provided results that were moderately significant. The t-test value between Sample B and Sample A was at 1.48. While this is less than the c-value at 8 df of 2.306, it is greater than 80% level of confidence, which is at 1.372. Although this does not show the statistical significance between these two sets as 95% confidence level must be reached to do so, there is evidence suggesting that Sample A is better at inhibiting the growth of human saliva compared to Sample B. While this is not enough to generate statistically significant conclusions between the samples, it is possible to understand how Sample B inhibits the growth of human saliva less effectively compared to some other brands. Concluding that one brand has the best antibacterial properties is not possible for these results, but can instead allow for inferring that certain samples may be better at inhibiting the growth of human saliva than others.

It can be concluded that natto has the ability to inhibit the growth of human saliva as all the samples had inhibited the growth of bacteria in human saliva by over 50%. However, there is no statistically significant data to prove that one brand is better at inhibiting the growth than another at 95% confidence level. It can also be concluded that different brands with different protein and lipid levels do not have a correlation to the ability for them to inhibit the growth of human saliva.

While I was unable to accurately determine whether natto had antibacterial properties on the growth of bacteria in human saliva, I have gained a better understanding of how certain properties of natto

Nov 23-24, Tokyo

How do varying protein and lipid content in different types of natto affect the growth of bacteria in human saliva?

such as dipicolinic acid, proteins, and lipids can cure several diseases such as gastrointestinal and cardiovascular diseases. Looking at the varying levels of nattokinase or pyrazine in natto may allow for understanding and answering whether natto has a significant antibacterial property.

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Whether Unkind Words/Kind Words Affect Plants?

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Abstract – Talking to plants has effect on plants’ growth, but does the way we talk matter with the plants? A research was carried out in one month with some pairs of plants by Spring Hill Academy students with the teachers’ supports, where they whispered selected words to respective selected pots of plant and it turned out that the way we talk to plants really has effect on their development. It could be either positive (the plant grows more strongly and flowering sooner) when kind words are whispered to a plant or it could be negative (the plant grows slowly with less buds and late or even no flowering happens) when unkind words are used.

Key Words – Kind words, unkind words, effect, plants

INTRODUCTION

Have you ever plant a garden? Most of the people know that water, sunlight, soil and nutrients play significant roles in plants’ growth and development. Sufficiency of provisions lead to healthy growth of plants. But are there any other things that can affect the plants’ development?

There was a project shown on Discovery channel, in the Mythbusters show, named “Talking to plants” where they said that talking to plants had some certain effects on their development [1][2]. This conducted a study in which pea plants divided among 7 greenhouses which they play the tape recordings to the plants: one silent house, two nice talking houses, two nasty talking houses, one classical music house and one rock music house. This experiment turned out that the pea plants grew the best in music houses and then talking houses and they were worst in silent house. This information was so fascinating and with the help of our school teachers, we decided to work on a research to find out whether or not the manners we talk - unkind words and kind words - affect the plants.

We hypothesized that the properties of language we use to talk to plants, either kind or unkind, would have different effect on plants’ development, just like when we talk to other fellow students nice words, they will be happy but they do not like to listen to mean words. If this hypothesis is true, it could help every gardener and farmer so much growing their plants better.

On the other hand, we once heard about the ‘miracle’ apples story in which Mr. Kimura from Japan raised his apple garden without pesticides nor chemical fertilizers. Mr. Kimura had, beside reproduce the environment, the habitat of his apple trees, also talked his heart out to the trees (which should be all nice and kind words) in the garden, in order to succeed in raising his ‘miracles’[3]. Therefore we were quite positive with our hypothesis that kind words would enhance the development of the plants better than unkind words.

METHODOLOGY

In order to do this project we first had to take two large pots and add in the same amount of same type of soil.

Then we selected a kind of plant (we used moss-rose purslane), took one branch of this plant and cut it into 2 equal halves to make sure the two pots would have the same DNA.

Each half of the flower plant was grown in a pot. Everyday Mr. Quang, our Project supervisor would water the plants with the same amount of water and switch the position of the two pots so the plants could have the same amount of sunlight.

A group of students were asked to whisper some words, day by day, either kind or unkind ones to the respective pots that were carefully labelled with flags:

- **The neutral color flag** identified the pots receiving kind words such as *beautiful, amazing, awesome, wonderful, great, fabulous, You are absolutely incredible, I love you so much, etc.*
- **The black flag** identified the pots receiving unkind words such as *ugly, weird, crazy, stupid, bad, dumb, You are such a pain, I hate you, etc. .*

We had to identify very clearly, to make sure that the students did not mix up whispering words to the pots, otherwise the project will be ruined.

The experiment was repeated three times with three pairs of pots placed at three different places within Spring Hill Academy campus. Each pair of pots were handled in the same way as described above. Three different groups of students were in charge of the three pairs of pots in the

Whether Unkind Words/Kind Words Affect Plants?

research but all the students were instructed to follow exactly the experiment's requirements.

RESULTS

We observed the six plants every day and took photos of them when we found their differences.

We selected 2 photos of 2 significant milestones of the same pair of pots, named Set 1, Figure 1 is the status of two pots 2 weeks after we started the research and Figure 2 is the status of them after 1 month.



FIGURE 1
STATUS OF 2 POTS SET 1 AFTER THE FIRST 2 WEEKS

TABLE I
STATISTICS OF THE POTS AFTER THE FIRST 2 WEEKS

Set	Pot	No. of buds	No. of flowers
1	Neutral flagged pot	7	0
	Black flagged pot	3	0
2	Neutral flagged pot	5	0
	Black flagged pot	3	0
3	Neutral flagged pot	6	0
	Black flagged pot	2	0



FIGURE 2
STATUS OF 2 POTS SET 1 AFTER ONE MONTH

TABLE II
STATISTICS OF THE POTS AFTER ONE MONTH

Set	Pot	No. of buds	No. of flowers
1	Neutral flagged pot	10	3
	Black flagged pot	6	0
2	Neutral flagged pot	9	4
	Black flagged pot	6	1
3	Neutral flagged pot	11	2
	Black flagged pot	7	0

For the first set of pot, as we could see in the Figure 1, the black flagged pot, which was the one receiving unkind words is quite small with less leaves compared to the neutral flagged pot receiving kind words. We counted the number of buds and there were 3 buds in the plant grown in black flagged pot while the neutral flagged one holding 7 buds plant. The data is shown in Table 1.

In Figure 2, it is obvious that the plant receiving kind words looks much more lively with 3 flowers and big leafy branches compare to its neighbor, the plant receiving unkind words. The number of buds and flowers were also counted and reflected in Table 2.

The number of buds and flowers of the pots in set 2 and set 3 are also counted and reflected in Table I (for the status after 2 weeks) as well as in Table II (for the final status of the plants after 1 month), which show similar results as of the plants in set 1 – the neutral flagged pots were bearing better raised plants compared to the black flagged pot.

Whether Unkind Words/Kind Words Affect Plants?

CONCLUSION

From the experiment results shown above, we could conclude that words or what we speak could have serious effect on plants. If a plant is given nice and kind words, it will grow healthily and fully develop. On the other hand, under the same habitat or living conditions, like soil, water, sunlight, the plant which receives bad, unkind words will make the plants grow slowly, have less buds and doesn't even not have flowers at all.

This research would help the gardeners and farmers to know a better way to make the plants healthier and better but it is advised that a larger scale and more detailed experiment should be carried out to have clearer picture of how the human talks to plants affect them. Referring to the methodology of "Talking to plant" project in the above mentioned Mythbusters show [2], tape recorders are one good choice to carry out the experiment in large scale. But we predict the outcome will be better if the plants "hear" the words directly from the people. In additional, the experiment should have control plant which normal raising conditions are provided to the plant, i.e. no talking. The outcome of this control part will bring better persuasion to the audience.

When we think further, plants are living creature just like animals and human beings. Words that we speak every day could even affect plants' development which mean they can have effect on animals and people, too. It could be positive or negative effect, depending on the words spoken. We will think about doing another experiment on how human talking affecting on animals like pets or poultry or castles.

We feel very excited and happy when we completed this project. The lesson we learned is the important message we want to share to people: do not say bad words or words that hurt other's feelings. It could have serious effect on a person's future.

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Effects of Molar Ratio and Hardness of Glyptal, the Value-Added Product of the Production of Biofuels

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Abstract – The overreliance and harmful environmental effects of the use of fossil fuels as an energy source have led to research into alternative sources. One such alternative energy source is biodiesel, which is a carbon neutral fuel. However, due to its high cost of production, there is a lack of incentive to use this source. This paper focused on the byproduct of the production of biodiesel, glycerol and its ability to form value-added products which can then be used to lower the costs of biodiesel. Glyptal is a commonly used coating resin which can be formed with glycerol, phthalic anhydride, and sodium acetate. By changing the molar ratio of glycerol to phthalic anhydride (1:0.5, 1:1, 1:1.5, 1:2.0, 1:2.5) in the method of its synthesis, it was found that reaction mixtures with more phthalic anhydride resulted in the formation of harder resins, measured by a Shore D durometer test.

Key Words – Biodiesel, Glycerol, Glyptal, Polyester, Value-Added Product

INTRODUCTION

Despite the global acknowledgement that we have of climate change due to the excessive use of fossil fuels and its acceptance amongst the scientific community, our reliance on these fuels has only grown [1]. Global oil production and fossil fuel consumption has increased more than 2.5 times over the last fifty years [1]. Projections show that the use of these finite and polluting fossil fuels will continue to grow, and our reliance on oils and gas will account for more than 57 percent of the world's energy by the year 2040 [2].

As a measure to reduce this reliance, there has been extensive research in the use of biofuels as a carbon neutral alternative energy source to fossil fuels. Biofuel is produced through the process of base catalyzed transesterification with triglycerides and alcohol as reactants in the presence of the catalyst, sodium hydroxide [3]. The resulting ester is the biodiesel, a type of biofuel which can be used to replace diesel, which is derived from fossil fuels [3].

However, this process has higher costs of production than conventional diesel, offering little incentive for governments and industries to move away from using fossil fuels [4]. One possible solution to this is to find a use of glycerol, which is the major byproduct of biodiesel production. When producing biofuel, 10% (w/v) of the end product is glycerol [5]. Because of the surplus of glycerol,

researchers are now focusing on utilizing this waste product in creating value added products to lower the production costs of biofuel, and to further promote the biofuel industry as a viable source of energy [5].

One significant property of glyptal is its hardness, which makes it resistant to severe conditions [6]. In the research by Guimarães, Danilo, et al. (2007), it was found that the molar ratio of glycerol and phthalic anhydride affected the chemical composition of the glyptal formed [7]. In another study by Valerio, Oscar, et al. (2015), it was found that the ratio of glycerol to phthalic anhydride in the production of glyptal affects the degree of crosslinking [8]. Finally, it has been suggested that as the degree of crosslinking in a polymer increases, the mechanical property of hardness in the glyptal increases [9].

Although through these studies the chemical compositions of the formation of glyptal with the use of different molar ratios is known, there is a lack of sources which presents how these changes in chemical properties affect the mechanical properties of the polymer such as the hardness. Therefore, the focus of this investigation is to find the connection between the molar ratios of the two chemicals, and the hardness to find the molar ratio of phthalic acid to glycerol which would produce the hardest polymer. Finding this ratio would further optimize the properties of glyptal as a viable value-added product of glycerol.

LITERATURE REVIEW

Over the recent years, there have been many advances in glycerol-based polymers and many methodologies have been suggested [10]. For instance, the method for the synthesis of the polymer, “glycix” made from citric acid and glycerol has been presented as an effective polymer that has biomedical applications [11].

The suggested method for the production of this polymer was followed, but I was unable to yield a successful product. This raised uncertainty in the viability of this product as a replicable polymer. In contrast, the methodology followed for the synthesis of glyptal proved successful and I was able to yield large quantities of the product.

In the research by Guimarães, Danilo, et al, glyptal was formed using three different molar ratios of glycerol to phthalic anhydride: 1:1, 1:1.5, and 1:2 [7]. When there was more glycerol, the resulting polymer had an excess of

Effects of Molar Ratio and Hardness of Glyptal, the Value-Added Product of the Production of Biofuels

unreacted hydroxyl groups, found by the FTIR (Fourier Transform Infrared Spectroscopy) scan [7]. When the amount of phthalic anhydride was greater than the glycerol, the resulting polyester contained more unreacted carboxyl groups [7]. There was also a slight crystallinity for the polymers with more phthalic anhydride, indicating their more rigid chemical structures [7].

Furthermore, it was found that the ratio of hydroxyl (OH) to carboxyl (COOH) affects the crosslinking density and molecular mobility of the resin [8]. Both of these properties are important in the reaction of glycerol with phthalic anhydride as the cross linkage has been shown to affect the hardness, and the molecular mobility of the reactants is needed for the reaction to occur. Looking at the areas of the crosslinking for glyptal, the phthalic anhydride forms the bridges, which indicates that phthalic anhydride is responsible for the crosslinking in the polymer.

There has also been recent research from Ligot et al showing that as the crosslinking density of an ethyl lactate plasma polymer film increased, the hardness of the polymer created increased as well [9].

METHODOLOGY

The method used for the experiment has been adapted from two different methodologies designed to produce the same polymer. Modifications were made in order to accommodate the focus of the experimentation as well as resources limitations.

The molar ratios investigated from the study by Guimarães, Danilo et al was 1:1, 1:1.5, and 1:2 [7]. Upon running a series of preliminary experiments, I found that the glyptal resins could be synthesized from a 1:0.5 ratio, and anything above this ratio did not form a rigid structure. Also, I found that any ratio below the 1:2.5 ratio did not react, as the phthalic anhydride no longer mixed with the glycerol in the test tube. Therefore, the ratio of glycerol to phthalic anhydride investigated in my experiment were modified to: 1:0.5, 1:1, 1:1.5, 1:2, and 1:2.5.

TABLE I
AMOUNTS OF EACH REACTANT USED

Molar Ratio of Glycerol to Phthalic Anhydride	Volume of Glycerol/ml	Mass of Phthalic Anhydride/g	Mass of Sodium Acetate/g
1:0.5	4	4.04	0.5
1:1.0	4	8.24	0.5
1:1.5	4	12.16	0.5
1:2.0	4	16.20	0.5
1:2.5	4	20.28	0.5

In the experiment by Budhijanto, et al, glycerol as much as 71 mL was put in the reactor and heated [6]. After reaching the targeted temperature, 140.3 g of phthalic anhydride was introduced into the reactor and stirred until completely dissolved in glycerol. Due to the small amounts of phthalic anhydride and sodium acetate in the lab, the amounts of reactants were modified based on the volume of glycerol as 4ml.

Hardness is defined in this experiment as a measure of resistance to indentation [12]. The Shore Test is an instrument designed to measure the hardness of different plastics [12]. There are 4 types of durometers, and the Shore D tester measures the hardest plastics, and will be used for this investigation.

The Shore D testing durometer works by applying a force to the polyester and forming an indentation in the polyester [12]. The hardness is calculated by measuring the depth of the indentation caused by the standardized presser foot [12]. The depth of the indentation depends on the hardness of the material. This test has been used before, in the research by Zhang, J., et al in investigating the hardness of an epoxy resin and it been shown that this test is a reliable way to measure the hardness of polymers [13].

The glycerol, phthalic anhydride, and sodium acetate were poured into a disposable test tube. The test tube was held over a Bunsen burner using tongs. The test tube was moved side to side over the Bunsen burner until all of the phthalic anhydride and sodium acetate dissolved in the glycerol transforming into a colorless liquid. The test tube was held over the Bunsen burner until a light-yellow color change was visible. Twenty-five petri dishes (100 x 15 mm) were lined with aluminum foil. Finally, the contents of the test tube were poured into a medium sized petri dish lined with aluminum foil to cool in. This process was repeated five times for each molar ratio.

RESULTS

All 25 glyptal resins were successfully synthesized, shown in the picture below. The Petri dishes used were of the same size and depth, to ensure that the thickness of the polymer was constant. Furthermore, the aluminum foil was lined as smooth as possible to keep the thickness consistent as well.

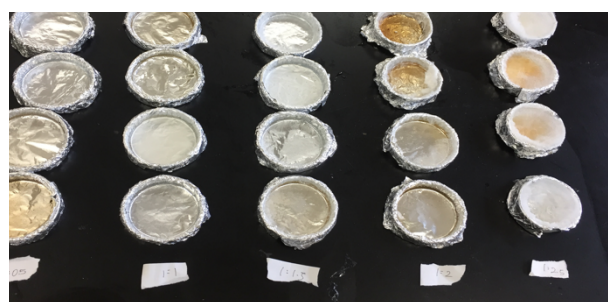


FIGURE 1
PHOTO OF ALL 25 GLYPTAL RESINS

To measure the hardness, the polyester was taken out of the petri dish and placed flat on a table. Three horizontal lines and three vertical lines were marked on the polyester to create squares of equal sizes.

Effects of Molar Ratio and Hardness of Glyptal, the Value-Added Product of the Production of Biofuels

A durometer was pushed perpendicularly to the points with the red dots as indicated in the diagram below and the hardness value was recorded.

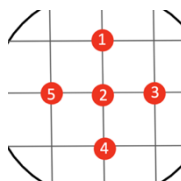


FIGURE 2
METHOD OF MEASURING HARDNESS

The following table shows all of the values of the hardness measurements for each of the glycerol to phthalic anhydride ratios.

TABLE II
RAW DATA OF HARDNESS AT EACH RESPECTIVE POINT

Ratio	Trials	Shore Hardness at each respective point					Average Shore Hardness
		1	2	3	4	5	
1: 0.5	1	35.0	37.0	35.5	37.0	36.0	36.1
	2	36.5	38.0	37.5	38.0	36.5	37.3
	3	37.0	37.0	36.0	37.5	37.0	36.9
	4	36.0	36.5	35.5	36.0	36.0	36.0
	5	36.0	36.5	36.0	36.5	36.0	36.2
1: 1.0	1	40.5	42.0	41.5	41.0	39.5	40.9
	2	42.0	40.0	42.0	43.0	41.0	41.6
	3	41.0	43.0	43.5	45.0	40.5	42.6
	4	41.0	42.0	42.0	41.0	42.0	41.6
	5	42.0	41.5	41.5	40.5	40.5	41.2
1: 1.5	1	47.0	49.0	51.5	52.0	52.5	50.4
	2	49.0	50.0	50.0	51.5	52.0	50.5
	3	50.0	51.0	50.5	52.0	51.0	50.9
	4	47.5	50.0	51.0	53.0	52.0	50.7
	5	49.0	51.0	51.0	50.5	53.0	50.9
1: 2.0	1	55.5	57.0	55.0	55.0	57.0	55.9
	2	56.5	56.0	54.0	56.0	56.5	55.8
	3	54.0	55.0	56.0	54.5	57.0	55.3
	4	56.5	56.0	56.5	56.5	56.0	56.5
	5	56.0	55.5	57.0	56.0	57.0	56.3
1: 2.5	1	67.0	66.0	68.0	66.0	65.5	66.5
	2	65.0	66.5	67.0	67.0	66.0	66.3
	3	64.5	67.0	65.0	68.0	67.5	66.4
	4	65.0	68.0	65.0	66.5	65.0	65.9
	5	65.5	65.0	66.0	67.0	66.0	65.9

The average and standard deviation was calculated for each of the glycerol to phthalic anhydride ratios. In addition, the 95% confidence interval was calculated. For example, for the 1:2.5 ratio, with 95% confidence the population mean is between 66.1 and 66.3, based on 25 samples.

The uncertainty for the Shore D durometer was taken from the estimation found by Stibler and Herrmann as ± 1.7 and the least count of the durometer, which is ± 0.1 . Thus, the overall uncertainty is ± 1.8 [14].

TABLE III
AVERAGE, STANDARD DEVIATION, 95% CONFIDENCE INTERVAL, AND RANGE CALCULATED FOR GLYPTAL

Ratio	Ratio as a Decimal	Average	Standard Deviation	95% Confidence Interval	Range
1:0.5	2.0	36.5	0.5	0.2	3.0
1:1.0	1.0	41.6	0.6	0.2	5.5
1:1.5	0.7	50.7	0.2	0.1	6.0
1:2.0	0.5	56.0	0.4	0.2	3.0
1:2.5	0.4	66.2	0.3	0.1	4.0

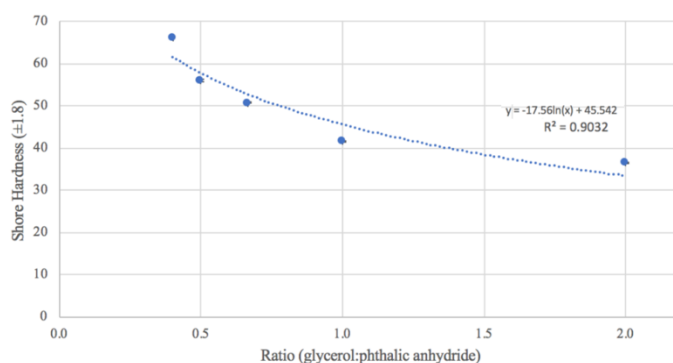


FIGURE 3
GRAPH SHOWING THE RELATIONSHIP BETWEEN THE MOLAR RATIO AND RESULTING SHORE HARDNESS

Figure 3 above shows the relationship between the ratios used and the hardness measured with the Shore D Durometer.

A logarithmic trend line was plotted in the graph as the points in the graph had a sudden decrease in the hardness for small ratio changes, and then the reduction in hardness becomes less significant as the saturation of glycerol is reached. The error bars represent the 95% confidence interval and looking at the graph these intervals do not overlap between the ratios. The R squared value of the trend line is 0.903, indicating a strong correlation between the points and the trend, and suggesting that there may be a logarithmic relationship between the ratio of glycerol to phthalic anhydride and hardness.

DISCUSSION

The synthesis of all 25 from glycerol, phthalic anhydride, and sodium acetate was successful. The Shore durometer test was used to measure the hardness of this polymer. In the method for synthesizing the resins adapted from the studies by Budhijanto, et al and Guimarães, Danilo, et al, the pan size of where the melted resin was poured into, and the amount of the sodium acetate catalyst added was kept constant to see the changes that the ratio of glycerol to phthalic anhydride would have on the hardness. The data collected showed that as the glycerol to phthalic anhydride decreased, the average Shore hardness increased. The research by Ligot, Sylvie, et al indicated that crosslinking makes the polyester more rigid, and there is an increase in the hardness of the polyester [9]. Since in glyptal

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Effects of Molar Ratio and Hardness of Glyptal, the Value-Added Product of the Production of Biofuels

phthalic anhydride was essential in the formation of crosslinks between the chains of phthalic anhydride and the glycerol molecules, this research mirrors my findings. Furthermore, although the research only investigated the glyptal up to the ratio of 1:2, a ratio above this value was investigated and it was found that the hardness of the 1:2.5 ratio glyptal was harder than the 1:2 glyptal.

This trend is supported from the logarithmic trend line displayed, and the high R squared value of 0.903. Although the trend of the first 4 points appears to be steeper than what the line suggests, overall, this trend line is representative of the data. Looking at the qualitative data, the time it took for the resin to dry was faster with the resins containing more phthalic anhydride. In addition, the hardness of epoxy resins, which are polymers that can be used for coatings, ranged from 74 to 90 using the shore D durometer in the research by Zhang, J., et al [13].

Although the polymers created were short of this range, the 1:2.5 glyptal had a maximum hardness of 68, which almost reaches the minimum hardness of the epoxy resins, indicating a high reliability in the data.

However, there were a few flaws in the methodology. For example, the use of a Bunsen burner in the heating and synthesis process of the glycerol and phthalic anhydride mixture led to inconsistencies in the temperature. This could have impacted my results as there may have been incomplete melting of the phthalic anhydride. As an improvement, a laboratory hot plate can be used. Also, another limitation was lack of confirmation of the identify the resin formed, due to the lack of access to spectroscopy equipment, aside from the qualitative observations and hardness measured. In ideal situations, a FTIR analysis would be used.

Qualitative characteristics of the resins observed were similar to the ones described by Beaucage, as a smooth and slightly yellow resin [15]. This characteristic was consistent for all of the resins synthesized using the method for synthesis. Furthermore, there was consistency in the hardness for each of the ratio of the resins, as shown by the standard deviation, 95% confidence interval, and the range in the data.

Thus, although there were some limitations in the methodology for the synthesis of the glyptal resins created for this experiment, the characteristics of the resins as well as their similar hardness across a ratio shows that the data collected was reliable.

As more applications of glyptal are discovered, this may raise the demand for glycerol, the byproduct of the production of biofuels. As a result, through bettering the economic viability of the process, the production of biofuels would be encouraged.

CONCLUSION

This paper has shown that the production of biodiesel yields a large amount of glycerol and has highlighted the need for finding an effective use and a value-added product of glycerol, as it could incentivize further production of carbon neutral biofuels as an alternative to fossil fuels. One such use of glycerol is its ability to undergo polymerization with phthalic anhydride to form glyptal, a substance that could be used as a coating resin.

Glyptal at ratios of glycerol to phthalic anhydride of 1:0.5, 1:1, 1:1.5, 1:2, and 1:2.5 were synthesized. A Shore D hardness test was conducted on all samples. The conclusions from the experiment showed that greater levels of hardness can be achieved with a smaller ratio of glycerol to phthalic anhydride. The maximum hardness of glyptal was found for the ratio 1:2.5 with a Shore hardness of 68.

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The Comparison of Microwave-Assisted Organic Synthesis and the Conventional Heating Method

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Abstract – A branch of green chemistry called microwave-assisted organic synthesis is explored. This procedure uses heat generated by reactant molecules under the electromagnetic field of radiation in microwaves to facilitate the reaction. A simple method was developed for synthesizing acetylsalicylic acid, commonly known as aspirin. To highlight the characteristics of this procedure, acetylsalicylic acid was synthesized using conventional methods that use a water bath as an energy source, as a comparison. Since the purity and yield is a great emphasis in green chemistry, purity and yield of acetylsalicylic acid synthesized using both procedures were determined using the iron (III) chloride test. The results showed acetylsalicylic acid synthesized using microwave assisted organic synthesis had higher yield and purity in a shorter reaction time compared to the conventional method. Furthermore, microwave-assisted organic synthesis did not require the use of a catalyst to produce high purity and yield, unlike the conventional method.

Key Words –Acetylsalicylic acid, ferric Chloride test, microwave-assisted organic synthesis

INTRODUCTION

Microwave-assisted organic synthesis (MAOS) [1]-[4] uses microwave technology [4][5] to synthesize organic molecules. Compared to the conventional method of organic synthesis, which uses an oil bath or water bath as a medium for heating [5][6] MAOS has many benefits including shorter reaction time [4]-[6], greater purity [5][6] and yield [1][6]. It also reduces secondary products [5][6] and activation energy [2][7] in some reactions. Because of these benefits, it is gaining increasing attention in the field of organic chemistry and is predicted that MAOS will be the mainstream method for organic synthesis in the near future. [2][5]

For the comparison, acetylsalicylic acid (ASA) was synthesized using both MAOS and the conventional method.

ASA, commonly known as aspirin, treats a wide range of symptoms such as headaches, inflammations, and fever, as well as prevention of heart attack in low doses. [8]-[10] Both purity and yield are important in the pharmaceutical industry since the effective use of ingredients is emphasized during the development and production of drugs as some ingredients are difficult or expensive to obtain.[1] To calculate the purity and the yield, the iron (III) chloride test is conducted using

colorimetry. This test was chosen because it allows the analysis of both quantitative and qualitative data.

RESEARCH

1.1 Microwave-assisted Organic Synthesis (MAOS)

Microwave-assisted Organic synthesis (MAOS) [1]-[4] uses the heat generated from interactions between reactant molecules and the electromagnetic field of microwave radiation to facilitate the synthesis of organic molecules. [1][3][4][6] In the presence of microwave radiation, reactant molecules attempt to align themselves to the electromagnetic field of the radiation. [3][4] In this process, molecules move in random motions which cause friction that translates into heat.[3][11] The generated heat is used as energy to facilitate reactions.[3][11]

1.1.1 Comparison with the conventional method

The conventional method of organic synthesis uses an oil bath or water bath as a medium to indirectly supply heat. [5][6] The uses of medium inevitably result in uneven heating because the area close to the heat source gets more heat than areas away from the source. [6] In contrast, MAOS provide energy directly as heat is generated by the reactant molecules. [1][4][6] Thus, MAOS results in even distribution of energy, increasing the possibility of successful collision of reactants. [1][4][11] This results in greater purity and yield of the product. [1][6] Furthermore, since the energy is directly applied to reactant molecules, MAOS has significantly shorter reaction time [4]-[6] and reduction of secondary products, [1][5][6] such as the bulk temperature of the medium. [6]

In addition, MAOS also decreases the activation energy (E_a) of synthesis because microwave radiation causes changes in the bond angle, bond length and electron cloud distribution of reactant molecules, leading to decrease in E_a . [3][7] In some reactions, the activation energy decreases significantly that use of catalysts is not necessary. [3]-[5][7] Considering that catalysts can be hazardous, expensive and difficult to isolate from the products, it makes reactions a lot simpler and cheaper to conduct. [5] For instance, the phosphoric acid commonly used in the synthesis of ASA is hazardous.

I.III. Limitation of MAOS

Despite the advantages of MAOS, there are limitations. Firstly, MAOS can only facilitate synthesis involving polar molecules or ions. [4]-[7][12] The sufficient amount of heat is only generated when polar molecules or ions resist aligning with the electrical field from the microwave radiation. [7][12] Since non-polar molecules do not possess resisting forces such as intermolecular forces and electric resistance to restrict its motion, it aligns with the electrical magnetic field without producing sufficient heat. [4][13] This issue can be easily solved by adding a solvent, catalyst or reactant that are polar such as water. [3][4] Most organic molecules are non-polar because of C-H bonds.[14] However, most organic molecules contain functional groups that are polar, [15] which allows MAOS to facilitate most organic reactions.

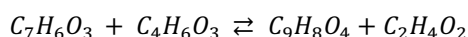
Secondly, the application of MAOS to industrial production scale is difficult and expensive. [13][16] There is a limit on the penetration of microwave radiation, which is usually 5cm~10cm depending on the object. [13][16] Thus, MAOS on a large scale is quite ineffective and loses many of the benefits it had over the conventional method, such as the shorter reaction time. [16] Furthermore, using microwaves on a large object can result in extremely high temperature and pressure, making the method dangerous. [13][16][17]

However, a design of microwave known as continuous flow system was developed in the late 1990s, allowing the application of MAOS on an industrial scale. [13][16] This design maintains the benefits of MAOS. [16] However, the continuous flow system is difficult to implement because of its complex design and the expensive price point. [16][17] Thus, it is currently used in only a few factories, which reported successful organic synthesis in the kilogram scale. [16] Since this is a new technique still being developed, scientists are optimistic about wide implementations of this design in the near future. [16]

Nonetheless, MAOS is currently suitable for research purposes and drug discovery. [1][2] With the conventional method, development of drugs took a long time due to the time requirement for drug synthesis and optimizations. [1] Because of this, research teams often did not have enough financial resources to continue or even start the research. [1] MAOS is a great method to overcome these issues as it synthesizes drugs faster [4]-[6] and uses ingredients more effectively.

II Le Chatelier's principle

ASA ($C_9H_8O_4$) is synthesized using salicylic acid ($C_7H_6O_3$) and acetic anhydride $C_4H_6O_3$, as following equation shows. Acetic acid is produced as by product. [8]-[10]



The reaction is reversible, thus, equilibrium is established. [10][20] Once equilibrium is reached, the products react with each other to produce the original reactants. [18][20] Hence, Le Chatelier's principle can be adapted to shift the equilibrium to the product side to maximize the yield. To do so, the reactant, in this case acetic

anhydride, is added in excess. [18][19] Furthermore, heat is added because this reaction is endothermic. [19]

III The iron (III) Chloride test

The iron (III) Chloride test is used to determine the purity [19][20] of synthesized ASA. The iron chloride acts as Lewis acid to covalently bond with the two functional groups of salicylic acid, $-OH$ and $-COOH$, to form a complex, $([Fe(H_2O)_6]^{3+})$. [19][20] This ion has an intense purple color. [19][20]

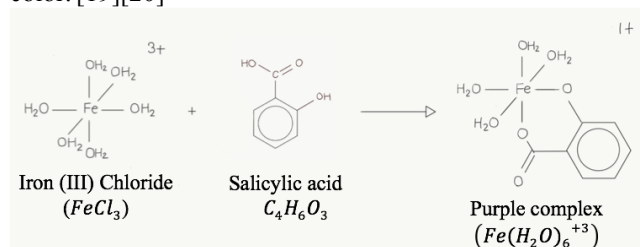


FIGURE 1
THE IRON (III) CHLORIDE REACTS WITH SALISYLIC ACID TO FORM A PURPLE COMPLEX

The colorimeter is then used to measure the transmission percentage. According to Beer-Lambert's law, the colored solution has a property to absorb a certain wavelength of light when monochromatic light passes through it. [20] The amount of light absorbed by a solute is proportional to the number of absorbing molecules. [20] Thus, the intensity of the observed color is proportional to the mass of salicylic acid in the solution, [20][21] e.g. higher concentration, darker purple color.

METHODOLOGY

Due to the hazardous nature of reactants used, goggles, lab coats and gloves were used throughout the experiment. 2.00g of salicylic acid and 5 ml of acetic anhydride was mixed in a 150 colonial flask in the fume hood.

For MAOS, the flask was placed in microwave cleaned with distilled water. The flask was heated for 2 minutes at the maximum heat. After heating, 10ml of cooled distill water was added to react with the excess acetic anhydride. This converts acetic anhydride into acetic acid which is less toxic. Then, the flask was placed in a beaker filled with ice for 15 minutes to recrystallize the product.

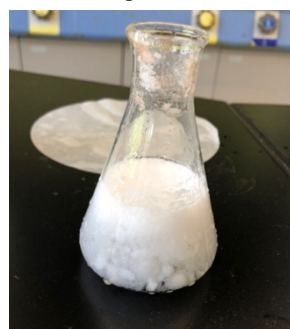


FIGURE 2
THE SYNTHESIZED PRODUCT IN THE FLASK

Nov 23-24, Tokyo

The comparison of Microwave-Assisted Organic Synthesis and the Conventional Heating

After the recrystallization, the synthesized product was isolated using filtration. The cold distilled water was used to assist the filtration to prevent the dissolving of product. The isolated product was placed flatly in a labeled petri dish and dried for 2 days.

For the conventional method, the flask with the same amount of reactants was placed into a boiling water bath, with heat supplied by a Bunsen burner. The flask was heated for 15 minutes. Products were cooled and isolated using the same method. In another treatment, one drop of phosphoric acid was added as catalyst in this synthesis. This examines the effect of the catalyst. Three treatments, MAOS, the conventional method without catalyst and with catalyst, were all repeated five times.

For the iron (III) chloride test, 10ml of ethanol was poured into 7 test tubes. In four of them, the following mass of salicylic acid was added.

TABLE I
THE MASS OF SALICYLIC ACID ADDED INTO EACH TEST TUBE

	Test tube 1	Test tube 2	Test tube 3	Test tube 4
Mass of salicylic acid (g \pm 0.01g)	0.10	0.15	0.20	0.25

For the remaining three test tubes, 0.25g of the products synthesized using the three treatments were added.

1.00g of the iron (III) Chloride was dissolved in 50ml of distilled water. 1ml of this solution was added to each test tube. Seven cuvettes were filled with each of the solutions to approximately 2/3 full. A colorimeter was used to determine the transmission percentage at 420nm.

EXPERIMENTS

I. Quantitative data

TABLE II

THE MASS OF THE SYNTHESIZED PRODUCTS FOR EACH TRIAL OF THE THREE TREATMENTS

	Number of trials	Types of treatment		
		The conventional method without catalyst	The conventional method with catalyst	MAOS
Mass of synthesized product (g \pm 0.01g)	1	1.07	1.20	1.38
	2	1.22	1.42	1.40
	3	1.18	1.33	1.34
	4	1.10	1.29	1.44
	5	1.14	1.22	1.31
	Average	1.13	1.29	1.37

TABLE III

THE TRANSMISSION PERCENTAGE OF DIFFERENT MASS OF SALICYLIC ACID DETERMINED BY THE IRON (III) CHLORIDE TEST

The mass of salicylic acid	0.10g of salicylic acid	0.15g of salicylic acid	0.20g of salicylic acid	0.25g of salicylic acid
Transmission percentage (% \pm 0.018%) ²⁸	46.31 (\pm 0.8%)	34.2 (\pm 0.6%)	24.4 (\pm 0.4%)	0.29 (\pm 0.005%)

TABLE IV

THE TRANSMISSION PERCENTAGE OF THE SYNTHESIZED PRODUCTS OF THE THREE TREATMENTS

Types of method	The conventional method without catalyst	The conventional method with catalyst	MAOS
Transmission percentage (% \pm 0.018%) ²⁸	51.37 (\pm 0.9%)	57.21 (\pm 1%)	67.90 (\pm 1%)

II. Qualitative data

The ASA synthesized using the conventional method had reflective fibers on the surface, which resembled salicylic acid. It was also softer and paste like compared to ASA synthesized using MAOS, which were powdery. Since salicylic acid is relatively flexible, these characteristics indicate incomplete reactions for the conventional method

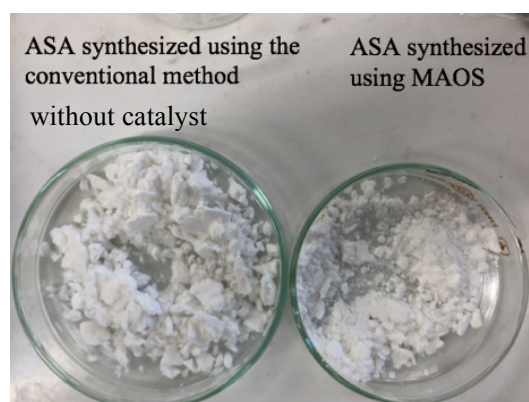


FIGURE 3

THE COMPARISON OF ASA SYNTHESIZED USING THE CONVENTIONAL METHOD AND MAOS

The iron (III) Chloride test for the conventional method without catalyst had the darkest color, indicating the largest mass of salicylic acid. On the other hand, MAOS had the light color, indicating the least mass of salicylic acid, indicating a higher purity compared to the conventional method without a catalyst.

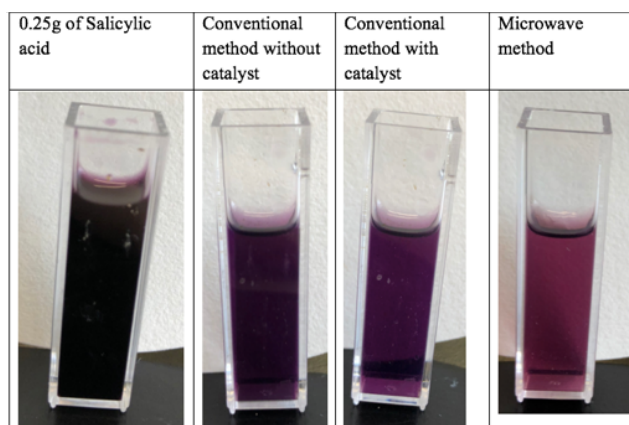


FIGURE 4

THE RESULT OF THE IRON (III) CHLORIDE TEST FOR ALL THREE TREATMENTS AND SALICYLIC ACID

UNCERTAINTY

I. Uncertainty of synthesized products

TABLE V

THE UNCERTAINTY PERCENTAGE OF SYNTHESIZED ASA

Percentage uncertainty of synthesized ASA		
The conventional method without catalyst	The conventional method with catalyst	MAOS
6%	5%	4%

II. Uncertainty of Purity and Yield

Percentage uncertainty in measuring the product. 0.01 is the uncertainty of the digital mass balance.

$$0.01 \div 0.25g = 0.4\%$$

Add percentage uncertainty of synthesized products:

$$0.4 + 4 = 4.4\%$$

Add percentage uncertainty of transmission rate:

$$4.4 + 1 = 5.4\%$$

TABLE VI

THE UNCERTAINTY PERCENTAGE OF PURITY AND YIELD

Percentage uncertainty of purity and yield		
The conventional method without catalyst	The conventional method with catalyst	MAOS
7%	6%	5%

ANALYSIS

Based on Table 3, the mass of salicylic acid was plotted against the transmission percentage, and the equation of $y = -301.66x + 78.338$ is obtained as a best fit equation of the data

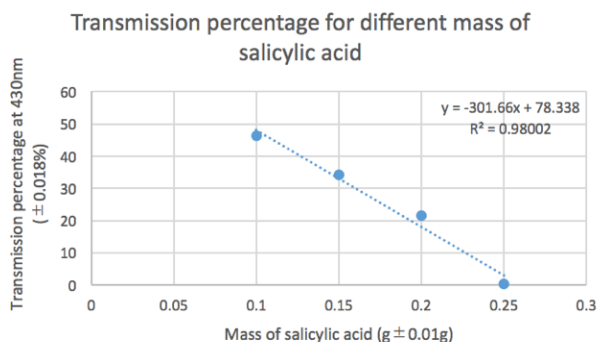


FIGURE 5

THE TRANSMISSION RATE OF DIFFERENT MASS OF SALICYLIC ACID

Figure 5 shows a strong negative linear correlation between the mass of salicylic acid and the transmission percentage, indicating solutions with the higher mass of salicylic acid had darker color. This corresponds to the secondary research on Beer-Lambert's law, supporting this primary data. The R-squared value is quite high which

increases the reliability of data drawn from this graph. By substituting the value of transmission percentage of synthesized products on Table 4, the mass of salicylic acid in each of the synthesized products is determined.

Example:

$$67.90 = -301.66x + 78.338$$

$$x = 0.035g$$

TABLE VII

THE MASS OF SALICYLIC ACID IN THE SYNTHESIZED PRODUCTS

The mass of salicylic acid in the synthesized products (g)		
The conventional method without catalyst	The conventional method with catalyst	MAOS
0.089 (± 7%)	0.070 (± 6%)	0.035 (± 5%)

Although the percentage uncertainty is quite high, there are no overlaps among different methods, which increases the reliability of this data.

Based on Table 7, the purity of the products is determined.

$$\text{Purity (\%)} = [1 - (\text{impurity} \div \text{total mass})] \times 100$$

Example:

$$\text{Purity (\%)} = [1 - (0.035 \div 0.25)] \times 100 = 86\%$$

TABLE VIII

THE PURITY OF SYNTHESIZED ASA FOR THE THREE TREATMENTS

The purity of ASA synthesized (% ± percentage uncertainty)		
The conventional method without catalyst	The conventional method with catalyst	MAOS
64 (± 7%)	72 (± 6%)	86 (± 5%)

Table 8 was calculated based on the assumptions that the catalyst, excess reactants and products were completely removed in the process of filtering due to the complete water soluble nature of these molecules. Table 8 shows that the ASA synthesized using MAOS had the highest purity whereas the conventional method without catalyst had the lowest purity. This indicates that catalyst helps to increase the purity of ASA, however, MAOS can result in greater purity without the use of catalyst.

To calculate the yield of synthesized products, the theoretical yield is first calculated.

Equation for calculation of the mole:

$$\text{Mole (n)} = \text{Mass (gram)} \div \text{Molar Mass (gram)}$$

The comparison of Microwave-Assisted Organic Synthesis and the Conventional Heating

Salicylic acid:

$$2.00\text{ g} \div (12.011 \times 7 + 1.008 \times 6 + 15.999 \times 3) = 0.0145\text{ mol}$$

Acetic anhydride:

$$5.0\text{ ml} \div (12.011 \times 4 + 1.008 \times 6 + 15.999 \times 3) = 0.0490\text{ mol}$$

The ratio between salicylic acid and ASA is 1: 1, hence, for 0.0145 mol of ASA is theoretically synthesized.

$$0.0145 \times (12.01 \times 9 + 1.01 \times 8 + 15.99 \times 4) = 1.57\text{ g}$$

Theoretical yield of ASA: 1.57g

To calculate yield, mass of synthesized ASA is calculated: the mass of synthesized product \times purity
Example:

$$1.37 \times 0.86 = 1.18\text{ g}$$
$$1.18 \div 1.57 \times 100 = 75(\%)$$

TABLE IX
THE YIELD OF ASA FOR THE THREE TREATMENTS

The yield (% \pm percentage uncertainty)		
The conventional method without catalyst	The conventional method with catalyst	MAOS
46(\pm 7%)	59(\pm 6%)	75(\pm 5%)

Table 9 shows that yield has similar trends with purity. This shows MAOS uses ingredients more effectively compared to the conventional method. Although the uncertainty percentage is high, there are no overlaps among these methods, which maintains the reliability of the data.

EVALUATION

The yield was quite low for ASA synthesized using all three methods. However, it is extremely difficult to obtain high yield due to systematic errors such as the transfer of products during filtrations. Furthermore, ASA is not completely insoluble in water which inevitably caused some ASA to be lost during filtration and crystallization. Despite the low yield, there were still distinct differences between the three treatments, which validated my data and arguments.

To reduce the uncertainty, the most precise equipment available to me was used. However, due to the limit in the mass of ASA that can be synthesized per trial, the uncertainty become inevitably large. Furthermore, multiple equipment and steps of calculation were used, which inevitably resulted in greater percentage uncertainty. However, the uncertainty did not cause overlaps between data points which suggest the data is somewhat reliable.

To ensure the reliability of the research, at least two independent sources are used for most statements. The sources are also written or supervised by professors or author who has PhD in the related field. In addition, the sources are written or updated within 10 years since MAOS is a new technology with constant changes.

CONCLUSION

By examining both quantitative data and qualitative data, I conclude the products synthesized by microwave-assisted organic synthesis method (MAOS) has greater yield and purity compared to the conventional method in a shorter reaction time. Firstly, the data on Table 8 and Table 9 showed MAOS has both higher purity and yield compared to the conventional method. The greater purity is also shown in quantitative data, which showed that the ASA synthesized using the conventional method had reflective fibers and were soft, which are characteristics of salicylic acid, indicating high impurity. There were distinct differences in the intensity of the purple color of the Iron (III) Chloride test, showing the mass of salicylic acid was highest in the conventional method without catalyst and smallest in MAOS. This correspond to my secondary research on Beer-Lambert's law.

Although the uncertain percentage was inevitably quite high for the data, it did not cause overlaps between any of the treatments. Thus, the data is reliable. All of these data validate that MAOS has greater purity and yield. This suggests MAOS uses ingredients much more effectively compared to the conventional method, making it suitable for research and development of new drugs, but also on the production at industrial scale in the near future.

Due to the strong correlation between the primary and secondary research of this experiment, this paper recommends further research into other benefits of MAOS such as reduction of secondary reactions. Furthermore, the effects of MAOS greatly depends on the property of reactants, including polarity, bond angle and bond length, thus, I recommend synthesizing different types of drugs using MAOS to further evaluate the appropriateness of MAOS in the pharmaceutical industry as a whole.

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Change in Sleeping Pattern Between Pre-Adults and Adults

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Abstract - Sleep is an important biological activity that is required in order for the body to rest and recover. Previous researches emphasized the importance of proper sleep and highlight the growing problem of inadequate sleep. In this research, we established the difference in brainwave activity in pre-adults and adults by analyzing EEG data of pre-adults and adults. In this study, we obtained data of EEG experiment and data of brainwaves during different sleeping patterns from pre-adults (18-20 yrs old) and adults (21-40 yrs old). In the result, Delta was found to be significant during all wake and sleep stages. Since delta is associated with restoration and rest, we can conclude that pre-adults are at a constant state of rest and recovery. On the contrary, adults had brainwaves that were constantly active in all wake and sleep stages. From this, it can be concluded that adults have a constantly active mind that does not attain sufficient rest and recoveries.

Key Words - δ waves, γ waves, network analysis, brainwaves, unified network

INTRODUCTION

Sleep is an important biological activity that is required in order for the body to rest and recover. In counterpart, when being awake, the body is constantly working and moving, however, it still has the moments of resting and recovery. Moreover, sleep is an active process that is essential for recuperation, memory consolidation, emotional modulation, performance, and learning [1]. The hypothesis of this research is that there will be difference in sleeping patterns between adults and pre-adults attributable to age difference and, subsequently, lifestyle changes.

LITERATURE REVIEW

However, due to 21st-century technological advances and, subsequently, lifestyle changes associated with these technological advances, sleeping activity is under pressure and it has now become a challenge to obtain the necessary amount of sleep [2]. Sleep loss impairs cognition, psychomotor function, and mood [3]. This would emphasize

the importance of proper sleep and highlight the growing problem of inadequate sleep.

Interestingly, it was never established how these sleep-related brainwaves would vary as an individual age. Moreover, to our knowledge, there are no published research work done that compared the brainwaves from infants to elderly.

From research we have already done so far, we have established the differences in sleep in pre-adults and adults. In this research, we established the difference in brainwave activity in pre-adults and adults by analyzing EEG data of pre-adults and adults.

METHODOLOGY

I. Metadata

The expanding digital era has allowed enormous amounts of data to be accessible and interpreted. In this study, we obtained data of brainwaves during different sleeping patterns from pre-adults (18-20 yrs old) and adults (21-40 yrs old) [4][5].

II. Brainwave network

The brainwave data obtained were utilized to create networks. The nodes and edges represent the brainwaves and connection. Brainwaves analyzed in these networks are α wave, β wave, δ wave, γ wave, and θ wave.

To explain, α brainwaves which are related to subconsciousness categorized as deeply relaxed, light hypnosis and at a mystical state; β brainwaves which are related to consciousness categorized as fully awake, alert and at an ordinary reality; δ brainwaves which are related to dream state categorized as deeply unconscious, sleep and visiting other dimensions; γ brainwaves which are related to superconsciousness categorized as highly attentive state of consciousness and perception, involved in higher mental activity and the organization of information; θ brainwaves

Change in Sleeping Pattern Between Pre-Adults and Adults

which are related to superconsciousness categorized as drowsy, tranquil and unconscious.

Brainwaves were considered to have a connection if multiple brainwaves had values above threshold simultaneously.

EXPERIMENTS

I. EEG Measurement

Throughout the study, volunteers (n=3, females) for each group, namely the pre-adults (<21 yrs old) and adults (>21 yrs old) were used following the ethics guidelines set by our collaborators from Nihon University School of Dentistry (EP16D011). Samples were collected on the same day between 10:00 to 11:00 AM. The reason why 21 is the cut off mark between pre-adults and adults is that these ranges were made by the metadata we obtained and the ranges had to be equal. [4][5] Otherwise, the results will be affected. 3 females were only chosen because those 3 females were the only ones that volunteered in this research. We utilized a commercially available EEG measuring device to obtain brain frequency patterns and brainwave activity among the volunteers. Figure 1 shows the EEG measuring device that was used.



FIGURE 1
PHOTO OF EEG MEASURING DEVICE

Initially, brain frequency and brainwave activity were established between pre-adults and adults. Subsequently, by considering sleep patterns, we looked into how brainwaves vary between the two groups and utilized network analytics to elucidate brainwave differentiation. In establishing sleep-related brainwave variation, we compared our experimental data with established sleep metadata (Bashan et al 2018; Faes et al. 2018).[4][5]

II. Network Analysis

One method for analyzing metadata is network analytics. Network analytics is a method wherein interactions between

a series of networks are analyzed for a possible interpretation of the network. A common computational tool used to analyze networks is centrality measurements. Networks based on the experimental data and the metadata (Bashan et al 2018; Faes et al. 2018) were designed using a specialized software called Cytoscape.

Centralities analyzed were: stress, betweenness, closeness, and edge betweenness. Similarly, a unified network was designed in order to identify what is significantly common among the different centralities. Briefly, stress centrality suggests how much impact a node has on the network, betweenness centrality shows the cruciality of a node in a network based on the amount of need of the node in order for the network to be retained, closeness centrality indicates how much a node impacts other nodes in the network, and edge betweenness centrality signify the cruciality of the edge (or interaction) in the network.

ANALYSIS

Figure 2, 3 are graphs that represent brainwave data obtained from pre-adults and adults while awake.

Figure 2 shows that the brain frequencies between pre-adult and adult vary in measurement and trend. Representative (A) Pre-Adult and (B) Adult frequencies (Hz) are indicated below the bar graph and represented by varying colors. Brain frequency trends are indicated by the white linear graph. Time points are measured as seconds.

Figure 3 shows that the brainwaves between pre-adult and adult differ in activity. Representative (A) Pre-Adult and (B) Adult brainwave activity measurements at varying time points are indicated. (Clockwise) Delta (D), Theta (T), Low Alpha (a), High Alpha (A), Low Beta (b), High Beta (B), Low Gamma (g), and High Gamma (G) are marked. Time points are measured as seconds. Color changes are consistent with brain frequency deviations. Unified brainwave network of T=120 were designed and analyzed based on stress, betweenness, and closeness centrality.

Change in Sleeping Pattern Between Pre-Adults and Adults

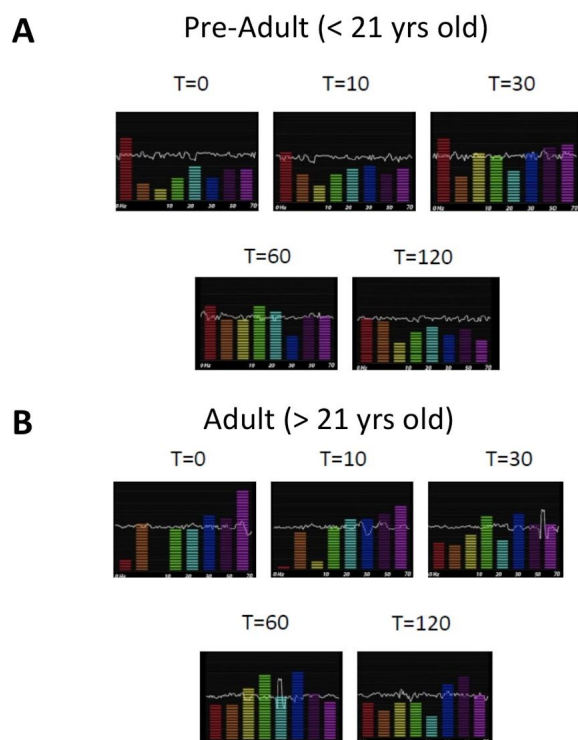


FIGURE 2
BRAIN FREQUENCIES BETWEEN PRE-ADULT AND ADULT

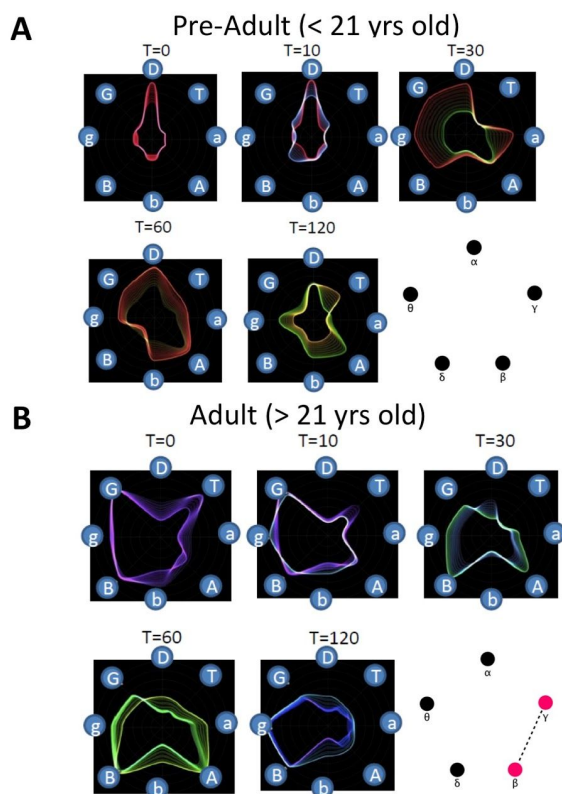


FIGURE 3
BRAINWAVES BETWEEN PRE-ADULT AND ADULT DIFFERENTIATION

In figure 2A, delta waves are constantly touching the edge of the graph, while in figure 2B, gamma waves are constantly touching the edge of the graph. This shows that pre-adults have delta-dominant brainwaves while adults have gamma-dominant brainwaves when awake, which is similar to the brainwave activity of pre-adults and adults when asleep.

This can also be observed by looking at the color of the graph. In figure 3A, the graphs are red and green and in figure 3B the graphs are green and purple. The colors represent the dominant brainwave and since red represents (0-4 Hz), green represents and purple represents, low-frequency waves are dominant in pre-adults whereas high-frequency waves are dominant in adults.

This is consistent with figure 2. The low-frequency waves are prominent in pre-adults while high-frequency waves are prominent in adults.

From figure 2, 3, 4, and 5, it can be observed that adults have fluctuating brainwaves whereas pre-adults have relatively fixed brainwaves.

Figure 4 presents the brainwave networks of (A) pre-adults and (B) adults are designed in the standard brainwave network design and analyzed using stress, closeness, betweenness and edge betweenness centrality. Unified networks were designed to unify the centrality measurements.

Figure 5 shows the brainwave network of pre-adults and adults during (A) awake and (B) sleep are designed in the standard brainwave network design and analyzed using stress, closeness, betweenness, and edge betweenness centrality. (A) is a network that consists of brainwave activity in pre-adults and adults during sleep that unified all centrality measurements.

Change in Sleeping Pattern Between Pre-Adults and Adults

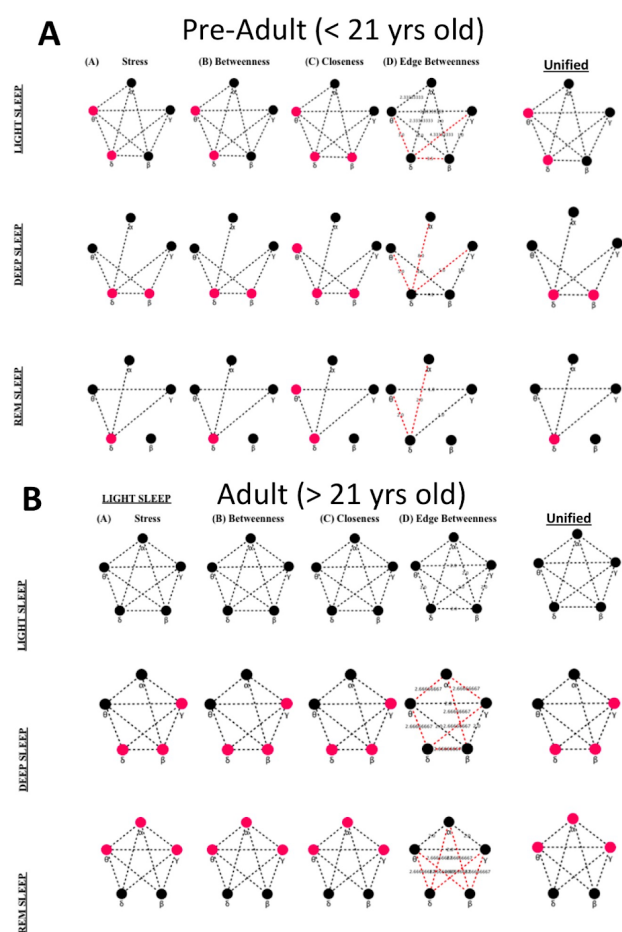


FIGURE 4
BRAINWAVE NETWORKS OF PRE-ADULTS AND ADULTS

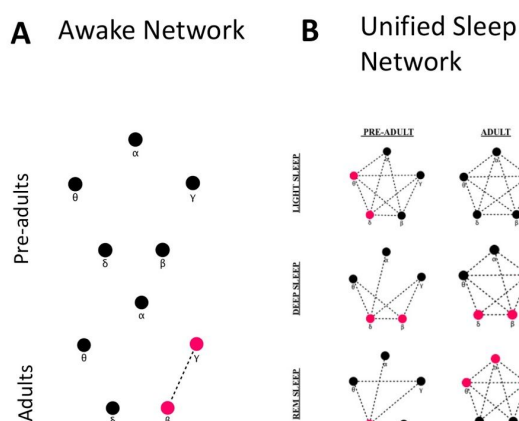


FIGURE 5
BRAINWAVE NETWORKS OF PRE-ADULTS AND ADULTS DURING AWAKE AND SLEEP

In figure 2, there are trendlines that represent the fluctuation in brainwave frequency and activity pattern. The trendlines

in figure 2A fluctuate more than figure 2B. this would mean that the brainwaves of adults are more active.

In figure 3, the shape and size of the graph in figure 3B change drastically compared to figure 3A. Figure 3B also have a spread-out graph that means that the brainwave of adults is more fluctuating.

Adults have brainwaves that constantly change in frequency and activity pattern whereas pre-adults have brainwaves that do not change as much. This would mean that adults do not get rest and recovery of the mind compared to pre-adults that have relaxed brainwave activity

In figure 4, 4, it can be observed that adults have a fluctuating brainwave activity since more nodes are simultaneously dominant.

Therefore, from figure 2, 2, 3 and 4, it can be observed that adults have more brain activity since fluctuating brainwaves are a symbol of active brainwaves.

Figure 4, 4 are networks that were designed to analyze pre-adult and adult brainwave data obtained from metadata. From figure 4A, in pre-adults, during light sleep, theta and delta waves are significant when analyzed based on stress centrality and betweenness centrality, and theta, gamma and beta waves are significant when analyzed based on closeness centrality. Combined, theta and delta waves are significant during light sleep(Figure 5A) .

During deep sleep, delta and beta waves are significant when analyzed based on stress and betweenness centrality and theta, delta beta waves are significant when analyzed based on closeness centrality. Combined, delta and beta waves are significant during deep sleep.(Figure 5A)

During REM sleep, delta waves are significant when analyzed based on stress and betweenness centrality and theta and delta waves are significant when analyzed based on closeness centrality. Combined, the delta wave is significant during REM sleep(Figure 5A) .

From figure 4B, in adults, during light sleep, none of the nodes were significant. Therefore, all brainwaves were active during this sleep stage.

During deep sleep, delta, beta and gamma waves are significant when analyzed based on stress, betweenness, and closeness centrality. Combined, delta, beta and gamma waves are significant during deep sleep.

During REM sleep, theta, alpha and gamma waves are significant when analyzed based on stress, and closeness centrality. Combined, theta, alpha and gamma waves are significant during REM sleep.

CONCLUSION

In this research, delta was found to be significant during all wake and sleep stages. Since delta is associated with

Nov 23-24, Tokyo

Change in Sleeping Pattern Between Pre-Adults and Adults

restoration and rest, in conclusion, pre-adults are at a constant state of rest and recovery.

On the contrary, adults had brainwaves that were constantly active in all wake and sleep stages. From this, it can be concluded that adults have a constantly active mind that do not attain sufficient rest and recovery. In addition, there is no chance that factors such as health, diet and other psychological factors are considered could cause the difference in sleeping patterns between pre-adults and adults.

In future research, we are planning to increase the number of volunteers used in this research and use the data taken by men. We are also planning to increase the age group and to research the difference between brainwave activities in women and men. As a possible future application of this research, we would like to propose reducing the amount of caffeine, alcohol and blue light in order to make delta wave more significant. (Landolt, 2018, Iskra-Golec et al., 2018)

[6][7]. By understanding this, the brain will restore more frequently and that will increase the efficiency of sleep.

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SAT Reading Analysis Using Eye-Gaze Tracking Technology and Machine Learning

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Abstract - We propose a method using eye-gaze tracking technology and machine learning for the analysis of the reading section of the Scholastic Aptitude Test (SAT). An eye-gaze tracking device tracks where the reader is looking on the screen and provides the coordinates of the gaze. This collected data allows us to analyze the reading patterns of test takers and discover what features enable test takers to score higher. Using a machine learning approach, we found that the time spent on the passage at the beginning of the test (in minutes), number of times switching between the passage and the questions, and the total time spent doing the reading test (in minutes) have the greatest impact in distinguishing higher scores from lower scores.

Keywords: Eye-gaze tracking, SAT reading, Machine learning, Analysis, Reading pattern

INTRODUCTION

The SAT is a standardized test that American students choose to take in order to enroll in some of the more prestigious universities. Students need to know how to perform well; however, currently, there are no non-intrusive methods to help establish this knowledge. Previous analysis of the SAT reading section has utilized post-test surveys, which are highly subjective and depend completely on the students' biased answers [1]. Therefore, a more objective analysis of the SAT reading section needs to be conducted in order to provide students with the most reliable techniques for reading the passages. Inexpensive and accurate eye-gaze tracking technology, like the EyeTribe eye tracker, has recently become readily available to the general public. Data collection using this technology is simple, non-intrusive, and objective. Using this technology and Khan Academy official SAT practice tests, we were able to collect data whilst maintaining a natural test-taking environment. Data collected from the eye tracking device allows us to analyze and identify different reading patterns, as well as uncover features that have a

significant impact on scores of test takers. After the collection of the initial data, we bifurcated the dataset into students who scored greater than or equal to 9, and students who scored less than 9, in order to identify any statistically significant habits in each respective group. With our new bifurcated dataset, we built and trained a model to predict whether a student can achieve a score of 90% or above on a passage. Our predictive model can be applied to any data set gathered using our method and can be used as a tool to allow educators to correct students' behaviors in order to maximize test scores prior to taking the official SAT.

RELATED WORK

Traditionally, College Board collects data about the SAT using qualitative post-test surveys. This has created a very unreliable and hard-to-analyze data set, as these post-test surveys are subjective and do not provide individualized feedback that the student can use to improve. Currently, post-test surveys are only used by College Board to improve the test or test-taking experience, and not student performance.

One method to reduce bias is to use a device that will collect data automatically and non-intrusively. Extensive research has been performed to verify the accuracy of eye-gaze tracking devices with respect to new sources of data including [2] and [3]. In [2], Ooms et. al. the experimenters verified that low-cost eye-gaze tracking devices can have comparable precision with the most well-established devices, given the correct setup and choice of software. Moreover, there is research in both [3] and [4] that has proved that eye-gaze patterns are related with reading comprehension; however, the papers, respectively, lack a real-life application and deeper analysis.

Our methodology aims to give students a more comprehensive and detailed way to further improve their test scores. In our previous paper [4] we described a method using correlation coefficients to analyze how reading pattern features correlate with scores. However, a major weakness in the previous method was that the correlation coefficient method was unable to show the difference between the

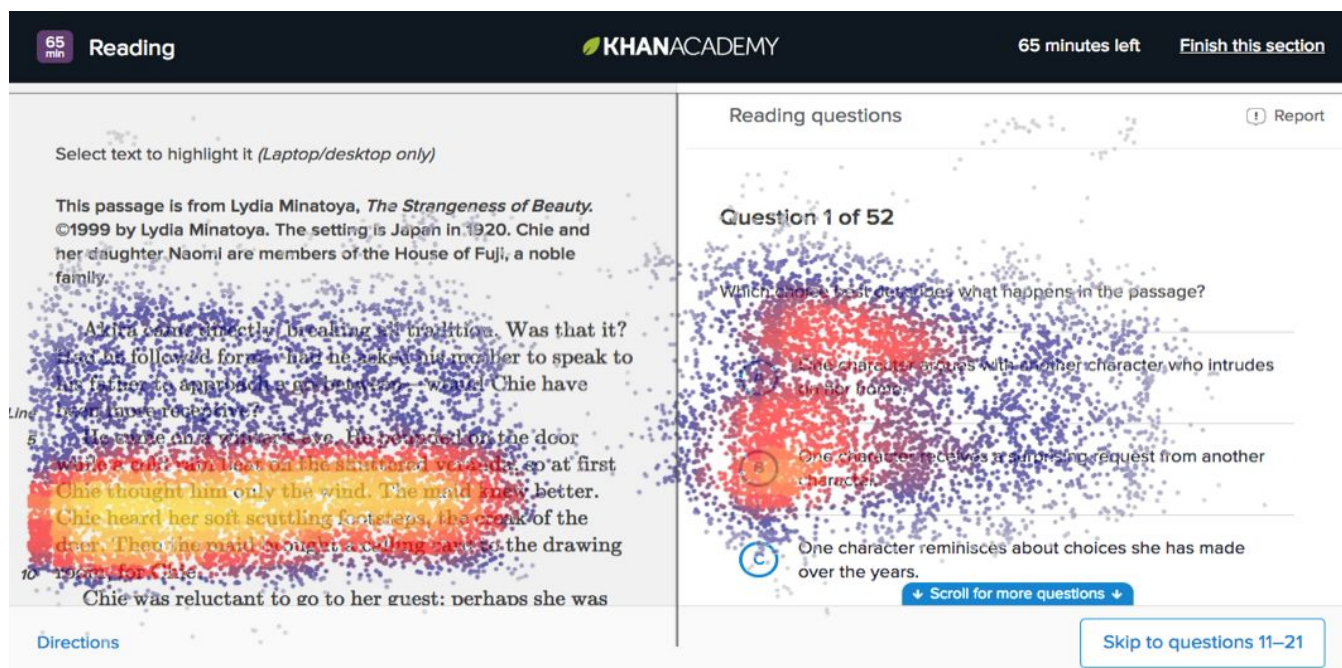


FIGURE 1
HEAT MAP OF EYE GAZES ON KHAN ACADEMY'S SAT PASSAGE TEST INTERFACE

reading methods of high achieving students and those of low achieving students. In addition, the correlation coefficient method does not show causality, and thus fails to achieve further insight into reading pattern behaviors. In this paper, we present a new method to further analyze the dataset using statistical tests and machine learning models. Our proposed method can show the significant difference in reading pattern features between students who have higher scores and those who do not and our machine learning model can give insight into how to achieve the best possible scores.

PROPOSED METHOD

This experiment used eye-gaze coordination data points in the form of time-series data in order to infer the reading patterns of SAT test takers. From the reading pattern features, we built a machine learning model to predict the outcome of the test. We interpreted that model and found the relationship between the reading patterns of the SAT test takers and their results. In the following subsection, we will explain each step we performed in order to achieve our results, from data collection to the creation of our prediction model.

I. Data Collection Method

We used Khan Academy's official practice SAT as the environment [5], where the passage was on the left side and the questions are on the right side of the screen. Students were required to take the test online while the eye-gaze tracking device was collecting the data. The coordinates of where the students were looking were stored

in a CSV file for analysis. We started collecting the data when the student began the test and we ended the collection process after the student answered all of the questions pertaining to a single passage. Fig. 1 shows the visualization of a test taker's heat map of eye gaze on the Khan Academy interface. In addition, we manually took note of the number of correct answers, incorrect answers, and unanswered questions as the ground truth information of the analysis.

II. Feature Extraction Method

Collected eye-gaze data were in a time-series format. From each sequence, we extracted 12 features from the raw coordinates of eye-gazes [4]. Table 1 below lists the 12 features.

TABLE 1.
LIST OF READING PATTERN FEATURES AND THEIR EXPLANATION

No.	Feature name	Explanation
1	Total Time	Total time to complete one passage (in minutes).
2	Percentage of total time looking at the passage	Percentage of total time looking specifically at the passage (in percent)
3	Percentage of total time looking at the questions	Percentage of total time looking specifically at the questions (in percent)

Nov 23-24, Tokyo

SAT Reading Analysis Using Eye-Gaze Tracking Technology and Machine Learning

4	Total switch count	Total amount of times the subject switches from looking at the passage to looking at the questions or vice versa (in times)
5	Time passage beginning	Amount of time spent solely on reading the passage at the beginning of the test (in minutes)
6	10-sec intervals passage reading	Number of ten-second intervals which have 80% or more of the ten seconds spent on reading for the passage (in times)
7	10-sec intervals question reading	Number of ten-second intervals which have 80% or more of the ten seconds spent on reading for the questions (in times)
8	Percentage of time looking at the passage in first 4 minutes	Percentage of time in first four minutes spent only on reading the passage (in percent)
9	Percentage of time looking at the questions in first 4 minutes	Percentage of time in first four minutes spent only on reading the question (in percent)
10	Percentage of time looking at the passage in last 4 minutes	Percentage of time in last four minutes spent only on reading the passage (in percent)
11	Percentage of time looking at the questions in last 4 minutes	Percentage of time in last four minutes spent only on reading the question (in percent)
12	Speed of reading the passage	The speed at which the test taker reads the passage measured by the distance between two pixels in a fixed interval.

III. Machine Learning Model

Typically, a machine learning model is trained from past example data and has the capability to predict an unseen dataset. However, we had a different approach. We trained a machine learning model and analyzed how the model learns to make the decisions in order to extract insights on the model. We split the data into two groups based on the results of the reading test: those that answered correctly 9 or 10 out of 10 questions (high score), and those that answered correctly lower than 9 out of 10 questions (low score). We chose a simple decision tree classifier to

train a classification model. The decision tree used the above features and learned how to determine whether the outcome of the test would result in a high score or low score. We used the whole dataset for training because our purpose was to extract the decision processes of the model not predict future occurrences. We also reported how well the model can perform on the same training dataset.

EXPERIMENTAL SETTINGS

We used an EyeTribe as our eye-gaze tracking device. The EyeTribe's sampling rate is 30 Hz. On average, for each reading test with one passage, we had around 12,000 coordinates in total.

Our test takers ranged in age from 14 to 18 years old: the ultimate beneficiary ages of this experiment. We asked them to read a passage and answer all the questions on the screen with no guidance on the reading method. After the first test, the students took the test two more times, but with a certain level of guidance. The first time, they were asked to read the passage first, and then move to the questions. The second time, they were asked to do the same method but in reverse order.

We collected a dataset of 30 native English speaking students from 10 different countries. In total, we had over 1000 minutes of reading data on 90 reading tests. Each test was associated with a particular score that they achieved for that test, ranging from 0 to 10.

RESULTS

After training the decision tree model to classify whether a test was a high score or low score, we realized that the decision tree had stopped using more features after four splits. Our decision tree used entropy as the criterion for measuring the quality of a split. The three features used by the decision tree were time passage beginning, total time, and total switch count. The feature at the root of the decision tree had the highest information gain. The decision tree is illustrated in Fig. 2.

TABLE 2.

CONFUSION MATRIX OF THE DECISION TREE CLASSIFICATION MODEL

		Ground truth	
Prediction		Higher-score	Lower-score
	Higher-score	33	17
	Lower-score	4	36

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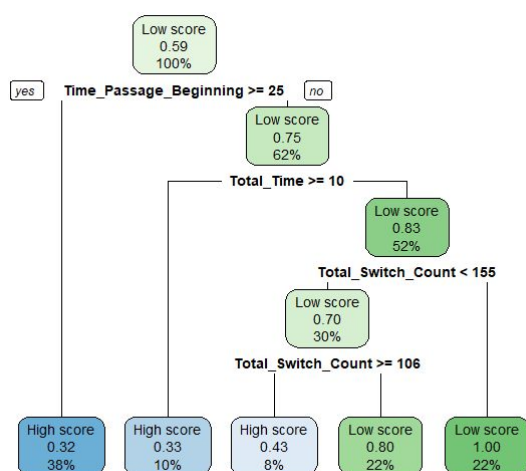


FIGURE 2

DECISION TREE CLASSIFICATION MODEL DECISION PROCESSES

If the test taker reads the passage for 25 seconds or more at the beginning of the test, he or she will be most likely to score higher (23 cases out of 34 cases). For those who read the passage for less than 25 seconds at the beginning of the test and have his or her total time either equal to 10.49 or be greater than 10.49 minutes, he or she will most likely score higher (6 cases out of 9 cases). A student who switches fewer than 155 times but more than 106 times between the passage and the questions will also be more likely to have a higher score.

The decision tree had an accuracy of 76.67% predicting its own training dataset. The confusion matrix of the decision tree is described in Table 2 below.

According to the results, we can infer some of the following insights: (i) A test taker should spend 25 seconds or more reading the passage at the beginning; (ii) a test taker should spend as much time as possible on a single passage (10.49 minutes or more), but pace themselves efficiently because one is only allotted 65 minutes for 52 questions; and (iii) a test taker should not switch between the questions and the passage too many times.

CONCLUSION

We have proposed a method to analyze the reading patterns of SAT reading test takers from raw eye-gaze tracking data. From the analysis, we can extract the reading pattern features and use them in a machine learning model. The machine learning model we chose is the decision tree classification model. This model gives us insights on how to improve student performance on the reading section of the SAT. Based on the results of the trained model, the features such as spending time on reading the passage at the beginning, the total time to take the test, and the number of switches between the questions and the passage are found to have a significant impact on SAT reading performance.

We plan to collect a bigger dataset in order to expand the research and use the predictive model in a more real-life application to help improve SAT reading test performances.

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Tennis Stroke Classification Using Myo Armband

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Abstract - This paper presents the methods and results of the classification of tennis strokes. We chose to incorporate my favorite sport to this project and we chose to classify the different tennis strokes. We collected the data by using an armband sensor Myo, and gathered data on four different features: the acceleration, the gyroscope, the quaternion, and the EMG. By using a supervised learning model, Support Vector Machine (SVM), we were able to classify very accurately on the strokes of a tennis swing. Moving forward, we want to further improve our project by being able to analyze the player's winning shots and their losing shots to improve one's play.

Keywords - tennis, stroke classification, myo armband sensor

INTRODUCTION

I started to play tennis in 2nd grade, simply for fun, and back then it did not mean anything much other than the fact that I was able to run around a lot. However, now tennis is the one and only sport I would consider exciting and thrilling. The stress relieving smooth hits on the balls, hitting clear shorts, everything about that sport has made a positive impact on my life.

Watching professional players on TV, it always amazes me by their ways of playing. It is as if they are on another level of the sport, and, as any other tennis player would want, I want to flourish as much as they do on the courts!

I wanted to somehow analyze the shots of a player to improve their skills. Many thoughts came into mind but one stood out to me: why not implement tennis into one of the projects for machine learning? By collecting data from various sensors in an armband attached on the player's arm, we would be able to utilize machine learning to improve one's skill of tennis.

To go into specifics, I worked together with my teacher and we came up with an idea that is perfect for me. My projects is going to be about distinguishing different types of strokes: forehand stroke, backhand stroke, and other strokes. By differentiating these strokes, we can go in further and see what kind of strokes were the "winners", or the winning shots in a match. This way, a player can understand their strengths and weaknesses in their play, in order to improve

their skill. In the near future, we are also hoping for my project to further advance in ways that may help the players even more; such as adding a video feature to capture more precise and accurate details on the players.

MYO ARMBAND SENSOR



For the project, we used a device called Myo [1], which collects data on the various movements of the arm. The user can put it on their arms and it would collect four types of data: the acceleration, the gyroscope, the quaternion, and the EMG. The acceleration is the speed of the movements. The gyroscope is the degrees of the movements. The quaternion is measured in four dimensions which captures the rotation and the orientation of the movements. Lastly, the EMG stands for electromyography, which records the muscle's movements. From these various types of data, we are able to gain information, relevant to our research.

DATA COLLECTION

The process of collecting data included six steps:

- We needed to pick a player to put the Myo armband on their arm.
- Then we synced the sensor to a computer in order to collect data.
- We specified the strokes that we are going to focus on with the data collection.
- After that, we told the player to swing their racket with the stroke we wanted the data of.

Tennis Stroke Classification Using Myo Armband

- As the player swung the racket and started performing, we collected the data for ten to fifteen seconds.
- We repeated this process around ten times for each stroke, in order for us to collect sufficient data.

METHODS

I. Preprocessing Raw Data

The raw data has four labeled features. It has the type of sensor, the ID of the collected data, the timestamp of each data, and the collected data for the varied dimensions, as the sensors have different numbers of dimension. We filtered the raw data into the specific type of sensors in order to analyze the data. After that, we cut the data in chunks in order to have each set of data in a standard size. By doing so, all the data would have the same size so that the statistical data would be more accurate. We chose to cut it in sections of two seconds because two seconds is adequate to measure one swing and it is close to the real time.

II. Feature Extraction

We extracted four statistical features from the raw data in the two second window. Those were the maximum value, the minimum value, the average, and the standard deviation. We extracted those features from each dimension in each category, acceleration, gyroscope, quaternion, and the EMG. The standard deviation feature is calculated according to this formula [2]:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad (1)$$

It measures how dispersed the data is around the average value. Table 1 illustrates the dimension of features.

TABLE I
FEATURES EXTRACTED FOR TWO SECOND RAW DATA

Name of Sensors	Properties	Feature extracted
Accelerometer	Sampling rate: 50 Hz # of dimensions: 3	Max value: 3 Min value: 3 Average value: 3 Standard Deviation: 3
Gyroscope	Sampling rate: 50 Hz # of dimensions: 3	Max value: 3 Min value: 3 Average value: 3 Standard Deviation: 3
Quaternion	Sampling rate: 50 Hz # of dimensions: 4	Max value: 4 Min value: 4 Average value: 4 Standard Deviation: 4
EMG	Sampling rate: 200 Hz # of dimensions: 8	Max value: 8 Min value: 8 Average value: 8 Standard Deviation: 8
Total features extracted		72

III. Applying Machine Learning For Classification

We used Support Vector Machine (SVM) as our classification model. SVM is a model which can be used for both classification and regression analysis. SVM plots the given data in a n-dimensional plane and tries to split the data in the best way possible to differentiate the two classes. [3]

EXPERIMENT AND RESULT

I. Experimental Settings

Two experimenters were selected, one male, one female. We collected three activities for each subject: backhand, forehand, and other activities. After collecting the data, we found out that there were 827 number of samples. We divided the data into two parts: test data and train data. We trained the SVM model on the training data, which contains 751 samples. Then we tested the model on the unseen test dataset, containing 76 datasets.

II. Results

The accuracy of the SVM model on our test dataset was 96%. Table two illustrates the confusion matrix.

TABLE II
CONFUSION MATRIX

		Prediction		
		Other	Forehand	Backhand
Actual	Other	27	0	0
	Forehand	2	22	1
	Backhand	0	0	24

Table three illustrates the F1 score, precision and recall of each class.

	Precision	Recall	F1-Score	Support
Other	0.93	1.00	0.96	27
Forehand	1.00	0.88	0.94	25
Backhand	0.96	1.00	0.98	24
Avg / Total	0.96	0.96	0.96	76

Tennis Stroke Classification Using Myo Armband

CONCLUSION

We have achieved 96% accuracy in classifying two types of stroke in tennis and also the other activities. This result will lead to an application of collecting data of what strokes lead to winning points, and potentially improve a performance of a player.

Our future work is to test this in real life where a player is actually hitting in a ball during a match play.

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INVESTIGATION OF SLEEP QUALITY PARAMETERS TO IMPROVE COGNITIVE PERFORMANCE IN CLASSROOM TESTS

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ABSTRACT

Potential ways to improve classroom test performance were explored through finding the correlation between sleep quality and cognitive performance in young adults. Participants were asked to track their sleep using a smartphone application, take an online cognitive test the following day and submit their results through an online form. Parameters of sleep such as total hours of sleep and hours of deep+REM sleep were measured using a built-in accelerometer in smartphones. The online cognitive test measured reaction times and accuracy of answers. Preliminary results show that more hours of deep+REM sleep lead to faster reaction times and higher accuracy.

INTRODUCTION

Sleep quality is an understudied area and often overlooked factor of cognitive performance. This can lead to a possible neglect in ensuring sufficient sleep, especially amongst high school and university students, which can result in a gradual decline in academic performance unknowingly. A poll conducted by the [National Sleep Foundation](#) established that 63% of surveyed Americans were getting insufficient sleep. A study conducted by June J. Pitcher (1997) investigated the difference in performance between sleep deprived and non-sleep deprived participants. Pitcher et al. split their participants into two controlled groups, one sleep deprived and one non-sleep deprived. Participants in the sleep deprived group were not allowed to sleep for 24 hours and participants in the non-deprived group had a set time for going to sleep and waking up. The participants were then subjected to the same test and results were compared. Some disparities in test scores were observed in both groups. Another study by Megan Lowry (2010) found that average amount of sleep per night was significantly correlated with GPA. Lowry required participants to fill out a self-evaluated survey on their past night's sleep and submit their GPA. In addition, K. Ahrberg et al. (2012) also investigated the interaction between sleep quality and academic performance, having their participants fill out a survey. The Pittsburgh sleep quality index, a numerical index derived from self-answered questions related to sleep habits, was used in the survey. The answers from the survey were compared to students' GPA. Using GPA to investigate the relationship between sleep quality and academic performance is influenced by individual IQ and the acquired GPA cannot be deemed to be a function of sleep quality exclusively. Furthermore, the work of Dewald et al. (2010) is a very comprehensive study of the influence of sleep quality in children and adolescents. The study investigated the effects of sleep quality, sleep duration and sleepiness on school performance as well as the possible influences of parameter assessment. It looked into different results based on age and gender as well as the relationship the two categories had with sleep. However, their methodology was quite different as no direct data was collected in their work. Instead, they used the data and results of other articles for their study. By looking at the way sleep was assessed in other papers, Dewald et al. noted that larger effects were found for studies using subjective sleep assessment methods. The data for all of the above-mentioned work on sleep quality and cognitive/academic performance were measured through surveys, which required self-evaluated answers. This approach can be considered very subjective. In all surveys, participants were asked elementary questions such as the time they slept, woke up, the number of all-nighters they pulled in the past week, their thoughts on their quality of sleep, and how they felt the next day. Such basic questions do not provide enough information because they are not specific, and the possibility of participants recalling past data inaccurately exists. In addition, data collected via such self-evaluated means have the following demerits: (i) they are non-statistical, (ii) they are prone to distortion based on participant mood, (iii) they suffer from bias, either being too lenient or too severe. Therefore, this research was conducted using technology-assisted data collection methods to investigate how sleep quality affects cognitive performance. A sleep tracking application and an online cognitive test were used for the data collection. Recent advances in technology have made collection of sleep data through smartphone devices more accessible to the public, thus allowing for quality sleep related statistical data to be collected easily. Three sleep parameters and four cognitive performance parameters were identified and their correlation studied. The major difference between academic and cognitive performance is that academic performance is derived from formal academic examinations testing school curriculum, while cognitive performance measures general problem solving and reaction behavior. The selection of cognitive performance over academic performance is that cognitive performance has the merit of isolating the sleep quality factor by eliminating other factors such as IQ. The rest of the paper is organized as follows: Section 2 describes the methodology, Section 3 analyzes the collected data using the Pearson Correlation, and Section 4 discusses the obtained results.

METHODOLOGY

Measurement of Sleep Quality

The study commenced with a systematic evaluation of several different sleep tracking applications to identify the most appropriate application. The sleep tracking applications considered were:

- i. Sleep Cycle by SleepCycle
- ii. Sleep Better by Runtastic
- iii. Sleep Time Free by Azumio
- iv. Pillow by Neybox
- v. Sleep Bot by SleepBot
- vi. Good Morning Alarm Clock by Apalon

The selection criteria was as follows: the chosen application had to be available on smartphones with different operating systems using a freemium model, previous history data had to be available on the phone, and the following sleep metrics had to be directly measureable:

- i. Length of total sleep,
- ii. Length of deep sleep,
- iii. Sleep efficiency,

Length of total sleep is simply the sleeping duration of a subject. The length of deep sleep is defined as the duration of deep sleep. Both of these metrics are measured using the accelerometer embedded in the phone. An accelerometer is a sensor that measures movement by detection of acceleration in the x, y, and z planes. Thus, with the phone placed next to the subject's pillow, the subject's movement during a specified interval of time can be measured. Measured movement is inversely proportional to the quality of sleep: greater movement would indicate lighter sleep, and less movement would indicate deeper or REM sleep. REM sleep stands for Rapid Eye Movement sleep, which is the deepest state of sleep a subject can obtain. The sleep efficiency is calculated by the sum of the hours of light sleep and deep sleep divided by length of total sleep and finally multiplied by 100.

where the length of light sleep is the difference between total sleep and deep sleep.

Based on the above selection criteria, the "Sleep Time Free" application was selected for measurement. For consistency, all participants were required to use the "Sleep Time Free" application for data measurement. Participants were asked to track their sleep a total of 4 times per person and limited to 2 times a week.

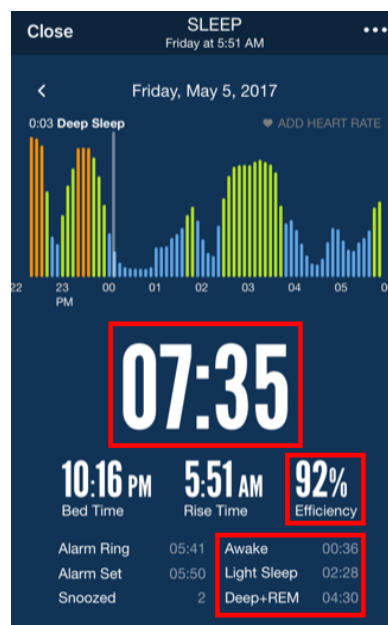


Figure 1: Screenshot of the "Sleep Time Free" application showing measured data

Measurement of Cognitive Performance

Selection of an appropriate online cognitive assessment was carried out next based on identified requirements. The following five candidate assessments were identified:

- i. [Test My Brain](#)
- ii. [Mental Speed Test](#)

- iii. [My Brain Test](#)
- iv. [Stroop Effect Test](#)
- v. [Mouse Accuracy](#)

Similar to the sleep tracking applications, the online test was chosen based on the fulfillment of certain conditions. Stipulated conditions were:

- i. IQ-free questions i.e. those questions that measure cognitive performance and mental quickness exclusively
- ii. Results showing speed and accuracy
- iii. Questions of sufficient complexity such that participants' sleep would be bound to affect results i.e. excluding simple questions that even sleep deprived participants could answer correctly

The assessment selected was the “My Brain Test”. This assessment comprises of True or False types of questions to state the correspondence between a graphics-noun pair, shown in the figure below.

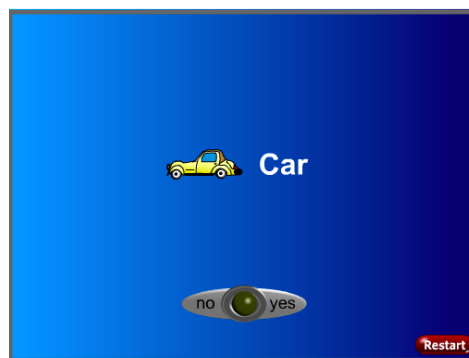


Figure 2: Example question of the “My Brain Test” that measures mental quickness

Specifically, the test displays a picture and word pair, and participants choose “yes” or “no” depending on the pictorial and literal correspondence. There are also trick questions labelled “reverse”, where a non-matching pair has true correspondence and a matching pair has false correspondence. There are 21 questions in each test. Parameters derived from cognitive performance were average reaction time, percent accuracy, standard deviation of average reaction time, and score. This is shown in the figure below.

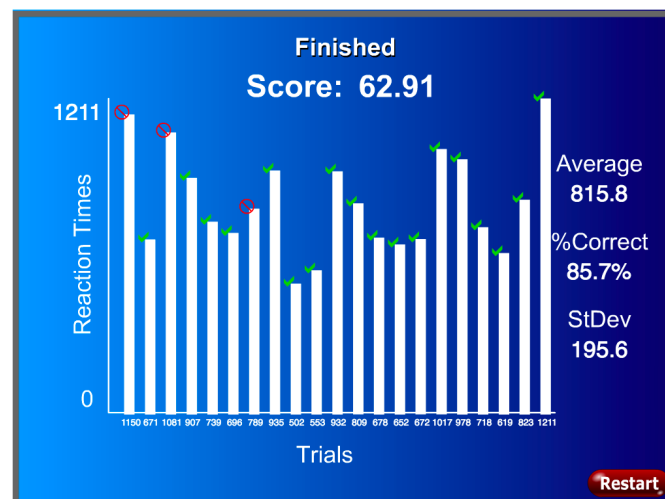


Figure 3: Example result of the “My Brain Test”

Population Surveyed

Our research had 12 participants, the age bracket being fourteen to fifty years old from mostly academic backgrounds. 58% of the population were male and 42% of the population were female. The mean age was 26.7 years and the median age was 24 years. The data collection was done in Tokyo, Japan from March to August 2017.

The data collection was primarily carried out through online means. Participants were required to enter their sleep quality data, collected using the “Sleep Time Free” application, through an online form and submit a

screenshot of their results from the “My Brain Test” cognitive test. The usernames of participants were kept consistent through multiple submissions to make analysis of individual data possible. In order to be able to objectively analyze and track individual sleeping patterns and make individual-specific conclusions, multiple individual responses were necessary. Thus, the survey population was kept low but multiple responses were supplied by each participant, ranging from 3 to 15. In all, a total of 70 responses were collected.

RESULTS

Using the collected data, the correlation between the sleep parameters and cognitive performance parameters were determined. Results are summarized below.

The Pearson correlation was utilized to establish the correlation between each of the two sleep parameters with all of the four cognitive performance parameters. Correlated pairs were:

- i. Sleep Efficiency (E) and Average Reaction Times (Average RT)
- ii. Sleep Efficiency (E) and Percentage Accuracy
- iii. Sleep Efficiency (E) and Score
- iv. Sleep Efficiency (E) and Standard Deviation of Average Reaction Times (SD)
- v. Deep Sleep (DS) and Average Reaction Times (Average RT)
- vi. Deep Sleep (DS) and Percentage Accuracy
- vii. Deep Sleep (DS) and Score
- viii. Deep Sleep (DS) and Standard Deviation of Average Reaction Times (SD)

The graph of Figure 4 below displays the combined correlated pairs outlined above for five individuals represented by the five individual colored bars.

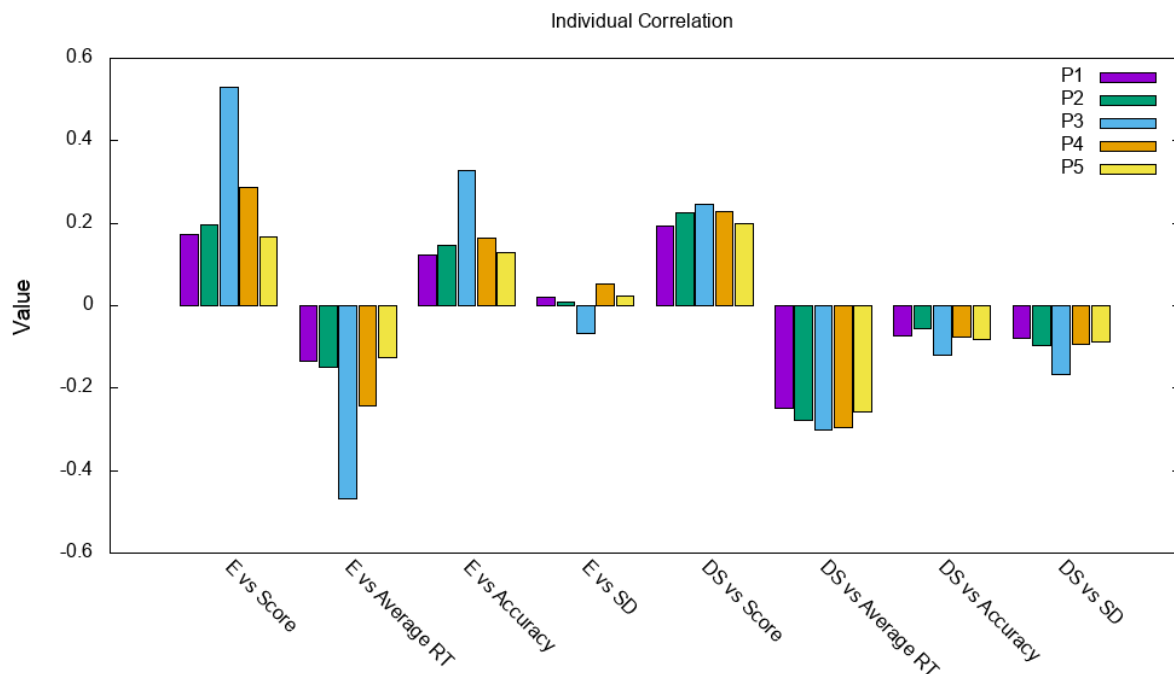


Figure 4: Graph of Individual Sleep Performance Correlation

As evident from the graph above, the correlation of Deep Sleep and cognitive performance parameters on the right half of the plot were tightly correlated, while Sleep Efficiency and cognitive performance parameters exhibited weaker correlation i.e. the correlation magnitudes varied significantly.

Figure 5 displays the average correlated pairs outlined above for all participants represented by the purple

colored bars. The error bars indicate standard deviation.

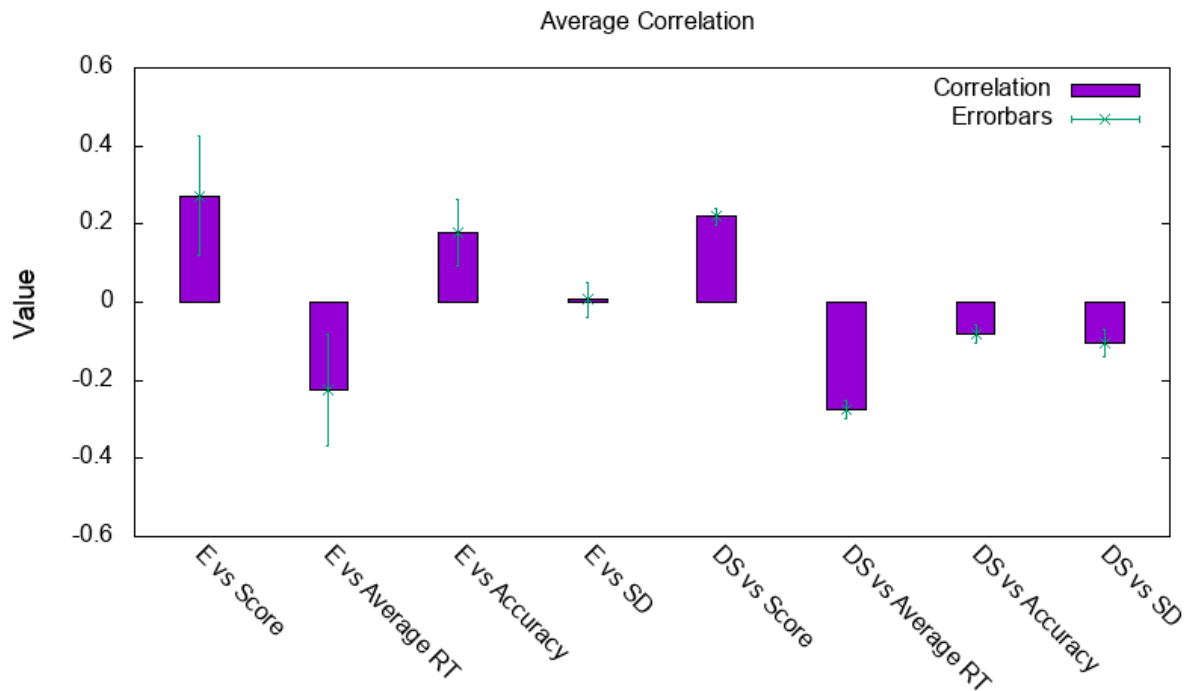


Figure 5: Graph of Average Correlation

As seen in the above graph, error bars of the Deep Sleep and Cognitive Performance parameter pair are smaller, indicating that the individual data was more consistent which is in agreement with the first graph.

The correlation between the sleep parameters and cognitive performance parameters of all participants is given in the tables below.

	Cognitive Performance Parameters	Correlation Value
Sleep Efficiency (%)	Average Reaction Times (ms)	-0.126
Sleep Efficiency (%)	Accuracy (%)	0.129
Sleep Efficiency (%)	Score	0.168
Sleep Efficiency (%)	St. Deviation of Avg. Reaction Times (ms)	0.023

Table 1: Table of Correlation Values between Sleep Efficiency and Cognitive Performance

	Cognitive Performance Parameters	Correlation Value
Deep Sleep (min)	Average Reaction Times (ms)	-0.259
Deep Sleep (min)	Accuracy (%)	-0.082
Deep Sleep (min)	Score	0.199
Deep Sleep (min)	St. Deviation of Avg. Reaction Times (ms)	-0.088

Table 2: Table of Correlation Values between Deep Sleep and Cognitive Performance

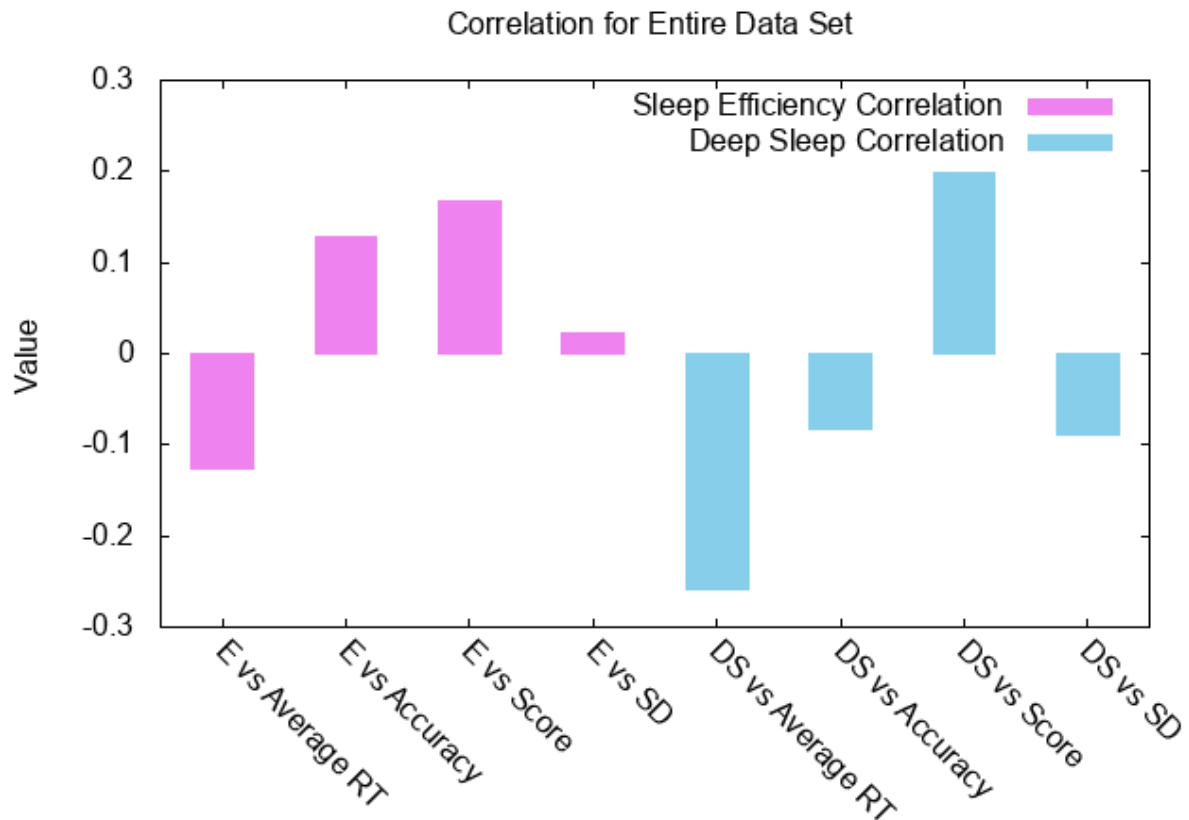


Figure 6: Graph of Correlation for Entire Data Set

By calculating the correlation between Sleep Efficiency and various factors, certain patterns in terms of Sleep Efficiency and cognitive effectiveness can be identified. The sign of the correlation value determines correlation type. A negative value indicates an inversely proportional correlation while a positive value indicates a directly proportional relationship. Specifically, the correlation between Sleep Efficiency and Average Reaction Times is **-0.126**. This medium negative correlation implies that a higher Sleep Efficiency results in faster average reaction times on the cognitive test. For the Sleep Efficiency and Accuracy correlation pair, a medium positive correlation of **0.129** was obtained. This implies a higher Sleep Efficiency results in a higher accuracy on the cognitive test. Similarly, the medium positive correlation between Sleep Efficiency and Score is **0.168** which suggests that a higher Sleep Efficiency will lead to a higher score on the cognitive test. On the other hand, a correlation value of **0.023** was acquired between Sleep Efficiency and Standard Deviation of Average Reaction Times pair.

Both the correlation values of Deep Sleep vs Average Reaction Times and Deep Sleep vs Standard Deviation of Average Reaction Times exhibit a medium negative correlation, with values of **-0.259** and **-0.088** respectively. This is interpreted as a longer duration of Deep Sleep resulting in faster reaction times, as well smaller standard deviations of the average reaction times. The correlation between Deep Sleep and Score is **0.199** is a medium positive correlation, implying that a longer duration of Deep Sleep results in a higher score on the cognitive test. The correlation between Deep Sleep and Accuracy is **-0.082**. A visual representation of these results is given in the graph of Figure 6.

CONCLUSIONS

Sleep quality related data was collected using a sleep tracking application and the correlation between sleep parameters and cognitive performance was investigated. It was determined that a longer duration of Deep Sleep and higher Sleep Efficiency would result in faster reaction times and a higher score. In addition, higher Sleep Efficiency would result in higher accuracy on the cognitive test. From the results, it was determined that the correlation between duration of Deep Sleep and cognitive performance parameters were more similar among individuals. Since the calculation of Sleep Efficiency includes total length of sleep, total length of light sleep, and total length of deep sleep, results show that out of the three durations, deep sleep is most important in terms of affecting cognitive performance. Thus, it was concluded that Deep Sleep could possibly affect cognitive performance more consistently than Sleep Efficiency. Based on these results it is reasonable to conclude that

ensuring better sleep quality is one potential way of improving cognitive performance in classroom tests.

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A Machine Learning Based Approach for Automated Used-Car Price Evaluation

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Abstract—Artificial Intelligence and Machine Learning have been successfully applied in many fields recently for automated systems. Recent business trends raise a demand of automating the process of predicting the prices of used cars as it helps to reduce a lot of human effort. In this paper, we investigate the application of supervised machine learning techniques to evaluate the price of used cars. Our analysis is based on real datasets collected for over 8 years in a cars dealing business of a used cars seller in Japan. Possible data processing techniques and regression analysis methods, e.g., multiple linear regression and decision tree regression, have been tested to achieve a reliable prediction accuracy. Our evaluation results show an accuracy of over 90% for random forest, which is a promising achievement, especially when the datasets contain rather large amount of noises such as missing values and outliers. This paper summarizes our work including data processing methods, machine learning models building, models accuracy evaluation and achieved results at the current stage.

I. INTRODUCTION

Artificial intelligence and machine learning have become emerging technologies that applied in many automated system nowadays. The ability to learn is a hallmark of intelligent behavior, so any attempt to understand intelligence as a phenomenon must include an understanding of learning.

Research on learning is made up of many fields. At one extreme there are systems that monitor their own performance and attempt to improve it by adjusting their own parameters. Among those techniques, regression analysis is a helpful one for predicting continuous values such as scores of students, performance of players, prices of goods, etc. In this paper we focus on learning techniques related to regression analysis to estimate a price of cars.

Evaluating the prices of used cars is not a simple task. It requires a lot of effort and time, especially if it is done purely by human. In order to minimize human effort in evaluating used-cars prices that Japanese second-hand car dealing companies is practicing, we provide the solution to support that procedure. The aim of this project is to create a machine learning based system to estimate the prices of used-vehicle. Our aim is not to fully automate all of the price evaluation and just focus on analysing and predicting the prices based on input datasets. The process of creating the price estimator starts with data collection. Our analysis is based on real and reliable datasets collected for over 8 years in a car dealing business of a cars seller.

As we know, business data is not always perfect and contains lot of noises, e.g., missing values, redundant features,

outliers, especially when such data is manually collected. Such issue requires lot of systematic analysis and feature engineering to clean the data, select valuable features and make the data ready for training and testing machine learning models.

After refining the datasets, we perform the data pre-processing which includes integration (combining of all datasets into one big dataset), transformation (transforming the data into the form most appropriate for future usage), and reduction (optimizing the data to eliminate unnecessary features) so that it is ready for training and testing machine learning model. The more careful data processing is conducted, the more accuracy of models we may achieve. In this paper, multiple linear regression model, decision tree model, random forest models, extra tree models, gradient boost has been examined and evaluated. The R-Squared value and Coefficient of Determination have been used to evaluate the regression model. With our proposed methods, we have achieved an prediction accuracy of over 90%, which is a promising result at the current stage.

This paper is organized as follow. The next section introduces a review of background knowledge and related works. Section 3 describes how we process the datasets and build machine learning models. In section 4, we show our evaluation based on cross-validation to observe the accuracy of our models. Section 5 concludes our work and suggestion for future improvement.

II. BACKGROUND

The trade market of used-vehicles in Japan and in the world has been increasing in the recent years. Supporting this trend, the registration of used car based on Japan Automobile Dealers Association has been on a steadily uptrend^[1] which indicates a potential growth in the overall market. Additionally, a forecast^[2] indicates that by the end of 2021, Asia-Pacific used-vehicle market including Japan would likely compete against the US market which has been the dominant market. As the trade market of used-vehicles increases, the demand to systematically evaluate prices of the vehicles also inevitably increases. However, the current procedure of evaluating the car price solemnly relies on human effort which takes both significant amount of time and money. Application of machine learning in the price evaluating procedure solves such problem through fast, accurate, and reliable analysis. In this section, we discuss the base

knowledge of our proposed methods and implementation, which includes regression analysis, i.e., decision tree, and random forest.

In general feature engineering is a central task in data preparation for machine learning. It is the practice of constructing suitable features from given features that lead to improved performance. Feature engineering has been conducted by authors of this paper relying on the domain expertise and iterative trial and model evaluation.

Often time, the accuracy and reliability of any machine learning based program comes down to the size, reliability, and the cleanliness of the data being processed. The more reliable and clean the data is, the less chance dataset containing random error and bias, resulting in much higher accuracy. Therefore, the quality of data collected from the start affects directly to the performance of the machine learning.

Even though the dataset is provided by a legit Japanese company, there is no guarantee that the dataset has no errors. All the obtained information has been inputted by human. In order to ensure a good accuracy of the model; datasets needs to be cleaned. Good quality of the date has been achieved by conducting a systematical analysis of features to find all the missing or abnormal parts. After the data is refined, datasets need to go through the process of integration, transformation and reduction. The quality of this steps impact the performance of machine learning algorithm.

A. Regression Analysis

Regression analysis is a process of finding underlying pattern and relationships among variables.^[3] In this project, regression analysis is used to find the price of the used car based on the underlying patterns and relationships the prices of used cars have with other features such as car mode, condition, mileage, age of the car. In regression analysis the main factor to predict is called dependent variable. Independent variables are the factors suspected to have an impact on the dependent variable, for example a car price.

B. Regression Analysis Model

In this paper, the term regression analysis model and machine learning model are used interchangeably as they both refers to the method used for regression analysis. Based on what the type of regression analysis model, the accuracy can drastically vary despite the dataset being the same.

C. Decision Tree Model

Decision tree model is one of the most widely used machine learning model that works for both classification and regression analysis. A decision tree algorithm is used to partition the data into subsets. The process continues to split the data until no more splits can be performed. The Decision tree approach is able to encapsulate the training data in the smallest tree. As the final result is a tree with leaf and decision nodes. A decision node might have many branches, each representing values for the tested attribute. Leaf node might represents a decision on the numerical target for instance a car price. Decision trees can handle both categorical and numerical data.

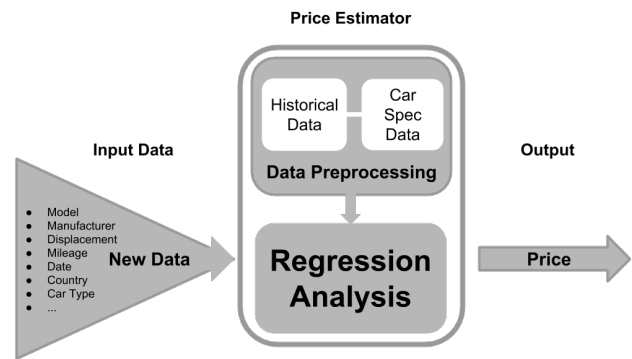


Fig. 1: The working flow of the price evaluating process based on regression analysis.

One of the main algorithms for creating decision trees that we applied is ID3 that implements a top-down, greedy search through the space of possible branches. The ID3 algorithm can be used to construct a decision tree for regression by replacing Information Gain with Standard Deviation Reduction. A tree is built starting from the root node that involves partitioning the data into subsets that contain instances with similar homogenous values. Standard deviation is used to compute the homogeneity of a sample. The characteristic worth noting is that the decision tree model can deal well with noisy data and the speed of learning is one of the fastest among all machine learning models.

D. Random Forest Model

Random forests model is a machine learning model that is built using multiple decision trees. Random forest is a learning method for classification or regression by constructing a multitude of decision trees at a training time and outputting the class that is the mode of the classes or mean prediction of individual trees. Random forests fix for decision trees habits of overfitting to the training set. Its main advantage over decision tree model is that it resolves most of the problems decision tree model have in term of accuracy performance.

III. PRICE ESTIMATOR SYSTEM

This section explains in details how we preprocess the collected raw data, and built machine learning models for our price estimation system. Various data processing methods has been applied to process the raw data including refining, transforming, integrating the datasets and reducing noises. From the preprocessed datasets, we conduct regression analysis to find the underlying patterns and the relationship that the prices have with other features, e.g., car model, manufacturer, mileage, displacement, sold date of cars, current dates. Fig. 1 shows the diagram of what the price estimator is made of and its application in the price evaluating procedure.

$$Price = f(X) \quad \text{where } X \text{ is the input data} \quad (1)$$

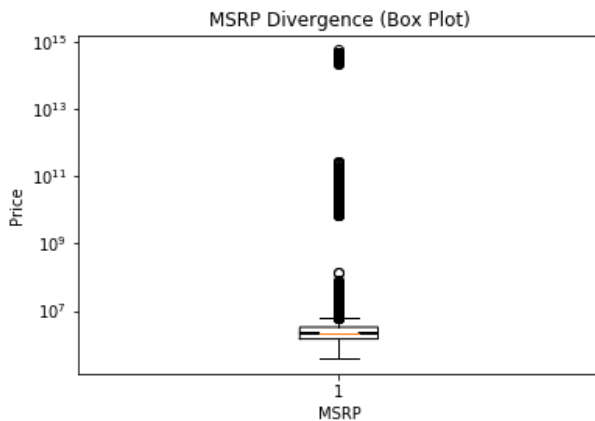


Fig. 2: **Boxplot of MSRP Divergence.** Circles with black rim are the outliers found based on IQR rule. The price is in Japanese yen where 10^8 JPY equates to 1 million USD with an approximate conversion rate of 100 JPY/USD.

A. Data Collection

All datasets used in this project are provided by a used-cars dealer located in Japan (called CFJ). There are three datasets which contain the following contents:

- Dataset 1: Over 8 years of transactions. This dataset includes over 90,000 transactions with 17 features.
- Dataset 2: 53 attributes, e.g., engine model, transmission type, length, width, weight of over 80,000 cars.
- Dataset 3: attributes of 202 ports all over the world based on the volume sizes of cars.

B. Data Preprocessing

Much of the effort in building the price estimator was in data preprocessing steps as noises in a dataset deteriorate the performance of machine learning and costs of faults in a dataset devastate the prediction result. As mentioned earlier, a preprocessing steps typically include refining, integrating, transforming, and reducing of the datasets. The following subsections explain in details about those processing steps.

1) *Refining Data:* During the refining process, abnormal values (e.g., outliers, missing values), unnecessary features (e.g., redundant, meaningless feature), and inconsistencies (e.g., spelling mistakes, discrepancies in categorization) are processed for all the three datasets. Numerical features go through statistical analysis and are visualized using boxplots and histograms for understanding the trend and characteristics of data and setting the thresholds for outliers. Fig. 2 shows how visualization is used for deciding the threshold for outliers. In this particular case, the threshold was set at 108 JPY. Non-numerical features are visualized using a bar graph as in Fig. 3. in which no anomaly was spotted. When analyzing each feature, regardless of its type, if the feature has over 10% of missing values, it would be eliminated from the dataset. Additional, rows containing any missing value of essential features are dropped from the dataset.

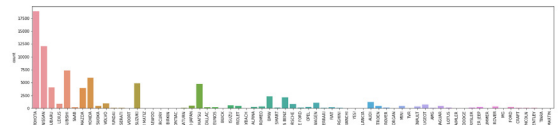


Fig. 3: **Bar Graph of Car Manufacturer Divergence.**

2) *Transforming Data:* The data are transformed into an appropriate form for further processing steps to finally be ready for training and testing machine learning models. We conduct various transformation steps such as modifying each value to the uniform unit, changing the data types (e.g. object type to date time or float), and eliminating the commas in price.

3) *Integrating Data:* Integration of data combines features from multiple datasets into one. This is done by concatenating features from dataset 2 and dataset 3 to dataset 1 using the common key that dataset 2 and dataset 3 have with dataset 1.

4) *Reducing Data:* The data reduction process is used to decrease computational expense by reducing the sample size or dimensions of data. This process evaluates the importance of each feature through calculating correlation among features. If a feature shows no correlation with other features, it will be dropped out of the dataset. One of the feature that is eliminated from this process is the feature ID which contains unique IDs of car transactions.

The steps above are carefully conducted for processing our datasets. Through such preprocessing steps, the resulting final dataset contains 75584 rows with 31 features. The following sections discuss how we build machine learning models for our used-cars price estimation system.

C. Model Selection

In order to find a suitable machine learning model that produces a reliable accuracy for our price estimation system, various regression analysis models are tested. The following regression analysis models are tested and evaluated:

- Multiple Linear Regression Model
- Decision Tree Regression Model
- Random Forest Regression Model
- Extra Trees Regression Model
- Gradient Boosting Regression Model
- XGB Regression Model
- Decision Tree Regression Model using Adapatation Boosting
- Random Forest Regression Model using Adapatation Boosting
- Extra Trees Regression Model using Adapatation Boosting
- Decision Tree Regression Model using Bootstrap Aggregation
- Random Forest Regression Model using Bootstrap Aggregation
- Extra Trees Regression Model using Bootstrap Aggregation

Multiple linear regression model is first tested and evaluated. The evaluation result shows that the model has less than 50% of accuracy. This is considerably not a reliable result that could be applied for a production prediction system. Therefore, we further investigate decision tree model that does not depend heavily on linearity. With this approach, we achieve an accuracy score of over 82%, which is better than the multiple regression model. Further, various additional regression models have been investigated and tested including Random Forest Regression, Extra Trees Regression, and Gradient Boosting Regression. Through the evaluations of these models based on R-Squared Score, we achieve an accuracy of over 90%. This is the highest accuracy that we have achieved and we believe that this result is valuable and promising at the current stage towards the goal to be applicable for a production used-cars price evaluation system.

IV. EVALUATION

A. Evaluation Method

R-Squared Score (R^2 Score, or Coefficient of Determination) is used for evaluating each regression model. R^2 Score is a statistical metric that shows how much a machine learning model fits trained dataset^[4]. The formula of R^2 score is as follow:

$$R^2 = 1 - \frac{SS_{Explained}}{SS_{Total}}$$

$$\text{where } SS_{Explained} = \sum_s (y - \bar{y})^2,$$

$$SS_{Total} = \sum_s (y - \hat{y})^2,$$

y is the actual value,

\hat{y} is the predicted value,

and \bar{y} is the mean of y values.

(2)

R^2 score is a number in a range of [0, 1]. The higher R^2 value is, the higher percentage of dependent variable is explainable by the independent variables. However, R^2 value does not necessarily indicate the accuracy between the actual value and the predicted value. Therefore, what is really measured is the accuracy of how well the regression model analyze the dataset, not the accuracy of the predicted value.

B. Results

Various machine learning models have been tested and evaluated as candidates for our price estimation system as specified in section 3.3. Among those models, the highest score that we achieved is based on Random Forest Regression using Adaptive Boosting. That model produces a R^2 score of 0.9088. This means that 90.88% of the variance of the price is explainable by the rest of the independent variables. Interestingly, all the tested regression models except the multiple linear regression have R^2 values in a range of

Model	Accuracy(r^2)
Multiple Linear R.	0.4559
Decision Tree R.	0.8396
Random Forest R.	0.9009
Extra Trees R.	0.9004
Gradient Boosting R.	0.9051
XGB R.	0.9009
Decision Tree R. using AdaBoosting	0.9002
Random Forest R. using AdaBoosting	0.9088
Extra Trees R. using AdaBoosting	0.8971
Decision Tree R. using Bagging	0.9002
Random Forest R. using Bagging	0.8982
Extra Trees R. using Bagging	0.9036

R. means regression model, AdaBoosting means Adaptive Boosting, and Bagging means Bootstrap Aggregation

TABLE I: R^2 Value of Various Regression Model

[0.8396, 0.9088] as shown in Table I. On the other hand, the lowest score that we achieved is based on the multiple linear regression with a R^2 value of 0.4559.

C. Discussion

As mentioned in section 4.1, R^2 value is the selected evaluation method for our regression models, not the evaluation of the predicted value from the regression models. Table II shows our evaluation results that well supports for such trend. Based on the results, despite the high R^2 value, the mean of the percent errors of 26 sample is 8.9463%.

Actual Value	Predicted Value	Difference	Percent Error
2500	2380.50	-119.50	-4.780
1600	1959.70	359.70	22.48
2950	2991.70	41.70	1.41
4220	3628.50	-591.50	-14.02
2800	3200.10	400.10	14.29
2165	1934.00	-231.00	-10.67
1400	1794.50	394.50	28.18
1770	1960.00	190.00	10.73
6950	5152.10	-1797.90	-25.87
2850	3134.10	284.10	9.97
1975	2171.60	196.60	9.95
1800	3026.70	1226.70	68.15
12500	17750.00	5250.00	42.00
2213	1845.50	-367.50	-16.61
4200	4185.00	-15.00	-0.36
8000	9610.00	1610.00	20.13
1973	1951.42	-21.58	-1.094
2000	2332.80	332.80	16.64
2840	2980.00	140.00	4.93
2080	2491.50	411.50	19.78
19700	15163.30	-4536.70	-23.03
7850	6855.00	-995.00	-12.68
4667	3049.80	-1617.20	-34.65
1189	2130.80	941.80	79.21
2600	2957.30	357.30	13.74
1700	1950.80	250.80	14.75

TABLE II: Predicted values of 26 randomly chosen samples by random forest model and their percent errors

For further improvement in terms of estimation accuracy, we investigate the adaptation boosting method and bootstrap aggregation method to the decision tree, random forest, and extra trees models. This tweak produces an accuracy of

over 89%, but there is still no significant improvement in the accuracy rather than accuracy of over 90% achieved with the random forest and extra trees model. Currently, random forest regression using adaptation boosting provides the highest accuracy of 90.88%.

V. CONCLUSION

This paper introduced our approach for building a automated system for used-car price estimation. We based on real datasets collected for over 8 years in a used-cars dealer. Various data processing techniques have been used for cleaning the collected data, and machine learning based algorithms have been tested for models building, and accuracy evaluation to achieve a reliable prediction accuracy for the system. Experimental results show an accuracy score of over 90% achieved based on a Random Forest model that is trained with the processed datasets. This is a promising accuracy result considering the rather large amount of noises of the manually collected datasets. Further improvement in terms of prediction accuracy can be investigated that includes possible steps such as further refinement for the data processing and experiments on other models like Deep Forest [5] or Deep Neural Decision Forest [6]. These are the directions for future works.

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Flower Classifications Using AI Model

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Abstract – This project was about using an AI to recognize 3 types of flower via their pictures taken from different angles under variable light conditions. Our objective for this project was for us to know more about AI and as to how we can apply our learning's to develop an AI system to help others learn more about flowers. Foremost challenge we faced was to learn take photographs of the selected flowers for which our teacher supervisors helped us understanding camera functions and their use. Nevertheless, another challenge was the photograph angle, lighting and distance at which the photographs were required to be taken. Consequently, we took more than three hundred photographs for our project. During 8 weeks of this project, we used tools like model Inception V3 and Google Colab. Color, Angle and light intensity were the factors of photographs used for this project. The results of this initial project were encouraging though not that promising providing scope for enhancements and improvements.

Key Words – AI, classification, flowers, data, experiment, coding.

INTRODUCTION

Going through this project made us believe that this project would be beneficial to people keen to learn or know more about. Primary objective of this initial project was to explore the possibility of development of an AI system to teach children easily without engaging industry experts' on species of flower.

Increasingly, AI is being used to boost human lives in various aspects. They have done many things that we can't do or time intensive. There are many high-end AI out there but our project is very first step of ours in the world of AI. Our

project was about AI using picture/data identify flowers and build a system for education. Before learning about AI, we only knew that AI stands for artificial intelligence and that technology is really helpful. We did not actually go deep inside and had lots of misconceptions. Our understanding and thoughts started to clear up when we started to learn AI with Mr. Khoa and Mr. Phong.

The project we did was the use of AI model to identify 3 species of flower which are Rosa, Hibiscus Rosa-Sinensis, and Bidens Pilosa. To do this project, we took pictures of those flowers at different angles and in different lighting conditions with the view to make it difficult for the AI model to identify and we could use to test at the same time. After taking pictures of the flowers, we started to code and send data to the AI model. If the AI model recognized it wrong, we taught it again and then retested.

METHODOLOGY

This project was carried out for 8 weeks from August to September.

We chose three types of flowers. Those species are Rosa (colloquially known as rose), hibiscus, and Bidens pilosa.

- **Color Test** – First we chose a color. In this project, we decided to go with red for hibiscus and rose because it makes the identifying easier, we also care about the color of the flowers, because color is also a hint to the AI, it can identify the flowers easier by checking its color. After red color experiment we went on training and testing of other colors.
- **Angle and Light Test** – Following color experiment, we then took pictures of the flowers in different angles and at different time of the day. Each picture had to be different from each other and not being repeated. If there are repeating pictures, the AI would receive the same pictures again and again and it would only be able to identify the flowers if we put them at the same angle and lighting.

For each of the flower we got there were more than 100 pictures taken and then we transferred these into model Inception V3.

After taking the pictures, we sorted which pictures to use. The picture should be clear, coverage of total flower body, each one must be at different angles. Then, we categorized the pictures into 2 parts. One for teaching and/or coding into the AI and the ones for testing. We used model Inception V3 as an AI and code in information and input the pictures into them. If the AI identified wrong, we had to fix it by coding

Flower Classifications Using AI Model

new or updating parameters to let the AI know that it was the wrong answer and try to improve it with new inputs.

Along with model Inception V3, we used Google Colab, a free cloud service. thereafter, we used model Inception V3 to designed a model to identify flowers. Model Inception V3 is a model that consists of two parts, featuring extraction part with a convolutional neural network and classification part with fully-connected and softmax layers. This is where the magic happens, we started coding into the Inception V3 and as we did this, we were teaching the AI. We could fix by coding the information if the computer was wrong. Refer to the Figure 2 for the result from the AI's identification.

TABLE I
FLOWERS AND NUMBER OF PICTURES TAKEN

Set	Rose	Hibiscus	Biden Pilosa
1	109	124	145

RESULTS

According to our hypothesis, which is AI will be able to identify flowers, and the results turn out to be right. AI could identify flowers using pictures. After a lot of "sending" pictures and coding, we found some mistakes during the experiment. Table 2 below lists the correct and wrong identification results AI made in our experiment:

TABLE II
THE RIGHT AND WRONG FROM THE AI MODEL WHILE EXPERIMENTING

Set	Right	Wrong
1	AI recognizes hibiscus right - Good lighting, made the picture clear	AI recognizes hibiscus as rose - The light was too less, makes the red blurry.
2	AI recognizes biden pilosa correct - The picture shows the whole flower, made the AI identify easily.	AI recognizes biden pilosa as hibiscus - The picture was focused on the pistil so it looked like a white hibiscus
3	AI recognizes rose right - The picture is at an angle facing the sun, but much more clear. Made it easier to identify because it's showing the whole side of the flower.	AI recognizes rose as biden pilosa - The picture is at an angle facing the sun and focused on the color. This made the picture hard to identify.



FIGURE 1
FLOWERS USED FOR CLASSIFICATION

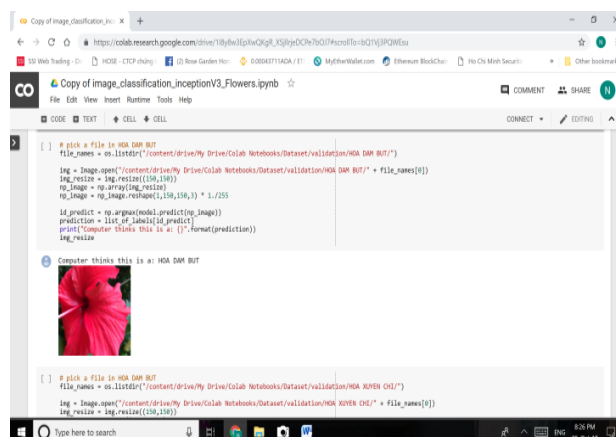


FIGURE 2
SCREEN SHOT THE AI'S CLASSIFICATION RESULTS

CONCLUSION

We carried out this research on flower classification using AI model limited to 3 species of flowers. Based on the results achieved with our current level of understanding of AI and efforts we see a bright future of this research project and improvise it to be practical.

ACKNOWLEDGMENTS

We have learned a lot in the lessons and maybe some of us will become an AI expert in the future. Special thanks to our parents and teachers for their invaluable support in making this project possible. Special thanks to Tokyo Techies for the opportunity to enter the Young Researchers' Conference 2018

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Flower Classifications Using AI Model

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Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players

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Abstract - Previously, an Open Source, post-match analysis software that recreates player and soccer ball movements as two dimensional trajectories as seen from a bird's eye view was created. Each player was outfitted with a Global Positioning System (GPS) device that collected high frequency data from geo-stationary satellites at a constant interval of less than one second. The collected player and soccer ball position data was visualized using animation-type plots developed using Qt Creator. For each player, the following metrics were determined: total distance covered, instantaneous velocity, possession percentage, and total touches. Inspection of such metrics gave an insight into the general performance of each player and team as a whole. In this work, a sensor-integrated soccer ball is in the process of being developed, which will allow for further accurate measurements of the aforementioned metrics. A further preposition into the design, construction, and testing of this ball is included in this paper.

Key Words - sensor-integrated, soccer ball, post-match spatiotemporal performance analysis, GPS

INTRODUCTION

In modern day sports, major teams and leagues are increasing their competitiveness every season. As a result, technology has started to play a major role in the accuracy and effectiveness of the different aspects of decision-making, as well as to improve player performance. This includes the implementation of technologies such as GPS devices and motion sensor technologies in various sports ranging but not limited to tennis, basketball, and soccer. For example, in the Association of Tennis Professionals (ATP), Hawk-Eye [1] has been implemented in every game, allowing for players to challenge a call made regarding whether the ball has been hit in or out of bounds. Specifically, in the game of tennis, a ball is considered in bounds as long as any part of the ball is in contact with the boundary lines. Human error is inevitable, and the naked eye cannot accurately make a correct call every single time. Thus, although most calls are made by the officials, controversial calls are accurately made by Hawk-Eye. Similarly, in the National Basketball Association (NBA), STATS SportVU [2] is used to create statistics based on metrics such as speed, distance, player separation, and ball possession. This software utilizes a six-camera system which is installed in the arena, which tracks real-time position at a

rate of 25 frames per second. This allows for the most sophisticated data stream of game statistics to be available. In Basketball, Instant Replay [3] is used to determine significant moments in-game, such as to determine if the ball was released by the player before the clock ran out on a buzzer beater play. With the use of similar technology, Replay Review [4] has been implemented into the game of baseball. In addition to this, both sports use video replay technology not only so that referees and umpires can go back to review a play, but also to determine statistics post-game, such as points, assists, and steals for basketball, and hits, RBI's, and outs for baseball. Both of the technology in those two, totally different sports accomplish the same task. The forms of technology in both tennis and basketball are isomorphic to the software and gadgets implemented in official soccer games worldwide. These gadgets in soccer include the miCoach Smart Soccer Ball [5] created by Adidas, where a GPS device is embedded in the ball and tracks metrics such as velocity, rotation, and power, as well as FIFA Goal-Line Technology [6] which uses sensors in both the goal and ball to determine if the ball has crossed the goal line. Another example is the Video Assistant Referee [7], where cameras are set up around the field, so when a controversial play is made in-game, the referee can stop play and review the play on a screen.

The software developed previously attempted to improve player performance along the same guidelines - through a GPS tracking device that visualizes spatiotemporal movements between the players and ball at a bird's eye view, post-game. In this work, we give the design of the sensor-integrated ball.



Fig. 1. Selected Device

A. Motivation

At The American School in Japan, commercial solutions mentioned above are not relevant for several reasons: 1) they are often too expensive to be implemented at a high school soccer game and 2) the school's pitch is not located in a

Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players

stadium but instead outdoors, which results in various difficulties. These include the installations of cameras around the field at an elevated height, adjusting the lenses based on the weather, and constant calibrations to be made based on other environmental factors. Therefore, games are filmed from the sidelines via video cameras with no tracking devices or sensors utilized. Although this allows for simple post-game analyses to be made, these are only limited to visual aspects of the game, lacking the statistical side of the game and resulting in manual rather than automated analyses to be made. Thus, the motivation behind the development of this product is for more in-depth analyses of high school soccer games to be made, where post-game, coaches as well as players' themselves can improve performance based on the automated analyses made, which contains both visual and numerical statistics.

The rest of the paper is organized as follows: Section II discusses the overall specifications. In Section III, the software application as well as performance metrics are described. Section IV gives the experimental results that were obtained from trialing out the software previously. Section V contains the new focus of the paper: the proposed design of the sensor-integrated soccer ball. Finally, Section IV proves a conclusion based on the effectiveness and accuracy of the software, as well as future plans for the ball.

ARCHITECTURE

A. Selected Device

The device selected was the Columbus V-900 Multi-functional GPS Data Logger [8], as shown in Figure 1. Powered by a MediaTek ARM super single chip, this device receives signals from satellites, which then collects the coordinate points of the current location the device is at. This is completed at a reacquisition time of 1 second, which is sufficiently fast enough for the speed at which soccer is played. This judgment is based on the fastest recorded top speed a professional soccer player has attained, which is 37 kph attained over a duration of approximately 4 seconds. Thus in this particular situation, the device is capable of collecting four points in those four seconds. Additionally, the device provides an accuracy of 3 meters per circular error probable of 50%, which is sufficient to discern the general two dimensional movement of a soccer player on the pitch. Moreover, the V-900 has an acceleration limit of 4G, and a jerk limit of 20 mps, allowing for collection of data even

Specification	Value
Size	(43 x 74 x 9.9) mm
Weight	80 g
Data Format	Date, Time, Latitude, Longitude
	Speed, Heading
Memory	SD Card (2GB)
Waypoints Amount	504,000 points
Sensitivity	>-165dBm
Reacquisition Time	<1 second
Accuracy	2.0 m/CEP
Acceleration Limit	4G
Jerk Limit	20 m/sec

Table 1. Columbus V-800 Specifications

while withstanding shock during player collisions or falls. The device, weighing in at 55g, is a 43 x 74 x 9.9 mm prism, which allows for it to easily be transported or attached to a player during the game. This device also can collect up to 25,000,000 points, resulting in a very dense data set which can be stored and retrieved from a SD Card with a maximum capacity of two gigabytes. The format of the collected data is displayed via date, time, latitude, longitude, speed and heading. The full list of specifications is shown in Table 1. Each device retails for approximately USD \$85. The device is strapped on to part of body.

B. Device Evaluation

In the early stages, data points of a person's current location was collected while walking a city block using the compass application on the iPhone. These data points were displayed in the form of degrees, minutes, and seconds. Post collection, the data points were converted to decimal format and copied into the GNU Plot application on Terminal to display an exact image of the block. Through the same iPhone application, a similar process was conducted where data points of a soccer field - where exact location and size are known - were collected. These points were again converted into decimal form where the distances between points was then calculated using the Haversine Formula (explained in subsequent section). The distances were then verified with the original dimensions of the soccer pitch.

C. Soccer Ball

Initially, the Adidas miCoach Smart Soccer Ball [5] was considered a possible option. This ball is a Size 5 regulation soccer ball implemented with a Bluetooth chip inside. However, the issue presented itself that a GPS-guided sensor chip was required to track the location of the ball, and thus this option was disregarded. The other option was to set up cameras around the field and use a normal Size 5 regulation soccer ball. Instead of using a GPS chip to track the ball, the cameras would visually monitor the position of the ball on the field. This alternative, however, completely contradicted the goal to create a cost-effective software. Therefore, an original design of a sensor-integrated soccer ball is proposed. The proposition can be found in Section V.

SOFTWARE DESIGN

A. Tools

The tool selected for the software development was Qt Creator (version 5.7.0), an open source, cross-platform compatible integrated development environment. Qt Creator has two main components, one for coding and one for the user interface. All code in Qt is written in C++ language, and the visual result of the software can be developed through the code. On the other hand, the user interface refers to the visual aspect of the software, which is the aspect of the software that will be seen in the final product. The user interface utilizes widgets and visual drag-and-drop over hands-on coding. The

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Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players

combination of both coding and user interface allows for rapid prototyping to be completed.

Using Qt Creator, the original process explained previously (see Device Evaluation) can be replicated and further enhanced. If the collected points are copied into the code on Qt Creator, they will be displayed in chronological order on a scatter plot. This display is run through the user interface. The major difference between Qt Creator and GNU Plot is that Qt Plot can not only plot multiple different sets of points - which is needed when tracking both players and ball - but the data displayed is constantly moving rather than stationary, as it is in GNU Plot.

B. Metrics

1) Total Distance Covered: Total distance ran represents the sum of distances covered by each player throughout the game. Let the raw GPS satellite data collected by each player be denoted by

$$D \in \{\lambda_i, \phi_i\} \quad i \leq n \quad (1)$$

where λ and ϕ represent latitude and longitude respectively, and n represents the total number of data points collected by each player. The total distance, T_d , ran by each player is then the accumulated Haversine distance, Hd_i , between each pair of points for all points in D . This is given by the following formula:

$$T_d = \sum_{i=1}^n Hd_i \quad (2)$$

where

$$Hd_i = 2R \tan^{-1} \left(\frac{\Psi}{\Omega} \right) \quad (3)$$

$$\Psi = \sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_i) \cos(\phi_{i+1}) \sin^2\left(\frac{\Delta\lambda}{2}\right)} \quad (4)$$

$$\Omega = \sqrt{1 - \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_i) \cos(\phi_{i+1}) \sin^2\left(\frac{\Delta\lambda}{2}\right)} \quad (5)$$

and R is the radius of the Earth. The unit of Hd_i depends on the specified unit of R . The above formula is used since the points are present on Earth's surface, which is curved, rather than flat (see Figure 2).

2) *Instantaneous Velocity*: Instantaneous velocity describes the velocity of each player attained at each instant of time. It is favored over average velocity because it gives a better insight of player activity, since average velocity will only give one value represented by the averages of the instantaneous velocity collected overtime. This is given by

$$V_{inst} = \frac{Hd_i}{ts} \quad (6)$$

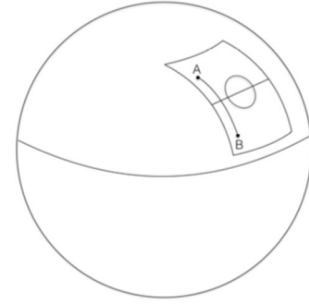


Fig. 2. Soccer Field in Relation to Earth's Surface

where ts is the sampling rate at which the GPS collects data.

3) Percent Possession: Percent possession has several different definitions including "a ratio as a percent where the two numbers added will always equal 100" and "how much time each side held the ball, excluding when the ball is not held by either team". In this case, percent possession is defined by the number of times the ball enters a radius of a certain distance around each player. The radius is set at 2 meters, a reasonable distance for a ball to be considered in a player's possession. The percent possession is represented by the formula

$$PP = \frac{\beta}{T\beta} \times 100 \quad (7)$$

where β represents each individual player's possession of the ball and $T\beta$ represents the team's total possession.

4) Total Touches: Total touches is the collective number of touches made by an individual player throughout the entire game. A touch is defined as contact between ball and foot, therefore a radius separate from the one used for percent possession is set. This radius is set at 50 centimeters, for the diameter of a size 5 soccer ball is roughly 22 centimeters [9], and the average shoe size of player's on the soccer team in the American School in Japan is 28 centimeters. The sum of the two values adds up to be 50 centimeters.

EXPERIMENTAL RESULTS

A. Experiments

In the following experiments, the four metrics given in Section III, Part B are tested individually using the V-900 Multifunctional GPS Data Logger. The trials were conducted using two participants. Participant 1 acts as the player and Participant 2 manually records results for experiments that require a second source, which establishes a ground truth to be used for comparisons. Additionally, each experiment is conducted three times in order to account for any possible human error.

Nov 23-24, Tokyo

Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players

1) Total Distance Covered: In this experiment, the player with the GPS attached runs a fixed distance of 100 yards (91.44 m), which becomes the ground truth. This allows the results calculated using our software to be compared to this truth. The method in which the GPS will calculate this distance is through the Haversine Formula of Section III, Part B, where the distance between the first point collected and the last point collected will be determined. The total distance ran was 88.964 m. This leads to a percent error of 2.71% due to the GPS logger's tracking speed of 1 point per second, allowing us to assume that the distance of 100 yards was achieved less than one second after the last point.

2) Instantaneous Velocity: In this experiment, the player with the GPS attached runs an arbitrary distance. This distance is again calculated using the Haversine Formula (Section III, Part B), and then is divided by the sampling time of the GPS. This value will be compared to a velocity value displayed by an inertial measurement unit (IMU). Our calculator's results and the GPS logger's results display similar trends based on the player's velocity. However, the absolute values are different, and we are currently investigating the reasons for this discrepancy.

3) Percent Possession: For this metric, the intended experiment will be conducted in which the assisting player will pass the GPS-equipped ball to the player with the GPS attached a certain and known number of times. Since the GPS has a range of 3 meters per circular error probable of 50%, the device will only be able to locate the ball when it has entered the GPS's radius. The number of times the device locates the ball will be compared to the number of times the assisting player passes the ball in order to test the accuracy of the GPS.

4) Total Touches: In this metric, the intended experiment will be conducted in which the player with the GPS will make contact with the ball a certain number of times. Due to the average size of a player's foot on ASIJ's soccer team being 28 cm, and the diameter of a soccer ball being 22 cm, the distance at which the soccer ball is deemed to be in contact with the soccer player will be set to 50 cm - the sum of the two values. The results will then be compared to the number of times the assisting player counts the contact between the ball and the other player.

It is anticipated that the four experiments above will prove that the developed software can visually represent a simplified version of the results attained.

Figure 3 displays a screenshot of the current version of the application. In the top right corner, an image of the player is displayed to show which player is being evaluated. Underneath is a drop-down box that allows the user to navigate through all eleven players. The box is followed by the four metrics described in Section III, Part B. The metrics are displayed as single values that change dynamically every time the position of either the ball or player is shifted.



Fig. 3. Final Application

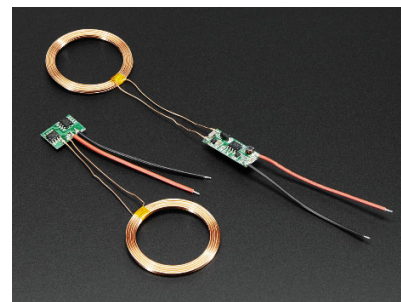


Fig. 4. Adafruit Inductive Charging Set

The majority of the screen is taken up by a visual representation of the soccer player (green dot) and the ball (red dot) in relation to the soccer pitch. Below that is a slider that allows for the speed at which the positions are displayed to be changed. The two buttons at the bottom allow for the user to plot, as well as clear the visuals.

DESIGN OF SENSOR-INTEGRATED SOCCER BALL

In order to collect data on the position of the soccer ball in relation to the players on the field, a GPS tracker must be embedded into the ball. However, the sensors in the ball must be charged, and since the ball cannot be cut open after every game, a wireless charging kit must be included in the ball as well. In the following sections, a more detailed explanation of every component will be provided.

A. Wireless Charging

The wireless charging kit selected is the Adafruit Inductive Charging Set. The system is based on inductive charging, which consists of a transmitter and a receiver. Supplying power to the transmitter creates an energy field between the coils, which induces a voltage in the receiver. The plan is to set the receiver coil inside the ball and place that area above the transmitter when charging. Initial experiments show that inductive charging is successful even with the ball's layering placed in between the two coils. The kit weighs a total of 11.2 grams, which is a weight light

Sensor-Integrated Soccer Ball For Spatiotemporal Performance Analysis Of Soccer Players

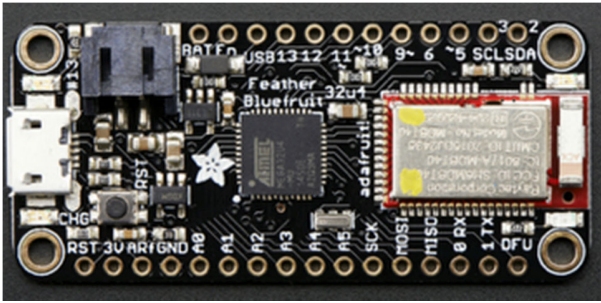


Fig. 5. Adafruit Feather 32u4 Bluefruit LE

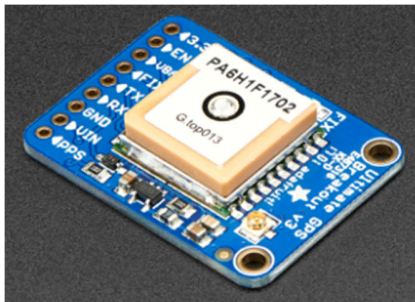


Fig. 6. Adafruit Ultimate GPS Breakout

enough to not have any significant effect on the movement of the ball. The charging strength is set at 5V, meaning that the ball would not charge immediately. However, this is not an issue considering this ball will only be used a few times a month at most.

B. Wireless Data Transfer

Physical or manual methods of data transfer are both tedious (connecting ball to computer via tether) and destructive (cutting ball open to retrieve memory card), thus a wireless data transfer kit is required to transfer the data collected. The product selected to conduct this operation is the Adafruit Feather 32u4 Bluefruit LE. This device contains a built in microSD card that allows for the storage of collected data. The results can then be transferred via the Bluetooth Low Energy board, which works on a 2.4 GHz spectrum. This means that wireless protocol can be conducted using either an iOS or Android device. It is also supported by Mac OSX and Windows 8+.

C. Position Measurements

The Feather board does not come with a GPS, so a separate attachment was purchased. It was important for this attachment to be compatible with the board itself, or else the collected data could not be stored in the USB compartment. Thus, the part purchased was also produced by Adafruit: the Adafruit Ultimate GPS Breakout. This GPS tracker has a high sensitivity of -165 dBm, which means it is accurate and will have a smaller radius of error. It is also battery-compatible, which means that it can share the same power source as the wireless charging kit.

D. Microcontroller

The actual microcontroller itself is the previously mentioned Adafruit Feather 32u4 Bluefruit LE. The device is a 51 x 23 x 8 mm board that weighs only 5.7 grams. Even if the weight of the wireless charging kit is taken into consideration, a total of 16.9 grams of excess weight to the original weight of the soccer ball will have an insignificant impact on its movement. The board also contains a reset button, which allows for a new data set to be created after each game.

CONCLUSION

In the previous paper, the software for the player-tracking application was developed. In this work, the aim is to determine the position of the soccer ball. Due to the lack of any existing solutions, an original design was proposed. This design consists of a microcontroller-based data logger with a GPS receiver embedded into the soccer ball, allowing for the coordinates of the position of the ball to be recorded onto the on-board microSD card. The battery powering the microcontroller is charged using a wireless inductive recharging circuit, with the receiver installed on the inside surface of the ball and the transmitter on the outside. Current experiments show that the energy field between the two coils is not influenced by the surface of the soccer ball, and thus the wireless charging can be completed successfully. The data collected is transferred wirelessly using Bluetooth technology.

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Classification of Ballroom Dancing Music Using Machine Learning

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Abstract - Ballroom dancing is a set of partner dances enjoyed both socially and competitively around the world. There are 10 different types of ballroom dancing, each danced to different styles of music. However, there are currently no algorithms to help differentiate and classify pieces of music into their individual dance types. This makes it difficult for beginner and amateur ballroom dancers to distinguish pieces of music and know which type of dance corresponds to the music they are listening to. We have created a machine learning classification model, which, by learning from known examples, is able to classify which dance type pieces of music correspond to. The final accuracy of this model is 89%. With this model, beginners to ballroom dancing will have an easier method of searching for and distinguishing between specific types of ballroom dancing music. This can also help people socialise and enjoy their time dancing with a partner.

Key Words - ballroom dancing, classification, machine learning

INTRODUCTION

Ballroom dancing is a set of partner dances all around the world, both socially as a hobby and competitively in dance festivals such as the Blackpool Dance Festival [1]. These dances are characterised in different ways and are always danced in the same way. There are 10 types of dances which are categorised as ballroom dancing; these include Chacha, Foxtrot, Jive, Paso Doble, Quickstep, Rumba, Samba, Tango, Viennese Waltz and Waltz.

Each different type of dance corresponds to a different type of music specific to match it. Though these different types of music have characteristics unique to their dance type, it can be extremely difficult for the human ear to distinguish these characteristics and classify pieces of music into their specific dance category. This process can be greatly facilitated using machine learning. Using knowledge about these unique characteristics, a model can be created to aid professional and amateur dancers to immediately match music to its corresponding dance type. This can be

extremely of use when it is necessary to find a song for a specific event or when curious about which type of dance to dance to a song.

To be able to classify music in this way, the requirements were knowing how to use a programming language (Python), along with working with sound data and signal processing.

MUSIC AND SOUND DATA

Sound data consists of a wave converted into an electrical signal. Firstly, the sound wave is translated into an analog signal. An analog signal is a continuous representation of a sound wave, and can consist of any values. After being converted into an analog signal, the signal is then converted into a digital signal using an analog-digital converter (ADC), allowing the sound to be represented in a way that can be stored digitally. Digital audio consists of a continuous sequence of numerical samples. A digital signal is formed by using the analog signal to capture digital values which represent the amplitude of the signal. □

When working with sound waves, it is important to know that frequency is equal to the pitch of the sound. The higher the frequency, the higher the pitch of the noise. Frequency is measured in Hz units. The human hearing range is from 20 - 20kHz. To capture all frequencies that humans can hear in an audio signal, ADCs sample recordings at a frequency that is approximately double the human hearing range, at a rate of 44,100Hz. [2]

FEATURES ENGINEERING FOR SOUND DATA

1. Data Collection

To create and train a model to achieve an accurate way of classifying ballroom dancing music into its specific dance category, an essential requirement is the collection of data.

For each type of dance, pieces of music were collected as examples for the classification model to learn. These pieces of music consisted of songs of a known dance type, and therefore were sorted into different files according to their category. These files were then converted from mp3 into wav files. In order to increase the number of music samples

Classification of Ballroom Dancing Music Using Machine Learning

for machine learning algorithms, the data was cut into smaller windows. This also allowed the size of each piece of music to be standardised, making it easier to extract statistical features.

I. Feature Extraction

In order to classify a piece of music, research must be done in order to know what characteristics of the music make them unique to their dance type.

The first feature extracted from the pieces of music is the BPM counts, i.e the beats per minute or the tempo. This indicates the speed of the song. Each dance type has a different range of tempos at which they are danced:

Chacha -	120 - 128
Foxtrot -	112 - 120
Jive -	168 - 184
Paso Doble -	120 - 124
Quickstep -	200 - 208
Rumba -	100 - 108
Samba -	96 - 104
Tango -	120 - 140
Viennese Waltz -	174 - 180
Waltz -	84 - 90

[3]

Another important feature extracted was the time signature of the piece of music, ie the count. The main significance of this feature is to facilitate the differentiation between Waltz which has a time signature of 3/4 and the other categories of dance music which have a time signature of either 2/4 or 4/4.

A third feature extracted from the pieces of music is a fingerprint record of the song. A fingerprint consists of a list of 5 values combined to form one hashtag. These values are the most common frequencies of the piece of music within different frequency ranges. In a sound bite, frequency is the determinant of pitch. Therefore the fingerprint of a song can be interpreted as a series of pitches which appear most frequently within their frequency ranges within the song. The five ranges were: 30-40Hz, 41-80Hz, 81-120Hz, 121-180Hz, and 181-300Hz. [4]

The final 34 features extracted further increased the ability of the final model's classification. Both short-term and mid-term features were extracted from each piece of music. Short term features can be described as features extracted from the piece of music after having split it into several short-term windows. Mid-term features can be described as certain statistics extracted from the short-term features such as the mean and the standard deviation.

TABLE I
FIRST 5 FEATURES OF THE PYAUDIOANALYSIS PROGRAM [5]

Feature ID	Feature Name	Description
1	Zero Crossing Rate	The rate of sign-changes of the signal during the duration of a particular frame.
2	Energy	The sum of squares of the signal values, normalized by the respective frame length.
3	Entropy of Energy	The entropy of sub-frames' normalized energies. It can be interpreted as a measure of abrupt changes.
4	Spectral Centroid	The center of gravity of the spectrum.
5	Spectral Spread	The second central moment of the spectrum.
...

EXPERIMENTAL SETTING

The first step taken in creating the model was collecting the necessary data. For each 10 different types of dance, 15 different songs were collected from different sources in order to start the research.

To further increase sampling and data size, each piece of music, i.e each song, was then split into 10 second windows each with a 5 second overlap. The total number of windows was approximately 6000, around 600 per dance type.

The first feature extracted from each piece of music was the beats per minute. Using a function from the library named "Librosa", a program was derived in order to extract the bpm of each piece of music in the dataset. Once the program was run, the results were collected and entered into a table with their corresponding song name and dance type.

The second feature extracted was the time signature (count) of each piece of music. The program used for this process was from the library "Madmoms". Within this program, a function called "DownBeatTrackingProcessor" allowed the time signature of each piece of music to be extracted and written in a table.

To extract the fingerprint of each piece of music, a library called "Scipy" was used. This library extracted the

Nov 23-24, Tokyo

Classification of Ballroom Dancing Music Using Machine Learning

values of the most common frequencies within the different frequency ranges, and then combined them into a hashtag. The hashtags were then sorted into a table with the name of their corresponding song name and their dance type.

To extract the final 34 features from each piece of music, the program used was from a library created by Theodoros Giannakopoulos. The library name was “PyAudioAnalysis”. Each feature was extracted by this program and then entered into a data table.

RESULTS

Once all features had been extracted from the pieces of music, they were used to train several classification models to recognise and classify the pieces of music into their corresponding category of ballroom dancing.

Several different types of classifications models were trained and evaluated in order to maximise the accuracy of the final model chosen. These models were: ‘Support Vector Machine’, ‘K-Nearest-Neighbours’ with neighbours=5, ‘Simple Decision Tree’, ‘Random Forest’ with 100 trees, and a ‘Deep Neural Network’. The samples of pieces of music were separated into two data sets: one to train the model and one to test the model. The data from the training set was fed into the codes for each model. Once the model had been trained, it was run on the test data in order to output predictions for the dance type of each piece of music in the test data. The predictions were compared with the actual dance types of each piece of music in order to evaluate and calculate the accuracy of each model.

Accuracy and F1 Score of Classification Models

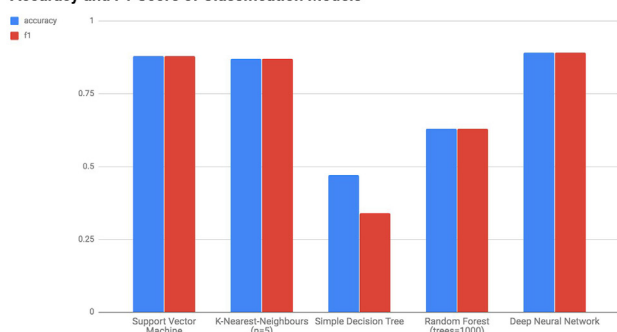


FIGURE 1

CHART COMPARING THE ACCURACIES OF CLASSIFICATION MODELS

TABLE 2

ACCURACY AND F1 SCORE OF EACH CLASSIFICATION MODEL

Classification Model	Accuracy	F1 Score
Support Vector Machine	0.88	0.88
K-Nearest Neighbours	0.87	0.87

(n=5)		
Simple Decision Tree	0.47	0.34
Random Forest	0.63	0.63
Deep Neural Network	0.89	0.89

The classification model which achieved the highest accuracy was the ‘Deep Neural Network’ classification model, with an accuracy and f1 score of 89%. The results of this model can be interpreted using a Confusion Matrix as shown below.

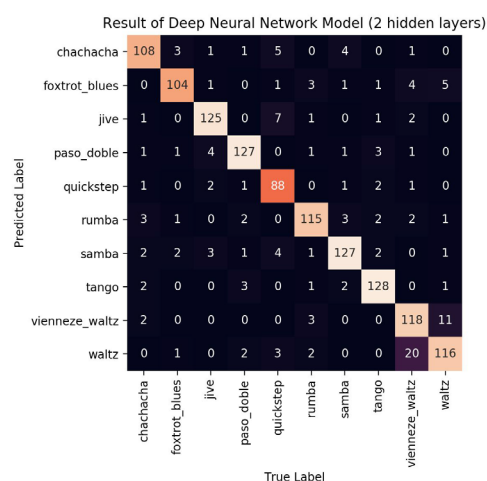


FIGURE 1

CONFUSION MATRIX DISPLAYING RESULTS OF DNN MODEL

The vertical axis of this chart represents the classification model’s prediction of which dance type each pieces of music correspond to. The horizontal axis represents the actual dance category of the piece of music. Therefore, any values which are situated in the middle diagonal line of the chart represent a correct prediction (matching the true label of the song). The high density of values found in the middle of the Deep Neural Network confusion matrix confirms above helps visualise the high accuracy of the model. The main area of error is shown in the bottom right corner of the chart: distinguishing between Viennese Waltz and Waltz. 11 pieces of music were predicted as as Viennese Waltz but were in fact Waltz pieces of music, and 20 songs which were predicted as Waltz were in fact Viennese Waltz. This is due to the two dance types having extremely similar distinguishing features. Other than between these two dance types, the rest of the pieces of music were mostly predicted into the right category with a couple exceptions for each dance type.

Nov 23-24, Tokyo

Young Researchers’ Conference 2018

CONCLUSION

The final machine learning classification model achieved an accuracy of 89%. This classification model used a range of machine learning algorithms in order to classify different pieces of music into which specific type of ballroom dancing which they corresponded to. In the future, this model can be used to build an application for people to be able to search for and classify ballroom dancing music easily throughout their daily lives. The next step in order to achieve this is to begin by verifying the method used by testing the machine learning classification model with more known pieces of music.

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An Exploration of the Effects of Alternate Realities on One's Identity through *Neverwhere* and *The Neverending Story*.

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Abstract - One perspective on identity is how it is shaped by a person's subjective and spatial reality. Where how one perceives and experiences the world, as well as the immediate environment that they are in, defines a person's reality. Due to this, reality stands as a paramount foundation to a person's core identity. Yet, there are many ways of experiencing different realities such as in fantasies, dreams, virtual reality etc. This concept is a fundamental cornerstone of Neil Gaiman's *Neverwhere* and Michael Ende's *The Neverending Story*. Both novels present the protagonists being subjected to both their everyday reality and the alternate fantasy of the respective novel. Through this, an exploration on concepts of escapism and identity work as the authors showcase their characters being consumed by the fantasy. This establishes the theme of the novels: fantasy diverts one from their reality. Exploring this notion, it is apparent how the two authors are able to put forth separate commentaries on the effects of different realities on identity.

Key Words - Escapism, Fantasy, Identity, Subjective and Spatial Reality.

INTRODUCTION

In the fantasy genre, a common literature trope features a protagonist who becomes, willingly or not, involved in the affairs of a fantasy world. This concept of alternate realities that coexist with each other is a central aspect of Neil Gaiman's *Neverwhere* and Michael Ende's *The Neverending Story*. In both novels, the presence of an alternate reality exists as a setting in which the protagonists become irreversibly involved. In Gaiman's *Neverwhere*, this is presented in the form of "London Below" [1]: a distorted London where those who "lose themselves" [1] end up. In contrast, Ende's *The Neverending Story* creates an entire fantasy world of "Fantastica" [2] with phenomenal and awing characteristics that entrance those who become involved. While the alternate realities are presented as opposites of their real counterparts London Above and the real world respectively, both settings created by each author consume the protagonists, putting them on a path of self-discovery and

growth. The development of these topics through metaphors and imagery establish a key central theme of the two novels; that a fantasy diverts one from their reality. The question, 'In what ways, and to what effects are alternate realities used in the novels *Neverwhere* and *The Neverending Story* to address issues surrounding identity?' allows for the exploration of the concept of escapism. This essay will showcase how the same conceptual notion of escapism within the theme are developed and explored, but bring forth two separate commentaries on establishing one's identity. Through *Neverwhere* Gaiman puts forth the notion that fantasy allows for self-discovery and the realization of one's place of belonging. However, Ende establishes the dangers of losing one's identity and grasp of reality through *The Neverending Story*.

THE ROLE OF REALITY IN ONE'S IDENTITY

The common theme between the novels *Neverwhere* and *The Neverending Story*, that fantasy diverts one from their reality, is explored through the respective identities of the protagonists Richard and Bastian. One's place both spatially and temporally is bound by the reality that one experiences which subsequently defines one's identity. Due to this, one's cornerstone identity is defined by several factors, 1) the immediate spatial environment of a person, 2) one's temporal moment in their spatial reality, and 3) one's subjective perspective within these two realities. In *The Social Construction of Reality* by Berger and Luckmann, the notion that, "Everyday life presents itself as a reality interpreted by men subjectively meaningful to them as a coherent world," p.33 [3] is explored where the reality of everyday life is "paramount" p.39 [3] to the existence of a person. In this regard, identity is closely associated with one's reality as the latter imposes itself on the former. Therefore, one's identity will be comprised of one's motivations, views, and place of belonging, as these are all dictated by the aforementioned three aspects of one's reality. Both Gaiman and Ende develop and integrate this concept, establishing Richard's and Bastian's reality respectively, creating within the reader the identities of their protagonists. In both cases, the protagonist's interactions and interpretations of the alternate reality are rooted in how they identify with their routine manner of

An Exploration on the Effects of Alternate Realities on Identity

living. The motivations for both Richard and Bastian to return to their real-world lives exists due to the paramount nature of everyday life in their created identities. Thus, this notion presented by Berger and Luckmann allows for Gaiman and Ende to make their respective commentaries on identity.

NEVERWHERE

Neil Gaiman establishes Richard's everyday reality in London through the descriptions of his life and relationships. For this, Gaiman characterizes Richard's subjective and spatial reality with three clear traits: being unhappy, being in denial, and living life in a dull city. In doing so, Gaiman is able to portray how Richard's reality is ill-suited to him both spatially and subjectively. The opening line of the novel, "The night before he went to London, Richard Mayhew was not enjoying himself," p.01 [1] puts significance on Richard's unhappiness and is carried throughout his characterization in London Above. This significance is further emphasized later in, "three years in London had not changed Richard," p.09 [1] showing the unwavering reality of Richard's subjective unhappiness. In the depiction of Richard's spatial surroundings, Gaiman uses visual imagery in describing London as a "grey city, even a black city" p.09 [1] and "a city in which the very old and the awkwardly new jostled each other" p.09 [1]. Through the stimulation of the reader's visual senses, Gaiman depicts the modernizing London in a dull 'grey' light which defines Richard's spatial reality.

Lastly, in the depiction of Richard's ill-suited reality, Gaiman portrays his denial of his toxic engagement with his fiancé Jessica. In portraying this relationship Gaiman shows the lack of equality through Jessica's self-centered interactions. "Richard would trail behind Jessica as she went shopping..." p.12 [1] or "Richard would accompany Jessica on her tours..." p.12 [1] depicting the one-sided nature of their engagement. Furthering this aspect, Gaiman illustrates Richard's denial of his reality as he defends Jessica with "She's really sweet, once you get to know her" p.13 [1], against the warnings of his peers. By these, Gaiman conveys Richard's character as one who is unhappy and not in his true place of belonging. It is in this way that Gaiman establishes Richard's identity as ill-suited due to his unfitting reality.

Gaiman depicts Richard as an outsider even in his reality of London Above prior to entering London Below as he is "sitting and shivering on the sidewalk outside the pub..." p.01 [1] while his farewell party occurs inside. In Courtney Firman's "Fantasy Making the Invisible Visible: Liminality in Neil Gaiman's *Neverwhere* and *American Gods*", the author writes that "The going away party is a symbolic act, representing Richard's pending separation from the community" p.07 [4]. Furthermore, as Richard sits by the gutter, a "liminal space" p.07 [4] he is mistaken for a homeless man by a passing elderly woman, as she recognises homelessness due to formerly being homeless herself. The liminality expresses Richard's isolation from his friends inside but also goes to foreshadow his eventual invisibility to the people of London Above once he becomes involved with the affairs of London Below. While Richard is depicted in a

liminal light, Gaiman also mirrors this trait with the society of London Below. The entire alternate reality is depicted as a feudal society with fiefdoms and domains. This juxtaposes the aforementioned modernizing London Above with a society locked in the past. By depicting London Below as a neglected society, one without the notice of London Above leading to its stagnant development and chaotic nature, Gaiman attributes the very same liminality as he did for Richard. Through these sequences, Gaiman establishes Richard's identity as being homeless as perceived by the community of London Above, which furthers the notion that London Above and Richard's current reality as ill-suited for him. Moreover, in depicting both London Below and Richard's identity as liminal, the readers are able to understand how Richard would identify with London Below.

Richard's interaction with the alternate reality illustrates how the fantasy diverts him away from his reality and beings to challenge his true place of belonging. In order to do this, Gaiman uses extensive sensory imagery in the depiction of the Market, a trading centre of London Below. This is first seen with auditory imagery in the line, "people argued, haggled, shouted, sang" p.109 [1], furthering the aforementioned chaotic society of London Below. The imagery of a smell in, "the smells of curries and spices... of grilling meats and mushrooms," p.110 [1] and the visual imagery of "counters that, during the day, had sold perfume, or watches, or amber, or silk scarves," p.110 [1] are both cases of literal imagery to depict the immersive experience of London Below. In conjunction with the visual stimuli, the use of extensive listing makes the sensory detail more significant creating fullness and splendour. This combination of sensory images establishes the overwhelmingly distracting force this alternate reality has over Richard and subsequently the reader. Gaiman stresses this detail where Richard acknowledges the fact that he didn't cognitively interpret the taste of his food as "he realized as he finished... he had no idea how anything he had just eaten had tasted" p.113 [1], which illustrates the extent of the fantasy directing Richard's cognition in favour of the splendour of the Market. The chaotic imagery works with the aforementioned feudal London Below to illustrate a backwards society and Richard's fascination with it. Through these uses of imagery, Gaiman is able to depict how Richard's cognition is being overridden through the immersion of London Below. In doing this, Richard is depicted as completely taken aback by the fantasy allowing Gaiman to further Richard's diversion of reality.

Gaiman sets up Richard's literal shift in reality through the uses of dialogue, word choice, and narrative perspective. Exploring the theme of fantasy diverting one's reality, Gaiman portrays over the course of the novel how London Below gradually becomes Richard's true reality, and how he identifies with the alternate reality of London Below. This is depicted on the line, "in many ways it was quite wonderful" p.109 [1], in reference to the Market, showing Richard's subjective view of this fantastical alternate reality which juxtaposes Richard's aforementioned unhappiness. Despite the chaotic and backwards society of London Below,

An Exploration on the Effects of Alternate Realities on Identity

Richard views it as 'wonderful' and thus depicts his acceptance of the fantasy. Furthermore, this prospect is emphasised again later in the novel where Richard feels "happy" p.201 [1] after drinking the wine of the angel. This is followed by the line, "It made him think of skies bigger and bluer... a golden sun hanging huge in the sky; everything simpler, everything younger than the world he knew" p.201 [1], which contrasts Richard's depiction of the 'grey' and 'black' London Above. The visual imagery of a 'golden sun' and the 'blue skies' is figurative but creates a utopian effect in the reader, which depicts Richard's perspective on the appeal of London Below. Furthermore, Richard's role in society changes as he slays the beast in the labyrinth, going from being a salary man in London Above to being the 'Hunter' of London Below. Gaiman cements Richard's change, as upon returning to his normal life Richard concludes that "I thought I wanted a nice normal life... But if this is all there is, then I don't want to be sane" p.371 [1]. It is through these techniques that Gaiman establishes the change in Richard's identity as his spatial and subjective reality change leading to Richard's decision to stay in London Below.

Throughout the novel, Gaiman distinctly establishes the two realities and their effect on Richard's character. Richard's identity was one of unhappiness and without a sense of belonging in London Above which was dictated by his spatial and subjective reality. In contrast to this, Richard's interaction with London Below brought a new perspective on himself and this fantasy, immersing him in chaos, and subsequently happiness. In many ways, Gaiman presents a case of Richard escaping from his problems subconsciously as he is unaware of the extent to which London Above is ill-suited to him. Despite his former identity residing in London Above, the readers are led to question this identity as Richard is shown to relate to and admire London Below. In doing this, Gaiman is able to express the central message of the novel that fantasy can be an outlet for discovering one's true sense of self and place in the world. The result of this can be seen as despite Richard being able to return to his former life in London Above, he chooses to return back to London Below as he has acknowledged his place in both realities.

THE NEVERENDING STORY

In Michael Ende's *The Neverending Story*, the theme of fantasy diverting one's reality is explored through following Bastian Balthazar Bux. The novel follows Bastian as he reads a magic book in his school attic called "The Neverending Story" p.09 [2] which details the quest of Atreyu until the eventual merging of Bastian's world and the world of "Fantastica" [2]. In a similar light to Gaiman, Ende establishes Bastian's reality as an unsatisfactory one which defines his existence and his motives. Ende uses imagery and narrative perspective to depict Bastian's spatial and subjective reality allowing the reader to understand the creation of his identity. However, through the fantasy of Fantastica, Ende showcases how a change in one's sense of reality can lead to irreversible destruction of one's own

identity. In contrast to Gaiman, *The Neverending Story* addresses the diversion of reality and the losing of one's true place of belonging.

Similarly to Neil Gaiman, to establish the theme of the novel, Michael Ende portrays Bastian as unhappy with himself and his reality in the real world. To do this, Ende uses imagery in defining the specific qualities of Bastian's reality. Bastian's spatial reality is depicted as "outside, it was gray, cold, rainy November morning" p.05 [2], which incorporates both visual imagery of 'gray, cold, rainy' and touch imagery with 'cold' to establish the sad and dull reality of Bastian's everyday life. Ende also portrays Bastian's relationship with his family to be unhappy and misfortunate, as Bastian's mother passes away prior to the novel, resulting in him being neglected by his grieving father. Bastian's relationship with his father has collapsed as "he couldn't talk to his father anymore" p.31 [2] and how the father "no longer" p.32 [2] played with Bastian. Furthermore, Bastian is a victim of bullying in part due to him being fat, resulting in his ostracization and loneliness. Berger and Luckmann write that on top of one's spatial reality, one's ability to share an intersubjective reality is integral to one's place in society and their identity p.37 [3]. In the case of Bastian, his lack of friends and family results in his inability to "share" p.37 [3] his reality with his peers which serve to isolate him further in society. Through these Ende defines Bastian's identity by clearly establishing the misfortune and unhappiness of his reality. In doing so, Ende is able to contrast the two realities as the theme of fantasy diverting reality is developed.

In contrast to the depiction of Bastian's reality, Ende portrays Fantastica as fulfilling and magical using imagery to depict its entrancing effect on Bastian. One of the first locations that Bastian travels to is the Desert of Colors, where the landscapes are of "every imaginable color" p.185 [2], which directly contrasts the aforementioned 'gray' world that Bastian came from. Furthermore, the first feeling Bastian experiences are, "warm, velvety darkness in which he felt safe and happy" p.171 [2], which depicts the differing effects of the darkness of the attic and the darkness in Fantastica. The 'warm' juxtaposes an earlier depiction of a "freezing attic" p.171 [2] as well as the aforementioned 'cold' depiction of the real world. Through this, Ende is able to show the instantaneous effects of the alternate reality; giving a feeling of safety and happiness. The use of both visual and tactile imagery creates a similar effect to the imagery of the Market in *Neverwhere*, illustrating the captivating nature of a fantasy. Furthermore, the line, "It was a wonderful feeling, a sense of release and boundless freedom" p.171 [2], illustrates Bastian's state when he is transported into Fantastica. The appeal of having the freedom to do what he wants defies Bastian's reality as he depicts his school as a "prison" p.12 [2] and his life a "misery that would continue until he grew up" p.12 [2]. This allows Ende to portray the phenomenal and awing nature of this alternate reality and establishes the theme: fantasy diverts one's reality.

Ende portrays the fantasy and how it begins to reshape Bastian's identity as the fantasy begins to divert his

Nov 23-24, Tokyo

An Exploration on the Effects of Alternate Realities on Identity

reality. Within the world of Fantastica, Bastian holds a gem called AURYN that grants his wishes. Initially, unbeknownst to Bastian, with each wish granted he loses a piece of his memory. Despite this, Ende alludes to the consequences, subtly hiding its initial significance through the alliteration in, “the beauty that had been bestowed on him made him forget... that he had ever been fat...” p.177 [2] The alliteration of ‘b’ sounds in ‘beauty that had been bestowed’ gives the change a harmonious effect which downplays the consequences of making wishes. Through this use of alliteration, Ende is able to illustrate the appeal of AURYN’s power to the reader, who, like Bastian are unaware of the gravity of these consequences. As a result of his wish, Bastian becomes “delighted at being handsome” p.177 [2] and subsequently, his subjective reality is altered. Despite being given AURYN to save Fantastica Bastian’s wishes instead serve his self-interest allowing him to escape from his reality. According to “Fantasy, Reading, and Escapism” by Jo Walton, if life is restricted, having creative options can help cope with problems [5]. However, Bastian’s wishes of being beautiful, wise, strong are all linked to his unbearable reality in the real world and are fuelled by Bastian’s desire to escape from his problems. Ende shares Walton’s ideologies in the depiction of Bastian’s happiness but highlights the difference between coping and a more extreme form of escapism in order to allow for the exploration of the dangers this can pose.

In depicting the dangers of fantasy, Ende develops Bastian’s degrading identity as his wishes for perfecting himself grow with his greed. This greed for perfection is most notable in the lines, “He also wanted to be strong, stronger than anybody! The strongest in the world!” p.178 [2] The tricolon of increasing superlatives emphasizes his greed, as each superlative builds off of Bastian’s inability to settle for anything but the best. This desire manifests itself in the simile, “Slashing with the side of his hand as if it had been a machete” p.178 [2]. The depiction of Bastian as a weapon and that Bastian takes this prospect “for granted” p.177 [2] highlights Bastian’s change in identity. No longer is his identity dictated by his unhappy reality of being ‘fat’ and isolated, instead, he has become the complete opposite of his real self. The final change in Bastian’s identity comes when he becomes the antagonist of his own story as denoted in, “He wasn’t innocent, he wasn’t harmless... He wanted to be dangerous, dangerous and feared. Feared by all” p.267 [2]. Ende progressively reveals Bastian’s antagonism cementing any remanence of his former identity and reality in the real world to be lost.

Ende showcases throughout *The Neverending Story* how important reality is to one’s identity. Bastian’s existence was initially defined by his misfortunate background and subsequently as a coping mechanism was consumed by his own greed. Unlike Walton’s notion of another reality serving to help cope with one’s problems, Bastian willingly erases his true self in favour of a new identity. This is evident as Atreyu senses holes in Bastian’s memory and confronts him about it and yet Bastian disregards Atreyu’s warnings stating “I don’t want to go back (home) anymore” p.225 [2]. In many ways,

the degradation of Bastian’s identity stems from his compulsive desire for validation, thus his wishes to become a perfected version of himself. This perspective of Bastian’s self-destruction aligns with the ideas presented by Darius Ciknavicius’s *The Trap of External Validation for Self-Esteem*, where, due to the desire for validation, those who are invalidated respond with “anger” and “dysfunctional behaviour” [6] which can be seen in Ende’s depiction of Bastian. Ende’s use of character development over the course of the novel in depicting how the fantasy diverted Bastian’s reality entirely, goes to question the heroic status bestowed on Bastian as he slowly degrades into the antagonist of his own story. In this light, Bastian’s identity was forcefully overridden by the very fantasy he let himself be consumed in. In doing this, Ende comments on how an alternate reality, the fantasy of Fantastica, warped Bastian’s identity producing someone blinded by the satisfaction of the fantasy. Through this, the dangers to one’s identity and purpose due to the effects of different realities are made clear.

CONCLUSION

Throughout *Neverwhere* and *The Neverending Story*, the authors explored the theme which states that fantasy diverts one’s reality. In illustrating this theme, both authors depict the alternate reality with wondrous sensory immersion which juxtaposes the dullness of their respective realities which led to the suspension of cognition. Comparing Richard and Bastian, it is evident that both cases present escapism; with Bastian it is conscious whereas in Richard it is subconscious. In many ways, Richard was aware of both realities by the eventual turning point in his identity. On the other hand, Bastian completely lost his grasp on his former self. In the case of *Neverwhere*, in developing the theme and addressing the effects of realities on one’s identity, Gaiman clearly addresses how the questioning of one’s identity can come about through the subjection of a fantasy. Where Gaiman shows that through experiencing the alternate reality of London Below Richard was able to find his true place of belonging. On the other hand, Ende addresses the opposite, developing the dangers of losing your sense of self. The dangers of being consumed by the alternate reality and losing every aspect that defined your existence, which in *The Neverending Story* corrupted Bastian’s character.

Despite both authors developing the same notion, the resulting messages contrast with each other significantly. However, the two authors ultimately discuss how realities in both their spatial and subjective sense play an integral role in defining one’s identity. The similarities between the two novels, wherein the effects of multiple realities can alter your identity, connects to the real-life problem of differentiating fantasy and reality and the line that separates the two. It is therefore important to consider the boundaries when indulging in fantasies as even seemingly unrealistic realities can bring about changes in our identities.

An Exploration on the Effects of Alternate Realities on Identity

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Change in Japanese Economy and How Prime Minister Abe's Word Choice is Influenced by the Economy

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Abstract - This paper looked into the effect of the policy, Abenomics. I analyzed the situation using the following economic and societal factors: GDP, unemployment rate, female working condition, and inflation rate. Furthermore, the Prime Minister's speech was also analyzed, because I believe his word choice in the speech is influenced by the movement of the economy. This was actually the case and depending on how successful his policies were, the content and his delivery for his speech altered. Also, Mr. Abe's speeches were compared with the speeches done by Mr. Obama, a well-known speaker. There were significant differences between the two speakers and it was evident that Obama was more persuasive and convincing to the audience. One of the factors that influenced this was that Obama often used "we" and included the citizens in the first-person pronoun use while Mr. Abe does not.

Key Words - Abenomics, GDP, Inflation rate, Three arrows, Unemployment rate

INTRODUCTION

Abe Shinzo has been the Prime Minister of Japan from 2012; while he has come up with numerous policies, one that amazed me and many other Japanese citizens was the concept of Abenomics. Abenomics is a word coined by him, combining "Abe", his own last name and Economics, the study of the production, distribution, and consumption of goods and services. This policy focuses on improving the Japanese economy and he derived the name from Reaganomics, an economic policy that President Ronald Regan came up with in the 1980s. In this paper, I will be evaluating the economic effect of Abenomics and how the movement in the economy influenced his word choice.

Before understanding what Abenomics is, we must first establish the economic situation in 2012. Japan experienced an economic bubble burst from 1986 to 1991 and this led to deflation, decreasing the average price level of goods and services, leading to an increase in the value of the Japanese yen. Furthermore, Japan is an aging society and the number of people available for workforce decreased. This led to a decrease in governments collecting tax, eventually leading to an increase in national debt. To restore and solve these issues, the policy of Abenomics was created.

When Mr. Abe presents his opinions and ideas, he uses speech format. Often times, country's leaders often use speeches to address their ideas and the presenters use

techniques to persuade the audience. While there are many objectives in doing a speech, one of the main reason is to gain trust from the citizens. This will lead to an increase in the approval rate. This essay will look into the economic situation in Japan and how Mr. Abe's word choice is influenced. However, before moving onto that, the paper will analyze characteristics of a good/convincing speaker.

GOOD SPEAKER AND THEIR CHARACTERISTICS

Speeches appeal to the audience and its number one priority is to get a positive response from the audience. However, even if the speech is emotionally appealing, this may not be a good speech. An example of this would be when the message is not clear. In this section, I will use Barack Obama, one of the well-known speakers in the United States as an example of a good speaker. First, he uses simple English and repetition to make the message clear. Just like Martin Luther King Jr uses "I have a dream", Obama uses "Yes We Can" and other phrases repetitively to leave the audience with a stronger image.

Furthermore, according to a linguist, Shoji Azuma, Obama uses the pronoun "we" to refer to the citizens as a whole. By using "we", he successfully unites the citizens' minds together and brings in solidarity within the country. Furthermore, he intentionally does this to center his speech around the audience, rather than himself. To statistically support my case, Obama uses "I" 3 times, in comparison to 62 times of "we" throughout his presidential inaugural address. [1]

Also, Mr. Azuma introduced the idea of "report talk" and "rapport talk". "Report talk" is a communication between the speaker and the listener. Often times, this deals with facts and evidence. On the contrary, "rapport talk" focuses on building a relationship between the speaker and the listener and this tends to focus on more abstract elements. We usually enjoy the rapport talks more because it builds sympathetic emotions. Obama focuses mainly on rapport talks and not report talks.

These are one of the many reasons we are moved by Obama's speeches and why he is called the master orator. Before analyzing how Mr. Abe performed his speech, we would look into the concepts of Abenomics.

OBJECTIVE OF ABENOMICS

Abenomics is a policy created on December 2012 under the idea of the "Three arrows". As the name suggests, three arrows is a combination of three ideas combined. The first

Change in Japanese Economy and How Prime Minister Abe's Word Choice is Influenced by the Economy

idea is “dramatic monetary easing” and this idea focuses on combatting deflation, one of the main economic issues during the time. The Japanese economy aimed to achieve a 2% inflation rate. By doing this, the Japanese economy will get out of deflation and would increase the money supply. The second idea is “a robust fiscal policy” and it aims to improve infrastructure by increasing government spending. The last idea is “Policies for growth to spur private investment” and this aims to increase investment opportunities for firms. By doing this, it will improve the working environments for the elderly and females, securing the number of workforce. Through these three arrows, Mr. Abe mentioned that he will improve and stabilize the Japanese economy.

However, in 2015, he came up with the “New three arrows”. Again, this policy had three main ideas. They were, “Robust economy that creates hope”, “Child care support that fosters dreams” and “Social security that fosters sense of safety”. “Robust economy that creates hope” is connected with the original three arrow policy, aiming to increase the nominal GDP to 600 trillion yen by 2020. “Child care support that fosters dreams” aims to fix the aging society, increasing the birthrate from 1.4 to 1.8. This is one of the ways Mr. Abe believes we can increase the population of youth and increase the workforce. Lastly, “Social security that fosters sense of safety” aims to reduce workers leaving the working environment due to elderly care.

From these policies, it is evident that in 2012, Mr. Abe has policies that directly affected the economy. On the other hand, the new three arrows not only focus on the economy but also focus on the social issues that indirectly affect the economy. Now, we would look into how the economic issues and social issues were resolved from 2012.

PRIME MINISTER ABE'S SPEECH

Mr. Abe has spoken in front of the citizens numerous times but in this paper, I would analyze his speech on May 22nd, 2017 at the Boston Consulting Group annual meeting and September 20th, 2017 at the New York Stock Exchange. I would be looking into the following features: introduction, repeated words, use of data, use of pronouns and sentence structure.

First, his speech at the Boston Consulting Group annual meeting, he claims that he is contributing to the economic situation. He shows his confidence in the introduction of the speech. In the introduction, he mentions the example of Yoshihide Kiryu and young Major League Player that was in the attention for many baseball fans that time. By doing this, he was able to get a good introduction to lead into the topic of Tokyo Olympics. Furthermore, in his speech, he refers to his future goals as a goal that is “achievable”. In order to do this, he uses the past accomplishments, using examples from the restaurants that got Michelin star in Tokyo, leading to an increase in foreigners. While this is not an evidence of how he will achieve the goals, he assumes his past successes will allow him to be successful now. Also, through the humor incorporated in the introduction, Prime Minister is connecting his introduction to his later parts of the speech. Typically, Japanese people are known for not saying too many jokes. Therefore, the humor in his speech

serves as an attention grabber and it makes him seem confident. Typically speaking, Americans tend to enjoy humor. Therefore, by making the audience laugh, he is trying to change the stereotypical Japanese image of being null and boring. Furthermore, humor allows the speaker to connect emotionally with the audience and bridge the gap between them. By doing this, Mr. Abe successfully grabs the audience's attention and makes the other parts of the speech more convincing. [2]

Furthermore, at the New York Stock Exchange, he creates a word called “Womenomics” that refers to creating an environment where females can work effectively. He is known for using words like “Abenomics” and “three arrows” to grab the audience's attention and address his points clearer. To him, these words are just like Obama's “Yes we can”. These words create a stronger image in the minds of the audience and the media, making his overall speech stronger. When these words are raised in the media, we tend to remember better and the overall message is delivered better. These allow his speeches to become more convincing.

Furthermore, he uses statistics to support his claim and make him credible. “5 years ago, it used to be 17% but now it is 88%” and “In the past 4 years, the employment rate for Japanese elderly (65 years old over) and females both increased by 3%” [3] are examples of his use of statistics. While this does add credibility to his speech, the effectiveness is unclear. While the use of data adds credibility, the audience will have a difficult time understanding the information and the overall message may weaken. Furthermore, when he uses statistics, he often times lists them. Therefore, the audience would not be able to understand fully with the information overflowing. Therefore, this may not serve as the best strategy. While some statistics must be used to support the case, too much information would just weaken the argument.

Next, I would be analyzing the use of first-person pronouns in his speech. While there are many types of first-person pronouns in Japanese, Prime Minister Abe mainly uses one. His word choice reveals a lot about his intentions. In his speech, “I” is used 24 times while “we” is only used 5 times. This clearly shows that the pronoun “I” is used more. From this, we are able to analyze that Mr. Abe is self-centered and is not audience-inclusive. Furthermore, when he refers to the citizens, he uses the word “everyone” instead of “we” or “us”. This reveals the mindset of the prime minister. He believes that he is superior to the citizens, creating an invisible wall in-between the two. While this is not a criticism, this is a distinct difference between Obama and Mr. Abe.

CHANGE IN ECONOMY AND HIS SPEECH

The goal of increasing GDP is raised in the policy, “Robust economy that creates hope”. Therefore, in order to measure the successfulness of Abenomics, we must look at the change in GDP. As seen in figure I [4], it is evident that there has been an increase in the GDP per capita since 2012. This shows an improvement in the Japanese economy, showing an increase in each individual's production and an increase in consumption. When these things take place, it

Nov 23-24, Tokyo

Change in Japanese Economy and How Prime Minister Abe's Word Choice is Influenced by the Economy

shows that the Japanese economy is flourishing and the living standards are improving in Japan.



FIGURE I
GRAPH OF JAPAN'S GDP PER CAPITA FROM 2012 TO 2016

However, Abenomics did not mention anything about GDP per capita. Instead, it mentioned that they aim to increase the Nominal GDP to 600 trillion yen by 2020. However, as seen in figure II [5], this may be an unattainable goal, looking at the past achievements of Abenomics. The IMF, International Monetary Fund, predicted that Japan's nominal GDP will reach 600 trillion yen by the year 2023. While this is simply a prediction and this may not be the actual case, we can assume Japan will not reach 600 trillion yen by the year 2020. Therefore, we can conclude that this part of the policy was not successful.

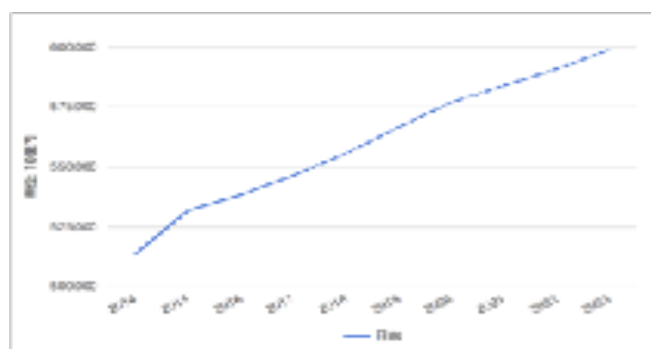


FIGURE II
JAPAN'S NOMINAL GDP FROM 2014 TO 2017 AND AN ESTIMATE UNTIL 2023

Yet, in his speech, Mr. Abe shows an optimistic view about "the improvements in the Japanese GDP. He claims that the Japanese nominal GDP has increased by 50 trillion yen, making it the highest in the past years" and "In the past 5 years, nominal GDP improved by over 11%" [6]. While this is completely true, he is disregarding the fact that his original policy may not be achievable. By providing numerous statistics in one speech, he is making the audience believe that the policy was successful. In a speech, it is hard for the audience to remember all the statistics. Therefore, he is providing a false view of the Japanese economy. However, Mr. Abe successfully gains trust from the audience and the citizens by using numbers and by asserting that he is successful.

Next, I will be analyzing the unemployment rate in Japan. As seen in figure III [7], the unemployment rate has steadily decreased from 2012. After the economic bubble

burst, the Japanese unemployment rate increased, worsening to 5.36% in the year 2002. However, with the Abenomics policies, the unemployment rate dropped to around 2%. Because of the existence of frictional and structural unemployment, the unemployment rate would never get to 0%. Therefore, the current situation with an unemployment rate of around 2% is the best Japan would achieve. As seen on the figure, it is clear that Abenomics has boosted the Japanese economy.

However, there is an issue regarding gender equality, one of the goals that Abenomics raised. In 2015, the average income of males were 5.21 million yens while females only earned 2.76 million yen. [8] This shows that while the Japanese economy provided workplace for females, gender inequality gap is not closing. According to "The best countries for women to work in", Japan ranked 28th out of the 29 countries in OCED. This was in 2017, 5 years after Abenomics was implemented. This shows how Abenomics failed to reduce gender gaps.



FIGURE III
JAPAN'S UNEMPLOYMENT RATE FROM 2010 TO 2018

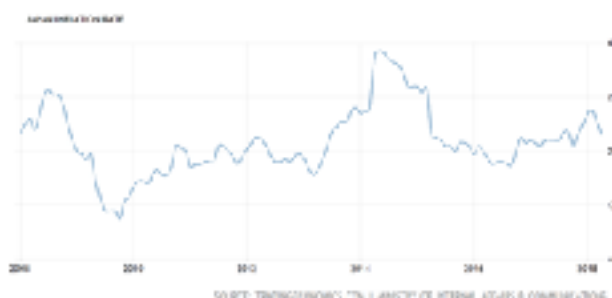
Because unemployment decreased significantly, it is obvious that Mr. Abe speaks confidently about that. However, he would not want to talk about the work environments for females due to his failures. Yet, in his speech, he mentioned that "the employment number increased by 1.85 million people and more than 80% of them are females. The unemployment rate is 2.8% and most of the people are employed." [9] He included the statistics from both unemployment and female work situation. By talking at the same time, he makes it seem as if both economic effects are successful. However, when we look into the details, it is evident that female work situations are not improving. When Mr. Abe focuses on the numbers employed, not the working situation, he is deceiving the audience in believing that the situation is improving.

Lastly, we must analyze the inflation rate. When the world experienced an economic recession in 2008, the world had a low rate of inflation. Some countries even experienced a severe deflation. Therefore an analysis of the inflation rate is necessary. As seen in figure IV [10], the inflation rate is not stable in the past years. The "dramatic monetary easing" aimed to have an inflation rate of 2%, however sometimes the inflation rate was close to 4% and also reached close to 0%. Then, is this a failure? No. There is a specific reason the Japanese government set the goal for inflation rate at 2%. Inflation rate is hard to control and it could fluctuate over time. When the inflation rate is high, it can be controlled with some government intervention. Therefore,

Nov 23-24, Tokyo

Change in Japanese Economy and How Prime Minister Abe's Word Choice is Influenced by the Economy

by setting the inflation rate goal at 2%, the government is reducing the probability of the Japanese economy going into deflation. Therefore, I personally believe the Japanese economy was successful in controlling the inflation rate. There were only two cases in which Japan experienced deflation and the economy went back right away. Therefore Abenomics was successful.



In fact, Mr. Abe's speech can be reliable at times. "I created a situation where deflation is reduced." He is confident when he claims this because his policies were successful. When Mr. Abe talks about inflation rate, he takes a longer time, compared to other economic policies. This is probably because he is confident about it and is comfortable talking for a long time.

CONCLUSION

Through the analysis of Prime Minister's speech, it was evident that he uses report talks, uses self-centered first-person pronouns and formally presents his speech. Furthermore, for the policies that were successful, he speaks confidently. On the other hand, for policies that were not as successful, he tries to deceive the audience. He does this by combining it with parts he is confident about or simply changing the story. When we compare his speech with Barack Obama, a prominent speaker, Prime Minister Abe's speech may not look as good. However, this may be simply due to a difference in the language, Japanese and English. Therefore, looking into the key differences in language as well as the different techniques that other prime ministers use may be interesting to look into in the future.

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Adidas And The Evolving United States Footwear Market

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Abstract – This research paper examines Adidas and its performance in the United States footwear market. From 2011 to 2016, Adidas was experiencing many losses in the United States. However, due to a cultural trend in the U.S. called “athleisure”, Adidas’s sales and market share, particularly for footwear, increased significantly in 2017. This paper examines what Adidas should do to further increase market share in the U.S. footwear market to achieve their goal to have 15-20% market share of the U.S. general sportswear market (includes footwear and sports apparel) by 2020. In order to determine what Adidas needs to do, a marketing mix (product, price, promotion, place) analysis was undertaken on Adidas and its biggest rival and the market leader of the United States footwear market, Nike. By comparing and contrasting Adidas’s marketing mix to Nike’s, a better understanding of the adjustments Adidas needed to make in the marketing mix was obtained. In order to achieve market share goal, Adidas needs to adjust the product, price, and promotion components of its footwear marketing mix.

Key Words – Adidas, Footwear, Market share, Marketing mix, U.S. market.

INTRODUCTION

Adidas, a multinational corporation founded and headquartered in Herzogenaurach, Germany is currently the largest footwear brand in Europe and the second largest in the world- in terms of total revenue- after Nike [1]. Adidas designs and manufactures various types of sports goods and sports apparel such as accessories, shoes, clothing, etc. Adidas operates in over 100 countries producing more than 900 million products every year which translate to sales of \$25.487 billion (2017) [2].

Despite Adidas’s success in Europe, Asia, and Africa, where they are the first or second largest sports manufacturer, the one market- also the biggest sportswear market- they have not performed so well in, is the USA. From 2011 to 2015, Adidas struggled to grow in the U.S. market where the company’s overall revenue fell back to back years in 2013 and 2014, while Nike and Under Armour grew by large gains [3]. For the first time ever, in 2015, Adidas slipped from the 2nd to the 3rd biggest sportswear brand in the U.S., at Under Armors benefit [3]. In addition

to falling to third in the overall sports market, the Adidas Group’s biggest product, footwear, has not been as competitive to the other brands like Nike, its main competitor.

However, as of 2017, The Adidas group has made a major comeback in the U.S. footwear market, where they accomplished two major features. First, their market share rose from 6.3% in May of 2016 to 11.3% in May of 2017, nearly doubling their market share in the U.S. footwear market, at the cost of its competitors [4]. Additionally, for the first time in the company’s history, the Adidas brand held the second most market share in the U.S. footwear market by taking Nike’s Jordan brands place in April 2017 [5]. As of August 2017, the Jordan brand focusing on basketball shoe sales fell one-third compared to the year before, while the Adidas group experienced basketball shoe sales increasing by 40% [4].

These breakthroughs are credited mostly to Adidas’s ability to be ahead of the trends of modern society. One of the reasons why Adidas has made a comeback is because the sporty but modern casual streetwear trend known as “athleisure” started gaining mass popularity in the U.S. [5]. Adidas has always specialized in “athleisure” and casual footwear, where other competitors like Nike and Under Armour have not been as successful [5]. In addition, the collaborations Adidas has done with other influential people like Kanye West, Pharrell and Stan Smith to create and design innovative and high tech sneakers like the Yeezy, NMDs, and Stan Smiths have contributed to their success in this market [6]. Furthermore, making the U.S. its “priority” and being the creative, innovative and open-minded brand allowed them to attract many consumers in the U.S., even those once loyal to Nike [7].

Despite Adidas’s recent success in the U.S. footwear market, they are still far from being at the top. In terms of the U.S. footwear market share, The NPD Group (a market research company) puts Nike- which includes the Jordan brand and Converse- at 44%, while Adidas remains at around 11.5% of the U.S. footwear market share [7]. However, Adidas’s momentum is the highest among any brands, with sales numbers, stock prices, and popularity increasing- hurting Nike and Under Armour [6].

Recently, Adidas announced their goal to increase market share to 15-20% in the U.S. general sportswear market by 2020 [8]. Currently, Adidas has close to 10% market share in the U.S., general sportswear market [9]. In

Adidas And The Evolving United States Footwear Market

order for Adidas to further increase market share, Adidas must find effective ways to keep attracting new consumers, stay ahead of the trends, communicate with consumers, and to improve the brand image to attract and keep loyal customers. In this paper, the footwear market will be explored, as shoes have been a major success for Adidas in the past couple of years. The marketing mix of Adidas's footwear will be compared to the marketing mix of main competitor, Nike. This is in order to assess what Adidas should do to further increase market share in the U.S. footwear market as a contributing factor to achieve their goal to have 15-20% market share of the U.S. general sportswear market by 2020.

ANALYSIS (MARKETING MIX ANALYSIS)

Product

For Adidas and Nike, the product is their various types of footwear. In order to compare the product mix, numbers of shoes from their U.S. website have been taken and put into a table below.

TABLE I
THE PRODUCT LINE OF SHOES FOR ADIDAS AND NIKE (NUMBER OF SHOES)
AS OF 5/11/2018 [10][11]

Type of shoe	Adidas	Nike
Running	712	695
Women	382	143
3 major sports(baseball, basketball, football)	461	434
Soccer	140	109
Total	1760	1396
Shoes in the top 10 of 2017 (Top selling)	2	8

In terms of sales for the categories of lifestyle, soccer, and running, Adidas does well. Nike does well for the 3 major U.S. sports (baseball, basketball, and football) [3].

Surprisingly, Adidas has over 300 more shoes available for retail than Nike. Furthermore, in terms of running shoes, Adidas offers well more than half of what Nike does. In other categories, the number of shoes is fairly similar.

However, underneath the numbers of shoes in each category, further analysis and data can communicate more about these categories for the two companies. Lifestyle shoes- which refers to shoes that are worn for everyday use- for example, are very similar in terms of numbers of shoes available for purchase for both companies. However, this does not necessarily correlate to the popularity of the shoes. According to the NPD Group, in 2017, the top 5 "casual athletic" footwear brands did not even include Nike, whereas Adidas was the market leader [5]. As noted in the introduction, the "athleisure and casual athletic" style have become the biggest category in the USA where sales for casual athletic sneakers beat "pure performance" oriented sneakers [12]. In terms of numbers, casual athletic sneakers sales rose 24% in 2017 while "performance" oriented shoes and training shoe sales dropped 7% and 15% respectively [12]. This footwear category generates the most sales and is

a major strength for Adidas. Adidas's "Originals" brand (which includes the "Superstars"), specializing in casual athletic shoes, rose 22% in sales [12]. Furthermore, 2 of the shoes featured on the top 10 selling shoes in 2017, were from the Adidas Originals brand (Superstars and Adidas Tubular Shadow) [13].



[14]

FIGURE 1
THE ADIDAS SUPERSTARS

Thus, this casual athletic footwear trend is both a major strength and opportunity for Adidas. According to Forbes, this trend is still predicted to be prevalent in the near future [14]. Casual athletic footwear is where Adidas needs to capitalize on in order to further differentiate themselves from Nike who is not even in the top 5 casual athletic footwear brands [5].

Despite Nike's absence from this list, they occupied 8 of the top 10 selling shoes in 2017 in the USA [13]. In order for Adidas to continue to increase market share in the U.S. footwear market, Adidas must aim to land more shoes onto this list for 2018 and beyond. This is not just through their Originals brand but through a rapidly increasing women's market and running shoes as well [15].

Despite Adidas's recent success, soccer shoes have not been as successful in the U.S. compared to international markets. Soccer is not as popular in the U.S. as basketball, football, and baseball [3]. Furthermore, Adidas's sponsorship contract with the NBA did not work out for them as it did not result in increased footwear sales [8]. Thus, they chose not to pursue the renewal when the contract expired in 2016 [8]. Moreover, a major strength for Nike and a weakness for Adidas is Nike's enormous 93% (2015) market share of the U.S. basketball shoe market [16]. In contrast, Adidas only had 2.5% market share [16]. These numbers may have changed slightly now, however, the difference would still be very minimal and remains a major weakness to Adidas. Basketball is one of the top 3 sports in the U.S. and so it makes the most money from footwear sales and merchandising [3]. Furthermore, since basketball shoes are a major source of footwear sales [3], Adidas must make basketball a sport that people can comfortably and willingly think about when they see the Adidas logo. Adidas has announced they will try to increase footwear sales by increasing athlete endorsement deals [8]. This is a good decision, as these athletes have significant influence on customers and will encourage customers to buy the shoes that they wear. If not pursued, this will continue to be a major weakness to Adidas and will limit Adidas's ability to increase market share in the U.S. footwear market.

Nov 23-24, Tokyo

Adidas And The Evolving United States Footwear Market

Upon further research on Nike's website, they have a "top seller shoes" section. The top 4 top selling shoes were part of the Air Jordan's, Nike Air, Nike Free, and Chuck Taylor Converse All-Stars franchise brands [11]. For Adidas, the brands were the NMD, Ultra Boosts, and the Originals: Stan Smith and Superstars [10]. These shoes will be the focus for the rest of the marketing mix as they have generated the most sales- according to Nike and Adidas's websites. However, where appropriate, other shoes will be discussed.

Price

This section of the marketing mix refers to the pricing of shoes.

TABLE 2
THE PRICES (AS OF 6/11/18) OF THE TOP 4 TOP SELLING SHOES FOR NIKE
AND ADIDAS

Adidas Shoes:	Price (\$) ~
Superstar (Originals)	80
NMD (Originals)	130
Ultra Boosts (Running)	180
Stan Smith (Originals)	75
The average price of the top 4	117

Nike Shoes:	Price (\$) ~
Air Jordan's (Originals)	140
Nike Air (Running)	130
Nike free(Running)	110
Converse All Stars (Lifestyle)	55
The average price of the top 4	109

The table above shows the price of the top selling shoes for each company. Noticeably, the running shoes for Adidas are more expensive than Nike's running shoes. Interestingly, there is only one shoe on Nike's best sellers list that is less than \$60. This is because sneaker brands like Nike and Adidas over the last 40 years have been increasing the prices of sneakers [17].

Adidas, for almost all its products- apparel and shoes- use the price skimming pricing strategy [18]. This is a pricing strategy that involves setting a high price when initially launching a new product. These initial prices have gotten gradually higher and higher over the years [17]. This is done for two reasons. Firstly, to maximize short-term profit-margins before rivals enter the market with similar products. Another is because it relates to Adidas's brand equity [18]. Since all of Adidas's products use price skimming, this creates a brand image that communicates the impression that higher prices correlate to the high quality of the shoe [18][19]. This is also a reason why Adidas rarely uses penetrative pricing because this affects the brand equity and can give off a perception that lower prices mean inferior quality [19]. In addition, through the price skimming method, Adidas is able to target the middle and upper-class customers who will be willing to buy at a premium price. Then, when the shoe or sneaker loses momentum or exits the introductory stage of high sales, the price will eventually

be lowered so Adidas can attract customs with less disposable incomes.

This pricing strategy can be seen with the "Yeezy" shoe franchise brand which is an Adidas Originals and Kanye West collaboration [20]. The Yeezy Boost 750 is listed at a retail price of \$350. Since Yeezy shoes are sold in very limited numbers, Yeezy's are rare and have become very valuable to customers [21].



FIGURE 2
YEEZY BOOST 350

[22]

This has driven the demand for these products very high. So a price skimming strategy is an especially effective pricing strategy for Adidas because Yeezy shoes are released with limits, creating the impression of scarcity and leading a cycle of low supply and high demand [23]. This has been a major strength for Yeezy and Adidas, as this allows them to receive high profit margins and also strengthen their brand equity. Furthermore, since these shoes are very popular and earning lots of profit, lowering the prices is not necessary for the Yeezy-Original collaboration.

On the other hand, Nike uses a value-based pricing strategy. This is a strategy of setting a price by calculating and predicting the perceived worth of a product for a particular customer segment [24][25]. This is done by measuring what the target customer segment would be willing to pay for a certain shoe, and the projected maximum that companies can charge, so they can ensure the highest profits [25].

The Air Jordan shoes, for example, are all at least \$110 to \$200 [26]. Hence, it is reasonable to assume that the Air Jordan shoes are targeted towards a niche, premium and higher income customer segment. In addition, Nike also has shoes that are targeted towards customers with lower incomes and people who prefer simple inexpressive shoes. This can be seen with the Nike Tanjun (figure 3) and the Converse All Stars Chuck Taylor that only cost 65\$ and 55\$, respectively [27][13]. Although these two are a couple of Nike's cheapest shoes, they were number 1 and 2 on the top selling shoes in 2017 [13]. This is most likely because of the shoes' simple style for both women and men and most importantly, the inexpensive price tag appeal to a much larger market segment. This includes moms, people who do not collect shoes as a hobby, and lower-income families [13].

Nov 23-24, Tokyo

Adidas And The Evolving United States Footwear Market



FIGURE 3
THE NIKE TANJUN [28]

So as shown through these examples, this pricing strategy works very well for Nike because they have a very diverse mix of shoes targeted to different market segments. For Adidas, this is a weakness as they do not have a product line of shoes as *successful* as Nike’s in terms of sales that also can appeal to different customer segments. Adidas currently has successful shoes that appeal to the higher income families but do not have a significantly *successful* shoe that appeals to the lower income families. If Adidas can develop a shoe that is around \$50 to \$60 that appeals to the mass market and garners the popularity and sales in the same way that the Nike’s Tanjun and Converse all-star shoes does, it will be a major strength and a chance to increase sales and market share.

Promotion

This is a very important aspect of the marketing mix because promotion is how the entire marketing mix is communicated to customers. Both companies are very active in promoting their shoes through mass media like commercials, billboard campaigns, social media and athlete endorsements [18][24]. In this section, an effective and unique above-the-line promotion method for each company will be examined.

As society is moving into a more technologically driven future, the internet, specifically social media marketing, has become very important for many companies to reach out and communicate their marketing mix. For Adidas, this has been a major strength, as they have a very strong presence on social media. In 2015, Adidas’ Originals shoe were by far the most liked picture on Instagram with 78.23 million likes [29]. Nike’s “Air Jordan” brand had 23.8 million likes [29]. Furthermore, Adidas has been recognized as the “most visible brand” on all social media platforms from the study, “2018 Brand Visibility Report” [30]. This study analyzed over 250 million pictures posted on Instagram and Twitter. The study found that Adidas, by far, was the leader of brands with 6.6 million pictures featuring its logo posted onto Twitter and Instagram every month (shown in figure 4) [30]. Nike was second on that list with 5.5 million average pictures including its logo posted monthly. Both companies are using this platform as an effective promotional tool, while Adidas had a competitive edge [30].

Rank	Brand	Average unique images per month
1	adidas	6,664,170
2	Nike	5,134,017
3	Google	3,888,432
4	Emirates	2,841,215
5	Puma	2,719,715
6	Coca-Cola	2,534,527
7	Starbucks	2,294,695
8	McDonald's	2,015,792
9	Disney	2,000,062
10	Apple	1,964,235

FIGURE 4
THE TOP 10 MOST VISIBLE BRANDS ON SOCIAL MEDIA IN 2018 [31]

The Adidas Originals Twitter page (4 million followers) interestingly has more followers than the Adidas Twitter page itself (3.4 million followers) [31]. In addition, the Adidas Originals Instagram account (27.5 million followers) has significantly more followers than the Adidas Instagram account (21.2 million followers) (as of 8/14/18) [32][33]. This trend is no different on Facebook either [32]. This shows that the Originals brand is not just a sports brand but is a lifestyle fashion brand which is a way to appeal to a larger customer base. Part of the success of Adidas’s Originals- which is also a reason for Adidas’s recent success- are behind their powerful existence on social media through their fresh, modern, and personable marketing approach [29].

Firstly, the Original’s social media marketing team hypes up the fans by posting teasers, run-ups to shoe releases and is always active with communicating with customers to excite them [34]. Adidas Originals collaborates with high profile personalities like Kanye West, Pharrell Williams, and Stan Smith [29]. Secondly, through these collaborations, one way Adidas attracts interest from its customers is by putting a large focus on the involvement in the actual designing process of the shoes on their social media [34]. By involving the collaborators throughout the entire process, the collaborations feel much more authentic and personal than purely sales driven [34]. This is a unique selling point of Adidas’s social media promotion.

Social media promotion for Adidas and its Originals has been one of the strongest and distinctive points when compared to Nike. With U.S. social media users estimated to increase to 220.6 million people in 2022 up from 208.6 million in 2017, social media promotion will be an opportunity for Adidas to succeed as they will be able to connect their unique marketing to an ever-growing audience [35].

Nike’s competitive edge is the sponsors and athlete endorsements they have signed, especially in the big three sports in the USA: Basketball, Football and Baseball [3]. Nike advertises and has promotional campaigns with their superstar players like LeBron James, Kevin Durant and Peyton Manning wearing their own signature Nike shoes [36]. Nike has a clear competitive advantage over Adidas in athlete endorsements. This is evident when looking at how many U.S. players Nike has signed of the top 100 highest paid athlete endorsers in the world (2016) [36]. Amongst

Adidas And The Evolving United States Footwear Market

that ranking, Adidas had only signed 3 players from the top 3 sports in the USA [36]. On the other hand, Nike signed 35 athletes from just the top 3 sports in the USA [36].

Through these endorsement deals with superstar athletes, Nike is able to boost credibility for their brand and their shoes because everyone's favorite superstar is wearing them. Furthermore, by associating themselves with top athletes that appeal to many fans in America, especially from the big three sports, Nike is able to bolster their brand image when these players are performing well. This was a partial reason for Adidas's weakness in this field because the few stars that have signed with Adidas, including the NBA's Derrick Rose and Dwight Howard, have not performed as well recently [3]. This promotional method is going to be important for Adidas as brand image and credibility will increase for the reasons listed above; as well as increase exposure in the three big sports which will lead to more shoe sales and eventually market share.

As shown in the discussion above, it is clear that Nike's promotional method through endorsements with athletes is beneficial to them, despite a large amount of money they have spent on it. On the other hand, even though Adidas has done well in promoting their shoes, especially through their Originals and collaborations with influencers, their weaknesses fall in athlete endorsements when compared to Nike. In order for Adidas to increase market share for shoes in the U.S. and be remembered as a sports brand and not just a casual athletic brand, they must pursue more athlete endorsements. Otherwise, if not pursued, this will become a threat where a lot of potential sales will be limited from the company.

Place (Distribution)

This part of the marketing mix refers to the distribution of the products and services to consumers. Both Nike and Adidas are similar in this field where the major way they sell shoes is through E-commerce (their websites or other third party websites), wholesalers, and through retail outlets [37][18][24]. These retail outlets include the company's store but also other retailers like Walmart, Dicks, Footlocker, and others [24].

For Nike's distribution of shoes, wholesalers were the largest form of revenue, where 79.2% of sales were made from wholesalers and only 20.3% was made from Direct to Customer (DTC) sales in 2015 [37]. On the other hand, 25.4% of Adidas's revenue sales come from DTC [37][38]. DTC is a form of distribution that includes selling directly to the customer through in-line factory outlet stores and E-commerce (i.e. Nike.com and Adidas.com) [37]. Distributing through wholesalers is a form of two-channel distribution as it goes from the producer to the wholesaler then to the retailer and finally to the consumer.

This is a weakness to Nike, especially when compared to Adidas, as Nike is still relying more on a distribution method that includes two intermediary channels. As a result, this is a limiting factor in gaining

more revenue for Nike. However, it is a strength and a differentiating point for Adidas. Furthermore, by Adidas using a higher percentage of DTC distribution than Nike, it allows more direct involvement with the customers and helps to understand customers' needs and wants [38]. Additionally, using a DTC method has lower costs because there are less intermediaries involved. Furthermore, data has shown that higher profit margins can be made from DTC than from sales to wholesalers [37].

Despite the improvements Nike made to use more of the DTC distribution method for increasing revenue sales, Adidas is still at a competitive edge and also has the first mover advantage. Moreover, Adidas is focusing more on zero channel distribution by closing down many of their physical stores in the U.S. from this year [39]. This is because they want to focus more on (DTC) E-commerce sales through their website, as online sales are growing every year, while in-store sales are falling for them [39].

For Nike, this trend is also the case and have partnered with Amazon in 2017 to sell their shoes directly through E-commerce giant, Amazon USA [40]. This will allow them to also capitalize on a weakness of not being involved in DTC distribution. Furthermore, with an increasing number of people in the U.S. signing up for Amazon memberships, this will be an opportunity for Nike to market their shoes to a mass number of people [41]. As a result, Nike's new deal may pose a threat to Adidas, so Adidas must make sure to stay on top of the trend and maintain the competitive advantage over Nike in the E-commerce and DTC industry. Adidas focusing their distribution through E-commerce and closing down stores will not only cut costs but it also meets present and future consumer purchasing behavior, which will be important to keep increasing market share in the U.S. footwear market.

CONCLUSION

Through this marketing mix analysis, it is clear, in order for Adidas to continue to increase market share in the U.S. footwear market, they will need to adjust the product, price and promotion sections of the marketing mix.

First, in the product section of the marketing mix, Adidas needs to invest more resources in creating a brand image that is strong in sports and not just in "athleisure". However, capitalizing on the athleisure and casual athletic trends through collaborations and innovative designs for their casual lifestyle shoes will be important in increasing market share. Secondly, Adidas needs to create a more varied product mix of shoes that can appeal to multiple audiences which includes different income groups and the growing women's market. Thirdly, Adidas needs to focus on strengthening their presence in the three main sports, especially basketball, to develop a more sports-oriented shoe brand. This should be done by increasing athlete endorsements from the top three sports, where this promotional method will also help form a more sports-oriented brand image for Adidas in the USA. Lastly, since

Nov 23-24, Tokyo

Adidas And The Evolving United States Footwear Market

Adidas has the competitive advantage for the distribution of shoes, no adjustment for “place” are necessary.

Even though Adidas is still very far from being the market leader in the footwear market, if they continue to increase market share in the U.S. footwear market, they will be able to meet their goal of gaining 15-20% of general sportswear market share in the USA. This success and popularity in shoes will also open opportunities in their other categories of general sportswear in a U.S market where Adidas has struggled in the past.

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TPP11 and the Economic Revitalization of Rural Japan: The Effect of Culture and Consumer Preferences on Demand for Domestic Food Products

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Abstract: This paper explores the extent to which Japan's involvement in the TPP11 impacts the economic revitalization of rural Japanese communities through the treaty's influences on the domestic agricultural sector. In analyzing the various factors that influence the TPP11's effect on Japan's rural communities, the findings from this paper show that an increase in imports from other TPP member states is not expected to phase out domestic production completely, nor will it hasten the dwindling of already-shrinking towns across the nation. Rather, most domestic producers will be able to compete with a new wave of imports due to the unique consumer preferences and food culture of the nation.

The TPP11 and Current State of Japanese Agriculture

This paper explores to what extent Japan's involvement in the TPP11 impacts the economic revitalization of its rural communities through the treaty's influences on the domestic agricultural sector. The Trans-Pacific Partnership (TPP11) is a multilateral trade agreement drafted in 2015 intended to create a more dynamic, integrated and competitive commercial and investment environment for Pacific Rim member states following the withdrawal of the United States from the agreement. The treaty now includes the 11 nations of Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore and Vietnam, with the goal of significantly reducing trade barriers among members, harmonizing regulations, and setting minimum standards for labor rights and the environment. Ratification will boost the GDPs of member states - currently accounting for 13% of the global economy (\$10 trillion). It is expected to go into full effect sometime in 2019, as 6 of 11 members' governing bodies are required to ratify it before full implementation. While this treaty is yet to be fully ratified¹, existing literature provides a basis for assessing the potential economic impacts of a TPP-era in rural Japan.

According to the U.S. Census Bureau, the term 'rural' and the communities it encompasses are understood to be all regions within a country that exclude highly

developed, residential, commercial and industrial areas.

Rural regions typically carry common characteristics such as low population density and birth rate, a lack of development in infrastructure and state services, and general isolation from many of the legislative and financial workings of a nation.²

Though more difficult to delineate, 'economic revitalization' is defined as the economic and societal growth of a given community following a period of decline, characterized by increased employment, birthrates, real income, and development in institutions and infrastructure. Due to the unpopularity of agriculture as a viable employment opportunity, Japan has seen its rural communities shrink in size since the war ended, with an increasing number of towns and villages left with little hope of maintaining their existence - and in some case risk the threat of being abandoned entirely. In the backdrop of an aging society, an estimated 896 rural communities are expected to die out completely by 2040³, as the population decreases by 20 million from the current 127 million inhabitants. As the agricultural sector is in a drastic search for younger workers, 15,000 of Japan's 65,000 rural communities have more than half of their population over the age of 65, jeopardizing prospects for economic growth in the region.⁴ With the lack of career opportunities at home, it is common for young high school graduates to attend university in larger cities and towns, migrating from their hometowns in droves in search of a more comfortable life in urban centers. As a result, Japan's agricultural output is in a steep decline, with agricultural output decreasing from 11.5 trillion JPY in 1990 to 8.5 trillion in 2012.⁵

This paper examines how Japan's involvement in the TPP11 will affect the economic revitalization of its rural communities, looking into how this bold step towards a seamless, global trading community will impact the nation's most vulnerable regions.

Despite being touted as a "21st century, gold standard" agreement⁶ for its contributions to significant trade liberalization, analysts have voiced concerns over the potential implications of the TPP11 on the agricultural sector of certain member states. They argue that with the significant reductions in tariffs and quotas for imports, the treaty puts domestic producers - many of whom are reliant on economic advantages enforced by the government - at risk of diminished revenues and unemployment, stressing that such sweeping steps towards trade liberalization may expedite the destruction of rural communities. These concerns have

¹ Even following signage by 6 member states, some tariff lines will not be fully eliminated until 16 years after ratification

² Branch, Geographic Products. "Urban and Rural." *U.S. Trade with Haiti*, 1 Sept. 2012, www.census.gov/geo/reference/urban-rural.html.

³ Masuda, Hiroya. *Chihō shōmetsu: tōkyō Ikkyoku shūchū Ga Maneku jinkō kyūgen*. Chūōkōronshinsha, 2014.

⁴ Mantale, Peter. "Towards an Asia-Pacific 'Depopulation Dividend' in the 21st Century: Regional Growth and Shrinkage in Japan and New Zealand" *The Asia-Pacific Journal*, vol. 15, iss. 6, num. 5, 15 Mar. 2017,

⁵ Ramsey, Ford, and Tadashi, Sonoda. "Productivity and Exits from Farming in Japan," 2015 AAEA & WAEA Joint Annual Meeting, 26-28 Jul. 2015

⁶ "Market Access for Goods in the TPP11," Asian Trade Centre in conjunction with APL Logistics, May 2017

resonated widely within the Japan, the largest economy and leading proponent of the treaty.

In analyzing the various factors that influence the TPP11's effect on Japan's rural communities, the findings from this paper shows how an increase in imports from other TPP member states is not expected to phase out domestic production completely nor will it hasten the dwindling of shrinking towns across the nation. This paper argues that rather, most domestic producers will be able to compete with a new wave of imports due to the unique consumer preferences and food culture of the nation. Regardless of cheaper foreign alternatives, the public's affinity for high levels of quality and safety in agricultural goods unique to Japan will continue to reduce price sensitivity amongst domestic consumers, as they continue to purchase domestic agricultural goods despite it not being the most economical choice: a significant marker of Japanese food culture. Therefore, most domestic products such as rice, beef, and pork, are not directly substitutable with foreign versions of the same good. This protective food culture, in addition to the relatively high cost of entering the Japanese consumer market, dampens the possibility of a feared "foreign invasion" of goods that will overtake domestic producers. Conversely, goods lacking unique product differentiation and consumer loyalty are deemed interchangeable with foreign alternatives, namely dairy, wheat, barley, and tropical fruits. For these goods, the implementation of the TPP11 will mean increased downward pressure on their uncompetitive - albeit already small - domestic producers. Additionally, this paper discusses governmental policies as a part of the Japanese government's efforts to revitalize rural communities. These policies are intended to serve both as a cushion for uncompetitive producers who are likely to be affected by the presence of foreign competition, as well as a reliable source of support for new agribusinesses looking to capitalize off of growing demand for Japanese agricultural goods amongst member states.

Literature Review

The implications of Japan's involvement in the TPP11 are widely debated amongst researchers and legislators at all levels of society. Its potential impact on the country - most notably its shrinking rural communities - have often been scrutinized and assessed from different angles, leaving little consensus on whether the TPP11 will be a step

in the right direction, and which government policies, if any, should be implemented alongside it to work towards the economic revitalization of rural communities.

Proponents of the TPP11 argue that ratification would provide the necessary reforms towards the deregulation of various Japanese industries, from the agricultural sector to manufacturing and service-based industries that support rural communities. Solís⁷ and Honma⁸ argue that the increased competitiveness of cheaper imports will push out inefficient small-scale farmers while allowing for consolidated large-acreage farmers and export-oriented agribusinesses to expand their scale of production through newly acquired lands. Similarly, in the midst of decreasing domestic consumption due to a shrinking population, more accessible entry into overseas markets would allow for Japanese agricultural goods - known for their high quality - to be exported in much higher quantities, aiding the growth of Japanese producers in the long run.⁹ To convert domestic agriculture into a growing industry, the Abe administration has aimed to implement intensive structural reform as part of its "Three Arrows Strategy." Seeking to match structural reform with the tariff reduction component of the TPP11, this initiative aims to reform contemporary agricultural policies such as production restriction programmes and direct payment initiatives. This would, as Yamashita argues, reduce domestic producers' reliance on hefty tariffs on crucial "protected" consumer goods such as rice, barley, sugar, dairy and beef.¹⁰ I agree with the conclusions reached by Yamashita, in that combining structural reform with the trade liberalization offered by the TPP11, the government will be able to loosen its grip in controlling the fate of the agricultural sector and the communities it supports. Though the role of the state as a player within the market cannot be understated in importance for its work in providing a social welfare net for struggling domestic producers, it must divest from the hand-holding policies that prevent significant productive growth amongst new agribusinesses and innovative producers. As such, this paper expands upon Yamashita's argument of combining structural reform with the treaty, as it explores which governmental policies and regulations must be eliminated or maintained in order to produce the agricultural development and investment needed for job growth within rural communities.

The high level of market access coupled with the broad elimination of protective measures distinguishes the TPP11 as an opportunity for the liberalization of commerce

⁷ Solís, Mireya, and Shujiro Urata. "Abenomics and Japan's Trade Policy in a New Era." *Asian Economic Policy Review*, vol. 13, no. 1, 4 Jan. 2018, pp. 106–123., doi:10.1111/aepr.12205.

⁸ Honma, Masayoshi, and Aurelia George Mulgan. "Political Economy of Agricultural Reform in Japan under Abes Administration." *Asian Economic Policy Review*, vol. 13, no. 1, 4 Jan. 2018, pp. 128–144., doi:10.1111/aepr.12208.

⁹ Policy Brief written by Terada, Takashi. "Japan and the Trans-Pacific Partnership." *Sasakawa Peace Foundation*, Feb. 2012

¹⁰ Yamashita, Kazuhito. "Agricultural Trade Policy Reform in Japan: Options for Achieving Change." *Agricultural Subsidies in the WTO Green Box: Ensuring Coherence with Sustainable Development Goals*, edited by Ricardo Meléndez-Ortiz et al., Cambridge University Press, Cambridge, 2009, pp. 618–632.

within all sectors of the economy. Current figures estimate a yearly GDP growth post-TPP11 ratification range from 2.6% from the Japanese Cabinet Office to a more conservative 1.5% from independent researchers.¹¹ Such growth of rural agribusinesses as well as manufacturing is expected to include the disaster-stricken regions of Tohoku and Kumamoto, where manufacturing and agricultural output alike have dropped off due to damage from earthquakes coupled with the unprofitable nature of current production.¹² Though I agree that the TPP11 contains an aspect of trade and investment liberalization that can spur economic growth within rural communities, there lies a necessity by the state - especially in disaster-stricken regions - to provide an apt support system that would not be economically favorable to implement. This paper investigates the role of the state, including providing job training and infrastructure support for isolated regions. This allows such communities to connect to the global supply chain and to help local producers be in a position to take advantage of freer trade instead of being left behind by the dramatic growth of their neighbors abroad.

Conversely, many within the agricultural sector and political opposition object to the notion of eliminating its protective measures in trade, citing various risks from the heavy influences of foreign corporations to the crushing competition placed upon Japanese producers. Within the politically sensitive topic of agricultural trade policy, members within the Japanese legislature are split over the issue of TPP11 ratification. Current literature affirms that for many, the implementation of the treaty remains extremely unpopular, as legislators from rural areas and those supported by the JA have fervently opposed joining the TPP11, fearing the negative economic implications that may hasten the deterioration of rural communities.¹³ This potential to displace thousands of domestic producers has seen the Japanese public continue to express concerns over the treaty being an excessive infringement of their nation's rights as an individual state. Rallied by the politically powerful JA Zenchu, the opposition movement has gathered nearly 11 million petitions - nearly 10% of the entire population - against the agreement since 2011.¹⁴ Critics have also raised the possibility that without proper welfare support for uncompetitive producers, ratification may result in the inevitable downward pressure on incomes and production of domestic farmers.¹⁵ In addressing these fears of the TPP11's effect on small-scale, domestic producers, it is important to note the true extent to which producers are likely to be impacted by the elimination of tariffs and other trade barriers. In large, this paper questions the above research by exploring if there are other factors such as consumer preferences and food culture of Japanese buyers that might "protect" most domestic products. It is notable that such factors have, thus far, been left unconsidered or unexplored by the existing literature. Conscious of the unparalleled quality and safety, many consumers believe that domestic food products are not interchangeable with foreign alternatives, despite slight differences in price. The unique product differentiation of Japanese goods will maintain the market dominance of rice, beef, pork, and most produce growers, large sectors of Japanese agriculture that will preserve employment and similar revenues even in a TPP era.

Recent reports by Brady¹⁶ and Nishikawa¹⁷ identify that shifts in structural policy can work in tandem with the liberalization of the TPP11 to gear rural economies towards taking advantage of export markets, where demand for high-quality Japanese produce is high -- despite a higher price point. Mindful of both the promises and setbacks of such tremendous trade liberalization offered by the TPP11, many advocate for a reasonable mixed approach to the structural reform of Japanese agriculture. This would include a way in which that producers - most of them living in rural communities - can gain greater access to foreign markets while maintaining their economic and cultural sovereignty. One of many reform proposals put forth to accompany the TPP11 is the rollback of the "gentan" acreage reduction policy. Implemented in the 1970s to protect small farms by prohibiting large enterprises from renting land, the plan has allowed for Japanese agriculture to grow excessively inefficient, limiting the productive growth of competitive farmers to protect part-time farmers and their produce.¹⁸ The previous policy has aimed to reduce such measures, and in 2009 more than 1,000 agricultural businesses (agro-business)

¹¹ Davis, Christina. "Japan: Interest Group Politics, Foreign Policy Linkages, and the TPP." *Contested Megaregulation: Global Economic Ordering After TPP*, edited by Benedict Kingsbury, David Malone, Richard B. Stewart, and Atsushi Sunami, 7 Jul. 2017,

¹² Taken from Kim, Jemma. "The Political Economy of Japanese Trade Policy : The Trans-Pacific Partnership Reconsidered." an unpublished report. Paper prepared for delivery at the Annual Meeting of the International Studies Association, June 15-18, 2017, Hong Kong.

¹³ See footnote 8

¹⁴ See footnote 10

¹⁵ Honma, Masayoshi. "The TPP and Agricultural Reform in Japan." *The Political Economy of Japanese Trade Policy*, 2015, pp. 94–112. *SpringerLink*, doi: 10.1057/9781137414564.0009.

¹⁶ Research Report by Brady, James. "Japanese agriculture: towards a sustainable, trade-oriented future" *Asia Pacific Institute of Research*, 16 Sept. 2015,

¹⁷ Nishikawa, Kunio. "Free Trade and the Future of Japan's Agricultural Policy" *Asia Pacific Bulletin*, Number 342, 5 May. 2016,

¹⁸ Event Document of Webcast by Horlick, Gary, and Rogowsky, Robert A. "TPP and the Political Economy of U.S.-Japan Trade Negotiations" *Wilson Center Asia Program*, 22 Oct. 2014

began leasing additional land and increasing output. Likewise, advocates of reform are calling for production control measures to be replaced with direct subsidies to competitive farms, helping to develop productive farms while eliminating the price burden places upon low-income consumers.¹⁹ By favoring agribusinesses, proponents of a mixed approach are anticipating a long-term boost of jobs and economic growth in communities that have been long stagnant.

Much of the existing literature is heavily oriented towards quantitative economic indicators such as trade balances and output efficiency. While indeed important in calculating growth, the inclusion of various factors such as the demographic makeup of existing agribusinesses as well as Japanese labor trends and culture are equally important in assessing an approach combining both international treatise and government policy. For an agricultural sector heavily dominated by elderly workers in a country with a substantial aging population, it is significant to consider how labor demographics and social welfare programs will play a role in determining the success of rural communities. Additionally, it is much more difficult to analyze the effects that the sweeping changes brought forth by the treaty will have on domestic agriculture without taking into serious consideration the influences of Japanese consumer preferences. These tastes, which often become the final arbiter of a producer's success, are largely fueled by the unique Japanese food culture, which prioritizes significant product differentiation and the highest standards of quality and safety. In a time where consumer's diets are changing to encompass a wider variety of foods from abroad, it is necessary to examine how the price sensitivity of domestic goods will be affected by the inclinations of the Japanese public. As such, this paper gives consumer preferences and food culture an integral role in determining the success of the treaty in bringing about economic growth to rural producers. Through this emphasis, alongside an examination of current agriculture and land policy, I examine how if at all possible, the increased competitiveness of the TPP11 can serve as an impetus for growth and development.

Methodology

This research paper examines the potential effects of the TPP11 on Japanese rural economies following the complete implementation of the TPP11's clauses.²⁰

This paper follows methods used by other works of research in agricultural trade policy²¹, interpreting previously gathered data compiled in government and non-governmental databases. This allows for the examination of information more holistically, diving into the various components of more

subjective information while maintaining an ability to connect it to observable outcomes.

Much of the existing literature—from ministerial reports to figures from independent research bodies—called for me to translate from Japanese to English, requiring me to possess a deeper understanding of field-specific jargon and the cultural nuances surrounding the TPP11 from a Japanese perspective.

Theoretical Framework

In examining the effect of the TPP11 on revitalizing Japan's rural sector, I focus namely on the agricultural sector's and industry's ability to compete in domestic and foreign markets.

To do so, several theories on international trade were used, including the Heckscher-Ohlin theory and the Linder hypothesis. The Heckscher-Ohlin theory served as a way to understand price movements in Japanese agricultural goods, and provided evidence as to why much of rural Japan's agriculture is relatively uncompetitive in both foreign and domestic markets.²² The theory operates under two fundamental notions: 1) different regions and countries have varying factor endowments such as surplus capital or labor and 2) different goods require different factor-proportions for their production. In the case of Japan, the rural sector is regarded to have a severe shortage of labor and land but a relative abundance of capital. These differing factor endowments have a direct relation to the price of certain goods, and in case of Japan, traditionally capital-intensive goods such as microchips and automobiles have been favorably produced while labor and land-intensive goods such as timber and - in the case of agricultural goods - wheat, dairy, barley, have proven to be less competitive abroad. The differing levels of factor-proportion also affect the price of a good, so that the producer who can most efficiently meet the favorable combination of the two can thus produce it most efficiently and competitively. However, the Heckscher-Ohlin theory falls short in addressing the existing trade between countries with similar factor endowments, namely the wealthier, more developed economies of North America, Western Europe, and Japan. To explain the lapse in the HO theory, the Linder hypothesis was utilized to explain the differences in preference of goods in international markets. Supplementing the HO theory, the Linder hypothesis addresses the reasons why high-income countries continue to trade with each other in large quantities, despite similarly countries producing similar capital-intensive goods. The hypothesis assumes that high-income nations will automatically demand high-quality goods, and will produce and trade these goods with other countries but will

¹⁹ See footnote 8

²⁰ Though the treaty goes into full effect 60 days after six member states ratify, various clauses differ in start time

²¹ Davis, Christina. "Japan: Interest Group Politics, Foreign Policy Linkages, and the TPP." *Contested Megaregulation: Global Economic Ordering After TPP*, edited by Benedict Kingsbury, David Malone, Richard B. Stewart, and Atsushi Sunami, 7 Jul. 2017,

²² Much of domestically produced goods in Japan remain competitive due to highly protective tariffs.

differentiate products. The HO theory offers insight into how states and regions producing higher priced goods can trade competitively despite competition from less developed, labor-abundant economies.

Together, these two theories allow for the research to look into not only why much of modern Japanese agriculture is unproductive and uncompetitive compared to foreign goods, but sheds light onto recommendations for producers to achieve profitability help rural communities flourish. Additionally, the existing literature and research findings emphasized the unique position that Japanese agriculture is in, as its goods possess exceptional renown and value perception in the eyes of both domestic and foreign buyers.

For example, Japanese products such as Koshihikari rice and Kobe beef can remain immensely in demand in both developed and developing economies despite its high price point. This finding is supported by the Linder hypothesis which states that high-quality goods and product differentiation will allow for trade to occur between nations despite the presence of cheaper alternatives. Such a demand-based approach to Japanese agriculture supports the perspective that the conditions of the TPP11 will allow for the greater export of famously safe, high-quality Japanese agricultural goods in member countries. However, on the other hand, farmers and JA Zenchu alike have expressed worry for the inevitable downward pressure of foreign competition on agricultural goods that are still relatively labor and land-intensive. Cereal grains and dairy are still relatively land-intensive, and their competitiveness is much more sensitive to changes in price points than fruit and poultry. Thus, it remains true that despite gains made in its unique technological and educational advantage in production, other goods that are still more land and labor-intensive will be much more challenging to produce competitively in Japan. As a result, existing farms and producers will undoubtedly feel the brunt of their lack of comparative advantage as espoused in the HO theory.

Using the theories above, this paper finds that with the liberalization of trade brought forth by ratification, Japanese producers will be able to best capitalize off of their surplus in capital equipment and a skilled workforce. The reduction of trade barriers allows Japan to better meet the demands of member states demanding high-quality, capital-intensive agricultural products, something best suited to be produced by domestic producers with a surplus of said factors. In this research, I utilize the Linder hypothesis to determine that as the TPP11 allows for Japanese producers to access foreign markets, they will be able to take advantage of the highly developed economies of Canada, Australia, Chile, New Zealand and Singapore, as well as the growing upper-middle class of other member states.

Analysis: The Impact of the TPP11 and Future Policy

Overview

This section of the paper explores how the TPP11 will affect rural producers through the treaty's influences on their competitiveness in markets at home and abroad. These changes, as listed in the treaty and outlined in various government sources, comprise nearly all aspects of international trade, from tariff changes and a higher standard of regulation regarding food and worker safety to an expedited process of customs checks for goods traded between member countries. Due to the high number of member countries involved, the treaty is expected to achieve its goals in growing the sheer amount of trade output and business conducted between them. However, what must be analyzed - and remains one of the most contentious points of the treaty for most Japanese policymakers and interest groups - is the extent to which this purported increase in trade will affect the competitiveness and livelihoods of rural, domestic producers. From my findings, which utilized both official documents and figures from government offices such as the Ministry of Agriculture, Forestry, and Fisheries (MAFF) and the Cabinet Secretariat as well as interview findings from academics, bureaucrats, and producers in rural areas, I determine that the effects of the TPP11 on rural communities is dependant on the extent to which agricultural goods are price-sensitive. Simply put, price sensitive domestic goods will be impacted more by the influx of cheaper foreign imports, while less price sensitivity means that certain goods will remain competitive despite having a higher price point.

A large influence on price sensitivity lies in the quality of Japanese goods, its high level of taste and health benefits often quoted as the reason why consumers will continue to buy Japanese despite prices being lower elsewhere. This group includes much of the high-quality, capital-intensive²³ agricultural goods that Japan has become synonymous with. According to government figures and producers, this set of goods, which include high-end, brand-name beef, rice and many "native" produce such as peaches and apples, will not face any significant amount of pressure from abroad. Another determinant of price-sensitivity lies in the cultural aspect of consumer preferences. In this paper, "native" agricultural goods refer to products that Unique and "native" variations of common foodstuff such as cucumbers, tomatoes, and peaches have reduced the popularity for foreign alternatives, and thus decreasing price sensitivity ever more. Alternatively, price-sensitive goods are those that can be considered "non-native" produce. Shortly put, the difference in "native" and "non-native" is found in the degree of product differentiation exclusive to Japan, as well as the presence of well-integrated producer communities recognized amongst Japanese consumers to be vital in general society. These "non-native" goods are expected to face mild degrees of competitive pressure from member nations with a comparative advantage in their production, and Japanese producers are therefore expected to face significant downward pressure on their incomes due to an increase in cheaper alternatives.

The unique role of consumer preference and Japanese food culture to spite cheaper alternatives is further

²³ Capital-intensive as used here and other parts of the paper refer to the tedious, expensive nature of techniques used by Japanese growers in order to preserve quality and freshness

explained in my findings below. Often underrepresented in the analysis in favor of price and availability of goods, I examine the ways in which culture and consumer preferences unique to Japan will allow for a decreased level in price sensitivity to protect it from much of the expected foreign competition from TPP11 member states. I then investigate the effectiveness of supplemental government policy to help Japanese agriculture take advantage of the increasingly liberalized trade landscape. In conclusion, I find that through initial support to suddenly uncompetitive producers of mostly “non-native” goods, many of the policies that seek to reduce regulation and to consolidate farmland can in turn increase revenues in the face of an increased presence of foreign goods.

Price and Quality Factors

The price level of agricultural goods in Japan is largely made up of two main components, the basic factor endowment of a producing nation - its amount of surplus land, labor, and capital relative to other states - and secondly the influences of the Japanese government to a) keep the price of imported goods higher and to b) keep the price of domestically produced goods cheaper. As the Heckscher-Ohlin theory states, the pricing of a good largely relies on the producer’s ability to satisfy its necessary factor components, thus the reason why grain produced in land-abundant Canada heavily outcompetes Japan which lacks the same factor endowments.

Price is heavily influenced by the Japanese government’s protectionist approach to its agricultural policy, setting import quotas, high tariffs, and food standards to give domestic producers an advantage. Additionally, domestic policies such as the government stockpiling of domestic rice and grains as well as funding of leaving lands “fallow” - to be empty for a set time - also artificially drives down domestic prices to be competitive in the face of foreign competition. With these factors at play in setting the price for agricultural goods, producers and legislators are constantly in search of ways to reduce the price sensitivity - the level that price influences a consumer’s choice - to remain competitive.

Due to the high level of liberalization that the treaty garners, Japanese producers will now have to compete with a more significant number of foreign competitors from the ten other TPP11 member states. These producers abroad, whether they be of rice, beef, or fruits and vegetables, will obtain substantial access to the Japanese market through not only cuts in protective tariffs and import quotas but also with an expedited customs process for express goods.²⁴ This increased access is expected to allow foreign producers an opportunity to capitalize on their

relatively lower prices for products due to their distinct labor and land surpluses. The Heckscher-Ohlin theory states that in addition to the common comparative advantage in production, factors such as land, capital, and labor play a distinct role in the proportional makeup of each good, and surpluses these factor endowments will be able to be much more competitive at market. Japan, with some of the smallest farm sizes amongst OECD states²⁵, and a declining farming population²⁶, has a severe shortage of land and labor. As a result, many products within Japan will inevitably face increased pressure from foreign labor/land-intensive imports. This is in part due to not only the factor shortages addressed before but to decades of distributional agriculture policy, leading to higher price points for goods such as domestic beef, pork, wheat and certain produce and heavy reliance on the government for support. The increased pressure on price-sensitive goods will thus lead to a loss of income for already cash-strapped farmers, many of whom are elderly and have little options to turn to. This pressure can lead to near decimations in population and productivity and may lead to initial dips in the productivity of Japanese agriculture, a decrease that pro-TPP legislators are betting on to be reversed in the long-run.

Despite the significant steps taken in reducing trade barriers between member states, certain states - primarily Japan - have been steadfast in maintaining certain protective measures over what it considers to be “key” goods. For example, the Japanese government will maintain its nearly 256% tariff on barley and wheat, while maintaining similarly strict safeguards on imported rice as well. It is also noted that unlike other products which undergo significant change in price due to increased competition, Japanese representatives negotiated to maintain the current 777% tariff on rice from member states, and will only adjust import quotas on rice to increase by 2,000 tons on average. In addition to such minimal changes in current trade policy, the government instituted a policy of matching all imported rice by purchasing rice from domestic farmers to maintain existing price levels by artificially stimulating demand. As mentioned above, such protectionist policies are intended to promote two prongs of what is seen to be the state’s status quo approach to Japanese agriculture. First is to protect the incomes and livelihoods of all rice producers regardless of competitiveness in the name of preserving the national identity of rice production as well as minimizing dependence on foreign rice lest there be an emergency. Another side is to encourage Japanese consumers to maintain their share of domestic rice consumption in the midst of a drastic shift towards wheat and barley based meals such as bread and pasta. From a legislator’s point of view, without the artificial

²⁴ Article 5.7 of the treaty decrees that “Each Party shall adopt or maintain expedited customs procedures for express shipments while maintaining appropriate customs control and selection.”

²⁵ Bokusheva, Raushan, and Shingo Kimura. “Cross-Country Comparison of Farm Size Distribution.” *OECD Food, Agriculture and Fisheries Papers*, 2016, doi:10.1787/5jlv81sclr35-en.

²⁶ “Employment in agriculture (% of total employment) (modeled ILO estimate)”, ILOSTAT Database

price manipulation, domestic rice producers' share of the market will not only be diminished by cheaper alternatives (found not to be as significant due to extreme product differentiation) or other foreign foodstuffs such as wheat, meat, and dairy.²⁷ However, many of these strains of rice are unique to Japan, with the sticky, glutinous grains it has become a mainstay in the Japanese diet. According to the Linder hypothesis, this emphasis on high-quality agricultural beef and rice allow for greater quantities of trade to be conducted between similarly well-developed economies such as Japan's. The hypothesis supports the notion that due to similar tastes, wealthier countries will tend to import from countries with higher-quality goods, despite cheaper alternatives that may be offered at the expense of said quality. Consequently, it is expected that due to the importance of domestically produced rice in the national identity as well as extreme product differentiation, the TPP11 will not reduce rice output or the incomes of rice farmers significantly.

In conclusion, there is little change expected in much of the existing makeup of the beef market, with many rural communities renown for their high-quality beef anticipated to sustain its current level of income and development. A similar case can be made for other regions renown for producing popular "native" goods, such as rice, melons, apples and most vegetables.

Cultural Factors

While price and quality factors play a role in determining the competitiveness of Japanese agricultural goods, it must be noted that factors such consumers' cultural preference can also wield influence. For example, for producers of certain vegetables, fruits, and grains, the TPP11 is expected to have a much more significant impact on domestic production.²⁸ Many of these "non-native" goods produced within Japan lack protection from price sensitivity and have remained competitive only through the protectionist policies of the Japanese government and previous tariffs and NTBs. Despite both products undergoing the similar cuts in tariffs, the 17% tariff on foreign tea leaves and the 16% tariff on oranges²⁹ scheduled to be removed by the sixth year, the two are expected to face two completely different levels of competition from foreign imports. Though tariffs on both products are to be eliminated, domestic tea leaves are expected to remain competitive in the Japanese market due to its unique variation exclusive to Japan and consumer preferences for high-quality tea, whereas orange producers

are expected to face some increased pressure from similar, imported oranges from both Mexico and Australia.³⁰ Thus, for fruits and vegetable products that are not firmly established within the Japanese consumer's mind of native goods will be primarily made uncompetitive by increased foreign competition. The central role of cultural preferences will be expanded upon in the next section as I look into how the unique food culture of Japan is likely to reduce price sensitivity and to protect many higher-priced, domestic producers. Due to the affinity of certain Japanese goods to the cultural identity of the nation, Japan has maintained specific quotas and limits in the TPP11 to protect these goods, limiting the effect of the foreign competition expected to come about from the TPP11. In Japan, rice is an all-important crop, symbolizing not only the historical pillar of its domestic agriculture but as an integral part of the national identity. As such, any perceived threat to the established dominance of domestically produced rice is often met with harsh opposition from political parties and interest groups. Currently, Japan imports 770,000 tons of rice but produces 8,180,000 tons domestically, and domestic rice has a firm grasp on consumers throughout the country. In nearly all products, from raw rice to packaged rice balls in convenience stores, there lies an emphasis on the domestically produced aspect of the good, and it is a common consensus that unless used in foreign dishes, rice from abroad is rarely to be used in most meals.³¹ With such dominance in its own home country, Japanese rice is thus expected to be able to resist incoming foreign competition, despite increased import quotas on rice from Australia and Vietnam. The Japanese government has pursued a policy of strict protectionism for rice farmers due to the crops' intrinsic importance to the national cultural identity and the daunting memories of acute food insecurity during the Second World War.

Food security—primarily of rice—has remained an important goal for the government, in part due to its cultural implications. The culture of buying domestic rice is deeply rooted in Japanese consumer preferences, which allows for producers to be competitive despite having higher prices. It is worth noting, however, that the emphasis on the cultural nature of Japanese-produced rice does have its political implications. Called the essence of the nation's culture, the emphasis of both legislators and consumers' attention to domestic rice has been central to agricultural policy since the start of the post-war era, with protectionism at the expense of sustainable economic growth being the state's main tool for supporting farmers' incomes.³² The

²⁷ NTT Communications Research "The Change and Disruption of Diet" July, 2007

²⁸ "The Effect of TPP11 on Individual Agriculture, Forestry, and Fishing Outputs" MAFF, December 2017

²⁹ "The Effect of TPP11 on Individual Agriculture, Forestry, and Fishing Outputs" MAFF, December 2017

³⁰ Though regional varieties allow for some producers to remain competitive, domestic production has decreased by 13% over the last five years.

³¹ "Collection of Reports Regarding Rice" MAFF, March 2018

³² Wotjan, Linda S. "Rice: It's More Than Food in Japan," *Stanford Program on International and Cross-Cultural Education*, Freeman Spogli Institute, Nov. 1993

current Abe-led LDP administration is no different, undergoing significant turmoil throughout the ratification process as the split between legislators beholden to rural constituents and those at the forefront of trade liberalization were made evident. This has resulted in artificially manipulating prices of rice to favor domestic producers, despite rice farming becoming an increasingly inefficient operation as fewer farmers choose it as their main revenue source.

However, in the case of Japanese fruits and vegetables, the effects of the TPP11 on their output, as well as the incomes of their communities, seem to be a mixed bag. Though many relatively undifferentiated, “non-native” products such as oranges and kiwis are expected to take a large hit as consumers switch to cheaper alternatives, the same cannot be said for well established, “native” products and their output regardless of a shift in prices. “Native” products, such as spinach and eggplants have been strongly rooted in the Japanese diet and identity over a long period of time, and both have become ingrained to the point where they have become distinct variations unique to Japan. In the case of many fruits such as peaches, apples and pears, public perception of the premium quality and safety levels unique to Japanese products fosters a strong affinity for these domestic goods, increased by the distinct regional branding and product differentiation for respective species of fruit such as persimmons and tangerines. This corroborates the previous point on quality while introducing the importance of product differentiation in creating a pro-domestic food culture such as the one prevalent in Japan. An example of the key role product differentiation of “native” products plays is seen in the example of the orange and tea producers, who face completely different levels of price sensitivity to cheaper foreign competition. However, the difference in price sensitivity by “non-native” and “native” has its respective outliers, notably in products such as melons and grapes which are famously produced abroad but have become popular in Japan for their own unique domestic varieties such as Kyohou grapes and Yuubari melons.

According to Kento Nishihara, Head of Public Relations at JA Zenchu, in terms of production, the TPP11 will bring about great downward pressure on producers who are unable to compete with foreign producers with access to cheaper land and labor, whilst simultaneously opening up export opportunities for domestic high-quality products to rich consumers, per the Linder Hypothesis. Due to the tastes and preferences of consumers in developed “rich” economies, wealthier states are more likely to import a product from a similarly wealthy nation despite the option of cheaper, similar alternatives from developing economies. Additionally, the propagation of Japanese consumer preferences centered around a domestic product-friendly food culture will act to significantly limit the price sensitivity of most domestic goods. Emphasis on buying trusted, high-quality products - often a key selling point in most advertising for food in Japan - remains central in mitigating the competitive forces brought forth by the TPP11. This decrease in price sensitivity allows legislators and producers alike to focus on necessary change in Japanese agriculture, such as implementing a more streamlined and efficient

production method utilizing better watering systems, land consolidation for productive agribusinesses and producers, and allowing for Japanese producers to focus more on the production capital-intensive, high-quality agricultural goods to expand into TPP member markets abroad.

Supplementary Government Policy Following Ratification

In the paragraphs above, I analyzed the price, quality and cultural factors influencing the demand for locally-produced goods following trade liberalization led by the TPP11. However, to fully understand the extent to which the treaty will impact the economic revitalization of rural Japan, it is necessary to analyze the governmental policy that will follow post-ratification in tandem with the impacts of rapid trade liberalization. Examining these supplemental policies will aid us in understanding both the downsides that government agencies are hoping to mitigate from the TPP11, as well as the benefits of increased competition and export opportunities that they are hoping to capitalize on. Much of these downsides, such as the decreasing prices and increasingly difficult market entry, are expected to be felt most by producers of “non-native” goods, through legislation can useful in fortifying the dominance of “native” goods such as rice and beef. These policies can largely be broken into two separate groups, each seeking to help a relatively unchanged, “frozen” sector of Japanese agriculture adjust to an even stronger integration into a global supply chain. One group comprises short-term policies that aim to mitigate the downward pressure of foreign imports on currently uncompetitive producers, limiting the negative effects of decreased incomes and mass elderly unemployment within communities already struggling to provide jobs for their inhabitants. The other seeks to help further grow innovative and profitable agribusinesses by capitalizing off of Japan’s unique berth of cutting-edge technology and high-quality agricultural products in the long term. From my findings, I have found that the positive effects of the treaty are likely to significantly benefit rural communities in tandem with supplementary legislation, as it cushions the immediate economic ramifications expected to impact uncompetitive producers while duly adjusting Japanese agriculture to capitalize off of this large step towards long-term trade liberalization and alignment with the global supply chain. Both short-term and long-term approaches are instrumental in gearing the agricultural sector towards benefitting from increased trade between member states. Furthermore, I argue that the ultimate “success” of the treaty in helping promote economic revitalization in rural Japan will largely hinge on the government’s ability to mobilize its complex, bureaucracy to implement these initiatives in respective communities. Thus, the government - and other lobbying groups such as the JA Zenchu and Keidanren - must shed its long-held practice of overly complicated bureaucratic proceedings and intermittent passing off of legislative responsibilities between different departments in order for communities to best benefit off of the TPP11. Once underway, I believe that the TPP11 will offer a rare opportunity for the Abe administration’s to readjust the defunct, protectionist structure of Japanese agriculture, revamping its ability to compete within both domestic and

foreign markets, and for economic benefits of job growth and income generation to be felt in struggling rural communities.

Regardless of whether they support or oppose Japan's ratification of the TPP11, many believe that in the current state, Japanese agriculture is inefficient and that much of its future success (as well as the rural communities that are supported by it) is dependent on the enactment of new governmental policy. For skeptics of the treaty, such governmental policy usually means for the continued and increased purchasing of domestic agricultural goods by the government to keep many producers afloat, as well as simultaneously maintaining the high import tariffs it places on many "key", and vulnerable products such as rice, wheat, and meats, maintain and ramping up the protectionist policies instituted over 40 years ago. Said skeptics feel that with its substantial annual budget, the National Diet should move to support the agricultural sector even further, in part due to the decreased relevance of agriculture to national GDP due to significant growth in manufacturing and service industries. Additionally, they espouse the significance of agriculture and its laborers to be the spiritual and cultural backbone of the nation, requiring continuous support from the government to keep many communities afloat. Those who oppose the TPP11 also voice risks to food security and the increased threat of over-reliance on foreign products, looking to the government to help maintain domestic producers' definite share on previously mentioned critical products through additional protective policy. Alternatively, those in favor of the TPP11 for its economic benefits to rural communities often support policies that support the government's efforts to address the issue of noncompetitive agriculture. These policies include streamlining inefficient producers, integrating Japanese goods into the Asia-Pacific supply chain, and increasing telecommunication infrastructure to support profitable agricultural commerce. What can be deemed conclusive is that both sides of the argument deem further supplementary policy necessary to create sustainable changes for producers profits, market access, and production efficiency.

Conclusion

As the final terms of the treaty are debated amongst member states, the TPP11 is in a position to be ratified and obtain fully operational status in the coming year. The treaty, slated to be the largest of its kind due to the total amount of GDP and trade volume it encompasses, is a giant step in the global effort towards freer trade and investment between member economies. Following the withdrawal of the United States in 2017, Japan possesses the largest economy amongst member states, wielding significant influence over the terms of the treaty due to the sheer volume of trade it currently conducts with the other nations. This paper sought to examine how such a comprehensive trade deal would affect the economic revitalization of communities within rural Japan, where agriculture has been faltering due to rapid urbanization and an aging population. In this, I utilized the Heckscher-Ohlin theory of international trade and Linder hypothesis to understand how differences in factor endowments such as land and labor allow for certain states to be more competitive in producing agricultural goods. Much of the existing literature regarding the TPP11's impact on Japan states that the treaty favors manufacturing interests, and will diminish a large portion of domestic agriculture from the aggressive dominance of cheaper imports. In addition, many reports state that the treaty is likely to hasten the decline of Japanese agriculture, and impede the economic revitalization of rural Japan. However, from my findings, I have established that under the conditions of the TPP11, the majority of producers will not be entirely phased out due to cheaper imports but are likely to be "protected" from consumers' price sensitivity due to the unique food culture and preferences of Japanese buyers. This means that despite much protest from agricultural interests over the downward pressure on Japanese producers, the substantial product differentiation, high-quality, and Japanese consumers' trust in domestic goods is likely to reduce price sensitivity significantly. The relatively cheaper nature of foreign substitutes thus will not act as a determinant in demand for Japanese goods by Japanese consumers, regardless of cheaper foreign substitutes, Japanese consumers will continue to purchase what they deem to be "native" Japanese products, preventing significant drops in domestic production for goods such as rice, beef, and produce. However, I note that the significant reduction of tariffs for "non-native" goods which lack the protection of a loyal consumer base, such as wheat, barley, dairy and certain tropical produce are likely to be subjected to heavier competition from cheaper import substitutes though many of these sectors are already relatively small due to existing foreign competition.

Furthermore, I explore the TPP11's role as an essential piece in the Abe administration's efforts to restructure and streamline the archaic agricultural sector, as it opens up 10 bustling foreign markets to Japanese producers renowned for their safe, high-quality goods. I have found that the treaty alone will not bring about the needed structural changes to rural Japan's agricultural sector. This requires supplementary government policy in order for the country to benefit the most from the deal. This includes not only deregulating protectionist land policies such as the gentan system and fostering the growth of new, innovative agribusinesses but also a comprehensive welfare system for retiring producers. The need for a sound welfare system came about largely from my own time spent in a local farming community in Aichi prefecture, where I realized that without assistance from the state, many amongst the majority-elderly farming population would have difficulty adjusting to cut incomes, diminishing the treaty's efforts in revitalizing the economic successes of rural communities.

For further research, a quantitative examination of the treaty's impact would be vital to understanding how the TPP11 has affected domestic agriculture. Though I expect the treaty to boost both agricultural exports and imports (as it intended to), I believe that domestic agricultural output will not take any drastic hits, with the surge in foreign demand for Japanese goods and the continued support for Japanese products by domestic consumers. It would also be worth looking deeper into how shifting dietary preferences of Japanese consumers will allow for producers to readjust their production methods and variants. Finally, despite its size, the

TPP11 is but the only step Japan has taken towards greater global trade liberalization. Thus it would be worth analyzing how the recent EU-Japan FTA (though mostly comprised of automobiles on Japan's end), and the much greater Regional Comprehensive Economic Partnership (RCEP), will affect rural Japan and its rocky road towards economic revitalization.

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The Acquisition of Formal and Informal Political Power in the United States and Japan

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Key Words – Economics, Lobbying, Political Culture, Formal Political Power, Informal Political Power

INTRODUCTION

At the time of writing the United States midterm elections are less than a month away, and the impact of unseen processes are bound to influence the outcomes of this coming election, just as they did a year ago in the 2017 Japanese general election.

This essay will take Japan and the United States as comparisons, and show how the culture of the country determines the routes people can take to acquiring political influence. A key distinction at the heart of this essay is the difference between *formal political power* and *informal political influence*. Formal power is the legitimate acquisition of positions of political office through legal appointments and elections. Informal political power is lobbying and influencing the actions of people in public office, or the sentiments of the voting public.

Politics in The United States and Japan, both advanced democracies, have certain elements in common, such as the importance of the economy. This paper will focus primarily on economic anxiety, which exists in both countries, but manifests in different ways.

The economy has always been the most important issue for post-war Japan, as the country's so-called 'economic miracle' after the Second World War allowed it to gain a position on the world stage as the world's second-largest economy. The Liberal Democratic Party (LDP) rose to power after the war¹, and ruled Japan with a majority in the parliament from 1955 to 1993, and then from 1996 to 2009, as well as from 2012 to now. The LDP's 'legitimacy' to rule over Japan for so long has come from their ability to provide economic stability, as LDP prime ministers presided over a time of rapid economic growth in Japan. Both times

the LDP failed to win the general election; Japan was in a time of extreme economic instability.



This chart of the Nikkei 225 shows Japan's rapid economic growth (which the LDP presided over) and Japan's economic crash in 1989. [7]

In the United States, the economy has long been an extremely relevant and important issue in every election. In recent years, economic anxiety in the United States has led to major political changes. This includes the economic anxiety of rust-belt² voters, which led the election of Barack Obama and Donald Trump.

THE POLITICAL CULTURE OF THE UNITED STATES AND OF JAPAN

Americans expect a transparent and open government which serves the people³ "with the consent of the governed" [1], and they do not idolize their government, because in theory, "it is the right of the people to alter or abolish" an abusive government. The structure of the American government (the three branches: legislative, executive) aims to limit the power of one body so that if one body is acquiring too much power, other branches can step in. This system of separated powers ensures that the government is transparent because any kind of rogue or

¹ With some assistance from the American occupiers, who feared far-left political parties would turn Japan communist

² Voters who live in Midwestern states such as Michigan, Wisconsin, Pennsylvania, and Indiana where the industrial sector once boomed but now is in decline.

³ Two joint studies by Susan Welch of The Pennsylvania State University and John R. Hibbing of the University of Nebraska found that candidates with corruption arguments often lost more seats than those without any accusations [19]

secret activities by one branch would - in theory - be stopped by another branch.

Additionally, American politicians are expected to be 'normal' and are expected to be relatable to their constituents. Candidates have to appeal to their voters by campaigning on a variety of key issues that those constituents care about and can relate to. When politicians seem to be too 'out of touch' with the general population, this causes them to lose political support. For example, in the presidential election of 2012, a leaked video that surfaced in September of that year seemed to contradict many of Republican candidate Mitt Romney's pro-middle class statements and positions. In the video Romney states, "there are 47% of Americans who will vote for [incumbent President Obama] no matter what...who are dependent on government, who believe that they are victims, who believe the government has a responsibility to care for them...I'll never convince them that they should take personal responsibility and care for their lives."^[2] Romney's opponent, Barack Obama, quickly capitalized on this, attacking Romney for being too 'out of touch' with the general population, and also released ads attacking Romney for working at Bain Capital, an investment firm. ^[3] Romney suffered the political consequences of appearing too 'out of touch', and lost the 2012 election.

The Japanese political system, on the other hand, does not include a similar system of power separation that exists in the United States. Like most parliamentary systems around the world, the members of the legislature elect Japan's prime minister. In Japan, the prime minister must be a member of the lower house (the House of Representatives) of parliament. While a member of the upper house (House of Councilors) cannot become prime minister, the upper house still votes for the prime minister and is actively involved in decision making and passing new legislation. Therefore, the prime minister and his ruling government have some forms of checks and balance, although when one party dominates the parliament (as the LDP has done for an extremely long part of post-war Japanese politics) this system of checks and balance is virtually nonexistent ^[4]. Japanese political leaders are therefore expected to rule over the country lawfully and morally, and so the leadership qualities and qualifications of the ruling prime minister or the ruling party can become more important than their positions on certain political issues. This is evident in the often prestigious educational background of the most

powerful figures in Japanese politics, as well the fact that many powerful leaders in the LDP and other parties are descendants of former prime ministers. The two most recent LDP Prime ministers Asō and Abe are both descendants of former prime ministers.

WHAT THE U.S. AND JAPAN HAVE IN COMMON

In both countries, economic anxiety often becomes the driving force behind votes, and thus leaders who are able to tap into this anxiety end up rising to power. This holds true with those who hold formal political power⁴, as well as those who hold informal political power⁵. While there are other differences between the political systems, in addition to the aforementioned cultural divides, such distinctions are outside the scope of this essay.

1) In terms of *formal* political power:

United States After the Great Recession in 2008, many American voters turned to presidential candidates who could provide a sense of economic stability and who would put forth a populist platform that would help the country become economically prosperous again. Barack Obama's message of hope and change the American political system appealed to many of these voters. In 2008 Barack Obama won the presidency in an electoral landslide, winning all electoral contests in the so-called "rust belt". Obama strong populist plans promised to implement tough rules against the revolving door for former lobbyists and special interest workers. He stated that the federal government would gather all information on ethics and lobbying. He also promised to require more disclosure for earmarks⁶. In addition, he promised to sign a universal health care bill, cut taxes on 95 percent of American families, and repeal the Bush tax cuts on the wealthy⁷. ^[5] However, many Americans were disappointed at the way the Obama administration delivered on these campaign promises, most notably Obama's Wall Street bailouts and the rollout of his healthcare plan.

The Patient Protection and Affordable Care Act⁸, was signed into law in March 2010 after barely passing through the Democratic-controlled Congress. The goal of the law was to cover the 15% of the American population that had no health coverage and who do not receive any

⁴ Elected positions, official governmental positions

⁵ Unofficial political positions, such as lobbyists involved with the legislative process

⁶ Earmarks refer to the use of federal funds for local projects (politicians often advocate for earmarks for their local districts)

⁷ Tax cuts for the wealthy were implemented in the previous administration (the George W. Bush Administration)

⁸ Also known as the ACA or Obamacare

support from federal healthcare programs. The law required all Americans to purchase health insurance and all business with more than 50 full-time employees to offer health insurance to its employees offering subsidies to make coverage affordable. This was a victory for Obama, as numerous presidents had tried and failed since the early 1900's to pass a universal healthcare bill.

The first congressional election after the Citizens United v. Federal Election Commission supreme court case⁹ was held in 2010. The laxer regulations on free speech by corporations and legal persons allowed conservative special interest groups to run ads that criticized Democrats for a messy rollout, and many of these ads made claims that employers would have to cut employee hours to cover healthcare costs. The opposition to the Democratically controlled Congress was exacerbated by the use of over \$700 billion of taxpayer money to "bail out" dozens of investment banks. Voters felt that the victims of the recession were being forced to bail out the very perpetrators of the crash.

These concerns over the bailouts, as well as the concerns over the implementation of the health care bill, (strengthened by anti-Obamacare campaigns by conservative interest groups), contributed to a devastating loss for Obama and his Democratic allies in the Congress during the 2010 midterm elections. The Democratic Party lost 63 seats and their majority in the House of Representatives and 6 seats in the Senate, losing their House majority and just barely holding on to their Senate majority. [6] In 2010, Obama faced the severe consequences of squandering much of his political capital in the first two years of his presidency. In addition, Democratic members of Congress who had been supportive of Obama also lost much of their political capital as well.

In 2016, Donald Trump rose to power as a political outsider who promised to 'drain the swamp' of Washington D.C. from corrupt practices, including lobbying and special interests. He promised to bring back jobs that had been shipped overseas, to get the U.S. to leave "unfair" trade deals and international treaties, and he also constantly attacked foreign workers and companies, claiming that they were "stealing" American jobs. His campaign website also claimed that his tax plan included "reducing or eliminating most deductions and loopholes available to the very rich". [7] Trump attacked his opponents whom he competed within the Republican primary for their connection to the political elite. He continued this tactic in the general election as he constantly attacked Hillary Clinton for her connections to Wall Street¹⁰ and for being a part of the political elite. This made him popular with the rust-belt, the same demographic that had been popular with Obama. Many of these voters were white, working-class voters who

saw the decline of American economic prosperity, and some agreed with Trump's ideas that this was due to foreign influence. On the opposite side of the political aisle, Bernie Sanders challenged Clinton for the Democratic nomination and preached a similar form of populism, although his ideology was grounded in left-wing populism unlike Trump's right-wing populism. Like Trump, he attacked Clinton for her connection to big business and big banks, and advocated for more populist policies, such as making public college tuition free and raising the minimum wage to \$15 per hour. Sanders was also popular with rust-belt voters, who felt as though Sanders understood the problems that they faced but was not going to go about solving these problems through Trump's right-wing populist policies. Clinton lost the general election despite winning the popular vote, falling short of the 270 electoral votes necessary for victory. Pundits agree that this was because her policies could not appeal to voters which Trump had already attracted, and therefore she could not win states that typically lean Democratic. Sanders and Trump were both popular in these states, and Sanders won many of them in the Democratic primary, just as Trump won many of them in general election.

Japan The 2008 Great Recession, which preceded the 2009 election, exacerbated the financial instability and uncertainty caused by the "Lost Two Decades". In the 1980's Japan experienced an economic bubble, in which the prices of domestic stocks and real estate rose to unprecedented levels. However, this bubble would 'burst' in January 1990, causing property values - and by extension net worths - to plummet 87%. The Bank of Japan lowered interest rates from 0.5 percent intending to support investment, but people merely paid off their high-interest loans with new low-interest debt. The government introduced fiscal policy including spending on infrastructure to create jobs (this only created more debt for the government). Although the immediate response by the Bank and the government were relatively ineffective, the Japanese economy was able to come out of its 20-year slump in the late 2000's, and GDP growth was 2.1 percent in 2007 and 3.2 percent the first quarter of 2008.

However, the financial crisis which in the fourth quarter of 2008 sent the GDP growth rate of Japan down 12.9 percent. This was a result of slumping exports in auto and electronic sales, which made up 16 percent of the Japanese economy. When voters saw that the LDP could not provide economic stability after the recession, they turned to other parties and politicians.

The 2009 general election in Japan was a huge loss for the Liberal Democratic Party; out of the 480 seats in the lower house of the Japanese diet, The Democratic Party of

⁹ A major U.S. Supreme Court case from 2008, which essentially decided that corporations had the same rights to exercise free speech as individuals had, including in the form of money

¹⁰ This includes large donations to Super PACs supportive of Clinton, as well as the speech that Clinton gave to Goldman Sachs after leaving her post as the Secretary of State.

Japan (DPJ) won 193 new seats, and the LDP lost 119 seats. There were a number of factors that contributed to this devastating loss for the LDP, which include a recession and an unstable executive branch¹¹. The LDP had held power in Japan from 1996, but no prime minister served for more than two years (with the exception of Junichiro Koizumi¹²). This led many people both inside¹³ and outside the party to lose faith in the LDP's ability to properly govern.

After its national election victory in 2009, the DPJ held onto power for three years and elected three prime ministers who each served 1-year terms. In March 2011, Japan was hit by a massive earthquake, which triggered a tsunami and meltdowns at numerous nuclear energy sites. The disasters added economic challenges for Japan, which had just begun to recover from 20 years of deflation and recession. Prime Minister Yoshihiko Noda dissolved parliament in late 2012, citing a need for an emergency budget in response to the new economic crisis that Japan faced. This meant a national election would happen sometime in the next month. In that election, the LDP gained 173 new seats which gave them the majority in the House of Representatives. Shinzo Abe, the leader of the LDP and the former prime minister, was once again elected the prime minister of Japan. After he was elected prime minister in 2012, Abe had implemented a series of economic programs he called "Abenomics" which were intended to stimulate Japan's economy. Abenomics consisted of three 'arrows' - monetary easing, fiscal stimulus, and spending, as well as financial and structural reforms. While there has not been a clear consensus on the effectiveness of Abenomics and how it has been executed by the government, the Nikkei 225 has been on a constant rise since Abe took over in 2012, despite a minor drop in 2015 and 2016^[8]. Japan has experienced a constant decline in unemployment, and hit a 24-year low in 2018.^[9] ^[10] Abe's monetary easing policies have also gradually increased inflation-adjusted real wages.^[11]

II) In terms of *informal* political power:

In both the United States and Japan, lobbying is still an extremely influential way in which certain groups and individuals gain informal political power. Lobbying is

generally defined as any attempt by an individual or an organization to influence public officials, especially members of a legislative body on legislation. Lobbying can take many forms; some make phone calls or send letters to their elected officials, while representatives of large organizations may "buttonhole", or provide favors to, those officials with hotels, private homes, campaign contributions, and other services.^[12]

United States Lobbying in the United States is mostly conducted by large corporations and billionaire donors, and an analysis by the Sunlight Foundation¹⁴ concluded that between 2007 and 2012, the most politically active corporations in America spent \$5.8 billion ^[13] on lobbying and campaign contributions. Corporations spend almost about \$2.6 billion a year on lobbying ^[14], more than the \$1.18 billion spent annually to fund the House of Representatives or the \$860 million spent to fund the Senate.

One of the largest industries that profit from lobbying is weapons manufacturers and defense contractors. An article by The Hill revealed that Boeing, a company specializing in the production of military airplanes, was one of the top ten spenders of lobbying money in 2016^[15]. In 2014, Congress approved the F-35 Joint Strike Fighter. The jet was manufactured by Lockheed Martin, a company that spent \$14.4 million lobbying throughout the previous year. By threatening members of Congress with their political power, large defense contractors have been able to effectively persuade those members to vote against any cut to defense spending, even spending that is wasteful and unnecessary.

Powerful, wealthy people are also able to influence American politics through supporting and donating to a political campaign. While there are limits in the United States regarding how much an individual can donate to a political campaign, there no limits as to how much an individual can donate to a super-PAC (political action committee). The 2010 *Citizens United* case allowed Super-PACs to raise and spend unlimited amounts on advertisements and other efforts to get a candidate elected¹⁵, although super-PACs are technically not allowed to be affiliated with the campaign. Organizations known as 501(c)

¹¹ Japan was not only dealing with the effects of The Great Recession but also suffered economic problems due to the 2011 East Japan disasters. Internal problems within the DPJ (this was the first time they held power) also led to challenges in governing.

¹² 56th Prime Minister of Japan, served from April 2001 to September 2006

¹³ Includes voters, politicians, lobbyists

¹⁴ The Sunlight Foundation is a non-profit organization that advocates for government transparency.

¹⁵ Super-PAC contributions are not limited because of the 2010 supreme court case *Citizens United v. Federal Election Commission*.

(4)s (based on the IRS code for tax-exempt “social welfare” groups)¹⁶ also influence elections. Super-PACs disclose the names of their donors, while 501(c)(4)s do not. Wealthy billionaire donors, such as Republican Sheldon Adelson and Democrat Tom Steyer are often behind¹⁷ these organizations, and their funds have helped Republican and Democratic candidates win elections in the past.

Japan In contrast to the open lobbying conducted in the United States, lobbying in Japan is usually conducted through behind-the-scenes negotiations known as *chinjō* [16], largely by agricultural organizations and smaller local groups. The most prominent lobbying group in the country is the Japan Agricultural Cooperatives (JA). The JA’s long, close relationship with the Liberal Democratic Party (LDP) has allowed both sides to remain in power.

After holding power for the decades after the Second World War, the LDP suffered a bitter general election defeat in 1993 which triggered a change in the national electoral system. Prior to the 1993 election, each electoral district sent 3-5 representatives to the diet, based on the size of the constituency. After the 1993 election, each district could only elect one representative, which under Duverger’s Law theoretically establishes two strong parties as opposed to multiple distinct parties. In addition to the new single-member system, a system of proportional representation was adopted. However, the system maintained the malapportionment of votes, in which one rural voter would have much more power than an urban voter. This had always been advantageous to the LDP, which generally attracts more support from rural voters. Under this new electoral system, the LDP was able to win back their majority in the House of Representatives in 2005.

Since the beginning of post-war electoral politics in Japan, farmers (members of the JA) have been key supporters of the LDP, and support from such agricultural interest groups has allowed the party to extend its control over electorally crucial rural areas of the country. Because of this long-standing relationship between the two organizations, it can be said that the LDP has been largely dependent on the JA. This dependence on the organization can be seen in the LDP’s national election defeats, such as in 1989 when LDP politicians passed new laws regarding agriculture despite fierce JA and rural opposition [17].

In exchange for their support of the LDP, the JA is rewarded with heavy tariffs on foreign imports of Japanese

staple foods such as rice. The current general tariff rate for rice imports into Japan is 402 yen/kg [18] ¹⁸As a result, because competition is limited (because of the high tariff rates), not only are Japanese farmers able to maintain high prices, but they also produce higher quality, more profitable varieties of brand-named rice.

In addition to the vast influence that the agriculture lobby has over the Japanese government, smaller local groups also have influence over some of the most powerful people in the country. *Koenkai* are local support groups for a diet candidate in his or her home district. Comprised of influential people in the community¹⁹, *Koenkais* provide money and other support²⁰ to the candidate in exchange for pork barrel benefits. These benefits include the subsidization of local infrastructure projects (such as roads, tunnels, bridges). Therefore, construction companies and construction workers living in these - usually rural - areas become a key demographic supporting those candidates, in addition to local farmers. Such benefits are exemplified in the Japanese Shinkansen (bullet train) systems, for many train stations have been built in rural areas due to pork barrel subsidies over the years.

Anti-lobbying laws have also been initiated in both countries. In the United States, this includes several anti-lobbying laws such as the Honest Government and Open Leadership Act (HLOGA) as well as the Foreign Agents Registration Act (FARA). Many of these laws, however, have proved to fall short of actually ridding American governmental institutions of unwanted outside influence. As aforementioned, powerful industries still continue to influence politics through lobbying activities. Due to the *Citizens United* decision of 2010, campaign funding has also proven to be a reliable way for people to gain informal political influence. The Japanese penal code includes key anti-bribery laws, and the Public Offices Election Act of 1955 also includes rules that regulate a candidate’s interactions with potential supporters and voters. However, because local groups such as JA often conduct lobbying in Japan, these are limited in their power to stop unwanted outside influence.

CONCLUSION

It was against the backdrop of these two government systems and prevailing economic conditions that two different types of leaders rose to power starting in 2008. Despite the similarities that American and Japanese

¹⁶ Well-known 501(c)(4)s include Crossroads GPS (conservative) and Organizing for Action (liberal).

¹⁷ Donors not only fund political organizations, but also often hold executive positions in the organization.

¹⁸ As can be seen in Japanese grocery stores or online retailers, one kilogram of rice can cost between 500 yen and 1500 yen depending on the quality, meaning the tariff can be equal to somewhere around 25% to 80% of the retail price of domestic rice.

¹⁹ Such as bankers, school principals, heads of farming communities

²⁰ Includes organizing campaign events, spreading information, etc.

governmental systems have, as well as the common economic hardships that both countries have experienced in recent years, the reasons behind Abe's rise to power were different from the reasons behind Obama's rise to power and Trump's rise to power.

Abe became prime minister in 2012 after three years of leadership by the Democratic Party of Japan. The main appeal of Abe was a return to government which was stable. The historic nature of the 2009 DPJ victory meant that not many political pundits or voters were focused on the policy details of the new administration. While the DPJ did have policies to stabilize Japan's economy, they did not have an Abenomics-style structured program that reassured the voters of stability in the future.

Obama and Trump were both elected by economically anxious voters as revolutionaries, with the expectation that they would initiate major changes in American policy. Obama was expected to execute populist policies, although this was through his liberal and center-left approaches to governing. Trump also was elected based on his populist policies, although his voters expected him to do this through a right-wing approach.

These trends can be expected to continue in the approaching elections, as Japanese voters will continue to look to candidates that can maintain stability even in times of economic crisis, and American voters will look to candidates that can initiate radical change in times of crisis. The midterm elections, as well as the 2020 presidential election, will be a test of whether or not the American people continue to trust Trump and his promises to free Americans from economic anxiety. Similarly, the success or failure of the 2020 Tokyo Olympics and the continued stability of the Japanese economy will determine Abe and his party's legitimacy to govern.

Many economists theorize that the world experiences a full economic cycle within two to twelve years. The current economic cycle will end in 2020. Regardless of country, culture, or political system, leaders from around the world must learn to adapt to the dramatic changes that occur within their respective countries as we look to the future.

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Nov 23-24, Tokyo

The Acquisition of Formal and Informal Political Power in the United States and Japan

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A Study on Muong Language

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Abstract – The Muong have always learned Muong language by word of the mouth communication for generations. However, some Muong villages have been experiencing the less amount of Muong language uses in the community due to many factors. Schools in Muong area are not teaching Muong language, but are teaching Vietnamese instead. It is thought that the future generations of Muong people are vulnerable to lose their culture and language. Our studies showed that nearly all villagers living in Giang Mo village are not aware of their culture and language loss. However, the government of Vietnam is also concerned about the situation. They arranged to create a writing system for Muong language. We also interviewed some Muong villagers about their thoughts on letting their children learn Muong language and their writing system. They agreed that a language that has a writing system will be worth for their children to learn. The writing system for Muong language may be the key to preserve and promote Muong language and culture.

Key Words - Culture Heritage, Education, Linguistic, Muong Community, Social Studies

INTRODUCTION

The Muong people is one of 53 ethnic minority groups and also one of the five largest ethnic groups in Vietnam. According to National Statistic 2009 [1], there were 1.268.983 (takes the proportion of about 1.4% of Vietnam's population) Muong people in Vietnam. Muong people live mostly in the hill valley region of mountainous Northern Vietnam. Their inhabiting area is mainly in Hoa Binh, Thanh Hoa, Phu Tho, Son La, and Yen Bai provinces. Today, as a result of mobility, Muong people live in almost all of the provinces of Vietnam [2].

Vietnamese linguists and ethnologists categorize Muong language into Viet-Muong language group due to its similarities and closeness to Viet language [2]. They also mention that there has been no clue to show that Muong people have official written language or characters. Without a written language, Muong people are very rich in folk culture that includes songs, stories, ideas, dances, spiritual bibles, etc. All of their cultural heritage and values have been verbally transmitted generations to generations. Recently, the Muong alphabet and dictionary have been created and approved by the Provincial People Committee of Hoa Binh province [3]. The provincial government decides that this Muong writing system will be used for education and learning of the Muong people in all schools and public education centers in Hoa Binh province. Up to date, researchers haven't discussed how Muong people think of this decision and their new writing system.

Our school is located near a Muong community. Therefore, we have chances to meet Muong people whenever we go to the field or play on the ground. Hearing their voices with different tones, sounds, and languages yet very beautiful that makes us curious to study more about their language and how they think about their language used today. Such motivations inspire us to take our camera recorders and go to a picturesque Muong village named Giang Mo in Binh Thanh commune, Cao Phong district, Hoa Binh province to conduct a research project and a short documentary on the Muong language in the summer of 2018.

THE STUDY

Giang Mo village locates 10 km away from Hoa Binh city and 86 km from Hanoi city, in a valley of Mo mountain. The village is bounded by rice fields which make green or yellow background's color of the scenic view.



FIG.1

The panorama view of the Mo valley

Credit: An Do Chuc, Spring Hill filming crew member

This tranquil village has about 140 households. All of them are Muong people. They live in traditional wood stilt houses. The villagers mostly work on farms which cultivate rice on paddy fields and breeding. Youngsters would go uptown to seek for job opportunities. Muong children go to public schools where they are taught Vietnamese as an official language of teaching and learning. At home, the children speak Muong language with their family members. This makes ethnic minority students are bilingual or sometimes trilingual speakers.

A Study on Muong Language



FIG.2

A Muong woman and her grandchild
Credit: An Do Chuc, Spring Hill filming crew member

We stayed with a Muong family and interviewed 15 adults from the village with the following questions:

(1) Do Muong people have their written language?
(2) Do schools teach your children and grandchildren Muong language?

(3) Do you think the Muong language is important to Muong people?

(4) Do you fear that your children wouldn't speak Muong language one day?

During our stay, we had a chance to observe their daily life activities such as farming, cooking, taking care of children, chatting, etc. We also had the pleasure to watch their traditional gong performance and folk songs singing. In all such activities, they use their Muong language as if it is their nature, their essential part of life.



FIG.3

A Muong villager cultivating on the paddy field
Credit: An Do Chuc, Spring Hill filming crew member



FIG.4

A group of Muong women playing their traditional instruments

Credit: Spring Hill School team

With their permission, we had opportunities to record their daily practices and performances to make a short documentary on how they think of their language and some aspects of their language use.

You can watch the film on the following link: <https://www.youtube.com/watch?v=WYrdFHbm-78&feature=youtu.be>

When the villagers were asked the first questions on their written language, most of them were seemingly surprised by our bizarre question. It is because they don't think Muong people have a written language. This reaction makes us think that the provincial policy on Muong alphabet and the dictionary has not come to the villagers yet by any chances. However, when they were asked if the government makes Muong written language, would they agree to let their children learn Muong at schools, they all said yes immediately. The reasons for wanting to learn Muong written language at school was they hope if children know the written Muong language, they will remain speaking Muong language as well as their understandings of Muong culture.

With the second question, the villagers didn't think that the fact schools don't teach Muong language for Muong children is a big deal. They were fine when their children are taught Vietnamese instead of Muong language at school as they thought it would be better for the children's future. "We want our children to have more occupation and education chances in the cities," said one of the villagers. "In the globalization era, it is essential for us to integrate with the Kinh people; we should use their writing system in many cases."

For question 3 and 4, none of them said "no" for the answer to our upcoming topic. As we have said before, children use the Muong language to communicate with their family members at home, and it becomes their identity, their essential part of life and so familiar to them that they never question its importance as well as their fading in the future. This explains why the Muong people never lost belief of how their language is developing as if they never stopped communicating in Muong language.

We also visited the Museum of Muong's Culture and Heritage in the field trip and had a chance to speak to Mr. Bui Thanh Binh, the director of the museum. His ethnic identity is also Muong. Apart from all villagers' opinions that we interviewed, he claims us that Muong language is in danger of disappearing, and sadly, the majority of Muong is not aware of it. Furthermore, Mr. Binh also stated clearly of the fact that Muong people and many other ethnic minority groups in Vietnam, whose languages are not taught at public schools, might create disadvantages for the ethnic minority people as they cannot expand the popularity of their mother-tongue. Informing us of the government decision, he hoped for a bright prospective of maintaining the Muong people's peculiar history, local knowledge, and cultural activities and habits. He supportively agreed with that decision of developing Muong alphabet and dictionary. Following the implementing of Hoa Binh provincial government's plan [4], The Hoa Binh News was taking the lead by printing the Muong letters on their paper.

Nov 23-24, Tokyo

Young Researchers' Conference 2018

A Study on Muong Language

However, there is a controversial fact that the target population of Muong language education has been the Muong school students so far, who are not targeted audiences of The News.

FINDINGS

As we all know, the Muong language was crafted by the Muong people for many years. It developed from time to time and became a crucial element for the Muongs' lives. The language has contributed to the Muong society development. The main findings of our research show that: Muong people have dual feelings towards their language and the government's plan on their language.

(1) Muong people love their language and like using their language within their community. Their language is the tool to communicate to understand, to transmit, to express their cultural values and heritage as well as their daily activities. Thus it will be alive without any vanishing. They do think language and especially written language will help to preserve and promote their culture better. They hope that their children will continue their tradition by knowing Muong verbal and written language. Therefore, they seem to support the government's plan on their written language.

(2) Muong people don't think the learning of their language and writing system at schools would be important to their children to have a better future. Therefore, they prefer to let their children learn and speak Vietnamese at school so that they can have a better education and a better job in the future. They do believe that it's also the best way for their children to integrate into the Vietnamese society with the majority of Kinh people, who speak Vietnamese as a mother tongue.

Hence, their attitudes bring up a question in our mind that: How could it be balanced between these two sides of thoughts? Perhaps the government should think of a functional plan to introduce, promote and spread the use of the newly created written language of the Muong people in Muong communities.



FIG.5

The Muong stilt houses in Giang Mo village
Credit: An Do Chuc, Spring Hill filming crew member

CONCLUSION

The conclusion is always the most important but difficult part for us as writing. After doing this research project, we can understand the Muong's thoughts by talking to them, observing and staying with them though it was a short period. The Muong people assert that their language can not disappear, with or without a writing system, because it is a part of their lives - they simply can not live without it. They

would not only develop it through their daily lives and cultural activities but also never let the language stop flourishing. That is the reason why they were so glad to hear that they are getting their written language created by the government.

Our very first short film illustrates our depiction of their attitudes vividly towards their language. It also somehow portrays the beauty of the Muong culture through the beauty of their daily life, their houses, their songs, their costumes, their ways of expressing ideas and communicating, etc. It also expresses our good feeling to the Muong culture and their language during our fieldwork.

Therefore, we have thought of something practical and suitable for promoting Muong written language amongst Muong children from our perspective as children. We are purposing a more engaging way for the children to the lately Muong language, for instance, setting up projects on comics published in Muong. Comics can be provided to school libraries so that children can come and enjoy reading them. Most children love comics - and we believe the Muong children are not different. This shall be an interesting and more accessible approach for Muong children. We hope that someday, the Muong language would be common among schools and workplaces. More and more people would know about the Muong culture and its specialties.

We've done this research and film with an inadequate amount of time, knowledge and experiences. We expect to improve our research and filming skill and knowledge in the future work.

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Nov 23-24, Tokyo

Young Researchers' Conference 2018

A Study on Muong Language

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The Role of Moral Education in the Modernization of Meiji Japan until 1894

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Abstract – This paper will discuss the role of moral education, and its contributions in Meiji Japan until 1894. From 1868 to 1894, Meiji Japan’s moral education had developed gradually from a minor role to a device that distributed Japanese Nationalism to the Meiji population. This revolutionary change in the role of moral education had been stimulated through the changes in the Meiji ideology. Initially, the underdeveloped *Kokugaku* ideology was the basis of Japanese Nationalism. However, westernization in moral education had happened. This change proceeded with the emergence of Japanese Confucianism rose the role of moral education to the public. This resulted in the creation of the Meiji *Kokutai*, a fundamental concept that solidified Japan as an individual nation, with the Meiji emperor as the decisive leader of Japan, and the citizens as a subject to the emperor. This is explored through analysis on sources such as the “Imperial Rescript on Education,” and how the role of moral education had aligned with the state’s motives to move towards modernization by 1894.

Key Words – Meiji Japan, Moral education, Ideology, Imperial Rescript on Education, Japanese History, Japanese Nationalism (*Kokugaku*)

INTRODUCTION

In 1894 - 1895, the First Sino Japanese War broke out between two nations in Asia that both went through a modernization process during the late 19th century; Meiji Japan and Qing China [1]. During this period, Japan was amid the Meiji Restoration, attempting to implement Western ideals and systems from western nations such as America. Meanwhile the Qing dynasty of China was implementing measures such as the self-strengthening; which both aimed for having a modernized nation that could astound western countries such as Britain. Although the Qing had an advantage on the financial side and the number of soldiers that participated in the war, the war ended with Qing China giving Taiwan away to Japan through the Treaty of Shimonoseki [1][3]. As a result, this war was viewed to be a symbol of success in modernization for Meiji Japan, as it is quoted by the historian Marius Jansen; “Japan’s victory

over China could be credited in good measure to its greater speed in modernizing its society and its armed services.” [4]

TABLE I [2]

THE INDICATION OF THE DIFFERENCE IN MILITARY POWER BETWEEN MEIJI JAPAN AND QING CHINA BEFORE THE SINO JAPANESE WAR IN 1894

Country	Japan	Qing China
Number of soldiers	240000	630000
Number of battleships	60000	85000

TABLE II [3]

STATISTICS ON THE BATTLE OF PYONGYANG DURING THE SINO JAPANESE WAR

Country	Japan	Qing China
Number of soldiers	12000	15000
Number of deaths	180	2000

The results of the Sino Japanese War lead raises questions about why Meiji Japan was able to successfully modernize. In comparison to the western modernized countries such as America and Britain, Japan had been in seclusion until 1868, and could not benefit from having a continuous imperial system until 1894. Japan also did not have a continuous dynasty like Qing China. Through these disadvantages that Japan held, it is evident that there needed to be revolutionary reforms within Meiji Japan to achieve modernization by 1894.

In one of these reforms, there were the changes in of moral education in Meiji Japan. This leads to the question “To what extent did moral education lead to success in Japan’s modernization by 1894?” In which modernization would be defined as Meiji Japan being able to have a sense of a nation, comparable to Western powers such as Britain. When the changes in moral education in the long run are analyzed, it is evident that moral education eventually played a significant role in fostering Japanese nationalism, which contributed to a great extent in the modernization process of Meiji Japan up to 1894.

MORAL EDUCATION IN PRE MEIJI-RESTORATION

The moral education system before the Meiji restoration can be described as the basis for the system that developed in Meiji Japan.

The Role of Moral Education in the Modernization of Meiji Japan until 1894

During the late Edo period, schools called *Terakoya* were prevalent throughout Japanese society [1][5]. In these *Terakoya*, mainly writing and reading were taught for commoners, as well as mathematics for students who needed those skills for work. This was done through an individual “Mentor-Student relationship” within *Terakoya*, by textbooks such as the “*Jitsugokyou*” [6]. As a result, in the mid-19th century, there were approximately ten thousand and two hundred *Terakoya*, and the literacy rate was around 43% for men [7]. This was a significantly high number comparable to imperial countries such as Britain which the literacy level for men were around 40% [8].

However, there was a significant lack of moral teaching and education to emphasize nationalist ideals to the commoners’ population and to create the concept of national identity. The extent in moral teaching was done were teachings of simple Confucian moral teachings such as respect towards teachers and the importance of literacy as a virtue [6][9]. The role of moral teaching for the commoner’s population was not viewed as significant. Furthermore, there were no words that exactly represented “nation” and “nationalism” in the Japanese language [5].

But this did not mean that the early parts of Japan’s nationalism did not exist during this period. “Japanese nationalism (*Kokugaku*)” did exist, even before the Meiji government. This was debated amongst Dutch studies intellectuals and Japanese nationalists and was developed as an ideology through the Edo period. [10]

However, this was not a fundamental ideology that applied to all citizens, but was more of a study conducted by scholars such as Hirata Atsutane. The extent that Japanese nationalism was spread at a macroscale was through lectures that intellectuals such as Atsutane conducted towards commoners [10]. This was not institutionalized as education but was taught more as a religion amongst the population [10]. This shows the limited role that nationalism had in Pre-Meiji Japan.

Therefore, moral education in Pre-Meiji did not have a significant role in modernization, as moral education itself was not valued enough and was not institutionalized. However, the concept of Japanese nationalism had inspired Meiji moral education and its emphasis on nationalism [10].

WESTERNIZATION IN THE EARLY MEIJI MORAL EDUCATION SYSTEM

Moral education during the early Meiji period, to a great extent, did not teach Japanese nationalism or emphasis on the concept of Japan as a nation. However, it emphasized “westernization”, as it had taken significant amounts of teachings from western countries.

After the Meiji Restoration in 1868, the emphasis of westernization was prevalent in multiple layers of society. In 1868, the Charter Oath that showed Japan’s change in political structure and its resemblance to western principles was promulgated by the Meiji Emperor [11][12]. In 1872, the first steam train that ran between Shinbashi and Yokohama was made, and western items experienced

significant popularity [4]. From this, it can be suggested that for the entire Meiji society from 1868 to 1875, westernization was the equivalent to modernization.

This was same for Japanese Education. In 1871 - 1873, Genros or elder state members such as Kido Takayoshi were on the Iwakura mission; a mission that made Japan incorporate government structures and educational systems from European countries and America. [11][13]. When Kido inspected education in the united states, he directly stated; “The civilization we have in our country is not a true civilization, and our enlightenment is not true enlightenment” and “Our people are no different from Americans or Europeans today; it is all a matter of education [11][13]. This showed Japan’s initial understandings towards the importance of education as an indicator for the modernization level of a civilization.

From this, when the Meiji Education starts with the establishment of the Fundamental code of education (*Gakusei*) in 1872, it states that education will be distributed to everyone in the community in the aim to building up character and success, textbooks such as the Aesop fable were used as the basis for Japanese elementary school education [6][11].

Specifically, for moral education, in 1874, the translated version of “Elements of Moral science” by Francis Wayland was used [6][14]. This was a book that primarily focuses on moral teachings involving American Christianity and was used to incorporate moral values from western societies into Japan [6]. The “Moral stories from the west” were also applied similarly to teach French moral values to small children [6]. However, the importance of moral teaching was not particularly important at this point and was not an established subject in Meiji Education.

In conclusion, the Japanese moral education between 1868 to early 1880s was under a westernization process and was able to create a state justified educational system by promulgating the *Gakusei*. Therefore, moral education in Japan at this point did not emphasize nationalism. However, this was the first time for Meiji Japan to establish a national education system. This itself showed Meiji Japan’s attempt towards emphasizing the sense of national unity. Thus, showing that this was the start for Japan’s attempt to institutionalize moral education in the aim for modernization.

SHIFTS IN THE ROLE OF MORAL EDUCATION AND THE INCORPORATION OF CONFUCIANISM:

Moral education in the aim to foster nationalism was not prioritized during the Meiji until 1879, and it was rather “westernization” and the incorporation of western moral concepts that was prioritized, in the aim to create a civilization comparable to western societies.

However, in 1873, the emergence of the Freedom and people’s rights movement in 1873, created a split in Meiji society and undermined the authority of the Meiji oligarchy [1][11]. The Freedom and People’s rights movement was a revolutionary movement conducted by Itagaki Taisuke; a

Nov 23-24, Tokyo

The Role of Moral Education in the Modernization of Meiji Japan until 1894

politician in the Meiji government and was one of the most influential contributors to the creation of the restoration, and his party “Public party of patriots” [4]. The motivation behind this was the lack of the people’s voice in politics and how the government had dominated Meiji politics [4]. Thus, showing the limitations of the Meiji oligarch of steering the Meiji restoration into a modernization movement.

This was same for education in that, all the unsuccessful western textbooks were implemented directly by the government, while local villages and towns did not have much control over education under the code of education and was considered by the public as an unsuccessful moral curriculum [5][11].

Through this, Meiji Japan needed to have a moral educational system that unified the state and could control revolutionary acts were needed.

Therefore, in 1879, the “education order” (*Kyōuikurei*) was implemented, which assured that unlike during the fundamental code of education, where elementary schools were legislated by the Meiji Government, these were organized by each village and town to a greater extent under the education order [5][11][15]. From this, it may seem that the government had lost its influence and had failed to establish a national identity through an established unique education. However, at the same time as the people’s rights movement, a new moral education that did not resemble western moral education was starting to develop.

In 1879, the document “Great principles of Education” (*Kyōgaku Taishi*) was created [6][11]. This was promulgated by the Meiji Emperor, but the main ideas and values came from Motoda Nagazane, a Confucian scholar that served as a mentor for the young Meiji Emperor, and eventually became a court advisor in 1866 [6][11]. In this document, there is a significant emphasis on moral education through a Confucian approach and antagonizes the westernized education that the Meiji Government implemented through the previous system to a certain extent [6]. This is evident from direct quotes of the Great Principles of Education such as “The danger of indiscriminate emulation of western ways is that in the end our people will forget the great principles governing relationships between ruler and subject, and father and son” [11][16], and “For morality. The study of Confucius is the best guide” [11][16]. In the second part of this document; “Two notes on Elementary education”, it is directly stated how Confucian moral studies should be the core of Japanese education for all types of students, regardless of class or any circumstances [6][11]. It also states how many of the “common western words” were used by the young generation of the commoner class as a way to “show off knowledge” [11]. Since this contradicts with Confucian ethics mentioned previously, it was viewed by the emperor as a “evil effect” that came from a misguided education [11].

As a result of the Great principles of Education, when the revised version of the “new education law” came out in 1880, “Confucian moral teaching (*Shūshin*)” became a

proper and core curriculum in Meiji Education, and new textbooks that taught Confucian morals were implemented to schools [5]-[6].

One of the textbooks that were used in Elementary schools during the early to mid-1880s was the “Principles of early education (*Yōgaku Kōyō*)” written by Nagazane [6]. This was directly put in action by the Japanese Imperial Household Agency, implying that this moral teaching was not only from the government, but directly from the Meiji Emperor, which was very significant due to how it showed the shift in the definition of moral teaching from a western and weak topic to an imperial and essential aspect in Meiji Education [6].

The specific Confucian ideals that were presented in the principles of early education can be examined from specific extracts of the textbook. In one of the extracts, the infamous “Separation in Sakurai” story is told [6]. This story heavily emphasizes the relationship between Kusunoki Masashige who was famous as an imperial royalist, and his loyal son Masatsura, and how Masatsura must move on despite his loss of his father [17]. Therefore, being a Confucian moral story that conveys the theme of “filial piety” for students in Meiji Japan [6][17]. From the fact that these specific moral stories were implemented in the educational textbooks for elementary school children, the emphasis of moral teaching based on Chinese traditional Confucianism that was prevalent from the previous era, the Edo period, is evident, and strongly suggests that the Confucian moral teachings were initiated, in the aim to emphasize unity within Meiji Japan, and served as a foundation.

Therefore, moral education in Meiji Japan after 1879 had some contributions towards modernization, as Confucian morals has become essential attributes in textbooks, and education itself became further institutionalized as a teaching distributed by the Emperor. As Motoda states in the “Great principles of Education” in 1879 [11][16], moral education itself changed from a symbol of westernization to a method that conveys a unified ideology.

However, from the fact that the “principles of early education” was banned soon after it had been distributed to schools [6], and how the links to the concept of Japan as a “Nation” was not established through Confucian thought, moral education in Meiji Japan did not have a great impact towards modernization at this point.

IMPORTANCE OF NATIONAL IDENTITY FOR MEIJI RESTORATION AND MODERNIZATION

Throughout this discussion of Meiji education, the constant focus has been about its role of creating a national identity. But, the importance of establishing national identity in the context of the Meiji Restoration to facilitate modernization can be questioned.

Fukuzawa Yukichi; an influential educator in the Meiji period that had lived during this educational reform, argues that, to a great extent, the creation of Japanese Nationalism through education directly led to modernization, and could

Nov 23-24, Tokyo

The Role of Moral Education in the Modernization of Meiji Japan until 1894

be said that the creation of this ideology itself was modernization, and had enabled Meiji Japan to become closer to the Western nations.

Throughout his works, Fukuzawa claims that nationalism is the key aspect of a modern civilization [18]. In the “outline of a theory of civilization” written in 1875, Fukuzawa addresses Japan and China as a “semi-developed country” [11][19], while the western nations are the most highly civilized [11][19]. Therefore, stating that the westernization attempt of Meiji Japan was not absolutely flawed. However, he also states that the level of civilization is not determined primarily from intelligence or the level of industry, but through the “Spirit of entire nations” [11][19]. He later defines this as the manifestation of “knowledge and virtue” in the civilizations [11][19], and emphasizes the fact that the “amount of virtue” [11][19], in Meiji Japan is not sufficient compared to the modernized world. In the same time, Fukuzawa had argued strongly about the importance of “National Polity (*Kokutai*)”. “*Kokutai*” was the equivalent to a Japanese version of modern nationalism in which it had developed from Pre- Meiji nationalism. Fukuzawa stated that every nation had their own version of “*Kokutai*”. Therefore, showing that the establishment of Japanese nationalism was the roots in the Meiji sovereignty, and is an essential factor of modernization [20].

The importance of Japanese Nationalism in comparison to Confucianism is further developed in the discussion of comparison between “semi-developed nations” such as China, and Japan. In Fukuzawa’s “Goodbye Asia (*Datsuaron*)” he claims that Meiji Japan must follow the footsteps of western countries and allow influences of western civilization to flourish within Japan. He argued that countries like Qing China will be “wiped out” [21][22], due to the continuous reliance on factors such as tradition Confucian ideals and trying to limit the impact of foreign influence towards their civilizations [21][22]. This level of conservativeness was evident in Meiji Japan, as they had also relied on traditional Confucian ideals that Motoda had promoted through the “Great principles of Education [11][16]. From this, it is evident that in the eyes of Fukuzawa, reliance on western standards of civilization, and incorporating national polity that represents nationalism in the western societies were essential for Meiji Japan to leave the semi-developed Asian civilizations and advance towards modernization.

The importance of nationalism is also argued by Historians such as Beasley and Wazaki. Wazaki had argued that the definition of a modernized civilization can be defined by three main factors [5]. One is the identity as a “Japanese citizen” within the Japanese society, another is the concept of distinguishment between Japan and the world, and lastly, a constitution that symbolizes these two concepts. In addition, Beasley argues that Japanese Nationalism distinguished Japan against the western civilizations in the 19th century [23].

From this, it can be concluded that the concept of Japanese Nationalism was essential to Japan becoming a

modernized civilization. This is evident from Fukuzawa’s 19th century analysis towards Meiji Japan’s modernization process, as well as the analysis from the historian Wazaki and Beasley. In both analyses, the importance of *Kokutai* was established from distinct perspectives. In Fukuzawa’s perspective, he stated that the only decisive difference of civilization level between the western powers and the “semi-developed nations” such as Meiji Japan was the “amount of virtue” [21]-[22]. But, this could be overwritten by acting in converse with other Asian nations such as Qing China and emphasizing the concept of Japanese nationalism [11][19][21]. Both Beasley and Wazaki come to a similar conclusion to Fukuzawa, as they agreed that Japanese nationalism had held a central meaning when defining a modernized civilization that Meiji Japan aimed to become [5][23].

However, this also shows the inability of the Meiji moral Education system until the mid-1880s, as the educational system had been relying on traditional neo-Confucianism and had not fully conveyed Japanese Nationalism. Thus, remaining as a question, whether Meiji moral educational reforms have successfully stimulated modernization.

IMPERIAL RESCRIPT ON EDUCATION AND THE EMERGING OF NATIONALISM

Throughout the discussion of education and its attempts towards modernization, it has been justified that Meiji Japan’s moral education system was an evolutionary process, which had started from purely incorporating western texts and Christian moral concepts, in the name of “westernization” as the primary goal for the Meiji government. But, after that, the emergence of Confucian ideals through Nagazane became the curriculum for “moral teaching (*Shuushin*)”, as it was less superficial compared to the previous westernized moral education, and from the establishment of moral teaching, this showed how the role of education in order to create a modernized civilization, had been recognized furtherly by the Meiji Oligarch. But, as evident from Fukuzawa’s analysis, although the emphasis on Japanese national identity was essential for Meiji Japan to modernize, to a great extent, this was not emphasized in moral education that was prevalent until the mid-1880s.

However, in 1890, as the “Imperial Rescript on Education (*Kyouiku Chokugo*)” was distributed by the Meiji government [11][24], the emphasis of moral education as a method to distribute Japanese nationalism into society has increased to a great extent. This is evident from the content and context of the rescript, and the actions of the Meiji government corresponding to this distribution of the rescript.

The Imperial rescript of education had emerged through the consultation of multiple Meiji political figures; starting with Confucian scholars such as Motoda, western-based educators, the Meiji Cabinet members such as Yamagata Aritomo, and was finalized by the governor Inoue Kowashi [6][11][20][24]. In the end, this was promulgated by the

Nov 23-24, Tokyo

The Role of Moral Education in the Modernization of Meiji Japan until 1894

Meiji emperor [6]. Since, this was distributed right after the promulgation of the Meiji constitution [11], it can be inferred that the rescript was a source that defined Meiji Japan's educational intentions.

Furthermore, the rescript was a moral educational source that intended to restrict Meiji citizens into Japanese nationalism. In the same period, the Meiji constitution was promulgated by the emperor. This was a German style conservative approach to prevent revolutionary actions [11][25]. Similar attributes of this is evident when analyzing the rescript.

In the first line of the rescript, the term "subject" [6][11][24], establishes a clear relationship of the Emperor as the monarch of Japan, and the citizens as the people under him. After this, the term "nation" and how the source will be "education" is defined. Furthermore, the term "citizen (*Shinmin*)" [6][11][20][24], and them attaining to "the same virtue" had been stated [6][11][20][24]. All of this refers to the analysis of Fukuzawa, and how nationalism as a virtue is the biggest burden for Japan's modernization. Therefore, this realization of the Meiji government on the importance on patriotic ideas, and its distribution to the public as ideological restriction of nationalism is a significant step of the Meiji monarchy towards modernization, as it further emphasizes the sense of nation and state control.

Through this realization, the implementation of Japanese nationalism to the public had accelerated, as the ministry of education had made Inoue Tetsujiro to create a commentary and a translation for the rescript [6][20]. This became a textbook for Meiji Moral education in the 1890s, and 4 million copies were made [5][20]. Within this, the obligation of the Meiji population towards the state was emphasized, and the message of Japanese nationalism as a measure to counter the western powers were also established [20]. Furthermore, specific phrases such as "Collective patriotism" were also established through this textbook [20].

In addition to the distribution of purely nationalist textbooks, the pictures of Meiji Empress and Emperor had started to be showcased in elementary schools by 1891[6]. This suggests that the emphasis of nationalist education had been targeted by the Meiji monarch towards a wide range of the population and shows that the integration of nationalism through educational systems had become an essential aspect of Meiji modernization in the 1890s.

The impacts of this moral educational reform towards the creation of nationalism had been evident in the 1890s. In 1891, A patriotic song called the "Future of Asia" had also been popular in the Meiji society [6][20]. This song incorporated lyrics such as "Enemy struck down", in which the enemy is referring to western powers such as England and concluded with "Glorious flag of the rising sun" which pictures a patriotic view of Japan [20].

Furthermore, these impacts were significant to the extent that Qing China had gave great attention towards Japan's modernization process and had looked up to for the

sake of their own country's modernization. After Qing China's loss to Japan, the country had changed from having an absolute monarchy to incorporating a Meiji like constitutional law [26]. Following this, the Qing Scholar Kang Youwei issued "The need for reforming institutions", which specifically states "Take the Meiji reform of Japan as the model for our reforms" [27]. Moreover, Kang's disciple Liang Qichao criticized Qing China for its lack of nationalism and public morality directly after its loss to Japan in 1904 [26].

To conclude, the promulgation of the Imperial Rescript on education had shown Meiji Japan's moral education as a device to emphasize nationalism, as it had become a source of education that solidified the concept of Japanese citizens becoming subject to the Emperor. This was modernization itself, as it solidifies the concept of Japan as a nation, and was effective to the extent that nationalism became prevalent in pop culture and had become Qing China's model for modernization.

CONCLUSION:

Throughout this discussion, the changes in Meiji moral education from 1868 to 1894 has been examined, as an evolutionary process in defining the significance of education in Meiji Japan. In addition, the role of nationalism towards modernization has also been thoroughly examined by analyzing the perspectives of Fukuzawa and other analyses of historians towards 19th-century modernization.

Therefore, when answering the question; "To what extent did moral education lead to the success in Japan's modernization by 1894?", it is evident that Meiji moral education was initially not significant towards modernization, as it was rather based towards westernization, which did not significantly impact the moralities in Meiji Japan.

However, as Meiji Japan progressed to 1894, the role of moral education had shifted towards the distribution of Confucian ideals. This had contributed to modernization to some extent, as it had raised the importance of education in the Meiji society and had built the foundations for a nationalist educational system.

However, when the Rescript was established in 1890, moral education directly contributed to modernization to a significant extent, as the Meiji government was able to create a system where collective nationalism was distributed through moral education. This was successful to the extent that Qing China had modeled Meiji Japan as their modernization process.

In conclusion, moral education contributed to a small extent to modernization initially, as the emphasis of moral education was towards westernization. However, by 1894, moral education contributed to Meiji Japan's modernization to a significant extent as it had created a fundamental sense of nationalism within Meiji Japan.

Nov 23-24, Tokyo

The Role of Moral Education in the Modernization of Meiji Japan until 1894

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Nov 23-24, Tokyo

Investigation on the Time Taken per Cycle's Effect on 100m Breaststroke Record

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Abstract – Breaststroke is one of the four competitive swimming styles where stroke rate is one of the factors influencing the breaststroke record to some extent. There is a trend, which as the stroke rate became larger, the 100m breaststroke record became faster in Olympic breaststroke records. Despite the attention on stroke rate in competitive swimming, it is still unclear how stroke rate solely affects the time taken to swim breaststroke. Stroke rate is cycles taken in a minute and cycle rate is time taken for one cycle of breaststroke. This investigation answers the question, “How does the time taken for one cycle, or cycle rate, of breaststroke affect a 100m breaststroke record?” The data from the simulation, Swumsuit, shows that as the cycle rate became smaller, the forward velocity of a swimmer became faster, and the maximum forward velocity also increases. This result correlates with the Olympic breaststroke swimmers’ relationship between their stroke rates and their breaststroke records. In addition, the graphed data reveals the breaststroke’s unique pattern in velocity throughout the cycles.

Key Words - Breaststroke, Cycle rate, Simulation, Stroke rate, Swimming

INTRODUCTION

In breaststroke, a swimmer’s movements of arms and legs are corresponding. The definition of one cycle of breaststroke is one complete stroke of breaststroke. One cycle of breaststroke is measured in two ways, either stroke rate or cycle rate, cycles taken in a minute or time taken for one cycle respectively. Cycle rate is calculated 60 seconds divided by stroke rate [1]. Both stroke rate and stroke length have been discussed in competitive swimming to maximize the speed and efficiency of swimming [2]. As an example, the Olympic gold medalist, Adam Peaty, acquired his world record in the 100m breaststroke with the stroke rates of 60 cycles per min at the first 50m and 55 cycles per min for the last 50m. This is an outstanding stroke rate, as other swimmers have not shown this large stroke rate before [3]. The 100m breaststroke records of top three swimmers at Rio Olympic 2016 are shown in Table I to compare their records and stroke rate for the first 50m and last 50m.

TABLE I
STROKE RATE IN CYCLES PER MINUTE WITH 100M BREASTSTROKE TIME
OF 3 OLYMPIC SWIMMERS

Swimmer	Stroke Rate of First 50m (cycles/min)	Stroke Rate of Last 50m (cycles/min)	100m Breaststroke Time (s)
Adam Peaty	60	55	57.13
Cameron van der Burgh	40	45	58.69
Cody Miller	30	45	58.87

Table I shows the results of Men’s 100m Breaststroke, taken from BBC Sports and Swimming World [4]. As it can be seen from Table I, 100m breaststroke time is faster for the swimmer that has larger stroke rate. In addition, I have done a preliminary experiment on how stroke rate affects my velocity by measuring my 25m breaststroke time, and the result is shown below in Table II.

TABLE II
PERSONAL EXPERIMENT ON 25M BREASTSTROKE WITH DIFFERENT CYCLE RATES WITH STROKE RATE AND 25M BREASTSTROKE TIME

Cycle rate (s/cycle)	Stroke Rate (cycles/min)	25m Breaststroke Time (s)
1.0	60	31
1.5	40	23
2.0	30	28

Unlike the competitive swimmers, my breaststroke record did not improve even though the stroke rate became larger. Besides, swimming experiments are difficult to have a controlled environment. Hence, the scope of this research focuses on how the stroke rate, that is cycle rate, independently affects the time it takes to swim breaststroke by using a simulation. The research question is, “how does the time taken for one cycle, or cycle rate, of breaststroke affect a 100m breaststroke record?”

I. General Information About Breaststroke

Before proceeding further, it is important to have a better understanding of breaststroke itself. Competitive breaststroke rules are defined by Federation Internationale De Natation Amateur or FINA. At the start, a swimmer dives into a pool and starts with one full pull of arms and one butterfly kick follows [5]. After a swimmer comes up to the surface of the water, a swimmer starts the breaststroke cycles.

Since an Olympic-sized swimming pool is 50m, there is one turn taken place by a swimmer where the pull and

Correlation Between The Time Taken Per Cycle and 100m Breaststroke Record

butterfly kick follows after the turn again. These start and turning parts are not included in the stroke rate, although there are some speed contributions by these movements. This manuscript will focus on the main part of the breaststroke, which is between the dive to turn and between the turn to the finish.

II. Forces Contributed From Arms and Legs

One complete stroke in breaststroke includes the complete four phases of arms (outsweep, catch, insweep, and release and recovery), which are shown in Figure 1.

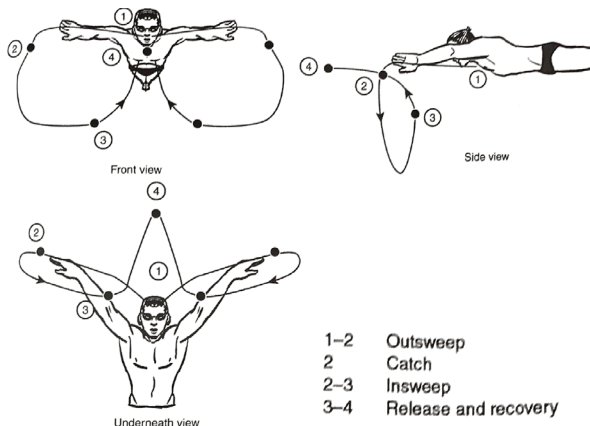


FIGURE 1

FRONT, SIDE, AND UNDERNEATH FOREARM STROKE PATTERNS OF BREASTSTROKE IN FOUR DIFFERENT PHASES [6]

There are five phases of legs (recovery, outsweep, catch, insweep, and lift and glide), which are shown in Figure 2 below.

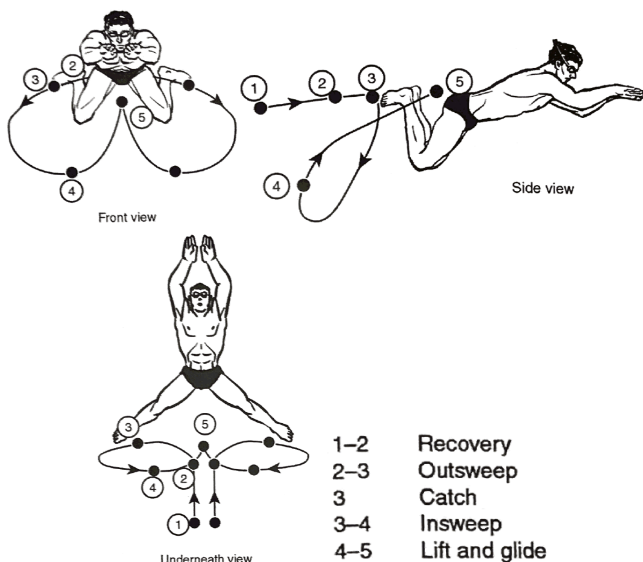


FIGURE 2

SIDE, FRONT AND UNDERNEATH FOREARM VIEW PATTERNS OF MOTION FOR FIVE PHASES OF BREASTSTROKE KICK [6]

Both arms and kicks have contributions to the forward velocity of breaststroke. The main forces acting on a swimmer are propulsion (also called as thrust), weight, buoyancy, and drag as shown in Figure 3 [1]. Five phases of legs (recovery, outsweep, catch, insweep, and lift and glide). Both arms and kicks have contributions to the forward velocity of breaststroke.

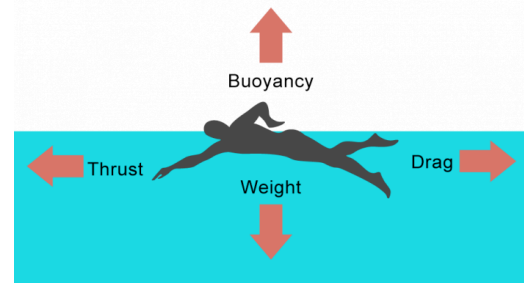


FIGURE 3

FREE BODY DIAGRAM OF A SWIMMER IN A POOL [7]

The arms create forward acceleration or thrust takes during insweep and decelerates during release and recovery. The legs create the most propulsive force from catch and insweep phases. However, legs create the largest fluctuation in velocity at recovery to outsweep phases [1]. From these different phases, there is a great change in swimming velocity throughout one cycle of stroke [8].

METHODOLOGY

I. Overview

As it was mentioned before, data was collected on the simulation to control all of the variables: independent, dependent, and controlled variables. To obtain the swimming velocity per swimming cycle, the collection of data was done on the simulation, Swimming Human Model with Synthetic User Interface Tools or Swumsuit [9]. The programming language, Fortran, is used for the mechanical calculations and Tcl or Tk language was used for the Graphical Users Interface [10].

II. Conditions

From the observations made in Table II, I assumed that breaststroke at under 1.0s per cycle will be difficult even for athletes and would not be practical for all the swimmers. Furthermore, breaststroke at over 2.0s per cycle is not a practical option, as it does not create enough lift force to keep the body around the surface of the water (see Table II). In addition, for female world-class swimmers of the 100m breaststroke, the stroke rates are between 47 cycles per min to 53 cycles per min [1]. This means that cycle rate is about 1.13 s per cycle to 1.28 s per cycle in a competitive event. Therefore, this range of cycle rate was applied to this experiment in this simulation, Swumsuit.

Consequently, the data will be collected on three different cycle rates of simulation: 1.3s, 1.5s, and 1.7s per cycle respectively. There is 0.2s difference between the

Nov 23-24, Tokyo

Correlation Between The Time Taken Per Cycle and 100m Breaststroke Record

successive cycle rates, because the difference in the velocity of a swimmer in this simulation becomes apparent from 0.2s difference in each cycle rate.

The data was collected with all the controlled variables that are embedded in the simulation already. The value of cycle rate was controlled at “Actual time for one cycle (s)” at Calculation Setting on Swmsuit.

	Root depth	Root width	Tip depth	Tip width	Length	Density
Lower_waist	0.0646334	0.0846963	0.0600203	0.0787683	0.0353079	1.042
Upper_waist	0.0600203	0.0787683	0.0711379	0.0846774	0.0718475	1.042
Lower_breast	0.0711379	0.0846774	0.0822555	0.0905865	0.0718475	0.7
Upper_breast	0.0822555	0.0905865	0.0585924	0.113724	0.0656891	0.7
Shoulder	0.0585924	0.113724	0.0406597	0.0406597	0.0312023	1.042
Neck	0.0406597	0.0406597	0.033903	0.033903	0.0164223	1.042
Head	0.041393	0.0405718	0.0551906	0.0486862	0.139062	1.042
Upper_hip	0.0646398	0.0846908	0.0654023	0.105926	0.0544169	1.042
Lower_hip	0.0654023	0.105926	0.0500197	0.10003	0.0748959	1.042
Right_thigh	0.0500148	0.0500148	0.0344282	0.0329589	0.187566	1.042
Left_thigh	0.0500148	0.0500148	0.0344282	0.0329589	0.187566	1.042
Right_shank	0.0344282	0.0329589	0.0203588	0.0203588	0.180938	1.042
Left_shank	0.0344282	0.0329589	0.0203588	0.0203588	0.180938	1.042
Right_foot	0.0378481	0.0203588	0.0106976	0.0282405	0.137193	1.042
Left_foot	0.0378481	0.0203588	0.0106976	0.0282405	0.137193	1.042
Right_upper_arm	0.0260342	0.0260342	0.0233552	0.0233552	0.186628	1.042
Left_upper_arm	0.0260342	0.0260342	0.0233552	0.0233552	0.186628	1.042
Right_forearm	0.0233552	0.0233552	0.0119648	0.0180051	0.15132	1.042
Left_forearm	0.0233552	0.0233552	0.0119648	0.0180051	0.15132	1.042
Right_hand	0.0119648	0.0294135	0.00410557	0.0150147	0.107331	1.042
Left_hand	0.0119648	0.0294135	0.00410557	0.0150147	0.107331	1.042
Shoulder joint - upper arm's root (yb):			-0.00779373233			
Shoulder joint - upper arm's root (zb):			0.0131378299		Actual Height [m]:	1.705
Neck's tip - Head's root (xb):			0.00599197012			
Lower hip's tip - hip joint (yb):			0.0500147909		Actual Weight [kg]:	64.9
Lower hip's tip - hip joint (zb):			0.068856305			
Shank's tip - foot joint (zb):			0.0374193548			
Rotating angle of both hip parts [rad]:			0.0140119644			

FIGURE 4
EXAMPLE OF CONTROLLED VARIABLES USED IN SWMSUIT SIMULATION
FOR THE DATA COLLECTION

The controlled variables of the simulation include other factors such as the shape and the density of a swimmer's body parts shown in Figure 4. The conditions of the pool are controlled and the data is embedded in the simulation already.

III. Errors

The simulation's values are based on the experimental values, and from the research [9], there is a 10% error in its calculations compared to the real values. Though, the qualitative phenomenon observed in the graphs is similar to the experiments. Also, take note that the effect of initial condition (one arms pull and one breaststroke kick underwater, after the starting dive) comes into account for the calculations in the simulation. Eventually, this effect disappears after nine stroke cycles [11]. Therefore, the data collection includes ten stroke cycles to make the calculations simpler.

EXPERIMENTAL RESULTS

Table III-I, III-II, and III-III show the forward velocity of a swimmer obtained from the simulation at different cycle rates for 10 consecutive cycles of breaststroke.

TABLE III-I
THE DATA TABLES OF NUMBER OF CYCLE OF BREASTSTROKE VS.
FORWARD VELOCITY OF A SWIMMER AT THREE DIFFERENT CYCLE RATES

Number of Cycle of Breaststroke	Forward Velocity of a Swimmer (ms ⁻¹) at 1.3 Cycle Rate (s/cycle)
1	0.864
2	0.897
3	0.933
4	0.896
5	0.954
6	0.890
7	0.967
8	0.890
9	0.921
10	0.883

TABLE III-II
THE DATA TABLES OF NUMBER OF CYCLE OF BREASTSTROKE VS.
FORWARD VELOCITY OF A SWIMMER AT THREE DIFFERENT CYCLE RATES

Number of Cycle of Breaststroke	Forward Velocity of a Swimmer (ms ⁻¹) at 1.5 Cycle Rate (s/cycle)
1	0.846
2	0.868
3	0.907
4	0.868
5	0.930
6	0.871
7	0.887
8	0.865
9	0.893
10	0.866

TABLE III-III
THE DATA TABLES OF NUMBER OF CYCLE OF BREASTSTROKE VS.
FORWARD VELOCITY OF A SWIMMER AT THREE DIFFERENT CYCLE RATES

Number of Cycle of Breaststroke	Forward Velocity of a Swimmer (ms ⁻¹) at 1.7 Cycle Rate (s/cycle)
1	0.828
2	0.842
3	0.877
4	0.845
5	0.871
6	0.847
7	0.841
8	0.844
9	0.844
10	0.844

From Table III-I, III-II, and III-III, the forward velocity of a swimmer for each cycle is different; however, this pattern is different from 8th cycle to 10th cycle of 1.7 stroke rate, as the forward velocity is constant. From Table III, the forward velocity of a swimmer vs. time for each cycle rate is graphed at Figure 5.

From the graphs in Figure 5, the total distance traveled by a swimmer is the area under the curves. By dividing the 'distance traveled' by the 'time taken to travel that distance', the average speed of a swimmer is calculated. Then, the predicted 100m breaststroke record is calculated, as written below.

Nov 23-24, Tokyo

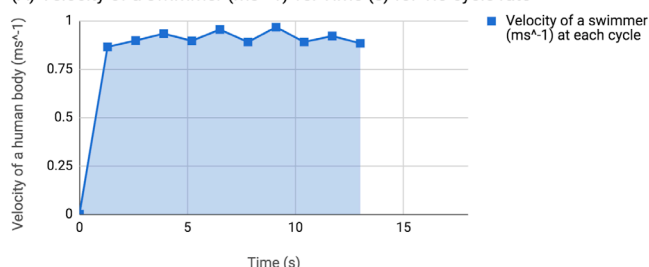
Correlation Between The Time Taken Per Cycle and 100m Breaststroke Record

For 1.3 cycle rate, the fastest velocity among the cycles took place at the 7th cycle, which is 0.967ms^{-1} . For 1.3 cycle rate, 11.25m is traveled in 10 cycles. Thus, the average speed of a swimmer is 0.865ms^{-1} .

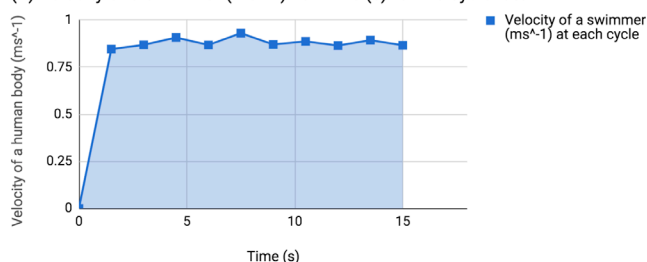
For 1.5 cycle rate, the pattern shown is similar to the 1.3 cycle rate, as the velocity changes during the cycles. The fastest velocity is achieved at the 5th cycle, which is 0.930ms^{-1} . The distance traveled by a swimmer is 12.55m in 10 cycles, therefore, the average velocity of a swimmer is 0.837ms^{-1} , which is slower than 1.3 cycle rate.

For 1.7 cycle rate, the pattern is similar to other two cycle rates, however, this pattern holds until the 6th cycle. The velocity of a swimmer does not change from the 7th cycle until the 10th. The distance traveled by a swimmer is 13.70m in 10 cycles, so the average speed of a swimmer is 0.806ms^{-1} , which is the least velocity among the others.

(A) Velocity of a swimmer (ms^{-1}) vs. Time (s) for 1.3 cycle rate



(B) Velocity of a swimmer (ms^{-1}) vs. Time (s) for 1.5 cycle rate



(C) Velocity of a swimmer (ms^{-1}) vs. Time (s) for 1.7 cycle rate

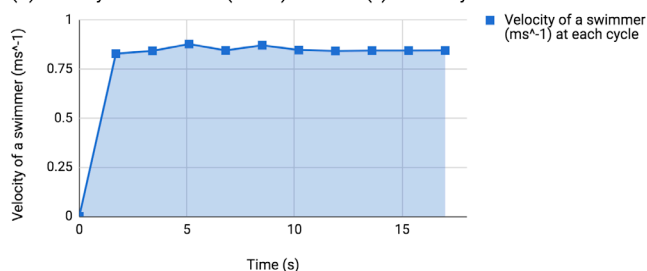


FIGURE 5 – A, B, C

THE GRAPHS OF TIME VS. VELOCITY OF A SWIMMER AT DIFFERENT CYCLE RATES

ANALYSIS

The time taken for 100m breaststroke for three different cycle rates were calculated using the average velocity of a swimmer obtained from the simulation up to 10 cycles. This result predicts that 100m breaststroke record, 115.56s, will be the fastest at 1.3 cycle rate. This is a significant

difference when compared with other cycle rates, as there are 3.94s and 8.49s differences in time with the 1.5 cycle rate and the 1.7 cycle rate respectively.

Figure 5 revealed an important pattern of the velocity throughout the breaststroke cycles. The forward velocity is not constant for each cycle, and this result suggests that the forces created in the former cycle are still present in the next cycle. Firstly, a swimmer experiences the force backwards, which is the drag, when the water pressure behind a swimmer is lower than the water pressure in front of a swimmer due to the difference in water movement. Secondly, the turbulent flow takes time to disappear, so the drag force that swimmer experiences will be different in each stroke. Hence, the movement of water created by a former cycle affects the next cycle of breaststroke, which resulted in the pattern shown in Figure 5.

For the reason above, constant forward velocity for the last three cycles in 1.7 cycle rate can be assumed. As 1.7 cycle rate takes a longer time to finish a cycle, the effect of a former cycle in water dissipates before the next cycle comes. Therefore, as the number of cycles proceeds, there are fewer fluctuations of forward velocity and eventually becomes a constant forward velocity.

Overall, as the cycle rate got smaller, the fastest velocity among cycle rates was recorded at each cycle number. These results suggest that if the deceleration period between the end of the propulsive phase of arms and the beginning of the propulsive phase of the legs gets closer, the overall forward velocity increases. Eventually, the average velocity was also the fastest at the 1.3 cycle rate compared to other cycle rates.

Moreover, the uncertainties are minimized by the use of simulation, however, there are limitations and improvements for future investigation.

Firstly, the range of cycle rates was limited since this investigation was aimed to find the result that would be practical for the swimmers. However, for the purpose of understanding hydrodynamics, the range of cycle rates can be increased to observe the proportionality of cycle rate vs. breaststroke record.

Also, calculating an accurate time for 100m breaststroke was limited since 100m breaststroke takes place at the 50m pool, which suggests that there will be a turn with the initial condition. Although the forward velocity for 10 cycles was measured, this does not represent the whole 100m breaststroke average speed. For further investigation, the forward velocity of a swimmer for a greater number of breaststroke cycles need to be measured to accurately predict 100m breaststroke time.

The conclusion lead from the data on simulation is valid only for a swimmer who has exactly the same body shape, density, strength, and others. Although the qualitative observations and pattern of the results will be similar, the exact cycle rate may not work for everyone. As my own experiment shows, different factors like fatigue will affect the forward velocity in reality [1]. Therefore, making the cycle rate small may or may not be the immediate or

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Young Researchers' Conference 2018

Correlation Between The Time Taken Per Cycle and 100m Breaststroke Record

achievable solution to increase the forward velocity of breaststroke for everyone.

Furthermore, maintaining the consistent cycle rate for 100m breaststroke is difficult in real life. The simulation assumes that the breaststroke cycles are consistent, but as Table II reveals, the stroke rate is not consistent throughout the race. Regarding this, the measurement can be analyzed by using a camera to record the movement of a swimmer for 100m.

This experiment opens various questions that could be answered in the future. As mentioned earlier, the simulation calculates the entire swimming strokes with a consistent cycle rate. This is not the most accurate representation of a swimmer, as a cycle rate varies throughout a race. Although this is not applicable in Swumsuit, how combining different cycle rates during the course of 100m breaststroke can affect its time can be a useful investigation for the swimmers. This study answered how the cycle rate affects the time to swim 100m breaststroke. In addition to the cycle rate, stroke length (also known as cycle count) can be investigated in combination, as they are interrelated to each other and heavily discussed topic in competitive swimming [2].

CONCLUSION

The research question for this investigation was: How does the time taken for one cycle of breaststroke affect a 100m breaststroke record? According to the results from the simulation, the time taken for one cycle of breaststroke does affect the 100m breaststroke record. The propulsion force created by the arms and legs interfere at the different time by changing a cycle rate, hence, the overall forward velocity also changes. As the cycle rate became smaller, the forward velocity of a swimmer became faster, and the maximum overall forward velocity took place at the 1.3 cycle rate (about 46 stroke rate) among the data collection.

Therefore, the cycle rate is one of the factors that a swimmer can adopt to improve the breaststroke record significantly.

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Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

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Abstract - Breast cancer incidence rates remain high especially in the United States today, which may be due to its poor soybean diet and hence, the low genistein consumption. Genistein is a type of soy isoflavones which is shown to have protective effect in inducing apoptosis in breast cancer cells. In this investigation, protective effect of genistein was tested by measuring the activity of genistein as an antioxidant in relieving the oxidative stress caused in *Saccharomyces cerevisiae* cells as model organism. Yeast cells were treated with white fluorescent light to induce oxidative stress, and cell viability was observed to measure the degree of stress. The results suggest genistein relieves oxidative stress in yeast cells, but its activity saturates at higher genistein concentrations. However, further studies are required to run additional trials and reconsider the factors that limited the reliability of the results. The results may suggest high value of genistein in cancer research and offer this investigation as initial stage of cancer research scientists can run.

Key Words – Biology, genistein, yeast, oxidative stress, cell viability

INTRODUCTION

I. Research Question

How does the amount of natto (fermented soybean) in yeast solution affect the cell viability of *Saccharomyces cerevisiae* (Baker's yeast) cells treated with white fluorescent light?

II. Background context to research question

Genistein is a type of soy isoflavones included largely in soybeans, and genistein is shown to have protective effect in inducing apoptosis in breast cancer cell lines [1] and acting as an antioxidant to inhibit carcinogenesis [2]. Today, breast cancer incidence rates in United States are clearly higher than Asian countries such as Japan [3], and one of the reasons behind this difference may possibly be traced back to how soybean remains greatly minor in western diet [4].

In order to examine the protective effect of genistein at a more manageable level, this investigation focuses on measuring the antioxidant activity of genistein in relieving oxidative stress in Baker's yeast (*Saccharomyces*

cerevisiae) cells, which is a model organism widely used in scientific researches, including cancer researches [5]. Treatment with white fluorescent light is shown to induce oxidative stress in the yeast cells [6], and the stress may result in apoptosis [7]. This investigation specifically tests how increasing genistein concentration in yeast solution treated under white light affects yeast cell viability, where cell viability indicates degree of oxidative stress.

The goal of this investigation is to reassure the protective effect of genistein as an antioxidant, and explore how genistein can possibly prevent oxidative stress in precancerous cells from becoming cancerous. The result of this investigation may be offered to scientists as an initial step in cancer research and reassure the value of genistein in cancer research especially for western countries such as U.S., to combat its low soybean consumption and its high rates of breast cancer incidence.

As pure genistein was very expensive and difficult to purchase, fermented soybean (natto) was used in this experiment. Natto contains genistein, and genistein content in natto was estimated to conduct the procedure. In the experiment, data was collected also for control group, the samples without light treatment, to determine whether light is actually causing an effect. I hypothesized that the more fermented soybean (i.e., genistein) in yeast solution treated with white light, the higher the cell viability as a result of reduced oxidative stress. I also hypothesized that the control group will not show an increase in cell viability regardless of genistein concentration.

LITERATURE REVIEW

I. Genistein and fermented soybean

Genistein is a type soy isoflavones, included largely in soybeans [8]. Fermented soybean (natto) also includes genistein, containing approximately 229.1 micrograms of genistein per gram of natto [9].

II. Genistein as protective agent against breast cancer cells

Laboratory studies demonstrated genistein has a dose-dependent influence on inhibition and induced apoptosis of the breast cancer cells [1]. In addition, stress proteins protect the tumor cells from undergoing apoptosis, but genistein inhibits the stress response [1]. Eventually, genistein inhibits cell growth and induces apoptosis to the cancer cell

Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

lines [1]. More cell growth inhibition was observed with higher concentration and longer genistein treatment [1].

Demographic study on the effect of soybean isoflavones intake on the risk of breast cancer was also investigated among sample of Japanese female population [10]. The study shows positive correlation of isoflavones, quantified with genistein, and reduced risk of breast cancer [10]. It was found that women with highest consumption of miso soup (i.e., isoflavones) approximately had half the risk of breast cancer compared to women with the least consumption of miso soup in a day [10].

III. Yeast as model organism

Baker's yeast (*Saccharomyces cerevisiae*) is widely used as a model organism in many researches, including cancer researches to study cell cycle [5]. Cell division cycle genes (CDC genes) were identified in yeast cells and scientists determined cancer cell division is unable to be controlled [5]. Many similarities were found in genes involved in cell cycle between yeast and humans, such as CDC genes and cyclin-dependent kinase genes (CDK genes) [5].

IV. Oxidative Stress on Yeast Cells

Although yeast cells do not have photoreceptors to detect light, research shows visible light can induce oxidative stress on yeast cells and alter its metabolic rhythms [6]. The study analyzed yeast metabolism by observing yeast respiratory oscillation (YRO) [6]. They showed visible light inhibits the activity of light-absorbing cytochromes that helps to regulate oxidative stress, and reduces period and amplitude of YRO [6]. The effect on oxidative stress on yeast cells increased with stronger light intensity [6].

Yeast cells can take several pathways to respond to the oxidative stress when reactive oxygen species accumulate inside (Figure 1) such as cell survival or autophagy [7]. However, high oxidative stress along with excessive autophagy can lead to apoptosis [7].

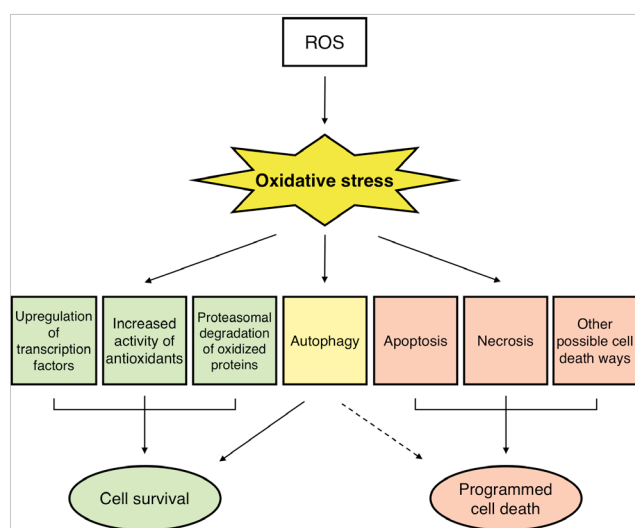


FIGURE 1
YEAST RESPONSE TO OXIDATIVE STRESS [7]

V. Antioxidant property of genistein

Genistein acts as antioxidants, by grabbing free radicals and reducing stress-response genes, thereby inhibiting carcinogenesis [2]. In addition, genistein has been shown to induce apoptosis and cell death of MCF-7 breast cancer cells by autophagy, and also the cytotoxic effect of genistein involved the modulation of antioxidant enzyme and signaling apoptosis to occur on the tumor cells [11].

VI. Material Context – Trypan Blue Assays on Yeast Cells

Trypan Blue is a fluorescent dye commonly used for cell viability staining [12]. Live cells contain intact cell membranes that regulate and distinguish certain dyes, including Trypan Blue [12]. However, since nonviable cells cannot exclude the dye from entering into the cell, viable cell will remain transparent color for its cytoplasm, whereas nonviable cell is stained and have a blue cytoplasm [12]. Trypan Blue assay is applied widely with yeast cell viability staining [13]. The staining is immediate on yeast cells, and applying this dye enables to distinguish between clear blue and transparent cytoplasm under standard microscope [13].

VII. Global Context – Soybean Consumption by Country

Average person in U.S. consumes approximately 40 grams of soybean per year, which is less than amount consumed by a Japanese person per day [4], which implies genistein consumption is low in U.S. as well.

VIII. Global Context – Breast Cancer Rates by Country

Comparing Japan and U.S., breast cancer incidence (Figure 2) increase as age and years increase, but incident rates are noticeably higher in U.S. compared to Japan.

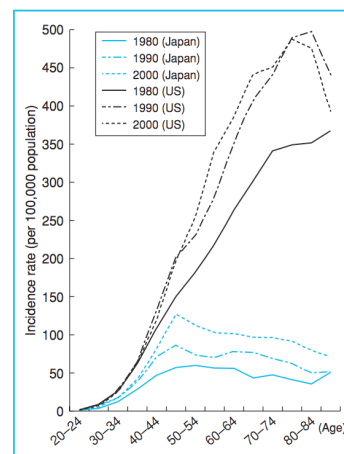


FIGURE 2
BREAST CANCER INCIDENCE RATES BY AGE GROUP, IN JAPAN AND U.S. [3]

HYPOTHESIS

I. Hypothesis for light-treated yeast

Fermented soybean (natto) contains genistein. [9]. Oxidative stress is caused when yeast is exposed to white fluorescent

Nov 23-24, Tokyo

Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

light [6], and these oxidative stress on yeast can lead to apoptosis [7]. However, genistein acts as an antioxidant, relieving oxidative stress [2]. With more amount of natto in yeast solution, (i.e., genistein) the oxidative stress would be relieved more, and yeast cell viability will increase.

II. Hypothesis for Light-untreated Yeast (Control Group)

Yeast solution not treated to light will not show increase in cell viability regardless of natto concentrations.

METHODOLOGY

I. Variables

Refer to Table I below for variables.

TABLE I
IDENTIFICATION OF VARIABLES

Variable	Identification
Independent	Amount of natto in yeast solution (0g, 0.29g, 0.59g, 0.88g, 1.77g)
Dependent	Cell viability of yeast cells (%)
Controlled	Time yeast solution is exposed to light (12 hours) Light intensity in the incubator (5000 lux) Temperature in the incubator (25°C) Magnification of the microscope (40x) Area of microscopic image to calculate cell viability (1072 × 712 ppi)

II. Justification of Procedure

The study that tested genistein and its cytotoxic effect on breast cancer cells conducted their procedure with 0, 5, 10, 15, and 30µM genistein [1], and these concentration ranges were followed in my experiment as well. In this experiment, genistein content was estimated in natto. Since the level of isoflavones in natto is approximately 229.1 micrograms of genistein per gram of food [9], this value was used to calculate the amount of natto that satisfies 0, 5, 10, 15, and 30µM genistein. In analysis, independent variable is referred to genistein concentration for simplicity.

Five milliliter of natto-yeast solution was then placed on petri dish to give a thin layer that allows consistent exposure of light to yeast. Then, the petri dish was placed in incubator for light treatment for 12 hours, which is the duration of the experiment of the study that investigated how white light causes oxidative stress in yeast [6].

Trypan blue was used to assess cell viability. To avoid large error in counting cells and considering time constraints, images of the yeast cells were each divided into 16 sections, and four random sections within were chosen to calculate cell viability from. The cells that are only fully present within the section were counted.

III. Experimental Procedure

Part 1 – Creating yeast-natto solution

1. Secure a separate conical flask in the water bath set to 37°C using ring stand and utility clamp. Put 5g of glucose in the conical flask [14].
2. Put 0.29g of natto (5µM genistein) and 50ml of 37°C

distilled water [14], and stir until dissolved.

3. Add 1g of yeast into the flask and stir [14].
4. Insert cotton wool on the opening of the flask.
5. Wait 30 minutes for the yeast to undergo fermentation.
6. Repeat step 1 to 5 four more times. For step 2, do not put any natto for one flask, and for other three, place 0.59g (10µM), 0.88g (15µM), 1.77g (30µM) each.

Part 2 – Preparation for light treatment

7. Place 5ml of the yeast solution into petri dish. Repeat this step for 25 times, with 5 petri dish per each natto amount in the yeast solution. Wash the pipette when moving on to the next conical flask.
8. Place the petri dish under white fluorescent light in incubator for 12 hours.

Part 3 – Preparing the slide and observing under microscope

9. Place 1 drop of the yeast culture from each petri dish after light treatment on a slide, add a drop of trypan blue, and place the cover glass. Wait for 10 minutes to dry. Repeat the step 25 times.
10. Observe the slides with microscope under high-power. Take the image of the area under microscope.

Part 4 – Calculating cell viability

11. Divide each image into 16 sections as Figure 3. Use random number generator to select four of the sections within the image, and calculate the cell viability from each section. The formula for calculating cell viability is shown below as Equation (1).

$$\frac{\text{number of viable cells}}{\text{total number of cells}} \times 100 = \text{cell viability (\%)} \quad (1)$$

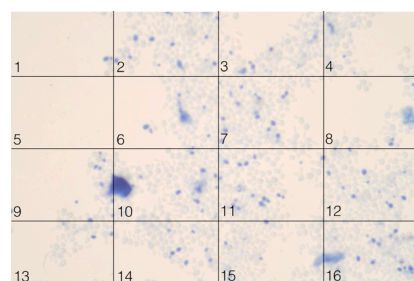


FIGURE 3
EXAMPLE OF THE IMAGE DIVIDED INTO 16 SECTIONS

The whole procedure was repeated twice to collect ten trials for each natto concentration. Due to time constraints, only one trial from each natto concentration was able to be collected for control group. For control group, part 1, 3, and 4 was followed similarly, and another tray was covered on top of the petri dish to prevent contact with light when placed in the incubator for 12 hours.

IV. Uncertainties

Uncertainties will be considered for genistein concentration and cell viability. For both variables, the uncertainty differs for each concentration and each picture to derive cell viability, so the highest uncertainty was taken to represent a general uncertainty. The highest uncertainty on genistein

Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

concentration was derived with $30\mu\text{M}$, with $\pm 0.3\mu\text{M}$. For uncertainty on cell viability, I took three pictures to count the number of cells again, but with more carefulness. The highest difference in cell viability was $\pm 0.5\%$.

RESULTS

I. Data

Refer to Table II for processed data. Each trial in the table refers to each petri dish cell viability was calculated from. Refer to Table III for data of control group.

TABLE II
PROCESSED DATA

Trial	Concentration of genistein ($\pm 0.3\mu\text{M}$)				
	0	5	10	15	30
Yeast cell viability ($\pm 0.5\%$)					
1	52.7	81.7	87.9	84.0	80.4
2	50.9	87.6	84.8	89.1	86.7
3	61.8	84.3	87.4	90.4	89.9
4	55.4	80.9	89.2	91.2	89.6
5	50.6	72.1	89.8	85.8	88.3
6	52.8	82.5	91.8	92.8	89.6
7	41.6	78.6	91.0	93.6	90.5
8	65.2	87.1	88.1	92.0	92.3
9	45.8	82.7	86.4	94.5	85.7
10	53.1	77.8	91.8	92.6	88.3
Average yeast cell viability ($\pm 0.5\%w$)					
	53.0	81.5	88.8	90.6	88.1
Standard deviation (%)					
	6.86	4.59	2.32	3.39	3.30

TABLE III
DATA FOR CONTROL GROUP

Trial	Concentration of genistein ($\pm 0.3\mu\text{M}$)				
	0	5	10	15	30
Yeast cell viability ($\pm 0.5\%$)					
1	48.4	80.9	82.7	85.9	90.9

Refer to Figure 4 and Figure 5 for graphical representation of data. Error bars on Figure 4 show standard deviation. Since only one trial on the control group was conducted, error bars for Figure 5 are not displayed.

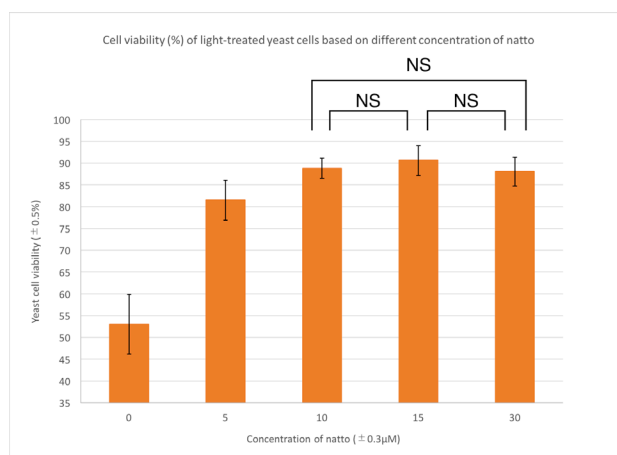


FIGURE 4
GRAPH OF PROCESSED DATA

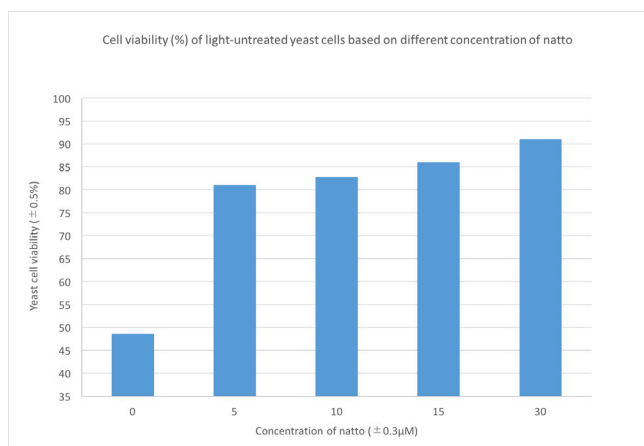


FIGURE 5
GRAPH OF DATA OF CONTROL GROUP

The data overall shows an increasing trend with cell viability along with increasing genistein concentration as seen from Figure 4. The expectation was to see a steeper increase from 15 to $30\mu\text{M}$ since it is the biggest intervals of genistein concentration, but the increase flattens afterwards and shows a slight decrease at $30\mu\text{M}$, which is an unexpected result. For control group, increase in cell viability was unexpected, but the data shows an increasing trend as seen with Figure 5.

II. ANOVA Test

To assess the differences between the means more precisely, statistical test was conducted. Since the data is in measurements and difference between the mean groups is to be tested, ANOVA test is suitable [15].

However, the data must be normal to conduct ANOVA test. To determine the normality of the data, Chi-Square Goodness-of-Fit test was conducted between each means of actual trials to derive the P-value. This test is used to assess the closeness of observed to expected values of the fitted model, in this case, the normality of the data [16]. P-value above 0.05 supports null hypothesis, determining the data is normal. Based on the calculation, the null hypothesis was supported, showing the data is normal that the ANOVA test can be conducted.

The ANOVA test was done between means of actual trials as well as between the means of actual trials and control group. As mentioned, there are no replicates for the control group, so normality of the data cannot be determined, and hence cannot be put under ANOVA test. However, it is important to compare results of actual trials with a control group, although this is a slight weakness.

III. ANOVA Test for Means of Actual Trials

One-way ANOVA test was conducted between two mean groups. The result is shown in Table IV. For all results, the degrees of freedom were 1 for between and 18 for within groups, and f-statistics was 4.41.

Nov 23-24, Tokyo

Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

TABLE IV
RESULTS OF ANOVA TEST FOR ACTUAL TRIALS

Mean Groups (first, latter)	First mean (S.E.M)	Latter mean (S.E.M)	Dif. of the means (%)	P-value	Support / Reject null hypothesis
0, 5 μ M	53.0 (2.17)	81.5 (1.45)	53.7	2.24E-09	Reject
0, 10 μ M	53.0 (2.17)	88.8 (0.738)	67.5	6.49E-12	Reject
0, 15 μ M	53.0 (2.17)	90.6 (1.08)	70.9	7.26E-12	Reject
0, 30 μ M	53.0 (2.17)	88.1 (1.04)	66.2	2.06E-11	Reject
5, 10 μ M	81.5 (1.45)	88.8 (0.738)	8.96	2.92E-04	Reject
5, 15 μ M	81.5 (1.45)	90.6 (1.08)	11.2	8.92E-04	Reject
5, 30 μ M	81.5 (1.45)	88.1 (1.04)	8.19	1.68E-03	Reject
10, 15 μ M	88.8 (0.738)	90.6 (1.08)	2.03	0.189	Support
10, 30 μ M	88.8 (0.738)	88.1 (1.04)	0.795	0.596	Support
15, 30 μ M	90.6 (1.08)	88.1 (1.04)	2.84	0.117	Support

The null hypothesis states there is no relationship between natto concentration and cell viability of yeast cells treated under light. The results suggest 0 μ M (53.0 ± 2.17) was significantly different ($p < 0.05$) from 5 μ M (81.5 ± 1.45), 10 μ M (88.8 ± 0.738), 15 μ M (90.6 ± 1.08), and 30 μ M (88.1 ± 1.04). Means of 5 μ M was additionally different to 10 μ M, 15 μ M, and 30 μ M. The others were not significant.

IV. ANOVA Test for Means of Actual Trials and Control Group

One-way ANOVA test was conducted between two mean groups from the same genistein concentration. The result is shown in Table V. Degrees of freedom and f-statistics were the same as results with means of actual trials.

TABLE V
RESULTS OF ANOVA TEST BETWEEN ACTUAL TRIALS AND CONTROL GROUP

Mean Groups (actual trials, controlled)	First mean (S.E.M)	Latter mean	Dif. of the means (%)	P-value	Support / Reject null hypothesis
0, 0 μ M	53.0 (2.17)	48.4	9.50	0.049	Reject
5, 5 μ M	81.5 (1.45)	80.9	0.742	0.669	Support
10, 10 μ M	88.8 (0.738)	82.7	7.38	1.46E-07	Reject
15, 15 μ M	90.6 (1.08)	85.9	5.47	3.72E-04	Reject
30, 30 μ M	88.1 (1.04)	90.9	3.18	0.0162	Reject

The null hypothesis states light treatment does not cause significant difference in cell viability. The results suggest significant difference among the two means of 0 μ M, 10 μ M, and 15 μ M. The others were not significant.

V. Findings and Suggestions

The data of actual trials overall shows the more genistein yeast cells are exposed to, the higher the cell viability, or the more the protective effect. However, the data shows the increase in protective effect is not significant as genistein concentration increased and showed slight decrease in cell viability at the highest concentration of 30 μ M, indicating a possible outlier.

The ANOVA test suggests the difference in cell viability between any two mean groups of the actual trials is significant, except between the mean groups of highest three

natto concentrations. This result, along with the pattern of the graph displayed on Figure 4, suggests the antioxidant activity of genistein may have reached a point of saturation at the highest three genistein concentrations.

The data of control group overall shows an increasing trend, which rejects my expectation. The result of ANOVA test between actual trials and control group indicates both significant and non-significant difference in cell viability, making ambiguous whether light treatment caused difference in yeast cell viability or not. However, since only one trial for control group was collected, the result of the ANOVA test cannot be given full reliability.

A possible suggestion could be that genistein increased yeast cell viability by reducing oxidative stress, but the source of oxidative stress was another factor, not light. Indeed, the study that studied visible light and oxidative stress in yeast suggested minor effect of oxidative stress at 90 μ molm⁻²s⁻¹ (approximately 6660 lux) [6]. The light intensity in the incubator I used was about 5000 lux, which may have been weak to cause oxidative stress. Based on this, aerobic condition may have been the alternative cause of oxidative stress [17]. A research shows under respiration, overproduction of recombinant protein α - amylase by yeast enhances oxidative stress in yeasts [17]. Since the yeast was left under aerobic condition in the incubator, this factor may have caused oxidative stress instead.

CONCLUSION

In this investigation, the antioxidant activity of genistein in reducing oxidative stress caused in *Saccharomyces cerevisiae* cells was investigated using white fluorescent light as a source of oxidative stress in yeast and observing yeast cell viability to measure the effect of oxidative stress. I have shown that antioxidant activity of genistein increases along with its increasing concentration, but saturates to a maximum at higher concentrations. Though, this result only partially supports my first hypothesis with actual trials as change in cell viability is non-significant between the highest three concentrations. My second hypothesis with control group was not supported since the results indicated an increasing trend, but more trials must be collected to carry out a more reliable data analysis.

Though, the results from this experiment suggests the protective effect of genistein as antioxidant, which is a valuable implication on how genistein may be able to inhibit precancerous cells to become cancerous. This factor is what researchers may want to identify at the initial stage of cancer research. The result of this experiment further assures value of studying genistein in cancer research, especially for western countries, such as U.S. to focus more on genistein in cancer research to combat its poor soybean diet and high breast cancer rates.

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Protective Effect of Genistein as Antioxidant, Included in Natto, on Yeast Cell Viability

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What Is The Relationship Between Keystroke And Timbre In Piano?

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Abstract – This paper is about ‘what is the relationship between timbre and keystroke of the piano?’. I confront this question and made a hypothesis by focusing on the hammer string interaction with Fourier series equation. Several hypotheses were made such as, decibel will decrease as harmonics increase. I conducted experiment by dropping coins from different height on piano key and analyzing it on the ‘Audacity’ to find difference in frequency spectrum. Results showed that at the bigger force, decline of decibel relative to harmonics was lower which led to brighter sound while at the smaller force, opposite result was shown leading to softer sound. At the same time, there was interesting results such as that harmonics content showed unique shape especially at larger force. This showed the complexity of piano and further variables of piano has to be considered to accurately predict the timbre of piano sound. This research and further work will be useful for pianist to have more accurate control on timbre with their keystroke rather than relying on senses which could be inaccurate.

Key Words – Fourier series, harmonic content, keystroke, piano, timbre

INTRODUCTION

I always had interest with piano and started practicing piano from high school as I had lots of free time after quitting Junior high school’s soccer club. Learning new pieces in piano was very fun and at some point, I learned that they are different key strokes in piano, different way of pressing piano key, such as staccato and legato. I knew that keystroke can control the volume of sound but I never knew to what extent do different keystrokes affect the timbre of sound such as bright and dark. This wonder lead to investigate the relationship between timbre of sound and keystroke from physics perspective.

BACK GROUND INFORMATION

In order to research the relationship between timbre and keystroke, definition of these two terms have to be clarified. Keystroke is separated into 3 parts, down stroke, hold, and lift [1]. Initially, I was planning to control these 3 components to replicate different kinds of keystroke. However, experimental trial indicated that controlling the lift was difficult. Therefore, I decided to concentrate on

down stroke by dropping coins on piano key from different height to remain it hold on key until sound diminishes. Therefore, in this paper, key stroke is defined as the force applied on down stroke.

Sound is composed of loudness, pitch, and timbre. Loudness is defined by amount of pressure difference caused by air molecules which has unit of decibel (dB) [2]. Pitch is determined by the number of vibration of air molecules in one second which is called frequency and it has unit of Hertz (Hz) [2]. Timbre is quality of sound. For example, there is difference in timbre between violin and piano that allows us to distinguish them even when the same pitch is played with same loudness. Timbre is composed of harmonics and dynamic characteristic [3]. Sound has a fundamental frequency that makes the pitch of the sound. At the same time, in reality, many sounds contain more than one pitch which are called overtone [3]. When frequency of overtones is integer multiple of fundamental frequency, they are called harmonics [3]. Human generally likes the sound which contains harmonics and musical instruments are designed to have the harmonics [4]. These harmonics has lower loudness than fundamental frequency so overall pitch of sound still remain the same but they add the characteristic to the sound which is essentially mechanism behind the timbre. Dynamic characteristic is how these harmonic content changes over time. In this paper, I will concentrate on harmonic content so timbre is defined as harmonic content, which is the relationship between frequency of harmonics and their loudness.

RESEARCH QUESTION

From these definitions of keystroke and timbre, my research question is, ‘What is the relationship between decibel, frequency of harmonics, and force applied on the C4 piano key?’

HYPOTHESIS

In total, 5 predictions are made.

(1) Inharmonicity will increase as the force on the piano key increase: Fundamental frequency of C4 is 262Hz [5] and frequency of harmonics will be its multiple integer. Inharmonicity occurs when the frequency of harmonics is slightly different from the multiple integer of fundamental frequency [4]. This happens because stiffness of string adds an extra force on restoring force (Hooke’s law) which quickens the vibration slightly [4]. As the stiffness of string

What is the relationship between keystroke and timbre in piano?

will increase as the string goes further away from the equilibrium position, inharmonicity is expected to increase as the force applied on piano key increase.

Following predictions are based on Fourier series formula for struck string [6],

$$f(x,t) = (2v_0L/\pi^2c) \sum_{n=1}^{\infty} (1/n^2) (-\cos(n\pi L_2/L) + \cos(n\pi L_1/L)) \sin(n\pi x/L) \sin(n\pi ct/L) \quad (1)$$

where x is a point in string, t is time, $f(x,t)$ is vertical displacement of point in string, n is number of harmonics, c is propagation velocity of wave, v_0 is an initial velocity of the string, L is total length of the string, L_1 and L_2 is the length from endpoint of the string where an interval between L_1 and L_2 is a contact length between string and hammer felt. c will be constant as $c = \sqrt{T/p}$, where T is tension of string and p is the linear density of the string, and both of these variables are set constant because both of these variables are included in formula of frequency, $f = \sqrt{(T/p)/2L}$, where frequency is set constant for C4 [4].

(2) As the force increases, decibel of fundamental frequency and harmonic increase: By momentum conservation in a collision, $m_{\text{hammer}}v_{\text{hammer}} = m_{\text{string}}v_0$ is formed. *Dijksterhuis* found that, $v_{\text{hammer}} = 1.32\sqrt{F_p - 0.44}$, where F_p is a force applied on a piano key [4]. Combining these two equation gives, $v_0 = (m_{\text{hammer}}/m_{\text{string}})1.32\sqrt{F_p - 0.44}$. This formula suggests that as the force applied on piano key increase, velocity of hammer increases inducing greater initial velocity of piano string, v_0 . Back to the (1), increase in v_0 increase the value of coefficient. Therefore, I predict that all the decibel in harmonic content will increase as force on a piano key increase.

(3) There will be a significant drop in amplitude at 8th harmonics: Hammer usually strikes at about $(1/8)L$ point of piano string. As result of this, having nodal point at $(1/8)L$ is unlikely thus amplitude of 8th harmonic is expected to be significantly low compared to other harmonics.

(4) Amplitude will decrease as the harmonics increase: In (1), there is component, $(1/n^2)$, and when the general graph of Fourier series formula was constructed, this had the significant influence on amplitude of each harmonic. Thus, in general, I predict that amplitude (decibel) will decrease as the harmonics increase.

(5) As the force increases, the decline of amplitude relative to harmonics will be reduced: There are two reasons for this prediction. First reason is due to the increase in contact length between string and hammer felt when force increase. Hammer felt has some elasticity so as hammer felt strikes string with larger force, it will compress more and contact length increase. This is representable by, $L_1 = (1/8)L - b$ and $L_2 = (1/8)L + b$, where b is half the contact length. Graphing the component in (1) which is related to the contact length, $[-\cos n\pi(1/8-b) + \cos(n\pi(1/8+b))]$, (it is absolute value form because distance of vertical displacement of string represents the loudness of harmonics irrespective of its direction), and changing the parameter b from 0.25cm to 1.5cm showed that slope of decline in amplitude relative to harmonic as predicted in (4) is reduced at bigger force [4].

Another reason is due to the contact time of collision between hammer felt and string. If contact time is close or bigger than the period of the frequency of string, then there will be a bigger disturbance on motion of string due to the contact between hammer felt and string [6]. From the work of Askenfelt and Jansson, the average contact time is about 3×10^{-3} s [4]. Period of fundamental frequency of C4 is about $T = 1/f = 1/262 \approx 3.82 \times 10^{-3}$. Even though contact time is lower, their order of magnitude is same and they are relatively close. Therefore, the effect of disturbance can be thought as significant. Since higher harmonics will have a shorter period, effect of disturbance will be larger for higher harmonics. Askenfelt and Jansson found that relationship between contact time, t_c and force applied on hammer felt by string, F_{hammer} is [4],

$$t_c \propto F_{\text{hammer}}^{-3}$$

Since the F_{hammer} increase as the hammer strikes the string with higher velocity (prediction (2)), F_{hammer} will increase as the force applied on piano key increases. Therefore, from above proportionality, contact time will decrease as the force applied on the piano key increase. As a result, as the force applied on piano key increase, contact time will decrease and loudness of harmonics will be less disturbed. Thus, decline in decibel relative to increase in harmonics will be reduced at the larger force.

METHODOLOGY

- **Dependent variable-** Decibel and frequency of each harmonic
- **Independent variable-** Force applied on piano key. This will be adjusted by dropping twenty 100yen coins from different height, 5cm, 10cm, 15cm, 20cm, and 25cm. Using the formula $F = (mgh)/d$ [7], m is mass of coins which is $20 \times 4.8 = 96$ g [8], g is gravitational acceleration near Earth's surface, 9.81ms^{-2} , and d is distance that piano key moves which is 9mm [4]. Calculation gives (each value is in 3 significant figures), 5.23N for 5cm, 10.5N for 10cm, 15.7N for 15cm, 20.9N for 20cm, and 26.2N for 25cm. Actual force will be slightly bigger than this by the weight of the tape which connects the pile of 100 yen coins but since its weight is very small compared to the mass of coin, its extra weight is negligible.
- **Controlled variables**
 - Stains on coin- weight of each coin have to be exact same in order for the calculated force to be accurate. I cleaned each coin with soap and water.
 - Angle of lid of piano- To have clearer sound recorded, I decided to open up the lid of the piano. As angle of piano lid will affect how sound diffract from sound board, angle of open lid is kept constant at 37.5° [4].
 - Position of recorder- due to the unique shape of piano lid and sound board, sound will diffract

Nov 23-24, Tokyo

What is the relationship between keystroke and timbre in piano?

and spread uniquely [4]. Since different harmonics will spread differently, I decided to keep the position of recorder (computer) next to the music sheet stand on piano.

- Room condition- temperature affects the movement of air particles so it will affect the quality of recorded sound [9]. When humidity is high, water molecules tend to absorb energy of high pitch sound and decays them faster [9]. Also, surrounding noise have to be minimized as much as possible. All of these room conditions are satisfied and kept consistent to great extent by gaining a permission to use the piano in larger school hall with door closed so change in temperature and humidity will be small as room is huge and the surrounding noise is minimized as it has sound proof system.

• Materials

- 100 yen coins \times 20, ruler ($\pm 0.5\text{mm}$), scissor, tape, paper tube (width under 2.3cm so it fit in single piano key), Acoustic piano (Yamaha's grand piano, C5X is used), computer and sound analysis software, 'Audacity' [10]

• Procedure

Firstly, cut the paper tube with scissor and create 5 cylinder tubes which has height, 5cm , 10cm , 15cm , 20cm , and 25cm . Then, pile twenty 100 yen coins and connect it tightly with the tape. Make sure to clean the coin with soap and water before sticking it. Place the 5cm cylinder tube on the C4 piano key with tape. Make sure that cylinder tube is only on the C4 piano key and does not intersect other piano keys. Then start recording with computer and drop the coin from the top of the cylinder tube. Finish recording as the sound completely diminishes. Repeat the recording for 5 times for each height.

Import all the recorded sound data to Audacity and use the function called spectrum analysis so Audacity will show the frequency spectrum of each recorded sounds.

I took the data of relative decibel of harmonics from 1st to 16th as amplitude was harder to indicate at higher harmonics. In Audacity, relative decibel is set relative to 0dB . Therefore, 0dB is maximum decibel and another decibel are recorded in negative sign. [10]

EXPERIMENTAL RESULTS AND ANALYSIS

I will analyze experimental result by responding to each prediction made in hypothesis.

(1) Inharmonicity will increase as the force on the piano key increase

Inharmonicity is calculated by subtracting measured frequency by ideal harmonic frequency.

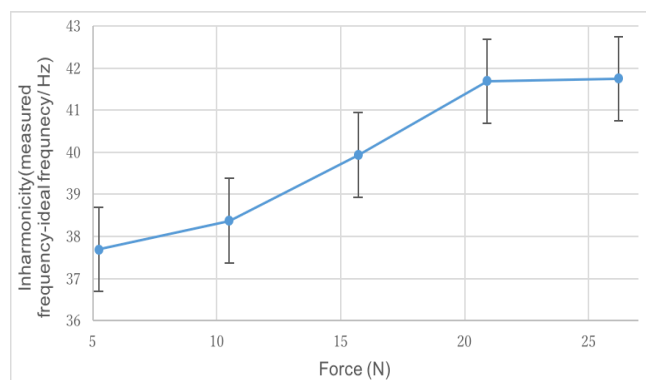
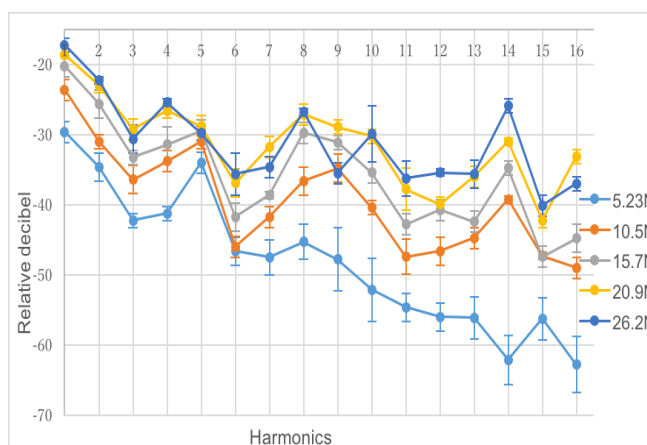


FIGURE 1

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN INHARMONICITY AND FORCE APPLIED ON PIANO KEY.

For uncertainty bar, absolute uncertainty of frequency in Audacity, which is 1 Hz, is used. All the value was positive and this shows that measured frequency was actually higher than ideal harmonic frequency. From graph, in general, average inharmonicity from 1st to 16th harmonics increased as the force increase and this supports the hypothesis. However, looking at uncertainty bar, uncertainty do overlap in some part and this shows the low precision of collected data.

FIGURE 2



GRAPH REPRESENTING THE RELATIONSHIP BETWEEN RELATIVE DECIBEL AND HARMONICS WHEN DIFFERENT FORCE IS APPLIED

Range is used for the uncertainty bar. Even though there is no overlapping of uncertainty bar at fundamental frequency, there are some overlapping at harmonics. This suggests that small difference in force applied on piano key has huge influence on composition of harmonic content. This shows how timbre of piano sound can be controlled with sensitive keystroke.

(2) As the force increases, decibel of fundamental frequency and harmonic increase

Most of harmonics and fundamental frequency in graph follows this hypothesis but they are some part where this hypothesis does not follow. For example, at 9th harmonics, decibel for 26.2N is lower than decibel for 10.5N, 15.7N, and 20.9N. This is highly due to the change in harmonics content relative to force applied on piano key.

Nov 23-24, Tokyo

What is the relationship between keystroke and timbre in piano?

(3) There will be a significant drop in amplitude at 8th harmonics

In the graph, there is no significant drop in decibel at 8th harmonics which opposes with the prediction. I predict that this is because due to the design of piano which I didn't considered in hypothesis such as resonance of other strings. Further research will be required.

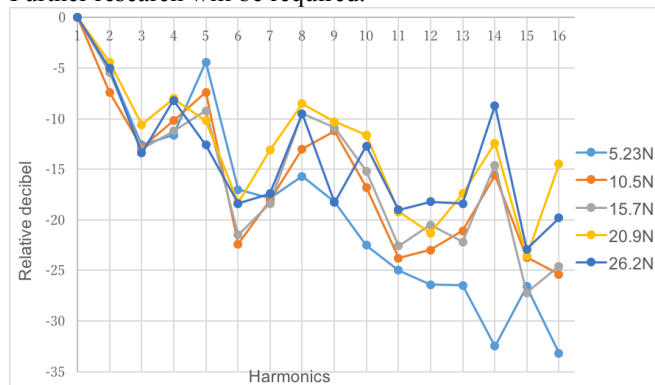


FIGURE 3

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN DIFFERENT IS APPLIED WITH DECIBEL AT FUNDAMENTAL FREQUENCY SET AT SAME POSITION

I set decibel of fundamental frequency at same position so I can compare their harmonic content clearly.

(4) Amplitude will decrease as the harmonics increase

In the graph, decibel did decrease from fundamental frequency to 16th harmonics but this relationship was not proportional. Rather decline slope takes very unique shape which represents the complexity of harmonic content. This unique harmonic content is what composes the original timbre of Yamaha's piano. However, since having 5 harmonic content in 1 graph was messier than I expected I decided to separate them into individual graphs. The decline in amplitude relative to harmonics can be compared by the slope of the trend line. Since amplitude is expected to decrease by $1/n^2$ as shown in the hypothesis, logarithmic function will be appropriate for the trend as they compose the similar decline shape.

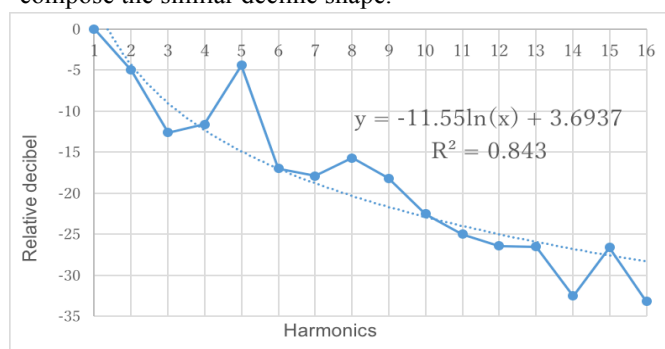


FIGURE 4

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN 5.23N IS APPLIED

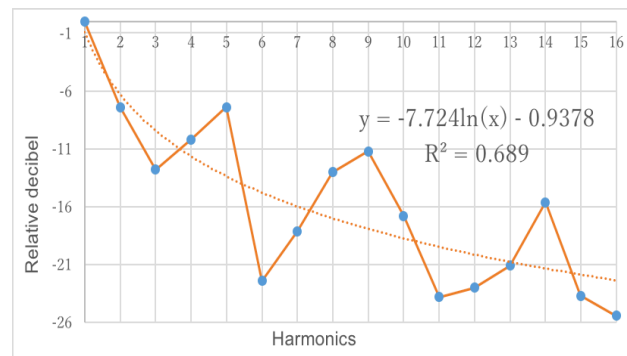


FIGURE 5

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN 10.5N IS APPLIED

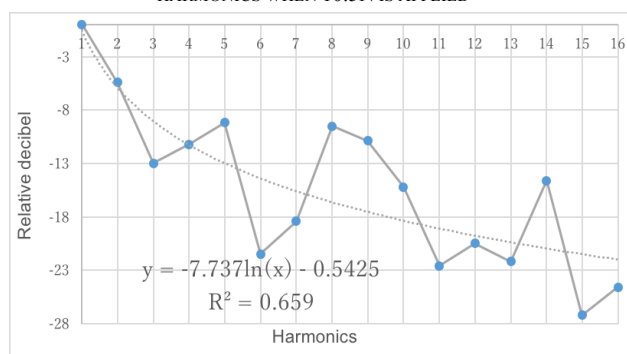


FIGURE 6

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN 15.7N IS APPLIED

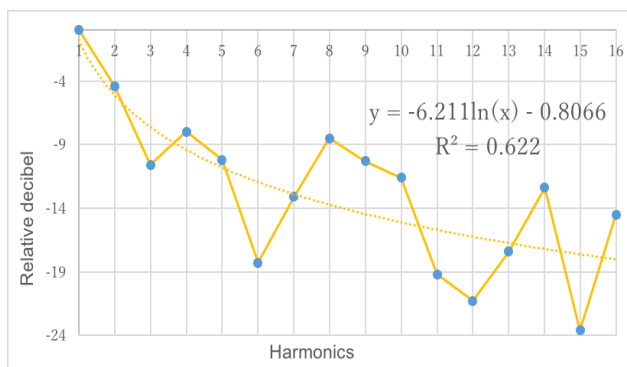


FIGURE 7

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN 20.9N IS APPLIED

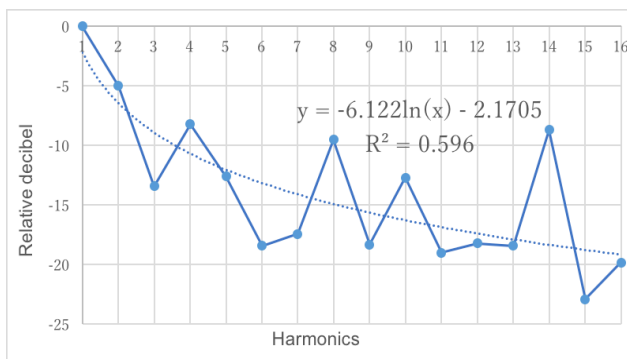


FIGURE 8

GRAPH REPRESENTING THE RELATIONSHIP BETWEEN DECIBEL AND HARMONICS WHEN 26.2N IS APPLIED

Nov 23-24, Tokyo

What is the relationship between keystroke and timbre in piano?

(5) As the force increases, the decline of amplitude relative to harmonics will be reduced

Comparing the slope for each graph, slope for $5.23N$ is -11.55 , $10.5N$ is -7.724 , $15.7N$ is -7.737 , $20.9N$ is -6.211 , and $26.2N$ is -6.122 . This data shows the slope increases as the force increase expect for $10.5N$ to $15.7N$. This trend supports the prediction (5) that decline in amplitude relative to harmonics is reduced as the force increased to some extent. Furthermore, for $5.23N$, R^2 value is 0.843 , 0.689 for $10.5N$, 0.659 for $15.7N$, 0.622 for $20.9N$, and 0.596 for $26.2N$. R^2 value is relatively high for $5.23N$ but R^2 value decreases as the force increases. This suggests that for bigger force, the harmonic content will not simply follow the relationship of '(3) amplitude will decrease as the harmonics increase' and become more complex.

CONCLUSION

In conclusion, brighter sound was produced at larger force and softer sound was produced at smaller force because, inharmonicity increased as the force increases and decline rate of decibel relative to harmonic was reduced as force increased expect from $10.5N$ to $15.7N$.

As other result, I found that as the force increases, decibel of harmonics increased in general and the small difference in decibel at fundamental led to huge difference in decibel at harmonics which shows sensitive keystroke can affect the timbre largely. Also, there was no decline at 8th harmonic and decibel did not decrease inversely proportional with harmonics. R^2 value of expected trend line drawn showed that it decreased as force increased and harmonic content became more unique rather than simply decreasing inversely proportional with harmonics.

WEAKNESS AND LIMITATIONS

- There was an inconsistency in the force applied on piano key because of the friction between coin and finger, and coin and paper tube which reduced the precision of the force as a random error to some extent. As one of the solution, coat lubricant oil around the coin and use metal tube so the friction will be reduced.
- All the data did not fit with the hypothesis and there were some outliers which reduces the validity of conclusion to some extent and I was only able to make general conclusion. Increasing trials and more accurate methodology for replicating keystroke will improve this experiment.
- Unique harmonic content seen in the graph is what forms an original timbre for Yamaha's grand piano C5X. Hypothesis on harmonic content was not accurate as I focused only on hammer-string interaction assuming it will follow struck string Fourier series formula. More accurate prediction will be possible by incorporating the design of different component in piano.
- There was an impact noise due to collision between coin and piano key, and this might have reduced the

accuracy of frequency spectrum to some extent as systematic error. To minimize this noise, soft material could be placed on the piano key or wrap the coin so the impact noise will be reduced.

- Harmonic content depends highly on tuning and condition of piano. However, it was unknown whether the piano is tuned properly and there is a possibility that unique harmonic content was due to mistuning. At the same time, harmonic content depends on the condition of piano such as oldness of hammer felt, string, wood used in soundboard. Therefore, the result of this experiment would be different depending on different grand piano which reduces the application of this result.

FURTHER WORK

As the further works, more different factors could be investigated to predict the harmonic content more accurately. For example,

- Horizontal vibration of string [4]
- Use of multiple string in one note [4]
- Effect of Aliquot stringing- some piano has extra string attached to resonate with struck string [11]
- Transfer of harmonic content from string to soundboard through bridge and rib. [4]
- More detail on how string-hammer contact affect the harmonic content [4]

To further investigate about timbre, dynamic characteristic such as ADSR (attack, decay, sustain, rest) could be researched [3]. Also, more different keystroke can be investigated such as by changing velocity of lift, softness of object pressing the key and so on. Furthermore, comparing harmonic content between different piano will be useful for pianist to distinguish them.

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Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere in a Low-Viscosity Newtonian Fluid

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Abstract – This paper answers, “What is the effect of temperature to the damping strength of a sphere that is viscously damped by water?” Viscous damping occurs due to the drag force of the fluid around the object. Using this, I created two mathematical models, the standard model which follows a common assumption about viscous damping, and an alternate model, which attempts to include the discarded information from the assumption. An experiment to test these models show that the overall trend is that as temperature increases, the damping strength decreases, similar to what the two models predicted. Although the models showed a trend that was consistent with the experimental results, it was concluded that it carries a limitation of having a high Reynolds number, as it causes a large systematic error. However, further studies can pursue an investigation of the differences between the two models proposed.

Key Words - Mathematical analysis, physics, fluid dynamics, viscosity, damped oscillations.

INTRODUCTION

A viscously damped system is a system where energy is dissipated due to the viscosity of the fluid. This has been widely researched and applied to inventions such as fluid dampers used in buildings such as the Beijing hotel [1]. When a force acts on the fluid damper causing it to stretch or compress, the piston inside will go back and forth [1]. This then causes the viscosity of the damping medium (liquid) to dissipate the energy that would otherwise be dissipated by the building itself. While these damping mediums are usually silicon oil, water can be used as an alternative [1]. For example, water has been used in another form of damping system utilizing the sloshing of water [2]. While water is not as effective at damping as a damping medium in a fluid damper, it has other advantages such as being easy to transport and lower cost.

Furthermore, water is in the group of fluids called Newtonian fluids, whose viscosity is largely affected by temperature [3]. As these dampers are integral in preventing structural failure of buildings, they have to be effective at all times. Therefore, the effect of temperature, a factor that changes throughout the year due to the seasons, should be

understood to what extent it can affect a component's effectiveness. This is especially true for the change in damping strength, which is the parameter determining how much the system is damped. From this, the research question was made: “What is the effect of temperature to the damping strength of a sphere that is viscously damped by water?”

LITERATURE REVIEW

Viscosity

Viscosity, or dynamic viscosity, is the measure of a fluid's tendency to resist flow or shear [4]. Shear stress τ is the ratio between a force F_s acting on the tangent to the surface of an object with area A [5]. This is written as:

$$\tau = \frac{F_s}{A}$$

This is important for the definition of viscosity, which can be seen by having two parallel plates A_1 and A_2 in a container of liquid, with the bottom one fixed. The plates are separated with a distance of Y . When the upper plate A_1 is moved with velocity u_0 by force F_s , the layer of liquid under the plate moves with it. This movement by the layer of liquid further causes the liquid under that layer to move in the same direction. This continues until it reaches the stationary plate A_2 , where the movement of the layer of the liquid will be zero. This is shown in Figure 1.

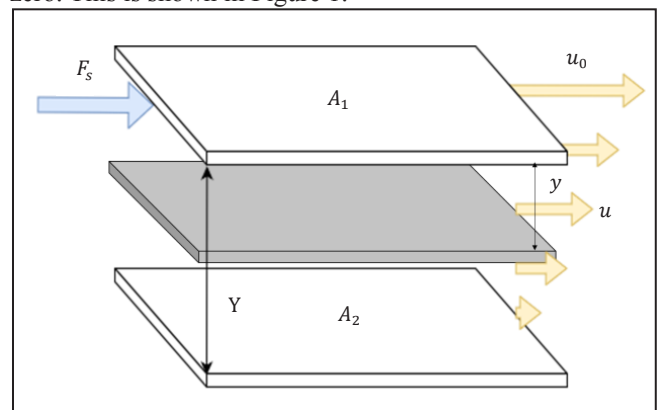


FIGURE 1

Two parallel plates with a fluid in between

Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere

The velocity u of the layer of the liquid that is distance y from plate A_1 has been shown to be [6]:

$$u = \frac{u_0 y}{Y} \quad (1)$$

Furthermore, the force acting on the upper plate F_s divided by the area of the plate A_1 is found to be proportional to u_0 and inversely proportional to Y , leading to the relationship [6]:

$$\frac{F_s}{A} \propto \frac{u_0}{Y}$$

We also know that $\frac{F_s}{A}$ is in fact the shear stress as the force is tangent to the surface of the plate. Furthermore, we can add a constant η to the proportionality, leading to:

$$\tau = \eta \frac{u_0}{Y}$$

The constant η is the definition of the dynamic viscosity of the fluid [6]. Since the ratio $\frac{u_0}{Y}$ is constant due to linear relationship between u_0 and Y from (1), the relationship can be expressed as:

$$\tau = \eta \frac{du}{dy}$$

This proportionality between shear stress and the strain rate $\frac{du}{dy}$ is also called Newton's law of viscosity [6]. The following section discusses the models for viscously damped oscillations.

MODELS FOR VISCOUSLY DAMPED OSCILLATIONS

There are multiple models suggested by scientists for the relationship between temperature and viscosity, both theoretically and semi-empirically [4]. However, before presenting these, the general trend will be discussed.

The general trend for gases is that as temperature increases, the viscosity increases. This is because the molecular interchange between the layers increases as temperature increases, due to the increased frequency of interactions between molecules [7]. On the other hand, for liquids, as temperature increases, the viscosity decreases. This is because as the temperature increases, the strength of the intermolecular forces between the particles decreases due to the increase in distance between the particles [7]. While a similar effect on molecular interchange occur for liquids, the net effect on viscosity decreases as temperature increases [7].

The model for the viscosity of water and temperature is correlated by several methods compiled by Dabir S. Viswanath, and the following multi constant model will be used in this paper as it was concluded to be the most accurate [4]:

$$\eta = e^{(A + \frac{B}{T} + C \ln T + DT^E)} \quad (2)$$

Where A is -51.964, B is 3670.6, C is 5.7331, D is -5.349×10^{-29} , and E is 10.

Furthermore, It should be noted that while pressure does affect viscosity, this change is negligible for fluids, so the discussion on pressure will be omitted [4]. The following section discusses the drag force on a sphere.

Drag force

For a sphere, the value for the damping force F_d can be found using Stokes' law [8]:

$$F_d = 6\pi r \eta u$$

Where r is the radius of the sphere. However, it has been shown by many that the original Stokes' law is insufficient for describing a viscously damped oscillating sphere. In fact, the damping strength is much larger for an oscillating sphere than Stokes' law predicts [9]. This is because Stokes' law assumes that it is a stationary motion [9]. Therefore, L.D. Landau and E.M. Lifshitz has derived a more appropriate equation for the drag force of a sphere oscillating in a fluid [9][10]:

$$F_d = 6\pi \eta r \left(1 + \frac{r}{\delta}\right) u + 3\pi r^2 \left(1 + \frac{2r}{9\delta}\right) \rho \delta \frac{du}{dt} \quad (3)$$

Where δ is the penetration depth given as:

$$\delta = \sqrt{\frac{2\eta}{\omega \rho}}$$

Where ρ is the density of the fluid. Penetration depth is an estimation for the thickness of the boundary layer of the fluids around the sphere [10]. To simplify calculations, the penetration depth will be assumed to be constant using the average viscosity as the difference was calculated to be small enough to be treated as a constant. Furthermore, the second term in (3) is dependent on the acceleration, which comes from the added inertia from the fluid that is moving with the sphere.

This equation is true if the diameter of the sphere is large compared to the amplitude. Furthermore, it is assumed to be in an ideal container, that is, a container with infinite volume. Therefore, a corrective term is needed to account for the finite volume. The suggested corrective term by Haubert is the ratio between the sphere and the width of the container, which therefore gives the expression:

$$F_d = q \left(6\pi \eta r \left(1 + \frac{r}{\delta}\right) u + 3\pi r^2 \left(1 + \frac{2r}{9\delta}\right) \rho \delta \frac{du}{dt} \right)$$

Where,

$$q = \left(1 + \frac{r}{D}\right)$$

Where D is the width of the container. We can also further simplify the equation by setting,

$$n = \left(1 + \frac{r}{\delta}\right)$$

Which gives the expression:

$$F_d = q \left(6\pi \eta r n u + 3\pi r^2 \left(1 + \frac{2r}{9\delta}\right) \rho \delta \frac{du}{dt} \right) \quad (4)$$

The following section discusses the motion of viscously damped oscillations.

Damped oscillations

Damped oscillations, or more specifically viscously damped oscillations, exhibit a movement that is similar to simple harmonic motion, but the amplitude decreases with every period due to the dissipation of energy to the surrounding fluid [8]. This dissipation of energy comes from the drag force due to the viscosity of the fluid it is in. As these systems oscillate, they are under-damped systems, where the damping

Nov 23-24, Tokyo

Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere

force is not significant enough for it to prevent the system from oscillating [8].

Most sources derive the equation of motion using the assumption that the damping force is dependent on the velocity leading to the force equation:

$$F_v = -kx - bu \quad (5)$$

Where F_v is the force acting on a viscously damped system, k is the spring constant, x is the displacement, and b is the damping constant. As this assumption is often used, for the purpose of this essay, (5) will be referred to as the standard model. It is important to note that this equation is the simple harmonic motion equation, but with an added term $-bu$, that is damping the system. Therefore, the term $-bu$ is the drag force.

Furthermore, an equation for the displacement from the equilibrium point can be derived from the force equation [5].

$$x(t) = Be^{-\frac{b}{2m}t} \cos(\omega't + \phi) \quad (6)$$

Where B is a constant for each system, m is the mass of the object, ϕ determines the phase of the oscillator and where,

$$\omega' = \omega \sqrt{1 - \frac{b^2}{4km}}$$

Which represents the angular frequency of a damped system. Examining the equation of motion (6) and Figure 2, we can see that the equation $E(t) = Be^{-\frac{b}{2m}t}$ envelopes the oscillation. This function will now on be referred to as the enveloping function.

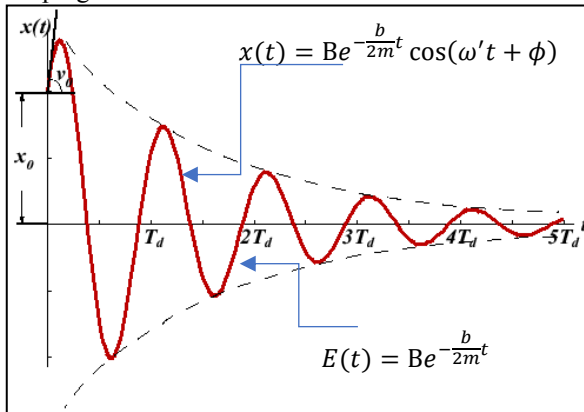


FIGURE 2
Damped oscillation and its enveloping function [11]

From the enveloping function, the parameter that determines how fast the function decreases, is $\frac{b}{2m}$. Therefore, we can say that this is the damping strength γ ,

$$\gamma = \frac{b}{2m}$$

Using this relationship, the relationship between temperature and the damping strength can be derived, which is discussed in the following sections.

Standard model

The following section discusses the damping strength following the standard model.

To find the relationship between temperature and the damping strength, the drag force has to be considered and how that fits into the force equation:

$$F_v = -kx - F_d$$

However, since the standard model assumes that the drag force is only dependent on velocity, only the term that is dependent on the velocity can be considered. Therefore,

$$F_d = bu = 6\pi r \eta q n u$$

$$b = 6\pi r \eta q n \quad (7)$$

From this, a more specific relationship between temperature and the damping strength can be derived from the temperature and viscosity correlation models proposed (2) and substitute it into (7):

$$\gamma = \frac{b}{2m} = \frac{6\pi r \eta q n e^{(A + \frac{B}{T} + C \ln T + DT^E)}}{2m} \quad (8)$$

Alternate model

On the other hand, we can create an alternate model by including the information that we have discarded in the standard model due to the assumption. This can be done by considering the second term of the drag force in (4) that is dependent on the acceleration. Therefore, the equation of motion will be slightly different using a new force equation:

$$F_d^* = bu + ca$$

$$F_v^* = -kx - F_d^*$$

$$F_v^* = -kx - bu - ca$$

Where F_d^* and F_v^* are the drag force and the force acting on the system for the alternate model, c is the damping constant for the damping term dependent on acceleration. The equation of motion for the alternate model $x(t)^*$ can be found to be:

$$x(t)^* = Ae^{-\frac{b}{2(m+c)}t} \cos(\omega't + \phi)$$

Note that the only difference is in the enveloping function, and so the overall motion of the system will be very similar to the standard model. Furthermore, because of the difference in the parameter in the power of e , we can say that for the alternate model,

$$\gamma^* = \frac{b}{2(m+c)}$$

Where γ^* is the damping strength for the alternate model. Also, it is clear that, similar to the standard model and from (4),

$$b = 6\pi r \eta q n$$

$$c = 3\pi r^2 \left(1 + \frac{2}{9} \frac{r}{\delta}\right) \rho \delta q$$

Therefore, the expected damping strength according to the temperature-viscosity models is:

$$\gamma^* = \frac{b}{2(m+c)} = \frac{6\pi r \eta q n e^{(A + \frac{B}{T} + C \ln T + DT^E)}}{2 \left(m + 3\pi r^2 \left(1 + \frac{2}{9} \frac{r}{\delta}\right) \rho \delta q\right)} \quad (9)$$

Nov 23-24, Tokyo

Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere

To test the two models, an experiment was designed, which will be explained in the following section.

EXPERIMENTAL METHOD

The methodology used is similar to Peter Alexander who investigated damping of a sphere in different fluids, but with some modifications [12]. The following are the modifications: instead of using a measuring cylinder, I used a beaker so that it could be heated. To change the temperature of the water, a hotplate was placed under the beaker as well. Furthermore, to monitor the temperature, a temperature probe with an uncertainty of 0.5K was used. A picture of the setup is shown in Figure 4.

Experimental setup

In order to measure the force acting on the spring, and therefore the displacement, a force sensor with an uncertainty of 0.01N is used. The spring constant was controlled by using the same spring for all trials, with a spring constant of 23.3Nm^{-1} . Furthermore, 300 ml of water was put into the beaker with diameter 78mm, and was maintained throughout the experiment, as (4) derived show that the container affects the drag force.

Data collection

The raw data collected is the force acted on the spring, which would allow for the calculation for the displacement, using Hooke's law, $F = kx$. The displacement would then be used to find the enveloping function.

To make the system oscillate, the string is pulled so that the ball will be at the bottom of the container. This was repeated for 333K, 323K, 313K, 303K, and 293K.

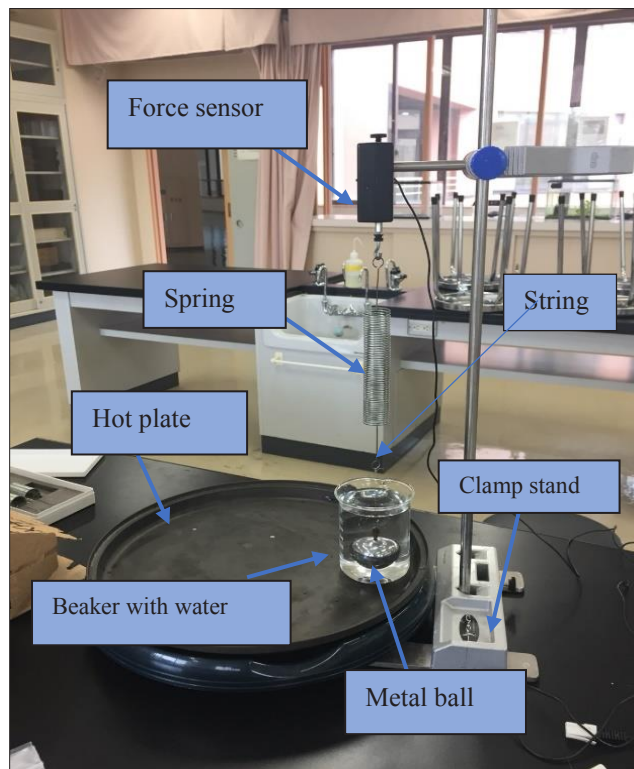


FIGURE 4
Picture and diagram of the experimental setup

ANALYSIS

The following is a sample of the raw data taken from the force sensor.

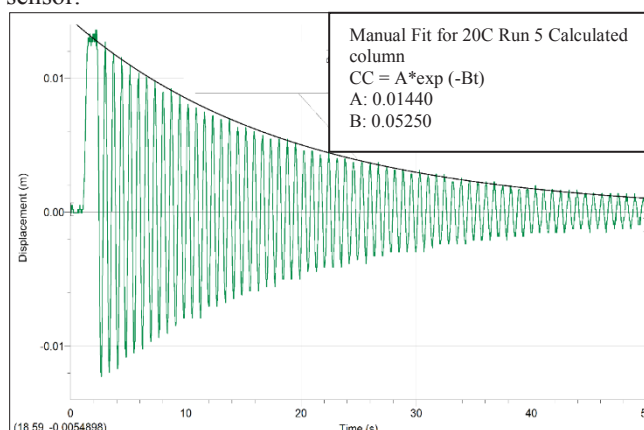


FIGURE 5
Sample of the raw data with curve fit

From this raw data, a curve fit for the enveloping function was drawn manually to find the coefficient of the exponent.

The curve fit that we expected for the enveloping function fits well. Since the curve fit was drawn manually, it is a source of error. This trend line was then used to find the parameters of the enveloping function (the value of the B in the graph). This value is the same as the damping strength, which is shown in the following data table.

Nov 23-24, Tokyo

Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere

TABLE I
Damping strength of the system varied with temperature

Temp. ±0.5(K)	Damping strength ± 0.003					Mean
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	
293.0	0.031	0.030	0.036	0.030	0.030	0.031
303.0	0.030	0.029	0.028	0.030	0.030	0.029
313.0	0.027	0.025	0.026	0.026	0.026	0.026
323.0	0.024	0.024	0.024	0.024	0.024	0.023
333.0	0.022	0.022	0.021	0.021	0.021	0.021

The standard deviation was taken for uncertainty for the damping strength as five trials were done. From the table, it is apparent that as the temperature increases, the damping strength decreases. Using this data, a graph was drawn, comparing the experimental values with theoretical values according to the two models.

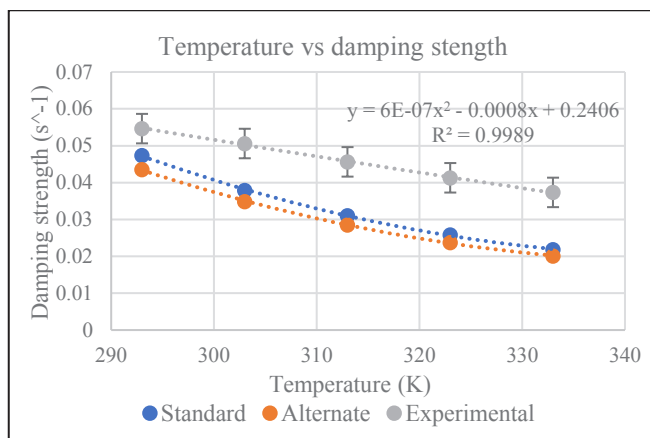


FIGURE 6
Temperature vs damping strength

The error bars for the theoretical models, as well as the horizontal error bars were omitted, since they were too small to be visible. From the graph, both the experimental and theoretical models predict the same trend: as the temperature increases, the damping strength decreases. This shows that as the temperature increases, the viscosity decreases, and the system will be less damped.

The curve fit for the experimental value was a quadratic one, with a high R squared value of 0.9989. The correlation is further supported by the fairly small error bars of the experimental values.

The Standard model and Alternate models predict fairly similar results. Furthermore, compared to the experimental values, the theoretical values predict a curve with more curvature. This signifies that, according to the theoretical models, the temperature starts to become a small factor at high temperature in terms of the damping strength.

From the graph it is clear that there is some degree of systematic error from the difference in damping between the theoretical models and the experimental data. The average of the percentage error is 30% and 36% for the standard and alternate model respectively. Furthermore, all the theoretical values are not within the error bars of the experimental model. The implication of this will be further discussed in the conclusion section.

CONCLUSION

From the processed data, I conclude that as the temperature increases, the damping strength of a sphere viscously damped by water decreases, due to the decrease in viscosity.

This conclusion is supported by several factors. First of all, Figure 6 supports my conclusion. Both the experimental and theoretical results predict the trend that as the temperature increases, the damping strength decreases. Evidence supporting this trend includes the high R squared value of 0.9989 supporting the curve, as well as the fairly small error bars in the experimental data points.

On the other hand, there are also evidence that refute my conclusion. The most prominent one being the difference between the experimental and theoretical model, suggesting high systematic error. In fact, the average percentage error for the standard and alternate models were 30% and 36%, respectively. However, this could be explained with effect of Reynold's number.

A dimensionless ratio called the Reynold's number, Re , is used for the prediction of the movement of fluid and drag force [8]. Reynold's number is defined as [8]:

$$Re = \frac{\rho u L}{\eta}$$

Where ρ is the density of the fluid and L is the reference length. For the case of a sphere, the reference length would be the diameter. Reynold's number is important as some models are shown to be accurate in specific ranges of it. According to Rhodes, experiments show that for a sphere in a fluid, Stokes' law is only appropriate when $Re < 2$ [13].

The measured maximum Reynold's number for this experiment was 588, taking the maximum velocity found by using the velocity equation, that could be found by taking the derivative of the equation of motion:

$$u(t) = Ae^{-\frac{b}{2m}t} \left(\frac{b}{2m} \cos(\omega't + \phi) + \omega' \sin(\omega't + \phi) \right)$$

A value of 588 shows that the Reynold's number of the experiment is largely above the specifications of the models [8]. In fact, studies have shown that in high Reynold's number, the damping decreases [14][15]. Therefore, this shows that Reynold's number is a valid explanation for the large systematic error.

It is important to note that when designing the experiment, the Reynold's number was attempted to be made smaller by making the amplitude smaller, which decreases the velocity. However, it was impossible to make it further smaller as if the oscillations became any smaller, then it would be impossible for the sensor to detect the displacement.

FUTURE WORKS

This paper raises a multitude of investigation that could be pursued.

A possible investigation is on the viability of the two models suggested in this paper. From my data, there were little difference between the standard model and the alternate model. To test the viability of each of them, damped

Nov 23-24, Tokyo

Investigation on the Effect of Temperature to the Damping Strength of a Viscously Damped Sphere

oscillation experiments with higher acceleration can be done to observe the deviation between the standard and alternate models.

Another suggestion is to investigate the relationship between temperature and the damping strength of Non-Newtonian liquids, the type of liquid that does not follow the aforementioned Newton's law of viscosity. This is because there can possibly be more application to Non-Newtonian liquids as damping as there are Non-Newtonian liquids that increase their viscosity when a force is applied. This may be useful in buildings and its protection against sudden force such as earthquakes.

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