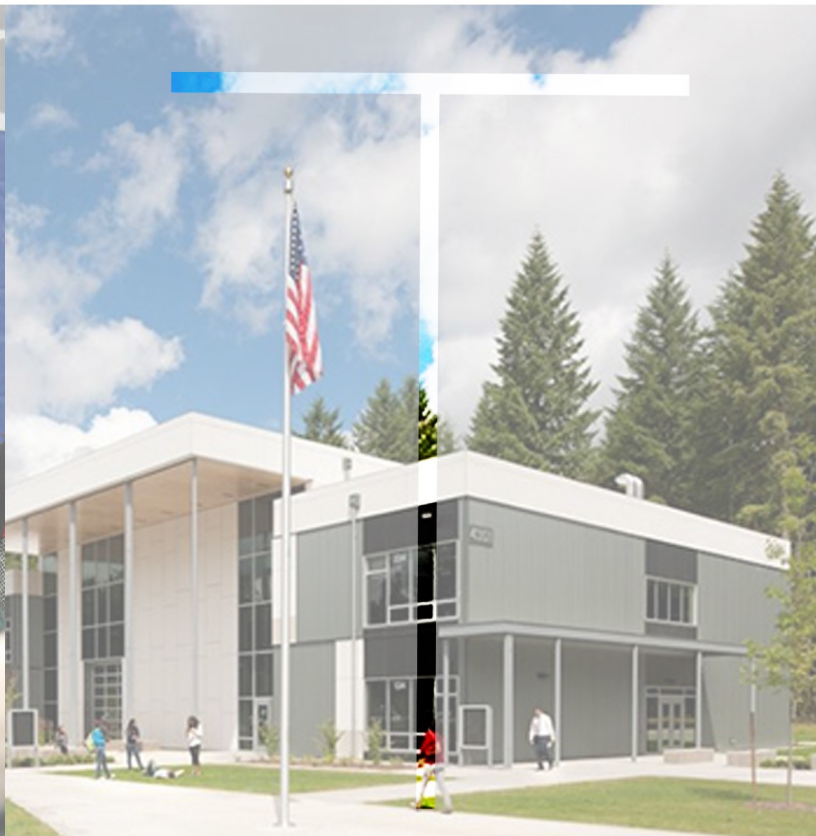


Nikola Tesla



Journal 2013-2014

Editor's Note

This second edition of the STEM Journal showcases the independent, classroom-based and competition-driven research of Tesla STEM High School students. The investigations presented this year reflect both our maturing research capabilities and the increasing diversity of our studies.

The online publication of this journal can be found at stemjournal.wordpress.com, and includes other opportunities for students, including internships and competitions. We encourage students to submit for next year's publication at thestemjournal@gmail.com.

The production of this journal would not have been possible without the dedication of the Journal staff, the support of our enthusiastic teachers, and the hard work of our student contributors.

**Editor-in-Chief,
Madison Minsk**

**Tesla STEM High School:
4301 228th Ave NE
Redmond, WA 98053
(425) 936-2770**

**Find us at:
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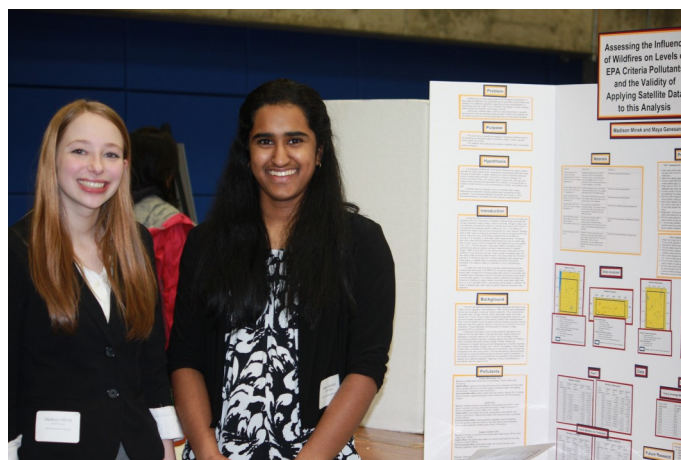
Assessing the Degree of Influence of Wildfires on Air Pollution

Madison Minsk and Maya Ganesan

INTRODUCTION

Air pollution causes thousands of illnesses and deaths each year. Among the factors contributing to air pollution and poor air quality are emissions from the combustion of wildfires. Wildfires likely contribute the primary pollutants organic carbon, carbon monoxide, nitrogen oxides, and non-methane hydrocarbons (NMOCs), the last two of which form ozone in a photochemical catalysis reaction (Jaffe et al., 2011). In order to better characterize the impact of wildfires on levels of air pollutants, data from both ground source measuring sites and Earth-orbiting satellites was used. As both forms of measurement are susceptible to external influence, data from multiple databases and methods was interfaced to better quantify the impact of wildfires, and the validity of this method of study was analyzed. The Mt. Bachelor Observatory (MBO) in Western Oregon provides a unique opportunity to compare accurate site measurements with satellite and ground source data. It is 9000 feet (2.8 km) above sea level, distanced from the influence of local pollution sources, but also able to take the same measurements as ground sites. Its elevation also allows the Mt. Bachelor site to be a better approximate of what satellites would see when viewing Earth. Thus, this research seeks to take a comprehensive approach by using data from varied sources to provide a more complete characterization of pollutant emissions from wildfires. To obtain more accurate air pollutant measurements, multiple sites in the IMPROVE monitoring network were used for organic carbon data, multiple EPA monitoring sites were used for ozone data, and satellite measurements were obtained for a given region to gather data on carbon monoxide levels and aerosol optical depth.

This research sought to determine the degree of influence of wildfires on ozone, carbon monoxide, particulate matter less than 2.5 mm in diam-



Madison Minsk and Maya Ganesan

eter ($PM_{2.5}$), and aerosol optical depth (the extinction coefficient when light is shined through a vertical column of air). In addition, the validity of satellite data, which is used to quantify some of these air pollutants, was assessed. It was expected that wildfires would most heavily influence organic carbon and aerosol optical depth levels because burned biomass—particularly wood—contributes almost all of the organic carbon in an area and therefore increases the haziness of the air, measured by AOD. The influence on ozone is expected to be smallest because ozone is a secondary pollutant, formed by a photochemical reaction between primary pollutants such as nitrogen oxides and volatile organic compounds. Although both these primary pollutants are generated from wildfires, the generation of ozone is subject to external factors, such as temperature, rainfall, wind patterns, and light. If satellite data is compared to ground site data, minimal differences are expected despite the number of potential environmental factors; this is because satellite instruments should be able to detect atmospheric compounds with just as much ease as ground site instruments that measure pollutants near the source.

BACKGROUND

The EPA set National Ambient Air Quality Standards (NAAQS) in the Clean Air Act, which was last amended in 1990. NAAQS were established for six main pollutants, known as “criteria” pollutants. These include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide (*National Ambient Air Quality*

Standards). When a region exceeds the standards placed on one or more of these pollutants, it must submit a State/Tribal Implementation Plan. A permit system is put into place to ensure polluting sources, such as factories, meet their goals for clean air (*Cleaning Up Commonly Found Pollutants*). These essentially limit the growth of industry in areas exceeding EPA air standards. A significant decrease in many of the pollutants regulated by the Clean Air Act has been seen in the past few years, largely thanks to a decrease in industrial regions (*Air Trends*). Yet, the acreage of land consumed by wildfires has been increasing sharply since the mid-1980s, a trend correlated with global climate change. Climate change has contributed to increased spring-summer temperatures, an earlier snowmelt, and a longer fire season (Westerling, et al., 2006). The Western United States is particularly vulnerable to forest fires due to its warmer, drier summers as compared to the rest of the country. The current trend in decreasing criteria pollutants could reverse and begin to climb as wildfires produce more and more air pollutants, notably, particulate matter and ozone.

Carbon monoxide (CO) is released when wood burns incompletely (van Donkelaar, et al., 2010). Carbon monoxide poisoning occurs because red blood cells have a greater affinity for CO than oxygen, blocking the uptake of oxygen into organs (Lary, 2011). CO also easily reacts with the hydroxyl radical (OH), forming carbon dioxide, a harmful greenhouse gas (*Carbon Monoxide: Its Environmental Impact*). Ozone (O₃) is a secondary pollutant, produced from the photochemical reaction between non-methane hydrocarbons and NO_x, both primary pollutants from wildfires (Jaffe, et al., 2008b). Ozone, also known as photochemical smog, can worsen bronchitis, emphysema, and asthma; as well as reduce lung function, inflame the linings of the lungs, and scar lung tissue (Lary, 2011). Ozone pollution harms sensitive vegetation and ecosystem, sometimes leading to a loss of species diversity and worsened habitat quality (Jaffe & Wigder, 2011). Organic carbon (OC) is the primary component of the particulate matter given off from fires (Jaffe, et al., 2008a). Fine particulate matter can cause cardiovascular and lung problems in humans as well as induce corrosion, vegetation damage and reduced visibility in the environment (*Fine Particulate Matter*). Aerosol Optical Depth (AOD)

is a measure of particulate matter (soot, sulfates, and other particles) in a whole atmospheric column, produced from burning (National Aeronautics & Space Administration, 2005). It can cause bronchitis and chronic inflammation of the respiratory effect, potentially leading to cancer (Anderson, 2001). AOD can also affect climate by changing when and where clouds are formed, as well reflecting and absorbing sunlight (National Aeronautics & Space Administration, 2005).

MATERIALS AND METHODS

Data was gathered on four measures of air pollution: organic carbon (OC), carbon monoxide (CO), aerosol optical depth (AOD), and ozone (O₃). Daily data was obtained from 2000 onwards depending on availability, and only values from the summer months (June 1 – September 30) were utilized in this analysis.

Data was gathered from the following online databases. Organic carbon data was collected from IMPROVE (Interagency Monitoring of Protected Visual Environments) ground sites maintained by Colorado State University; carbon monoxide volume mixing ratios were collected from NASA's Terra satellite orbiting Earth; aerosol optical depth data was collected from NASA's Atmospheric Infrared Sounder (AIRS) instrument on the Aqua satellite orbiting Earth; and ozone data was collected from EPA monitoring sites across the United States.

The ozone data collected provided pre-calculated MDA8 (maximum daily 8-hour average) values, the most common method of quantifying daily ozone, as EPA's regulatory standards are based on MDA8. In order for an MDA8 value to be considered representative, there must be 6 or more representative hourly measurements within the 8 hour period, and an hourly measurement must result from at least 30 minutes of sampling.

For each of the four variables measured, the monthly median values and yearly median values were calculated. The yearly median values for each variable were all plotted on the same axes, allowing for direct comparison between yearly trends and fluctuations in each variable. CO values were plotted on the primary axis, and OC, O₃, and AOD measurements were plotted

on the secondary axis. Some data sets were multiplied by a scale factor to optimize fit on the graph and enhance visibility of trends and patterns, although this multiplication did not affect statistical analyses.

Pearson correlation coefficient (r^2) analysis was then performed on individual pairs of data sets to determine the correlations between different pairs of air pollutants.

In order to determine wildfire influence, organic carbon data was used as an indicator. OC is produced through the burning of biomass—and in non-urban areas, such as those studied in this paper, almost entirely through wildfires (Jaffe, et al., 2008a). The average summer increase of particulate matter with a diameter smaller than $2.5\ \mu\text{m}$ (a primary component of which is organic carbon) ranged from 0.81 to $1.84\ \mu\text{g}/\text{m}^3$, varying between five regions measured in the western U.S. (Northern Rocky Mountains, Central Rocky Mountains, Southwest, California, and Pacific Northwest) (Jaffe, et al., 2008a). Therefore, levels of OC are expected to vary from region to region, depending on climate factors and the number of wildfires.

Four sites in the Western U.S. – west of the Rocky Mountains – were analyzed to cover differing climates and regions. Varying areas were selected in order to determine if a relationship could be determined across the entire western half of the country. Sites were picked in Northern Washington, Western Oregon, Northern California, and Southern Colorado.

In Northern Washington, three IMPROVE sites were used, at Snoqualmie National Forest, North Cascades National Park, and Pasayten Wilderness. The area examined for CO and AOD data was a square area encompassing all three IMPROVE sites and extended from 48 to 50 degrees latitude and -122 to -120 degrees longitude. Ozone data was collected from two EPA sites: North Bend, WA, and Anacortes, WA.

In Western Oregon, three IMPROVE sites were used, at Crater Lake National Park, Mount Hood, and Three Sisters Wilderness. The area examined for CO and AOD data was an area encompassing 42 to 45 degrees latitude and -124 to -121 degrees longitude. Ozone was collected from five EPA sites: Carus Trailer/Spangler

Road, Salem Turner at Cascade School, Eugene – Amazon Park, Eugene – Saginaw, and Bend Deschutes County Road Department. This data was compared to data from a measurement site at Mount Bachelor Observatory, which is strategically placed at 9,000 ft. elevation.

In Northern California, four IMPROVE sites were used, at Lava Beds National Monument, Redwood National Park, Lassen Volcanic National Park, and Trinity County. The area examined for CO and AOD data was an area extending from 40 to 42 degrees latitude and -124 to -120 degrees longitude. Ozone data was collected from nine EPA sites, Eureka Jacobs, Eureka Humboldt Hills, Shasta Lake—Lake Blvd., Redding Health Department, Anderson – North Street, Old Fire Lookout, Red Bluff, Lassen Volcanic National Park, and Yreka – Siskiyou.

In Southern Colorado, three IMPROVE sites were used: Great Sand Dunes National Park, Mesa Verde National Park, and Weminuche Wilderness. The area examined for AOD and CO measurements extended from 37 to 38 degrees latitude and -109 to -104 degrees longitude. Ozone data was collected from six EPA sites: Animas River Valley, Pine River Valley, Mesa Verde National Park, Weminuche Wilderness, Cortez Health Department, Miramonte, and Norwood.

RESULTS

Northern California

Year	CO (ppbv)	OC ($\mu\text{g}/\text{m}^3$)	AOD	O ₃ (ppbv)
2000			0.09	0.055167
2001			0.0855	0.045417
2002	113.3185		0.1	0.0551
2003	113.841		0.0915	0.054833
2004	112.115		0.075	0.056167
2005	111.011		0.0545	0.053
2006	112.002	1.185413	0.083	0.0565
2007	111.5365	0.568588	0.073	0.0465
2008	115.583	1.7299	0.16	0.048143
2009	109.301		0.074	0.046563
2010	110.2045		0.044	0.046938
2011	109.216		0.058	0.044389
2012	112.9105		0.073	0.046167
2013			0.046	0.041389

Southern Colorado

Year	CO (ppbv)	OC ($\mu\text{g}/\text{m}^3$)	AOD	O ₃ (ppbv)
2000		0.919692	0.157	0.053167
2001		0.6038	0.147	0.0445
2002	106.229	0.945108	0.171	0.048417
2003	112.4865	1.008808	0.16	0.052
2004	108.528	0.664375	0.148	0.053375
2005	108.499	0.653042	0.144	0.053667
2006	111.351	0.776267	0.159	0.0565
2007	112.457	0.722567	0.1665	0.057
2008	110.4495	0.799583	0.151	0.0541
2009	107.9755	0.696033	0.141	0.05175
2010	106.287	0.50535	0.099	0.052158
2011	105.327	0.594933	0.118	0.056958
2012	107.742	0.801408	0.119	0.0563
2013			0.1245	0.05265

Northern Washington

Year	CO (ppbv)	OC ($\mu\text{g}/\text{m}^3$)	AOD	O ₃ (ppbv)
2000		1.1398	0.093	0.02975
2001		0.764	0.089	0.029
2002	114.0833	1.09085	0.1015	0.03275
2003	116.4935	1.924	0.119	0.04
2004	113.427	1.38705	0.13825	0.0295
2005	112.2555	0.613275	0.0805	0.031
2006	111.3975	1.04075	0.12025	0.03325
2007	112.4573	0.5349	0.1	0.0305
2008	112.1698	0.542633	0.115	0.03
2009	110.3488	1.006675	0.16275	0.035
2010	111.2775	0.4608	0.09125	0.027
2011	109.703	0.55975	0.1015	0.03
2012	113.6355	0.76245	0.102	0.033
2013			0.0875	0.036

Western Oregon

Year	CO (ppbv)	OC ($\mu\text{g}/\text{m}^3$)	AOD	O ₃ (ppbv)
2000			0.063	0.032125
2001			0.0805	0.03425
2002	115.5745		0.1065	0.0375
2003	116.516		0.081	0.039875
2004	112.986		0.077	0.03425
2005	111.578		0.05	0.035125
2006	112.636	0.600415	0.074	0.03775
2007	112.878	0.539195	0.0625	0.032125
2008	114.44	0.525852	0.113	0.0345
2009	109.913		0.0955	0.036
2010	111.727		0.053	0.0327
2011	110.7835		0.059	0.0353
2012	114.7295		0.074	0.0377
2013			0.05	0.0353

Northern California

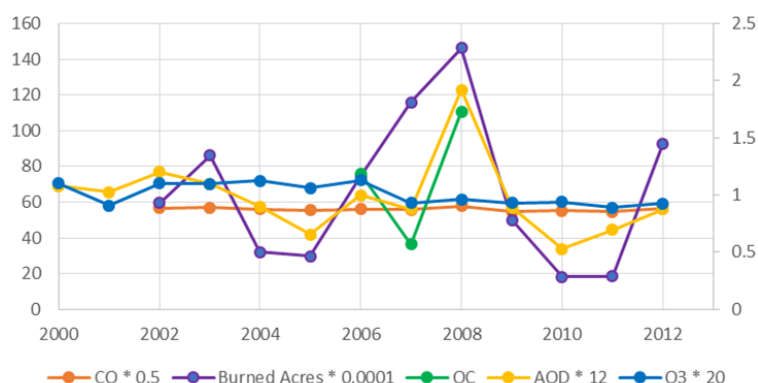


Figure 1.1: Time series of June- September median values for CO, burned acres (left axis), and OC, AOD, and O3 (right axis).

Northern Washington

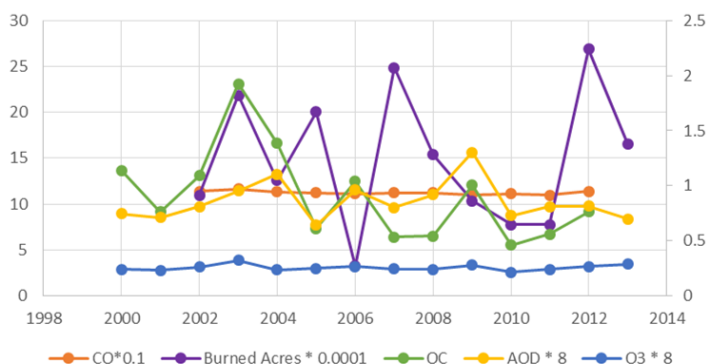


Figure 1.2: Time series of June- September median values for CO, burned acres (left axis), and OC, AOD, and O3 (right axis).

Southern Colorado

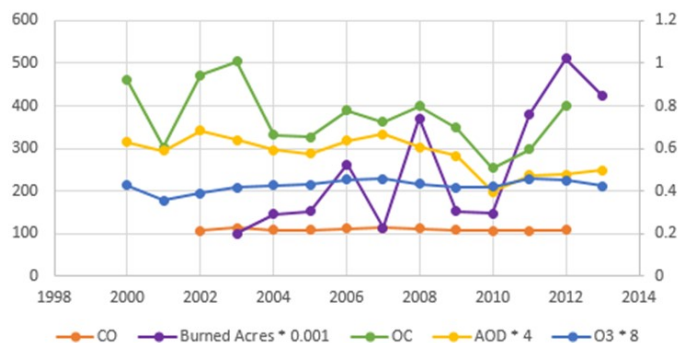


Figure 1.3: Time series of June- September median values for CO, burned acres (left axis), and OC, AOD, and O3 (right axis).

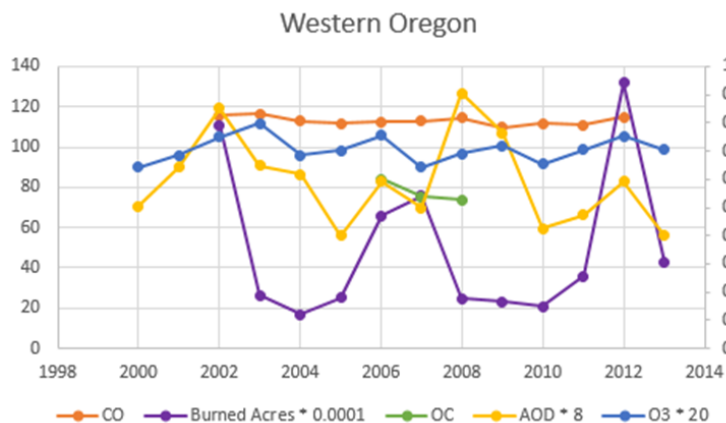


Figure 1.4: Time series of June- September median values for CO, burned acres (left axis), and OC, AOD, and O3 (right axis).

	Northern California	Northern Washington	Southern Colorado	Western Oregon
OC & CO	0.1953	0.494	0.316	0.0115
OC & AOD	0.8616	0.197	0.446	0.1944
OC & O ₃	0.116	0.5099	0.121	0.1114
CO & AOD	0.3165	0.0054	0.228	0.2296
CO & O ₃	0.033	0.318	0.18	0.070
AOD & O ₃	0.0882	0.20	0.09	0.005
Burned Area & AOD	0.548	0.43	0.183	0.026
Burned Area & CO	0.56	0.00009	0.123	0.188
Burned Area & OC	0.153	0.05	0.002	0.235
Burned Area & O ₃	0.003	0.0037	0.154	0.098

Figure 1.5: Pearson correlation coefficients for sites examined.

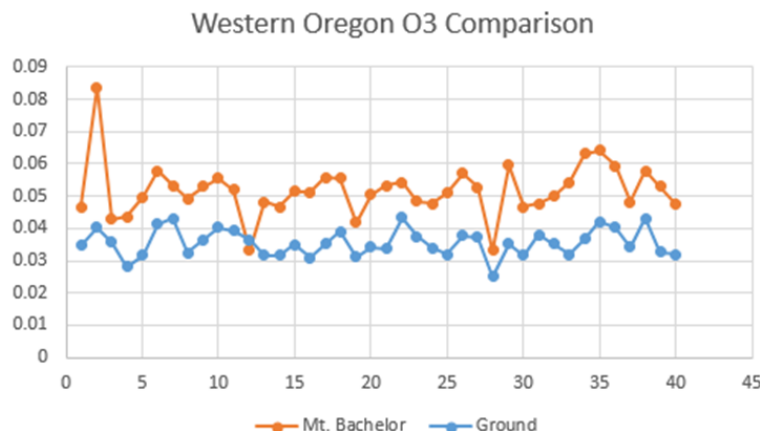


Figure 1.6: Comparison of ozone data from Mt. Bachelor and ground sites in W. Oregon.

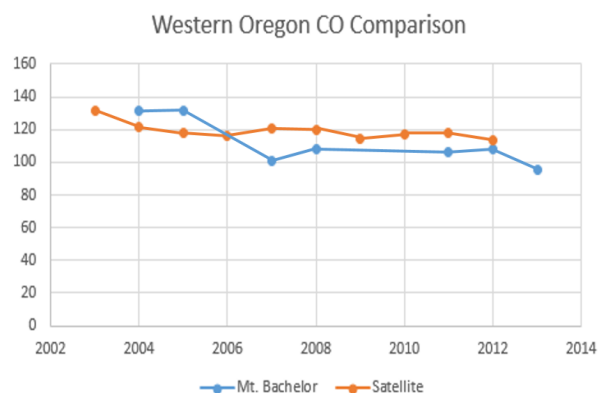


Figure 1.7: Graph of CO data from Mt. Bachelor and satellites over W. Oregon.

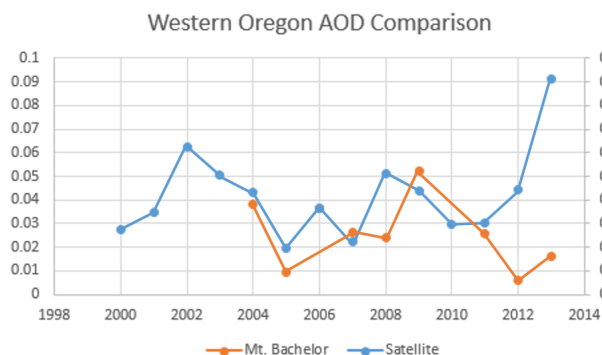


Figure 1.8: Graph of AOD data from Mt. Bachelor and satellites over W. Oregon

	O ₃ (ground)	CO (satellite)	AOD (satellite)
Pearson correlation coefficient	0.326	0.05	0.01

Figure 1.9: r^2 values comparing Mt. Bachelor and satellite data for 3 variables

DISCUSSION AND CONCLUSION

Although some of the r^2 values appear small and close to 0, they can be considered statistically significant. For Pearson correlation coefficients, the greater the degree of freedom (DOF), the lower the critical value of r . When looking at a linear relationship (as in the case of one variable plotted against the other), the degree of freedom is $n - 2$, where n is the number of data pairs. By using a Pearson correlation coefficient critical value

table, it can be seen that when the DOF is greater than 100 – as in the case of this analysis – the correlation coefficient can be less than 0.164 to be statistically significant. In this analysis, 0.164 is used as an overestimate of the critical value in order to ensure maximum accuracy. Values of satellite data and ground data from Western Oregon were compared with data collected at the Mount Bachelor Observatory in the same area. The Mount Bachelor Observatory (MBO), located at an altitude of 9000 feet, provides a unique opportunity to give accurate air pollutant measurements for Western Oregon. MBO is distanced from the influence of local pollution sources, closer to what the satellite sees, but is also able to take physical measurements.. The ground site value (ozone) showed a significant correlation of 0.326 with the Mount Bachelor values, while satellite values showed a smaller, less significant correlation. However, as satellite values can fluctuate depending on environmental conditions, this comparison would need to be investigated in sites across the western United States in order to make a more conclusive and general statement about the relative validity of satellite data.

Many correlations varied from region to region, reflecting differing climate conditions and implying wind transport influence. AOD & CO demonstrated a significant correlation in Northern California, Southern Colorado, and Western Oregon, but the correlation in Northern Washington was not statistically significant. AOD & OC were strongly correlated in Northern California and Southern Colorado—regions known for having a particularly high incidence of wildfires—while the correlations in the Pacific Northwest were smaller and almost identical. The correlations between AOD & ozone and CO & ozone were small across all sites.

The correlations between ozone and OC were nearly identical in Northern California and Western Oregon, notable in Northern Washington, and insignificant in Southern Colorado. The correlation between CO and OC was nearly nonexistent in Western Oregon and notable in the other three sites, although it was highest in Northern Washington.

This data demonstrates that the trends between all air pollution variables cannot be uniformly

quantified across different regions in the western U.S. There was little to no uniformity in trends of pollutant levels across the four regions selected.

Of particular note is the correlation between AOD & organic carbon, which demonstrated a significant correlation across the four sites selected. This is understandable, as organic carbon is a primary component of PM_{2.5}, which impedes light diffraction and therefore increases AOD.

Organic carbon and ozone showed a relatively significant correlation across the four regions, but the r^2 values were weak. Organic carbon and CO showed strong correlations in three of the four regions, but there was no correlation in Western Oregon. This may be due to external factors, such as rainfall, prevalence of wildfires, inaccuracies in measuring instruments, or wind transport of pollutants.

In conclusion, the data proved the original hypothesis regarding degree of influence to be correct. The burned area from wildfires affected particulate matter concentration—organic carbon and AOD—most extensively. There was a much smaller correlation between wildfires and ozone, or ozone and any other pollutant. The area with the most fires, Northern California, had a much greater correlation between all pollutants than at any of the other sites. This shows wildfires do affect the pollutants studied in this analysis, but to varying degrees based on climate factors.

Additionally, the ground source data collected for Western Oregon ozone measurements showed a very close correlation with the Mt. Bachelor data. This demonstrates that Mt. Bachelor is a reliable indicator of ground pollutants, and is not as affected by local confounding variables. The satellite data collected for carbon monoxide and AOD showed a much smaller correlation with Mt. Bachelor measurements for the pollutants. This questions the reliability of using satellite data as a method of quantifying pollutant amounts. Thus, both satellite and ground data sources are reliable indicators of trends in air pollutants, but not of specific quantities of the pollutants.

Works Cited

- Air Trends*. Retrieved from <http://www.epa.gov/airtrends/>
- Anderson, A., Cipriani, J., Cross, R., Davidson, K., Hamlett, A., & Stewart, D. (2001). *Climate, Aerosols, and Human Health*. Retrieved from http://icp.giss.nasa.gov/research/ppa/2001/2001_cross_etal.pdf
- Basic Information*. Retrieved from <http://www.epa.gov/glo/basic.html>
- Carbon Monoxide: Its Environmental Impact*. Retrieved from http://esseacourses.strategies.org/module.php?module_id=170
- Carbon Monoxide Poisoning*. Retrieved from http://www.redcross.org/images/ME/DIA_CustomProductCatalog/m4340092_FireCOFactSheet.pdf
- Cleaning Up Commonly Found Air Pollutants*. Retrieved from <http://www.epa.gov/air/caa/peg/cleanup.html>
- Health Effects*. Retrieved from <http://www.epa.gov/glo/health.html>
- Jaffe, D., Chand, D., Hafner, W., Westerling, A., & Spracklen, D. (2008). Influence of Fires on O₃ Concentrations in the Western U.S. *Environmental Science and Technology*, 5885-91.
- Jaffe, D., Wigder, N. (2011). Ozone production from wildfires: A critical review. *Atmospheric Environment*, 1-10.
- Jaffe, D., Wigder, N., Downey, N., Pfister, G., Boynard, A., & Reid, S. (2013). Impact of Wildfires on Ozone Exceptional Events in the Western U.S. *Environmental Science and Technology*, 11065-72.
- Jaffe, D., Hafner, W., Chand, D., Westerling, A., and Spracklen, D. (2008). Interannual Variations in PM_{2.5} due to Wildfires in the Western United States. *Environmental Science and Technology*, 2812-18.
- Lary, D. (2011, July 1). *Air pollution measurement from satellite data sources at the breathing level of atmosphere*. Retrieved from http://utdallas.edu/~david.lary/DavidLary/Grants/Etries/2011/7/1_Air_pollution_measurement_from_satellite_data_sources_at_the_breathing_level_of_atmosphere.html
- National Aeronautics & Space Administration. (2005). [Interactive map on wildfires and aerosol optical depth data]. *Earth Observatory*. Retrieved from http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD14A1_M_FIRE&d2=MODAL2_M_AER_OD
- National Ambient Air Quality Standards (NAAQS)*. Retrieved from <http://www.epa.gov/air/criteria.html>
- van Donkelaar, A., Martin, R., Brauer, M., Kahn, R., Levy, R., Verduzco, C., & Villeneuve, P. (2010). Global Estimates of Ambient Fine Particulate Matter Concentrations from Satellite-Based Aerosol Optical Depth: Development and Application. *Environmental Health Perspectives*, 118 (201). Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2898863/>
- Westerling, A., Hidalgo, H.G., Cayan, D., & Swetnam, T. (2006, August 18). Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science*, 313. Retrieved from <http://www.sciencemag.org/content/313/5789/940.short>
- Wigder, N., Jaffe, D., and Saketa, F. (2013). Ozone and particulate matter enhancements from regional wildfires observed at Mount Bachelor during 2004–2011. *Atmospheric Environment*, 75, 24-31.

(2010). *Fine Particulate Matter*. Retrieved from <http://www.airqualityontario.com/science/pollutants/particulates.php>

(2013, July). *Frequently Asked Questions*. Retrieved from <http://www.cdc.gov/co/faqs.htm>

Appendix

Pollutant	Data Source	Reference
Carbon Monoxide CO volume mixing ratio ascending at 802.0 hPa From 2002 to 2013 (June 1 through September 30 each year)	Satellite observations from the AIRS instrument. AIRS is the Atmospheric Infrared Sounder, an instrument aboard EOS Aqua satellite, in the “A-Train” series of satellites launched in 2002. Data was obtained from Giovanni database, run by NASA.	http://disc.sci.gsfc.nasa.gov/giovanni
Aerosol Optical Depth At 550 nm from 2002 to 2013 (June 1 to September 30 each year)	Satellite observations from Terra MODIS instrument aboard the EOS Terra satellite. Data obtained from Giovanni database, run by NASA.	http://disc.sci.gsfc.nasa.gov/giovanni
Ozone MDA8 (maximum 8-hour daily average) from 2002 to 2013 (June 1 through September 30 each year)	EPA outdoor monitoring sites across the United States. Data comes mainly from Air Quality System (AQS) database.	http://www.epa.gov/airquality/airdata/
Organic Carbon PM2.5 from 2002 to 2013 (June 1 through September 30 each year)	Aerosol data from the IMPROVE monitoring network. This network monitors aerosol, light scatter, light extinction, and scene samplers in National Parks and Wilderness areas.	http://vista.cira.colostate.edu/improve/Default.htm
Carbon Monoxide, Aerosol Optical Depth, Ozone, and Organic Carbon Hourly data from 2004-2013	Hourly measurements of pollutants taken at Mt. Bachelor Observatory (MBO) in Western Oregon. MBO is located 9000 feet (2.8 km) above sea level, closer to the atmosphere measured by the satellites.	http://www.atmos.washington.edu/jaffegroup/modules/MBO/
Acres burned yearly 2002 to 2013	Database of acres burned yearly due to wildfires including prescribed wildfires. The data includes reported fires from the Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, National Park Service, and Forest Service.	http://www.nifc.gov/fireInfo/fireInfo_statistics.html

The Effect of Manipulated Sleep Patterns on Adolescent Memory

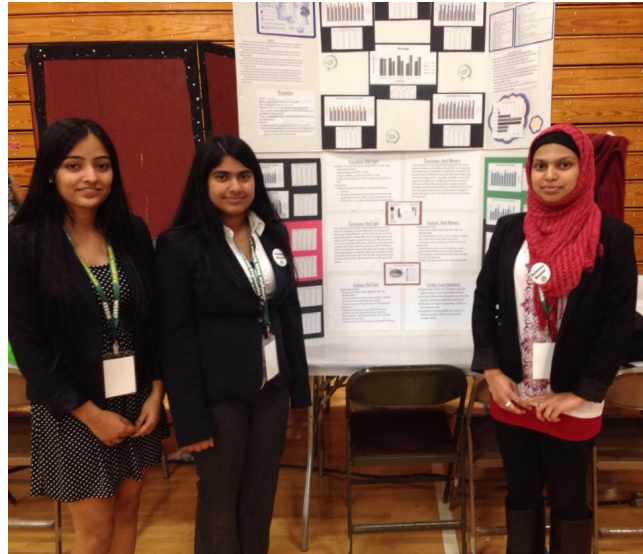
Meena Meyyappan, Daaniya Iyaz,
and Saakshi Dulani

Abstract

The epidemic of sleep deprived, underperforming students is spreading quickly and steadily as the usage of technology and sleep habits alter immensely. This experiment examines the correlation between sleep rhythm alterations and memory performance. To obtain results, volunteer subjects were assigned manipulated sleep schedules (either sleep and wake late, sleeping in thirty minute intervals, exposure to an excess of blue light before bed, and a control group that followed mentor recommended sleep schedules for adolescents) which culminated in a total of nine and a quarter hours of sleep. Subject memories were then tested by asking them to memorize and recite a list of standardized SAT vocabulary words at fixed intervals. The hypothetical theory expressed the sleep and wake late pattern would prove most effective. However, the experiment results reflected that the interval sleep pattern, closely followed by the mentor-prescribed sleep rhythm, was most conducive to better memory retention. Those who were tested with interval sleep had a 6% increase in their score as compared to those tested on a normal sleep schedule (sleeping early and waking up early). Those tested with the blue light and late sleeping plan performed 8% worse than those that slept in the control or normal conditions. Essentially, adolescents require an adequate amount of sleep (up to nine and one quarter hours) in accordance with periodic thirty minute or less naps to bolster memory performance throughout their waking hours.

Introduction

According to recent studies, average humans spend approximately 26 years of their lives sleeping ("How We Spend the Days of Our



Meena Meyyappan, Saakshi Dulani, and Daaniya Iyaz

Lives" 1). Humans spend over a quarter of their lives in this sedentary state, but what exactly occurs during this innate, unconscious phase? Sleep is a vital natural process and controls one's behavioral and physiological needs. Some factors which influence sleep include secretion of hormones based upon sleep patterns and time of day and focus and alertness based upon "dips" in sleep schedule. One requires sleep to be able to perform day to day tasks and to commence mental cognition.

Sleep is a natural healing process as psychological restoration occurs during sleep. During this time, the body replenishes diminished cell counts and combats viruses and other harmful cells. It also helps with physical healing while body cell productivity increases. Other than healing, sleep can also stimulate physiological as well as mental growth, and this is specifically demonstrated in adolescents.

Teenagers, with rapid development of the body and mind, demand more sleep than fully-grown adults, making them prime subjects in sleep research. This particular study will measure sleep in relation to memory with the sleep research age group set as adolescents whose memory performance will be measured by giving subjects a list of twenty SAT vocabulary words to memorize and test in two intervals. In this research, we are investigating the impact of circadian rhythm, sleep intervals, and blue light on sleep and memory performance.

Circadian Rhythm

The primary regulatory complex of sleep is an evolutionary process older than humankind- the circadian rhythm. Circadian rhythm is essentially the human biological “clock” that runs in 24 hour cycles (turned to 25 hour cycles after the advent of electricity). Along with dictating basic functions such as sleep patterns and hunger at corresponding intervals, it governs behavior and physiological changes in mammals which depends on synchrony with external timings conditions, an important evolutionary trait.

In the experiment one must anticipate and prepare for changes occurring during the 24-hour time period (related to light conditions), ensure the organism responds appropriately to situations based on daylight, provides internal temporal organization, and cause internal processes take place coordinately with each other. Without these factors, lack of synchrony with internal conditions and external environment can cause a multitude of health problems, ranging from jet lag to a shift in work schedule to sleep deficiency, which causes impaired cognitive function, altered hormonal function, and gastrointestinal issues. During sleep, vital bodily controls and psychological needs are met. It influences the execution of sending signals to raise body temperatures in order to achieve homeostasis and the production of vital hormones such as the stress hormone, cortisol, and the hormone that controls sleep levels, melatonin. In relation to biological clock, circadian rhythm regulates timings for sleep and wakefulness per day.

The circadian rhythm dips and rises during different periods of day, resulting in a fluctuation of sleep and wakefulness throughout the day. For adults, this dip occurs during 2-4 AM and 1-3 PM; these timings are dependent on the “owl” sleep paradigm (late sleepers and late risers) or the “lark” paradigm (early sleepers and early risers) (“Teens and Sleep”). This biological rhythm is based upon the organism’s previous sleep schedule; if sufficient sleep has occurred (an average of eight hours to 9 ¼ hours) then circadian rhythm dips will not be as intense. However, wakefulness can still occur, even following sleep deprivation as circadian rhythm is followed even if homeostasis requires you to sleep.

In our experiment, we are researching circadian

rhythm in adolescents. Changes to circadian rhythm typically occur during adolescence. For example, teenagers typically experience “sleep phase delay”, meaning that as they stay up later, their entire sleep pattern alters and shifts. This causes teenagers to naturally feel more awake and alert at night as most of them typically encounter a hard time trying to fall asleep before 11:00 PM (“Sleep and Teens Biology and Behavior”). This impacts teens due to early school start times; many teenagers suffer from sleep deprivation. The recommended sleep time for teenagers is 8.5-9.25 hours. Sleep deprivation alters “dips” in circadian rhythm which occur from 3-7 AM and 2-5 PM and the morning dip can become longer if sleep deprivation continues (“Body Clocks”).

Sleep Intervals

Within the circadian rhythm, sleep occurs in various stages with one cycle lasting 90 minutes. Stage 1 is when one is awake and alert and this is produced by beta waves. Stage 2 is when one is awake but drowsy and this is produced by alpha waves. Sleep spindles indicate when a person is about to enter or leave REM sleep because the body temperature and breathing rate begin to lower. This also occurs in the second stage of sleep. In the third and fourth stage of sleep delta waves (or slow wave sleep) night terrors, bed wetting, sleep walking, and sleep talking occur. These are the NREM (or non-REM) stages of sleep. REM sleep, or rapid eye movement sleep, is the most important stage of sleep. This is when sleep paralysis occurs and the body will be paralyzed but the mind will remain very active and the most vivid dreams occur (“90 Minute Sleep Cycle”).

As they mature, teenagers undergo hormonal changes and this causes changes in the sleep intervals, resulting in a drastic sleep shift; teenagers can go to bed at 10 PM but will not actually sleep until 1 AM. This is due to the fact that their body secretes the sleep related hormone, melatonin, at different times and thereby changes their circadian rhythm. The circadian rhythm for teenagers dips between 3-7 AM and 2-5 PM. The recommended sleep time for teenagers is 9 hours and 15 minutes. The circadian rhythm for adults dips between 2-4 AM and 1-3 PM. The recommended sleep time for adults is 8 hours

and 30 minutes (“Is it Unnatural to Sleep in Eight Hour Intervals”). Even sleeping later on the weekends causes sleep deprivation on Monday that can have a significant impact on the body’s circadian rhythm and therefore sleep intervals.

This research provides us with relevant information for our psychology experiment. Sleep intervals reveal the optimal time of napping which would be during the circadian rhythm dip. A study conducted at Brown University showed that 12 out of 25 teenagers could fall into REM sleep within 3 to 4 minutes of sleeping, which is significantly faster than that of a healthy adult. However their ability to nap is also snapped off after 7:30pm (“Sleep Drive and Your Body Clock”). This also provides the optimal time of studying, which would be after the circadian rhythm dip, and therefore after a nap because the brain produces more creativity and is rested in order to provide the most efficient and accurate brain processing and thereby increasing memory potential.

Blue Light

Apart from sleep intervals, mental performance and circadian rhythms are also influenced by digital constructs. From forms of communication to news to education, technology has rapidly become a crux of daily life. However, with the ubiquity and ease of technology comes a consequence—an increase in blue light exposure. Blue light is artificial light which comes from today’s new technology gadgets, from iPads, to cell phones. 37% of people reported they check their cell phones every 30 minutes or less, according to (Statistics Brain). Additionally, studies have also shown people use their mobile devices while driving a car, playing with family members, attending social gatherings, eating at restaurants, riding public transportation, and watching television. These constant interactions with cell phones drastically increase blue light exposure, but dependence on technology has leaked into daily life. Browsing the internet, listening to music, taking photographs, reading news, interacting on social websites, playing games, navigating with GPS, shopping online, and even conducting fiscal transactions are just a few examples of the myriad of contemporary activities that rely heavily on the usage of technology. However, this dependence on digital gadgets does not

end with the setting of the sun. Blue light continues to illuminate the night as millions bring their phones, tablets, e-readers, and laptops to bed. According to consumer research, 68% of people place their mobile phones next to their beds while sleeping at night (Statistics Brain)—a statistic that emphasizes the incessant exposure to blue light in one’s waking hours.

What is behind modern society’s obsession with having access to the latest digital devices? By examining social constructs, mental mindsets, and the evolving role of technology, an insight is offered into the modern digital daze. With the constant “new and improved” versions of gadgets coming out almost daily, people experience more pressure to update themselves along with their digital devices. Eighteen percent of people believe they *need* to have the latest mobile technology (Statistics Brain). iPhones are also becoming a necessity in each household with over 350,000,000 units sold—just over one iPhone per each person in the United States (Statistics Brain). Technology’s reach is additionally extending by interminable exposure to its fastest growing market—children. As the digital age becomes increasingly casual and accepted as a lifestyle, children are allowed access to gadgets at younger ages. In accordance to having cell phones in grade school, children are exposed to blue light through education. They spend six and a half hours per day gazing at laptops screens, educational video footage, typing up assignments, and looking at contemporary ActivBoards that have replaced antiquated white boards of the past.

Society is essentially shrouded in blue light— from the palms of their hands to the walls of their buildings, blue light illuminates the path of a new digital era. However, does this influx of light pose any consequence to the health of the people? The answer, found through extensive scientific observation of biological processes and sleep cycles, is yes. In ocular cells that are separate from cells used for vision, a photopigment called melopsin takes up residence in an individual’s eyes. Melopsin is specifically sensitive to blue light, and researchers believe that it has evolved before vision itself indicating that it plays a role for another purpose besides vision such as regulating sleep cycles. How is blue light related to sleep, one may ask? Simply stated, blue light is

prominently present in daylight so human bodies have a tendency to associate its presence with the appearance of the sun in the sky. Hence, exposure to blue light can stimulate the body to increase alertness and quicken response times ("Blue Light, Bright Light"). Harvard Medical School sleep researcher Steven Lockley says, "Blue light preferentially alerts the brain, suppresses the melatonin and shifts your body clock all at the same time" ("Blue Light has Dark Sides"). With the increase in mental acuity and suppression of sleep hormones provided by blue light, it is an effective source of sleep interval and circadian rhythm alteration. With extensive use of blue light during the day that also continues far into the night, an individual's sleep cycle can be completely manipulated due to blue light suppressing the urge to sleep.

Unfortunately, companies have done little in respect to combating this issue. Corporations such as Apple or Barnes and Noble have not provided blue light emission alternatives, keeping blue light a constant companion in society, especially for children. Ceaseless interaction with digital devices in accordance with increasingly later sleep times (due to school work or other extracurricular factors) and increasingly earlier school timings, adolescent stand at high-risk of sleep pattern disruption and sleep deprivation, resulting in accruing health conditions. Though technology may provide a cure for the common boredom, its ubiquitous and incessant use alters sleep cycles and circadian rhythm due to blue light exposure- and not always for the better.

Conclusion

To summarize, this experiment focused on memory performance based upon alterations to the circadian rhythm, sleep intervals, and blue light usage. Each subject had only one manipulated variable which consisted of the sleep pattern alterations or the blue light. Controlled variables include each subject sleeping for the same amount of time (9 and 1/4 hours) and the vocabulary lists were the same for each subject. Confounding variables, which are variables that could have skewed data, were a result of not all subjects having the same physical traits such as different BMIs, metabolic rates, or physical characteristics. Different environments also played a part in creating discrepancies in the experiment

such as some subjects attempting to sleep in a noisy setting versus a quiet one, or the type of furniture and location. All these factors can influence sleep patterns and create inconsistencies within the data. Also, the lack of supervision from researchers caused the conductors of the experiment to rely on the word of subjects rather than their own observations, which could have impacted the accuracy.

When repeating this experiment, one should perform it on a larger scale, and testing subjects should be grouped with other subjects with similar traits such as metabolic rate, gender, ethnicity, BMI. A supervised environment which is the same for all the subjects will also help eliminate some of the confounding variables. We found sleep is a vital bodily process and best when not manipulated. Our bodies are at their maximum potential if circadian rhythm is not manipulated with blue light, causing sleep phase delay, especially seen in teenagers. Naps taken according to circadian "dips" are refreshing for mental performance, but should not exceed 20-40 minutes; otherwise they will result in grogginess and impaired mental cognition. Though most of our body's natural sleep processes will remain shrouded in mystery, one thing is clear: adolescents require a consistent sleep pattern that corresponds with daylight hours and minimal interaction with technology before bed if they are to perform and learn well in an educational environment.

Annotated Bibliography

"Blue Light Has a Dark Side." *Harvard Health Publications*. Harvard Medical School, May 2012. Web. 16 February 2014.

The average length of the circadian directly related to circadian rhythm). In this Harvard study, blue light is proved to be the most potent light wavelength that suppresses melatonin, which can inadvertently cause an increase in cancer risk, diabetes, heart disease, and obesity. These health conditions, though linked to sleep disorders, only have preliminary research backing up the claims. Another Harvard study shows an increase in blood sugar and a decrease in leptin (the hormone that alerts your body with you are

full) following a shift in the circadian rhythm induced by light, proving that diabetes and obesity can be effects of blue light.

This article has a significant impact on our research paper due to the light that it sheds on blue light. It relates how blue light can adversely impact the circadian rhythm, which is one of the variables we are testing in our experiment. The scientific research conducted by the reputable source, Harvard Medical School, also provides a fact-based basis from which we can expand upon the health risks stated by this article in our own experiments and further research. In relation to the reliability of the source, it is a reputable administration that is backed by Harvard School, and the information is relatively current (two years), indicating a high reliability.

Eng, Monica. "Can't Sleep? Could Be the iPad." *Chicago Tribune*. 08 Jul. 2012: 1. *SIRS Issues Researcher*. Web. 19 Feb. 2014.

This passage contains information which recognizes excessive use of light at night can lead to disrupted sleep or initiate sleep disorders. This is especially true with children and adolescents. A certain type of light, blue light, is said to be the most disruptive to sleep. This is because the body is tricked into thinking that it is daytime, since blue light is mainly associated with day. This light suppresses the hormone melatonin, the hormone that makes us sleepy. This blue light is especially prominent in computers, phones, and television. However, the closer the light is to ones face, the stronger its effects.

This is important for our research since we are trying to find ways to help teens find the best times to sleep. Many teens stay awake past normal times to study for tests. The blue light can be beneficial to teens to help them stay awake, even though it would make them sleepier for a longer time in the morning. We will use this information and test blue light's effectiveness on teens. The article taught us

that we should use a phone, or laptop for our study.

Neergaard, Lauran. "School Bells Not in Sync with Sleepy Teen Bodies." *Providence Journal-Bulletin (Providence, RI)*. Oct. 5 1999: n.p. *SIRS Issues Researcher*. Web. 20 Feb. 2014.

This article outlines guidelines for better proposed sleep. In these guidelines it states that adolescents should avoid caffeine after noon, bright lights and computer screens before getting into bed, and avoid intense bright lights in the morning. Another concept it highlights is the circadian rhythm disruption that typically occurs in teenager during the weekend when they sleep hours later than they would on a typical weekday. This is proven to cause issues Monday morning when it's time to get up for school. Another topic this article presents is the hormonal changes in teenagers that affect sleep habits outlining that sometimes even when a teenager goes to bed at 10pm, they will not be able to fall asleep till 1am because the body secretes sleep-related hormone melatonin at different times thereby changing the circadian rhythm that guides people's sleep-wake cycles. It is proven that sleep deprivation cripples memory and inhibits creativity as well as increases mood swings, depression, and stress. A study conducted at Brown University showed that 12 out of 25 could fall into REM sleep in 3 to 4 minutes which is much faster than a healthy adult however their ability to nap snapped off at 7:30pm.

This resource is helpful in writing our research paper because it covers some information about the main variables we are testing: circadian rhythm disruption, blue light, and sleep intervals. This resource will aid us in providing background information about the subject with relevant studies from a qualified source. Though this article is not biased, it is favorable to ward our argument that students are not getting the quality of sleep they require for optimal performance. Also the article proposes resolutions for the correlations we

hope to find in our study. Exploring these resolutions will aid us in writing a comprehensive paper.

"Sleep Drive and Your Body Clock." *Body Clock & Sleep*. National Sleep Foundation, n.d. Web. 20 Feb. 2014. <<http://www.sleepfoundation.org/article/sleep-topics/sleep-drive-and-your-body-clock>>.

This article is about the circadian rhythm and sleep intervals in adults. This basically means the wakefulness and sleep cycle your body naturally maintains. When not enough sleep is achieved, the sleep carries over and forms a deficit that must be satisfied later. However this also occurs vice versa where too much sleep leads to problems as well. It is scientifically proven that in adults the circadian rhythm occur between 2-4am and 1-3pm The circadian rhythm dips for teenagers occur between 3-7am (sometimes later if lack of sleep is present) and 2-5pm. The recommended amount of sleep teenagers should be getting is an average of 9 hours and 15 minutes or at least 8 hours and 30 minutes. If teenagers do not get this amount of sleep, they will not perform at their best. The circadian biological clock is controlled in the Suprachiasmatic Nucleus (SCN), a group of cells in the hypothalamus that respond to light and dark signals and accordingly release hormones (melatonin induces sleep).

This article is essential to writing our research paper because it outlines the reasons we are choosing to test napping right after school as opposed to sleeping later in the night because the dip in circadian rhythm for teenagers is between 2-5pm. Also this article outlines the scientific, medical background of the our experiment and is essentially what we are writing our research paper on. Not only does this article talk about sleep in terms of teenagers but also adults so that can be compared and used as a reference point. This article is credible as well since it is sponsored by the National Sleep Foundation and is on their website, allowing it to

be a great source at our disposal.

Vitaterna, Martha Hotz, Takahashi, Joseph S., and Fred W. Turek. "Overview of Circadian Rhythms." *National Institute of Alcohol Abuse and Alcoholism*. U.S. Department of Health and Human Services, n.d. Web. 16 February 2014.

This article outlines and defines the circadian rhythm and its processes. It is an approximately 24 hour biological clock (though the constant exposure to light has prolonged it to near 25 hours), and it is dependent upon light exposure (a "daily light-dark cycle"). The circadian rhythm in mammals is located into regions of the brain called the suprachiasmatic nuclei, and these areas are responsible for most of the changes in behavior and physiology in the mammalian species. The circadian rhythm typically aligns itself with external time indicators (specifically light) through the secretion of the melatonin hormone. In addition, this biological clock also comprises a gene array that encodes specific proteins which control multiple physiological needs (hunger, mood, etc.) and are necessary for the daily functioning of the mammal.

This article would be useful in research due to the amount of scientific detail included. The intricate explanation of the physiological and genetic properties (shown later in the article and enforced by visuals) provides a thorough basis upon which further study can be continued. Also, sleep is based off the circadian rhythm so any additional experiment conducted will have to do with extensive knowledge of the circadian rhythm. The source itself appears to be highly reputable; each of the authors possesses a PhD in a biological/genetic department that is related to sleep and is affiliated with a national institute. The source is also sponsored by a U.S. department (the Department of Health and Human Services) as it is a government site (the URL ends in .gov). The factual analysis as well as the scientific credibility of this site provides a very useful source for our re

search paper.

Citations

Cherry, Kendra. "Circadian Rhythm: The Body's 'Clock.'" *Psychology*. N.p., 2014. Web. 23 February 2014.

Eng, Monica. "Light From Electronic Sleep at Night Linked to Sleep Loss." *Chicago Tribune*. A&E, 8 July 2012. Web. 23 February 2014.

Foster, Russel. "The Science of Sleepy Teenager." *New Scientist*. The Slate Group, n.d. Web. 25 February 2014.

"Later Start Times for High School Students." *Research Works*. University of Minnesota, June 2002. Web. 25 February 2014.

St. George, Donna. "Sleepy Teens: Montgomery Proposal to Start High School Day Later Draws Mixed Reaction." *Education*. The Washington Post, n.d. Web. 25 February 2014.

Reimagining the Electric Car: Application of a Dual Motor Drive with a Planetary Gear System to Increase Efficiency

Abhishek Swangaresan, Mrigank Bhardwaj
Madison Minsk, Anand Nambakam,
Pranav Vasudha, Srikar Murali, Aashray Anand,
and JD Daly

Why It Is Important to Optimize and Popularize the Electric Car?

Electric cars have failed to become the standard for American families even though these cars have the advantages of: saving families money in fuel costs, reducing our dependence on oil market pricing, increasing our energy sustainability as oil is a non-renewable resource, and perhaps most importantly, reducing climate change resulting from carbon dioxide emissions. Indeed, the electric car exemplifies a paradox of the war on climate change; much of the technology needed to battle climate change has already been invented.

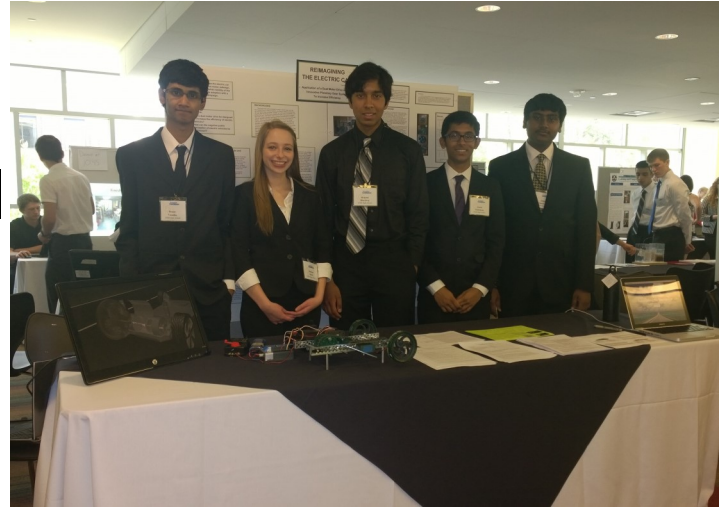
The obstacles inhibiting widespread adoption of electric vehicles include: range, battery life, and a perceived lack of charging stations.

Objective

To optimize the electric car through an innovative motor redesign, demonstrate the market viability of the design, and promote adoption with a public education campaign.

Questions

Can a dual motor drive be designed to increase the efficiency of electric vehicles?



*Pranav Vasudha, Madison Minsk, Mrigank Bhardwaj,
Anand Nambakam and Abhishek Swangaresan*

How can the negative public perception of electric vehicles be addressed?

Background

The dual motor drive concept is used in hybrid cars such as the Toyota Prius. In Hybrid systems, an electric battery powers the car during the start-up phase, speeds up to 20 mph. At speeds over 20 mph, the traveling phase, a gasoline fueled combustion engine powers the car. The reason this increases fuel efficiency is because the most energy-intensive period of a car journey is the start-up. The car engine must expend more energy to overcome rolling friction. This phenomena occurs because the friction between the road and the wheels causes the wheels to stall. Rolling friction is greatest when the wheels are moving relatively slowly. This energy-intensive start-up period results in more gas being consumed, a situation avoided in hybrid cars through the use of dual motors. The same rolling friction affects electric cars causing the battery to be consumed greatly during the start-up phase. If electric vehicles could adopt a similar dual motor transmission system, their range could increase as less battery would be needed to travel the same distance.

Experiment

To simulate the performance of a single motor drive and a dual motor drive in an electric car, models of each motor type are constructed. A program and algorithm simulating city and highway driving was written and used to control the

power driving each model. The voltage of the battery corresponding to each motor system is monitored during the simulation and recorded for comparison.

The Dual Motor Concept

The goal of the motor system is to increase the range of loads that the vehicle operates at its peak efficiency and thereby increase the range of the electric vehicle per a fully charged battery. Motors run at their peak efficiency at 65-75% of their rated loads. The load, consisting of air resistance as well as friction from the road, burdens the motor at this level only at high speeds. Thus, most cars travel at speeds and accelerations below their motor's peak efficiency. In order to attain peak efficiency at a broader range of speeds, we developed a dual-motor drive system to increase the distance the vehicle travels with the same amount of energy given by the lithium-ion battery.

A chassis with a small motor and a large motor emerged from our first prototype design. That a small motor requires less energy to run relative to a larger motor provides the fundamental idea behind the increased efficiency of the design. The law of inertia shows that a vehicle must first overcome rolling friction when it first begins to accelerate which requires more energy than a vehicle already in motion. If a single motor powers the full range of acceleration, it will be running less efficiently and consume more energy than if two motors are used.

In our first design, the small motor powers the initial, most energy intensive acceleration and then shifts to a larger motor to power the rest of the journey. This decreases the overall energy consumed by the vehicle.

Our second prototype was improved by using a system with two equally-sized motors. Inspired by the Toyota Prius Power Split Device, a system that allows for selective use of one of the two motors depending on the load. The second prototype system uses only one motor at lower loads and only engages the second motor at higher loads, as when accelerating to higher speeds. This system dramatically increases the efficiency of the car, allowing it to run at the same rate while consuming less energy. The system functions with a planetary gear system,

composed of the ring gear, sun gear, planet gears, and planetary carriers. In addition, an electronic, continuously variable transmission is used to transfer the force of the second motor onto the same axle as the first when more force is required. This will increase the range of the electric car significantly.

Methods

Materials

- 4 metal pinions to serve as planet gears
- 1 small green gear to serve as sun gear
- 2 large green gears to serve as planet carrier
- 2 sprockets plus chain to serve as ring gear
- 2 axles
- 2 motors of the same power
- 1 large green gear to serve as clutch disk
- Steel metal bars to comprise chassis
- 2 power generators

Assembly

The metallic gears are the planet gears, the small innermost green gear is the sun gear (driven by motor 2), and the larger outermost green gear is the planetary carrier. The set of four small green sprockets are attached to each of the planets and the chain that is wrapped around them is a substitute for the ring gear. The chain (ring gear) drives the sprocket which is attached to the same axle as the wheel and motor 1. After building the planetary gear set, it was mounted on a chassis rail with a set of two drive axles, and the ring gear of the system was attached to the sprocket, sharing an axle with motor 1 (which is directly attached to the drive wheel). The rest of the planetary gear set (sun gear and planetary carrier) remained attached to the second axle. The second motor was attached to the sun gear and allowed the planet carrier to rotate freely (to accommodate the speed difference when motor 2 starts up) by not locking it to the axle. On the same axle there is a clutch plate that can lock the planet carrier to transfer the torque from the second motor to the drive axle in order to assist the first motor.

The hypothetical single motor drive system has two motors connected to each other via sprockets forming a Large Motor Unit (LMU). In the LMU, both motors function in tandem (they cannot function independently) and behave as a single cohesive motor unit. Due to resource limitations, a motor twice as big as the motors used in the planetary system on the dual motor drive could not be sourced; however, this system still accurately demonstrates the concept. The LMU is the traditional single motor that is used in normal electric cars, but in this dual motor electric car concept, the two motors function independently of each other. The second motor assists the first only when additional power is required, such as when rapidly accelerating to higher speeds.

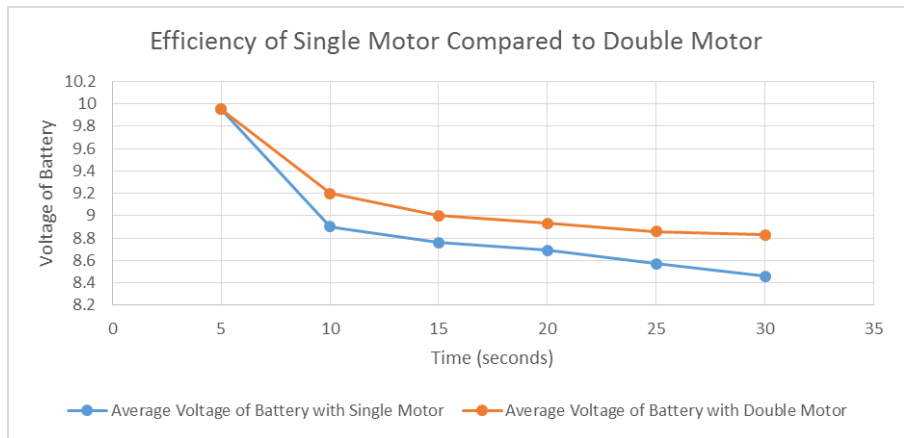
Procedure

To test the energy efficiency of our conceptual dual electric motor drive, versus a conventional single electric motor system, an algorithm was created that simulates city and highway driving conditions (the program repeats itself every 5 minutes). This algorithm was loaded into each model car and three trials were run, 30 minutes each, measuring the voltage of the battery at 5 minute intervals, to show the amount of energy the motor system uses.

Results

Average Voltage of Battery		
Time (minutes)	with Single Motor	with Double Motor
5	9.95	9.95
10	8.90	9.20
15	8.76	9.0
20	8.69	8.93
25	8.57	8.86
30	8.46	8.83

Average battery drain over 30 minutes	
with Single motor	with Double Motor
1.49	1.12



The higher average voltage of the battery with a double motor shows that it is draining less of the battery.

Conclusion

The results of our experiment indicate that there is an average of a 24.5% increase in efficiency with the dual motor system. The single motor system averaged 1.49V of electricity used compared to the dual motor systems use of only 1.12V. These results were consistent, with the dual motor system outperforming the single motor in all trials. The most efficient test was Trial 2, where the dual motor system outperformed the single motor by 31% (1.52V drained compared to 1.05V) with the least efficient being Trial 3, with an efficiency increase of only 21% (1.46V drained compared to 1.16V). Even on a small scale, the dual motor system is more efficient than the single motor system, despite the increased drive train loss and weight of the dual motor system. This small scale experiment demonstrates that the use of a dual motor system does improve energy efficiency.

This innovative dual motor system has been demonstrated to both function smoothly in our model electric vehicle and to provide increased efficiency of power usage. Implementation of this dual motor system with its planetary gearing system would extend the range of the electric car, thereby encouraging more people to accept the utility of electric vehicles.

Business Application of the Dual Motor System

Competitive Criteria: Price and Range

The design flexibility introduced by the dual mo-

tor system will be very attractive to car manufacturers. The two motors can be tailored to compete with cars in each of the electric car market segments. Proposed Model 1 competes with the Nissan Leaf in price. The second, Model 2, competes with the Tesla Model S in range. Both models can be designed to out-perform its counterpart.

Evaluation of Competitiveness

The following comparisons are based on the respective car's highway range and efficiency. This is where the cars will have to perform efficiently to outcompete the current market. To outcompete the Nissan Leaf, this entails maintaining the same range with less battery to reduce the cost. To outcompete the Tesla Model S, this means an extended freeway range.

Cost: Model 1 vs. Nissan Leaf

Nissan Leaf	Model 1
Cost: \$28,980	Cost: \$26,273
Range (HWY) 92mi	Range (HWY) 92mi
Top Speed: 97 mph	Top speed: 97 mph
0-60 (acceleration): 7.9 sec	0-60 (acceleration): 7.9 sec

Tesla Model S	Model 2
Cost: \$93,000	Cost: \$TBD
Range (HWY) 265mi	Range (HWY) 342mi
Top Speed: 130 mph	Top speed: 130 mph
0-60 (acceleration): 4.2 sec	0-60 (acceleration): 4.2 sec

The Nissan Leaf is known for its affordability. Powered by a front-mounted 80-kilowatt electric motor with 107 horsepower, the Nissan Leaf has a massive battery size of 24 kWh and boasts an average range of 84 miles total. Our proposed Model 1 replaces the front-mounted 80 kW motor with two smaller motors that each have 37.284 kilowatts or 50 horsepower. A single 37.284 kW motor requires much less energy than the 80 kW motor. When the car reaches higher accelerations that increase the load on the motors, the system begins to utilize both motors for a combined 100 horsepower. This is negligibly less powerful than the 107 horsepower that the Nissan Leaf's motor provides. Due to the

usage of less energy, our model allows us to use a much smaller battery and still achieve the same range as the Nissan Leaf. Decreasing the weight of the car lowers the load on the motors, increasing the range and efficiency of the car. With the battery being the major component of the weight and cost of electric cars, our design makes it possible to lower the price of the electric car and to further improve its efficiency due to decreased weight.

Range: Model 2 vs. Tesla Model S

The Tesla Model S is an electric car designed for range, capable of an impressive 265 miles on a full charge. The Model S uses an 85 kW battery pack and a 270 kW motor. This powerful motor has a larger energy draw, shortening the life of its massive battery. Our long-range model, Model 2, uses the same two 37.284 kW motors as Model 1, but with a larger battery. Using only one motor at lower loads enables a much smaller impact on the life of its battery when traveling at low accelerations, such as stopping and starting frequently in cities. Since this Model 2 uses a battery as large as current car models, the cost of the car is kept approximately the same; similarly, due to the increased efficiency of our innovative design, the range of the car greatly increases. Our system allows for a luxury model car with unparalleled range to be built due to higher efficiency and less energy waste.

Addressing Concerns about the Electric Car

Are electric cars just shifting the pollution source?

Forms of Fuel	Pounds of CO ₂ Produced per Mile
Gasoline	1.0889
Electricity (Produced by burning coal)	1.06964
Electricity (Produced with Natural Gas)	0.4148
Electricity (Produced with Geothermal)	0.192627
Electricity (Produced with Solar Power)	0

Even when the electricity used to power the electric car comes from coal, the pounds of CO₂ produced per mile are still less than that of gasoline fueled vehicles.

Public Education Campaign

In order to clear up some common misconceptions surrounding the electric car, a public education campaign was targeted at the people of Redmond, WA. Our team passed out informative flyers at local food markets and our high school. After interacting with hundreds of people, we were reminded of how difficult changing the public's conception of the electric car will be. Many people would not even take the flyer, and others simply tossed it to the ground. Although it is not always possible to change the minds of individuals, as one person told us, "I like the 300 horsepower of my Camaro. No way am I giving that up", we do hope to change society's perception of the electric car. We overheard many discussions started because of our flyers, and that was the biggest sign of success - starting the conversation.

Limitations

The most significant limitation was that the experiment to test efficiency was conducted on small-scale robotics parts as opposed to actual electric vehicles. Additionally, the small scale system was more bulky, and had more moving parts due to the lack of a compatible ring gear for the system (hence, a substitute system of sprocket and chain was used). This additional complexity increased the drive train loss in our system, along with the fact that we did not have ball bearings, or lubrication systems. Therefore, in theory, if this system was implemented in a real car with precision machined gears, along with ball bearings and lubrication systems, the drive train loss, overall weight, and footprint of the system would decrease. Thus, our small scale tests provide a conservative estimate of the efficiencies possible with the dual electric motor system.

Much of the data concerning the efficiency of electric cars at varying accelerations is not publicly released. Furthermore, most companies were not receptive to answering questions about their business decisions regarding installing charging stations.

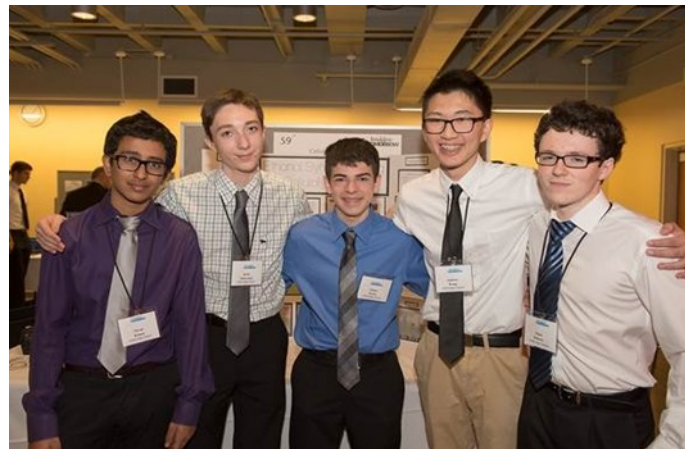
Future Research

Our team plans to do future research into increasing the battery efficiency of electric cars, and conduct an experiment to quantify the proposed improvements in the electric car battery itself.

- Investigate how the dual electric motor system can compete in the performance market segment, as exemplified by the Tesla Roadster.
- Investigate potentially viable solutions to issues with the battery itself, such as:
 - Substituting PFPE as the electrolyte to address weight and cost issues.
 - Using a solid electrolyte to eliminate flammability.
 - Using an aluminum air battery as an emergency backup.

Cellulosic Ethanol: A New Look at the Transition to Renewable Energy

Ethan Perrin, Andrew Wang,
Isaak Nanneman, Pavan Kumar,
and Oisin Doherty



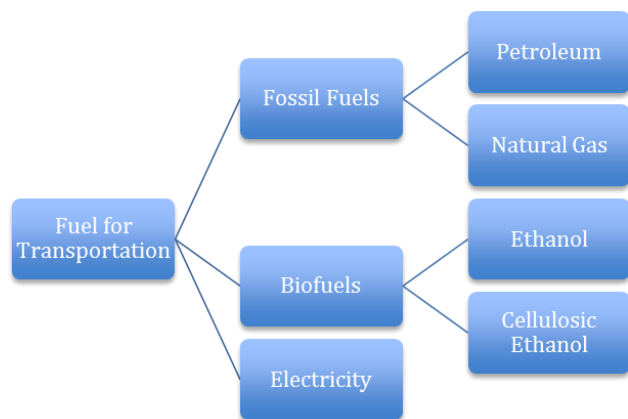
*Pavan Kumar, Isaak Nanneman, Ethan Perrin,
Andrew Wang and Oisin Doherty*

Abstract

The staggering percentage of consumable crops in the United States that is used for Ethanol production is unprecedented by the percentage waste it leaves. The goal of our experiment is to develop a more efficient and more cost effective way of synthesizing Ethanol from consumable crops or other cellulosic organisms.

Introduction

The transportation industry around the world has historically relied on the use of fossil fuels to power the combustion engine. However, in recent years, the use of alternative fuels such as electricity and biofuels has been on the rise. The most prevalent of which is Ethanol.

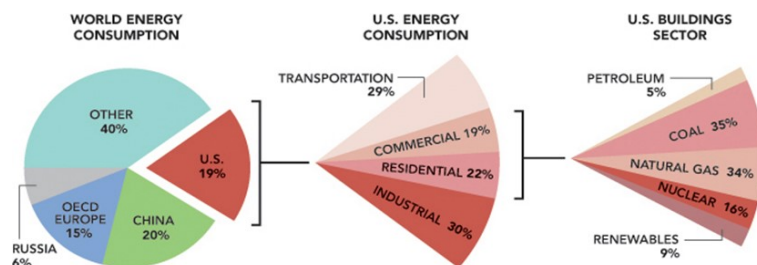


Ethanol is currently used as an additive to traditional fossil fuels in order to reduce total petroleum usage. In fact, developing countries are beginning to establish a certain percent mandatory ethanol blending for all petroleum fuels. For example, India has put in place a 5-percent manda-

tory ethanol blending for all petroleum fuels. It is clear that the world is moving towards the use of more alternative fuels (i.e. ethanol) as opposed to fossil fuels. However, in order for Ethanol to be the best alternative, the massive amounts of waste left over by its production needs to be reduced.

The Current State of Energy

Normal aspects of human activity are dependent on the use of multiple forms and sources of energy. In fact, there is a correlation between economic development and increases in energy usage and demand. Uses of energy can be categorized under four general categories: industrial, commercial, residential, and transportation. Together, these four forms of energy currently rely heavily on the use of fossil fuels, but with the rising cost of oil and its environmentally damaging factors, there is an urgent need for a replacement for the energy source that provides the



world with 87.1% of its electricity.

Transportation dominates the world's demand for energy. Worldwide, transportation accounts for 25% of the world's energy demand and 61.5% of

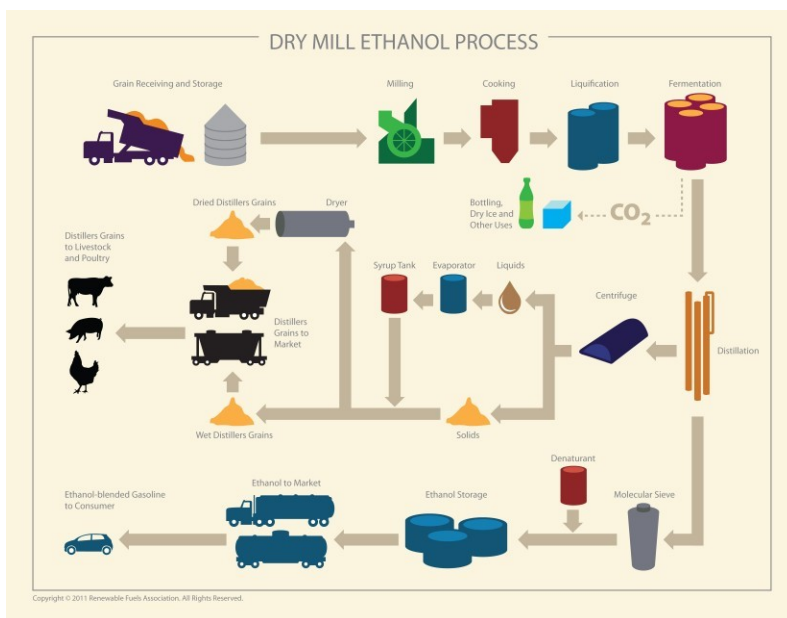
all the oil used each year. With alternative sources of fuel on the rise, there is a need for cleaner and cheaper methods for alternative fuel synthesis.

Ethanol

What is Ethanol? Chemically speaking, Ethanol is a colorless liquid with the chemical structure of $\text{CH}_3\text{CH}_2\text{OH}$ that is flammable and volatile. Ethanol first became prevalent as a fuel as early as the 1840's. However, the U.S.'s high tax on alcohols during the Civil War made ethanol uneconomical. After the tax was repealed in 1906, its use started to shift towards the transportation industry. For example, the Ford Model T was built to be able to run on both petroleum and ethanol. In recent years, its use as a fuel additive for internal combustion engines has taken off around the globe.

Production of ethanol from feedstock was one of man's first ventures into the concept of value-added processing. Although the same general steps have held true to the industry of today, companies have been looking for ways to decrease fossil energy dependence while manufacturing ethanol. The process of manufacturing ethanol can be seen below in the figure provided by the Renewable Fuel Association.

Although a shift towards ethanol and away from fossil fuels is good, the amount of energy and waste involved in the process of its creation limits the commodity's growth. Let's take a look at an example of normal ethanol production. Corn is the most prevalent crop used for processing ethanol. But, most of the corn stalk is not used. In fact, only the juices of the corn kernel are extracted for use, leaving majority of the cellulosic mass untouched. After the juices of the corn are extracted, the processes of cooking and liquefaction require massive amounts of energy. However, recently there have been developments in the ethanol processing industry that allows for the processing of ethanol from the previously thought cellulosic waste. This process requires a lot of energy from the source of fossil fuels to function. But what if this processing of ethanol required no energy?



Our Solution

The goal of our experiment is to genetically modify yeast such that it contains the enzyme cellulase. But what does this all mean?

Cellulase

Cellulase is an enzyme commonly found in the stomachs of animals that consume cellulosic organisms, such as a cow. The introduction of this enzyme to yeast will allow it to consume the cellulosic organism and use the energy gained for the production and excretion of alcohol.

Yeast

Yeast excretes alcohol as a byproduct. Yeast is ideal for our experiment because our goal is to create ethanol with little to no energy input. So, the use of yeast's natural process will allow for ethanol production with minimal input of fossil energy.

Genetic Modification

The only cases of naturally occurring cellulosytic yeast have been found in pond water in Japan. However, in order to make this process cost effective and to satisfy society's

desire for minimal foreign dependency, cellulolytic yeast needs to be able to be produced in the U.S. through the process of genetic modification.

What this will allow the yeast to do is consume the cellulose of cellulosic organisms and excrete alcohols (such as ethanol) as a byproduct. If the product of our experiment works as intended, then the process of collecting alcohol for fermentation and distillation will require no energy input after the yeast is manufactured.

Usage and Implementation

Ideally, the product of our experiment will replace the current method of producing ethanol. Our product will greatly reduce the use of fossil energy currently required to make ethanol and allow ethanol to enter the energy sector as a greener and cheaper source of alternative energy. We hope that the product of our experiment will help transition the world to cleaner, greener, and sustainable energy sources.

Sources

International Energy Outlook 2013 [Internet]. 2013 Jul 25. 2013 Edition. Washington (DC):U.S. Energy Information Administration; [2013 Sep 16, cited 21 Dec 2013] . Available from: <http://www.eia.gov/forecasts/ieo/correction.cfm>

Rodrigue JP, Comtois C. 2013. Transportation and Energy [Internet]. Third Edition. Hempstead(NY):Routledge; [2013, cited 2013 Dec 21] Available from: <https://people.hofstra.edu/geotrans/eng/ch8en/conc8en/ch8c2en.html>

How Ethanol is Made [Internet]. Washington (DC):Renewable Fuels Association; [cited 2013 Dec 21] . Available from: <http://www.ethanolrfa.org/pages/how-ethanol-is-made>

Greenhouse Gas Emissions: Transportation Sector Emissions [Internet]. Washington (DC):Environmental Protection Agency; [2013 Sep 9, cited 2013 Dec 21] . Available from: <http://www.epa.gov/climatechange/ghgemissions/sources/electricity.html>

Good D. 2013 Nov 12. Corn Used for Ethanol Production [Internet]. Urbana (IL):University of Illinois; [12 Nov 2013, cited 2013 Dec 21] . Available from: http://web.extension.illinois.edu/dmp/eb263/20131112_7576.html

Ethanol Fuel Basics [Internet]. Washington (DC):U.S. Department of Energy; [2014 Jan 17, cited 2014 Jan 25] . Available from: http://www.afdc.energy.gov/fuels/ethanol_fuel_basics.html

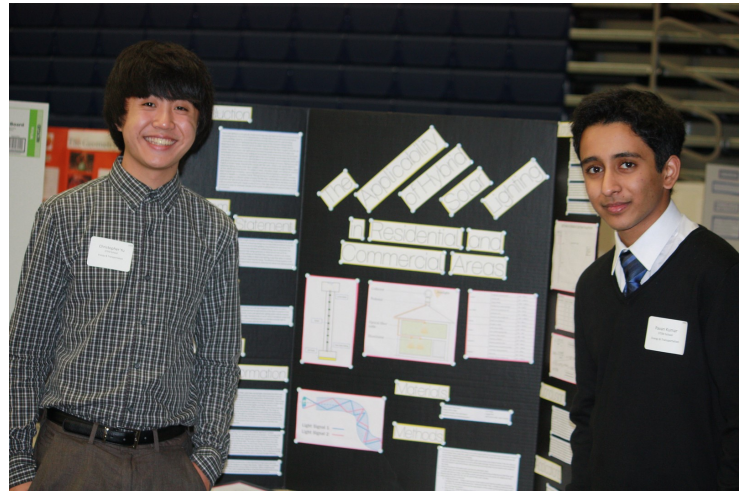
The Applicability of Hybrid Solar Lighting in Residential and Commercial Spaces

Pavan Kumar and Christopher Yu

Why Hybrid Solar Lighting?

Direct solar lighting is a conceptually simple technology that uses light from the sun to illuminate living and working spaces. In its most fundamental form, a window, little mind is paid to its commonplace value in buildings. However, as economic and environmental stresses push for reduced energy consumption, direct solar lighting has become a growing part of the renewable energy industry. Beginning as glass domes and basic mirrors to redirect light, this technology to redirect light has developed in an immense concentration of arrays and carefully wired fiber optic strands to bring the sun indoors. Advances in direct solar lighting have translated into parallel improvements in other solar technologies, including active water heating and photovoltaic arrays. Decreasing return-on-investment times continue to push this alternate lighting method into more buildings. Nevertheless, the benefits aren't limited to the wallets of users; reducing reliance on electricity from coal-burning power plants and other fossil fuel based energy production sources reduce greenhouse gas emissions, helping reduce the impacts of climate change.

Expanding from direct solar lighting using fiber optics formulates the concept known as hybrid solar lighting. The number of cables, orientation, length, and material are factors in determining the light distribution. Hybrid solar lighting allots effective lighting in rooms that lack windows or skylights in a simplistic manner. Through testing one can determine how much channeled sunlight can apply to a different number of rooms. The fiber optic cable bundles will effectively be able to provide solar light as the sole fixture in a very limited number of rooms, but has the ability to provide sufficient ambient lighting for a larger



Christopher Yu and Pavan Kumar

number of rooms. Fiber optic systems also act as an incentive for a customer to resort to renewable energies, as the system is rudimentary in its setup and cheap in terms of investment.

The History of Fiber Optics vs. Solar Concentrators

Prior to the introduction of optical fibers in 1990s, solar tubes and skylights dominated the direct solar lighting market. Both provided decent lighting, around 3000 lumens, the standard, and did not require a large initial investment; however, issues regarding the availability of actual sunlight stunted their popularity. Scattered light and other weather-related obstacles were overcome by the development of advanced concentrators. These arrays typically used a combination of lenses, mirrors, and vacuum tubes to focus large amounts of light into a relatively small surface area. Tracking software also evolved rapidly, pushing the efficacy of the technology even further. Beginning in the early 2000s, photovoltaic solar arrays made their commercial debut, generating electricity to existing light fixtures in buildings. The dollar-to-kilowatt ratio prevented widespread use, but further research in array geometry and positioning benefitted the direct solar lighting industry through increasing efficiency. Commercial solar lighting systems today are commonly marriages between concentration arrays and optic fibers, which in the past decade have dramatically decreased in price due to mass production and have grown over ten-fold in efficiency. These systems have low construction times and little heat transfer, in addition to a relatively cheap price.

Fiber optic engineering's ability to enhance solar efficiency is thoroughly depicted in the experiment regarding the coined term "LSC," or "Luminescent Solar Concentrators." An average solar panels efficiency can be increased thirty-five fold through the optimization of a proper practical fiber. While the components of fiber optic engineering are applied directly onto a solar panel, it can simultaneously be utilized to distribute light. The waves of light emitted from thin optic fibres have theoretical patterns that can be derived. Certain ranges of distances fall more sensitive to the fiber parameters. When arranging a fiber optic system, the positioning of the refractive index and length of the fiber radius is key in optimizing its utility. By drawing conclusive light scatter patterns, both of these determining factors can be narrowed down. This is imperative to the current inquiry in order to remove those confounding variables and to maximize the light diffusion.

A number of guidelines exist for the purpose of instructing one on the importance of light placement and comfortable lighting levels and values for a human in a modern-day home. "Light in Design" is essentially a manual regarding the various aspects to lighting and the various effects it can have. When conducting the experiment with solar lights and the fiber optic engineering, keep in mind that the standard levels of lux (the standard lighting unit for area) that are optimal for a home and to humans is paramount. Comfortable lighting is a key factor in interior design; high-lighting important objects and providing ambient lighting to illuminate other spaces must be carefully designed in tandem with solar lighting.

Creating the Scaled System

The experiment will incorporate three main steps: construction, data collection, and data analysis. Although this form of construction is not prototyping, its assembly's representativeness of reality is important in measuring the applicability of the system. Using the proper methods of data collection with a lumen meter will also be beneficial in retrieving accurate results. Scaling up the data collected to that of an actual system and analyzing the numbers by comparing it to current light systems is the optimal form of data analysis for this experiment.

A light-tight structure will be assembled from a

light delivery unit and adjustable room compartment, both of which will be mostly constructed from black foam core board. The light source will be a flat Maxxima LED diffraction board, and a predetermined number of .75mm fiber optic strands will redirect the light over a distance of two meters. The adjustable room will have 20 equally sized compartments to model separate rooms in a building. Black electrical tape will be applied along all edges of the structure and any other areas that may be susceptible to light leakage. A small space will be left open at the bottom of the compartment to allow a lumen meter's probe to rest.

Each trial will involve a different number of rooms that will be illuminated by the model direct solar lighting system, with an equal number of fiber optic strands in each room. The lumen meter will be placed in a light tight space, two inches from the LED diffraction board. Once the groups of fiber optic strands have been prepared and directed to their corresponding rooms, the lumen meter will be activated and the entire structure will be shut. The LED diffraction board will then be switched on, and a reading from the lumen meter will be recorded. This process will be repeated with two, five, ten, and twenty room configurations. The control value will be a single room configuration, which will allow for the finding of the baseline percentage of transferred light.

After the data has been collected, all lumen reading from the trials will be divided by the actual brightness of light emitted by the LED diffraction board. A graph consisting of the number of rooms on the x-axis and brightness in lumens on the y-axis will be produced from this data. The efficiency of the optic fiber strands will also be calculated from the control value divided by the brightness of the LED diffraction board. These values will then be brought to scale in comparison to an existing hybrid lighting system, so that proportional values of illumination in a full sized space can be produced. These values will then be compared to standard lighting requirements in working spaces; if they fall below the requirements, the lighting arrangement will be considered inapplicable, and vice versa.

Data Analysis and Evaluation

When observing the average lux of the receiving

end of the model hybrid solar lighting system with an increasing number of rooms, the strength of the light initially dropped gradually and then began to stagnate. The Maxxima Wafer Thin LED Board emitted 11371.4 lux, while the brightness from the sun on an overcast day will typically be around 1500 lux. In the use of 200 fiber optic cables to model one room receiving all the lighting, 38.66 lux was detected on average. With 100 fiber optic cables representing two rooms, 27.33 lux was read. Fifty fiber optic cables concentrated 19.33 lux on the meter. Forty cables resulted in 16 lux being read. The concentration of light decreased to 7.66 lux with 20 cables, and 10 cables only produced 3.66 lux. A value barely reaching 1 lux was read when running the system without the fiber optic cables.

All the average data values were multiplied by ten thousand in order to bring the 2cm^2 surface area of the model system to scale with a full-sized 2m^2 system. The new data values were then multiplied by $1500/11371.4$, to adjust the brightness of the lighting system used to that of the sun on an overcast day. These final values were then graphed, and a best fit line equation was calculated to fit the data points, producing a natural exponential graph.

A reverse Chi Square was conducted, where the minimum statistically significant value was calculated by determining the P-value as .05 and the baseline value as 3000 lux (the highest brightness recommended in a workplace). A value of 3107.34 lux was found, which was then placed as “y” in the best fit line equation. The “x” value was then solved and found to be 17.98, which is the maximum number of rooms that a single hybrid solar system can illuminate at over 3107.34 lux.

There was variation within trials of each room, ranging from 3.5%-17.1%. Steps were taken to ensure complete darkness and no foreign light pollution in the testing, so the variations may have been caused by a faulty light meter or inconsistencies in the lighting system’s batteries and/or LED diffraction board. Even with these irregularities, the data appears to demonstrate an exponential decay.

Conclusion and Further Research

The results of this experiment, though not match-

ing the hypothesis, supported hybrid solar lighting as a viable solution to increasing environmental and economic demands. The data very closely followed a natural exponential curve, and it could be measured with the equation, $y = 58200e^{(-0.245x)} + 3505$, that was derived from the data. The maximum recommended lighting in a working space, 3000 lux, could be satisfied by up to 17 separate spaces, and lower lighting demands could allow even more spaces to be effectively illuminated. A decrease in efficiency is expected as the length of each fiber optic strand increases; up to 65% of the initial light intensity can be lost if the strands reach 24.4 meters in length. This loss in efficiency can be accommodated with larger surface areas, or by simply dividing the system’s light between fewer rooms.

A number of advantages place hybrid solar lighting above traditional lighting methods. The installation of these systems is as simple as current electrical wiring procedures and requires little maintenance. The utilization of direct sunlight allows for use of renewable energy to keep a green home while at the same time keeping electricity costs to a minimum. Direct sunlight is known to improve health and moods, while also providing a complete spectrum of light for specialized work. Movements towards environmentally-conscious behaviors and technologies by a small group could spread into entire communities and regions, pushing the entire industry to a greener future.

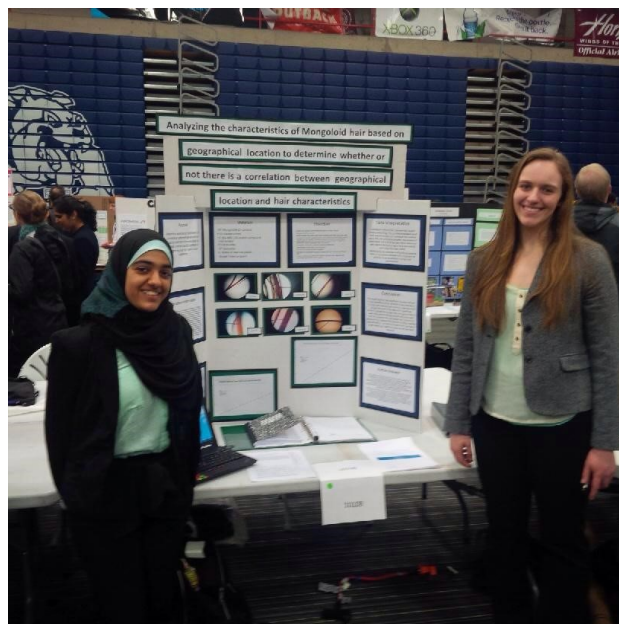
Analyzing the Characteristics of Mongoloid Hair Based on Geographic Region to Determine a Correlation between the Two

Marisa Messina, Warisha Soomro,
and Audrey Hyem

Introduction

Growing advancements in technology have allowed for vast changes in all sectors of law enforcement, and forensic investigation is no exception. Though trace evidence collection and analysis improved in order to become a vital role in crime scene investigation, further improvements have yet to be made. Trace evidence – material transferred and found to be useful at the crime scene – has gone from relatively little use to providing a great amount of information about a subject or scene, especially with Edmund Locard's discovery of "every contact leaves a trace," (Locard, 1904) supporting the collection and adding to the importance of fiber evidence by providing an explanation of hair or fiber transfer. In recent years, hair evidence proved as cause to exclude a suspect, due to the fact that hair divides into only 3 categories; the identification of a sample can automatically rule out the other two categories, therefore eliminating suspects. For example, a Negroid classification refers to hair from one of African descent, which therefore excludes Asian and Caucasian perpetrators from a suspect list.

The current scheme of hair analysis utilizes only one system of classification. Believed to limit the extent to which a suspect is identified, a new method must be developed to analyze hair in order to find trends that distinguish between the different regions of hair, eliminating a greater number of suspects as well as allowing for faster



Warisha Soomro and Audrey Hyem

and more accurate identification. Currently, a lack of specific characteristics in the three hair classifications prevents immediate racial determination, expending more time and labor than required.

In *Practical Homicide Investigation*, Vernon J. Gerberth, points out that hair (and fiber) evidence is useful in various situations such as aiding in the establishment of the scope of a crime scene, placing a perpetrator at a scene, connecting a suspect with a weapon, supporting witness statements, and linking crime scene locations (Deedrick, 2000). Through the course of this experiment, geographic classification could be added to the points listed above as it serves as an exceptional start to answer one of the many questions that constantly remain at the crime scene.

The looming goal in this experimental hair analysis involves finding characteristics of Mongoloid hair based on geographic location to determine whether there is a correlation between geographic location and hair characteristics. If so, a new classification system and database will be created for public reference. The proposition remains that hair samples from people in closer geographical location to each other will have a greater number of similar characteristics as opposed to those with greater distance due to factors including proximity, family heritage linking areas together, as well as similar climates, lifestyles, and cultures to better suit a region. If re-

gions are in close proximity – as in within one a distance of one country in between – then key features of a human hair sample's cortex will display similarities such as in medulla pattern or presence of cortical fusi because shorter distances will likely share similar geographic features – such as climate and landscape – that have aided in the evolution of human hair for hair types that “best fit” a location.

Background Research

“Each species of animal possesses hair with characteristic length, color, shape, root appearance, and internal microscopic features that distinguish one animal from another” (Deedrick, 2000). Like fibers, hair specimens are understood in forensic research as “class characteristic,” the “characteristics shared by one or more other objects in that group” (Forensic Science Central, 2011). At best, a hair may have enough similar properties compared with a known sample to be “consistent with” the sample; it cannot be said to be a definitively perfect match. While hair evidence can be used to exclude a suspect, as with a Negroid hair excluding white perpetrators, the analysis is only considered contributing evidence.

Today, microscopic observation of a hair's cortex allows for classification. Characteristics generally used include medulla type and pattern, medullary index, pigment distribution, the presence or absence of ovoid bodies and cortical fusi, visual appearance and texture, and cross section. There are four medulla types - fragmented, intermittent, and continuous and absent – used to describe the thick line running through a hair sample. The patterns corresponding with the medulla types are used to further describe the medulla in terms of visibility. Groupings consist of opaque, translucent, cellular and wafer. The index refers to how many times the medulla fits in the strand, side by side, to put size into perspective. Pigment distribution directs at the color of the hair and how the color is distributed along the cortex. As established, hair is categorized into three categories: Caucasoid, Mongoloid and Negroid. Caucasoid hair is found on people of European descent and is characterized by evenly distributed pigmentation, fine to coarse texture and an oval to round cross section. Negroid hair is found on people of African, African American

and British descent and is characterized by heavy, uneven pigment distribution, flat oval cross sections and a tightly curled appearance. Mongoloid hair is found on people of American Indian, Inuit and Asian descent and is characterized by its often heavy black medulla, dense, even pigment distribution, coarse texture and straight appearance and round cross sections. Supplementary research has not been done to further classify the evidence.

Hair plays a vital role in forensic science.

“Approximately 100 hairs are naturally shed by the human head everyday, therefore they are often found at crime scenes” (Forensic Science Central, 2011). Upon collection, hair analysis can indicate whether the source is human or animal, and also whether the source is a member of a particular race; it can determine if the hair has been dyed, cut in a certain way or pulled out, and where on the body it was located. In some cases, evidence of poisoning shows up in the hair – the hair shaft with a follicle can also offer genetic determinations, such as blood type or DNA, and since the external layer of the shaft resists decomposition. If a follicle remains present on a hair, positive identification can be determined by extracting DNA. If the follicle is not present, the hair is only able to be identified as being from one of three categories – eliminating only about 66 percent of all humans.

Methods

Additional research has not been conducted to further classify hair past the main three categories, leaving little room for error to ensure accurate results because accuracy is not yet known. Hair analysis can be a complicated process, thus staying true to the scientific method of gathering data is the best way to approach the issue. After getting organized and preapproved, the process of data collection, analysis, and finally relaying the data and use the understanding to reach the ultimate goal begins. In order to get started, however, samples are essential. To acquire Mongoloid hair, the first step is to gather human participants willing to contribute to the research. Humans who fill out a survey, acknowledge that they are at least a third generation of a specific race listed in the survey and have cephalic hair then fill out a consent form and place a hair into a small Ziploc bag provided, with the name of

the region labeled. The process is repeated until 50 different hair samples of varying regions are collected. The hair samples are then accumulated and sorted based on regions for analysis. Slides are made for each hair sample by placing two drops of clear, NYX nail polish on a slide with the hair sample – looped or turned into a circular shape around one's finger if it is too long to fit on a slide – placed on top, and a coverslip quickly placed on top with added pressure to keep the hair in place on the slide, making it easier to maneuver under a microscope (The Production of a Series of National Trace Evidence Database). Next comes the analyzing, where comparison microscopes are used to compare and contrast hair from various geographical locations in Asia. Information must be recorded with as much detail as possible. Essential components to delve into include the presence of cortical fusi as well as ovoid bodies, medulla components, pigmentation and visual vs. microscopic appearance. The data is used to look for trends and further classify what is known. Chi square tests are conducted to determine a correlation for each aspect before thank you notes are sent out to all participants for their aid in the research. Finally, a database must be created using Google fusion to categorize the hair based on the similarities and differences found. Once all the data is entered and pictures are in, the program's goal is that the specific hair types will be pinpointed on a map so that choosing a particular region will show all available information about it.

Analysis

Though the analysis is not yet complete, results show a correlation between regions closer together. Hair analyses show that the characteristics such as pigment distribution, presence of cortical fusi as well as ovoid bodies, and even microscopic colors were all relatively similar. When comparing medullas, though greater variation and unanticipated lack of consistency present, a weak correlation can be made. In order to anticipate results, interpretation by quantifying all data collected by tallying characteristics of each hair sample and type, then locating outliers proved effective. Those outliers were looked at once again for any variation in analysis and finally developed a chi square test to refute it. However more tests must be conducted from various

geographic locations for validation.

Conclusion

When the most brutal and loathsome crimes are reported, trace evidence can be counted on as evidence to support a conviction, but that alone will never be enough. Not yet, anyway, when the strand of hair found isn't analyzed fast enough or doesn't narrow the suspect list by enough to impact the timespan it takes to convict a potential cannibal or serial killer, when the data isn't specific enough to promote certainty, when the evidence left behind isn't compelling enough to sway a jury; the support just isn't resilient enough to pinpoint a suspect and bring a case to a speedy close without errors that could put the wrong subject behind bars. With the growing advancements in technology come speed and efficiency, which is the ultimate goal of finding a correlation.

Currently, hair is classified in three categories, though the overarching goal is to make many more in order to classify the evidence by region as well as make an all-inclusive database for people of mixed race as well. Though the field of trace evidence has faced changes in order to become a vital role in crime scene investigation, there is always room for improvement. As stated, the issue needing to be addressed is that there is only one system of hair analysis in the United States, which limits the extent to which a suspect is identified; there must be a way to analyze the hair to find trends that distinguish between the different regions, further eliminating suspects allowing for faster and more accurate identification. Using Mongoloid hair samples, the experiment was designed to correlate regions with defining characteristics that could carry over Negroid and Caucasoid hair classification as well. To quickly catch a killer or a criminal in general, one must be identified. The expectation for this research remains to do that, not simply for Mongoloid hair types, but both Caucasoid and Negroid as well. Classifying Mongoloid hair simply verifies the first step in success.

Bibliography

"Forensic Science Central." *Trace Evidence*. N.p., n.d. Web. 25 Nov. 2013.

"Forensic Science Communications." *FBI*. FBI,

01 Mar. 2011. Web. 25 Nov. 2013. <<http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/july2000/deedric1.htm>>.

"Mongoloid Race." *Wikipedia*. Wikimedia Foundation, 22 Nov. 2013. Web. 25 Nov. 2013.

"The Production of a Series of National Trace Evidence Database." N.p., n.d. Web. 25 Nov. 2013. <http://www.staffs.ac.uk/assets/national_trace_tcm44-12739.pdf>.

"Trace Evidence." *Johnson County Sheriff's Office* :. N.p., n.d. Web. 25 Nov. 2013.

Step on Carbon: Escalator & Elevator Technology

Christina Dias, Hana Keller, Lynsey Liu,
Catherine Yao, and Jennifer Yeh

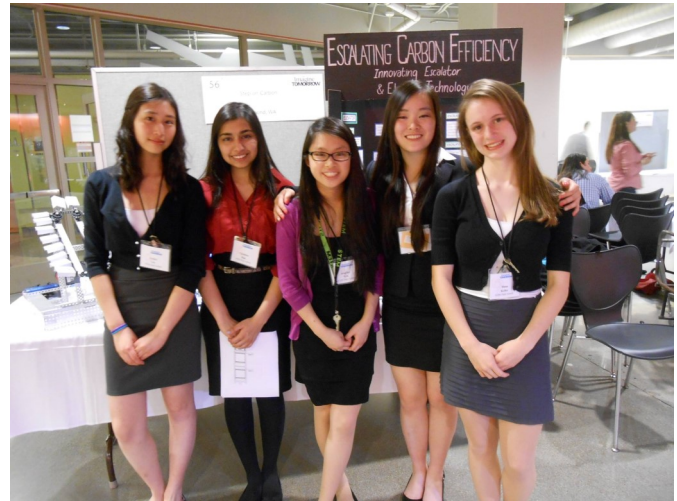
THE ESCALATOR

The new design that we propose utilizes only one system of revolutions around a gear in a lateral direction, in comparison to the typical design that requires two separate systems both going in a vertical motion. Furthermore, we intend to include a motion sensor that turns on the escalator to 30m/min during busy hours when many people are around, and slows it down to 10m/min when the escalator isn't in use as much (evening). Additionally, the motor is generally drawing more power than it needs because the capacity of the escalator is almost never completely full. Motor efficiency controllers can continuously monitor the power consumption of the motor and reduce the voltage when the motor load decreases, which can improve energy efficiency. One final component involves minimizing oil usage (lubricant) for the sealed chain links by using permanently greased seal chain links. These components ultimately strive towards reducing energy use and carbon emissions.

Escalator Component: Step-Chain

Proposed Lateral Motored Step-Chain: Our lateral motored chain would reduce energy usage by using only one chain for both the upwards and downwards escalator sets, therefore using only one electric motor to power the system. This lateral set-up also means that there will be fewer "unused" steps at any time, and having all of the steps accessible from the surface will improve ease of maintenance. More regular maintenance helps decrease energy usage as well, by ensuring that the escalators are always performing at highest efficiency.

Current Vertical Motored Step-Chain: The current escalator chain works on a drive gear attached to an electric motor that brings the rotat-



*Lynsey Liu, Christina Dias, Jennifer Yeh,
Catherine Yao, and Hana Keller*

ing steps up the incline, around under the ground, and looping back to the bottom. Thus, two of these chains are needed for a complete escalator set, with one chain for the up-escalator and one chain for the down-escalator.

Escalator Component: Sensor

Proposed Sensor Technology: A sensor on the escalator controlled by both a laser sensor system at the entrance and weight sensors on the steps increase energy efficiency by slowing down the escalator when it is not in use. Because stopping and starting the motor would take a greater amount of energy, slowing down the motor allows the system to use less energy when the escalator is not being used, cutting down on unnecessary carbon emissions.

Current Technology: The current escalator technology runs the motor at all times, no matter if there are passengers or not. Thus, a large amount of excess energy is used in unnecessary movement of the step-chain.

Escalator Component: Motor

Proposed Motor Efficiency Controller: SinuMEC (Sinusoidal Motor Efficiency Controller) These products are a new category of AC motor controllers that use the right voltage to improve efficiency of variable load motors running at constant speeds. It provides a pure SINUSOIDAL voltage wave-form when the motor starts and during normal operation. The SinuMEC continuously monitors the power consumption of the motor and reduces the voltage when the motor

load decreases, which involves improved motor performance and energy efficiency. Essentially, it improves power factor (high power factor is desirable—it is the ratio of active to total current)

Current Motor Efficiency: A current standard motor used for escalators is the 7.5 – 15KW inductive AC motor, which operates long hours and consumes a significant amount of electricity.

Escalator Component: Sealed Chain Link

Proposed Permanently Greased Sealed Chain Link: Patented carbon-based solid lubricants are mounted on the chain drive which allows permanent and low-maintenance lubrication without any pollution that is constantly transferred to the chain during its movement. Currently, these graphite-based lubricants are used on motorcycles and bikes, but this technology by XYCARB Ceramics can also be applied to other appliances that require chains. A large amount of lubrication is usually necessary and the frequency of maintenance highlights the immense amount of additional oil that escalators require which can be minimized through permanently greased sealed chain links.

Regular chain v. Permanently greased technology

Current Sealed Chain Links: Wear between the pin and bushing causes chain to elongate, until the chain is misshapen, weakened, and not spaced correctly. Wear failure causes material to be removed through abrasion which can ultimately prevent sprockets from fitting the chain. A solution that may prevent these effects involve lubrication which can extend chain life by as much as 100 times. Lubricant slows down wear between pins and bushings in the chain joints while also inhibiting rust, carrying away heat, and cushioning impact forces. Typically, a non-detergent petroleum base oil is used as a lubricant (antifoaming, antioxidizing, and extreme pressure additives are helpful), and manual lubrication must be applied once every eight hours.

THE ELEVATOR

A physical alteration to the elevator system that would reduce energy usage would be to layer cars; one serving odd floors and one serving even floors. Thus, only one elevator system

would be required to transport two passengers on adjacent floors simultaneously, reducing transportation time and distance needed. To decrease energy usage and increase efficiency of the elevator, we also propose to implement a new user input system in conjunction with an algorithm that increases communication between multiple elevator cars. Instead of using individual algorithms, this new system would use the input floor numbers to calculate an optimal route per car without operating each car on its own, saving both time and carbon emissions. Based on theoretical estimates, this form of algorithm would increase energy efficiency between 20 to 50 percent, depending on amount of usage and other factors.

Elevator Component: Layered Cars

Proposed Layered-Car Shaft: This technology entails having one elevator shaft containing a set of two elevator cars, one on top of the other. With this system, multiple people from different destinations or heading to different destinations can be taken there with less travel distance, and all in one shaft. Doing so increases the efficiency of service and energy usage per elevator shaft, and can possibly eliminate a few unnecessary elevator shafts. Doubling cars up, combined with an intuitive algorithm, can service multiple destinations at once, greatly decreasing overall energy usage by elevators for the building.

Current Single-Car Shaft: The current single-car system allows one shaft to service one entrance or one destination floor at a time. This means that to bring multiple people from different floors to various destinations, the elevator has to move a further distance up or down, requiring a greater energy input from the system.

Elevator Component: Input

Proposed User Input: With our system, the elevator is given an input of which floor the user is going to, through user input buttons outside of the elevator. With the information of destination floors, the elevator can determine the most energy efficient and fastest ways to transport to the various floors, and assign passengers to a car that will take the calculated route. Combined with the layered car system, the destination input will allow the algorithm to find a route that is most effective and the least amount of travel for a set

of cars.

Current 2-button Input: The elevator is given either an “up” input or a “down” input to work with from whichever floor the input comes from. Using this information, a request is assigned to an elevator as soon as the elevator is going to stop at that floor and signaled the corresponding leaving direction. This input system gives the algorithm little information to work with, thus increasing amount of floors the elevator will likely have to travel and reducing the system’s efficiency.

Elevator Component: Algorithm

Proposed Algorithm: The proposed algorithm alters from most current elevator algorithms in that using destination input, it works between elevator cars to calculate a most efficient route and assign it to a single car. For example, if the elevator were to receive two inputs for going to the sixth floor, instead of sending two cars down to take two people to the sixth floor like the original algorithm might have done (given only up or down input), the proposed algorithm would use the destination floors to send only one car down to complete the same task in the same amount of time, reducing energy usage and also freeing up the other cart for other routes.

Current Algorithm: Because the current algorithm is only given an up or down input, the cars in the elevator system work with algorithms independent of one another to transport between floors. After carrying out an up or down task, the elevator will be assigned to a “parking position,” usually on the first floor or sometimes a middle floor, to try to anticipate the next usage. A brief diagram and summary of the common elevator algorithm is below:

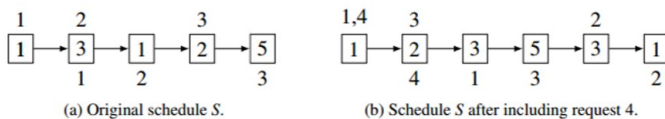


Figure 1: Serving request 4: $1 \rightarrow 2$ changes the structure of the schedule completely. Our graphical notation represents a stop by a boxed floor number. Numbers above or below a stop indicate requests picked up or dropped, respectively.

ple: traffic, type of service or building, type of usage, etc. which affect which floors are most commonly used and therefore, the algorithm. Thus, there is not always a generic elevator algorithm and the system is often made to suit the building.

However, elevator algorithms are highly specific and depend on many different factors, for exam-

Differences in Susceptibility to Fear Between Males and Females

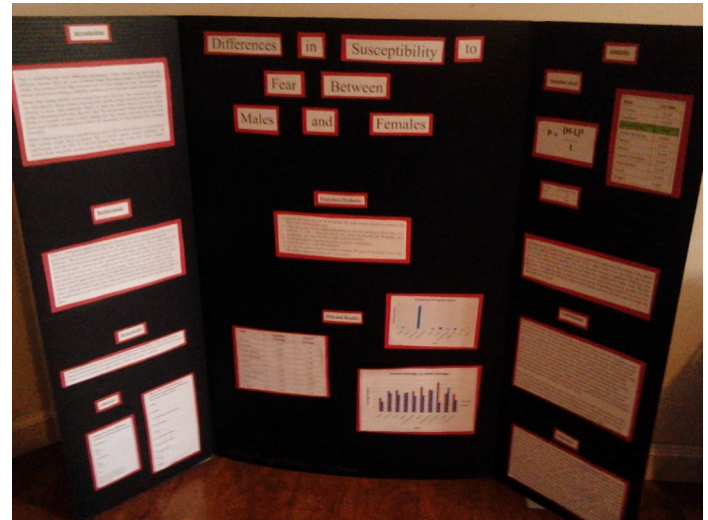
Cat Raggi and Heather Mathews

Abstract

It's been a long held belief that women tend to fear more than men, but is there any basis to this? That's the question this project answered as participants were asked to rate the common fears of clowns, darkness, public speaking, snakes, insects and arachnids, the supernatural, death, heights, sexual assault, and murder. The hypothesis stated that the type of fear affected the fear felt by either gender. Women were more likely to fear sexual assault, insects and arachnids, the supernatural, and the dark, while men would report a higher fear of snakes, heights, clowns, death, and public speaking. An online survey asked participants to rate the intensity of the aforementioned fears from 1-5, with 1 being the lowest. All but sexual assault proved statistically insignificant. Analysis of the data showed a P value of 0.168 for clowns, 0.034 for darkness, 4.563 for sexual assault, 0.005 for public speaking, 0.213 for snakes, 0.474 for murder, 0.169 for insects and arachnids, 0.354 for the supernatural, 0.144 for death, and 0.005 for heights. The hypothesis had been mostly incorrect, and results showed very little difference between the fears of men and women. According to this study, the belief that women are the more likely of the two sexes to feel fear is incorrect, with sexual assault being an exception.

Intro

Fear is something that every adult has experienced. While everyone can feel fear for different reasons, there are some common things that cause people to feel fearful and afraid. The amount of fear that everyone feels for these things can vary, from something intense and severe to feeling completely apathetic or even getting a sense of enjoyment. For instance, clowns terrify some people. They would prefer anything to being around one. At the same time, there are



people who enjoy the presence of clowns and would pay to see them in circuses or at birthday parties.

Research on fear itself is far from new. Something that had yet to be looked in depth at is the differences of what people fear based on their sex. It is commonly said that women fear more than men. How could anyone know for sure? Without statistics and numbers, this could not be proven.

Rather than testing whether or not women fear more than men, the research done was to see what specific things women fear more and what specific things men fear more. It is more valuable to know what particular objects or ideas are feared than it is to know which gender experiences more fear than the other. By seeing which things make people more afraid, it is possible to work towards helping men and women overcome their fears and focus more clearly on their lives without the discomfort of their greatest fears looming over them.

Before releasing the survey and allowing people to fill out their answers, it was believed that women would have a greater fear of sexual assault, insects, arachnids, the supernatural, and the dark. It was also thought that men would fear snakes, heights, clowns, death, and public speaking more than women would.

Women, according to the hypothesis, would tend to fear more abstract ideas as well as small creatures than men. Men would fear larger and solidified threats. This idea is based on the different

societal roles of men and women in the past. While men tended to go out and hunt in the past, women stayed at home and tended the family's lot and needs. This could lead to a greater fear of abstract things because they weren't sure what would happen to them. Smaller creatures that could spread disease were more commonly found in households and crowded areas than the outdoors. Men would encounter more large and forceful creatures that could easily kill them, leading to a possible greater fear of those things in men than women, solely because men dealt with those threats more often.

Background Research

While research has been done on fear dependent on one's gender, it is not an overly explored topic in today's scientific community. Still, some work has been done to identify differences between men and women that could relate to their variations in fear. Other research has been done to determine a very limited amount of fears and see how each gender varies in susceptibility to said fears.

Fear is a biological response developed to increase a species' chances of survival. Fear is processed in the amygdala and is the only emotion that does not pass through the thalamus. This is because fear is meant to be quickly acted upon. When under threat, the sympathetic system fires adrenaline throughout the body, creating an increase in heart rate, blood sugar, respiratory rate, and dilated pupils. In other words, fear prepares us to take on perceived threats. According to previous studies, gendered perceptions of crime can lead to varied fears between men and women. Men have shown a higher fear for crimes such as aggravated assault, but regarding all other crimes, women have generally reported more fear, even if they are statistically less likely to be a victim of the crime. Although many studies have targeted gendered crime perception, there are few studies done on sex based differences between more common and less threatening fears.

A survey created by Lesley W. Reid and Miriam Konrad helped give insight to the differences of men and women when it came to what they feared. Throughout their survey, women reported a higher level of fear of sexual assault than

men did. Sexual assault is an unfortunate occurrence that is primarily directed towards women. While men can be victims of this crime, they are not normally the target of rapists. This shows that women, as would be expected, have a higher fear of crimes that are often directed towards them. The mainly gender-neutral crime of burglary resulted in a fairly similar fear in both men and women, enforcing this idea. Interestingly, women also showed a higher fear of robbery, something that is primarily directed towards men.

A convenient answer to the question created by the results of the previous research was given by Carly M. Hilinski, Kindsey E. Pentecost Neeson, and Heather Andrews. They also conducted a survey, trying to learn the reason why women would fear robbery when it was a crime more often directed towards men. When their participants were asked why they had a higher fear of robbery, many women reported that their fear of sexual assault greatly impacted their fear of various other crimes. Also reported is that women that had previously experienced victimization of crime could influence the fears that they carried later on in life. This research suggests that fear is not solely biological, but can have strong roots in various external factors.

These two particular surveys were the most helpful to the research being done, though other articles and experimentation were looked at to get a better general idea of the topic and what had been previously done in that field. The idea that fear for certain objects or concepts could be influenced by external factors shows that it could be possible to eliminate, or at the very least reduce certain fears in order to make the people unprotected from potentially fearful things more comfortable. Better regulations and laws to capture rapists and burglars could greatly increase the physical wellbeing of people as well as removing the psychological problems that come with exposure to these criminals.

While research has been done regarding gender and fear, there are few solidified and widely accepted theories on this. Delving more into fear and how it affects people could be greatly beneficial to understanding fear in more depth and discovering ways to limit fears that aren't beneficial to survival.

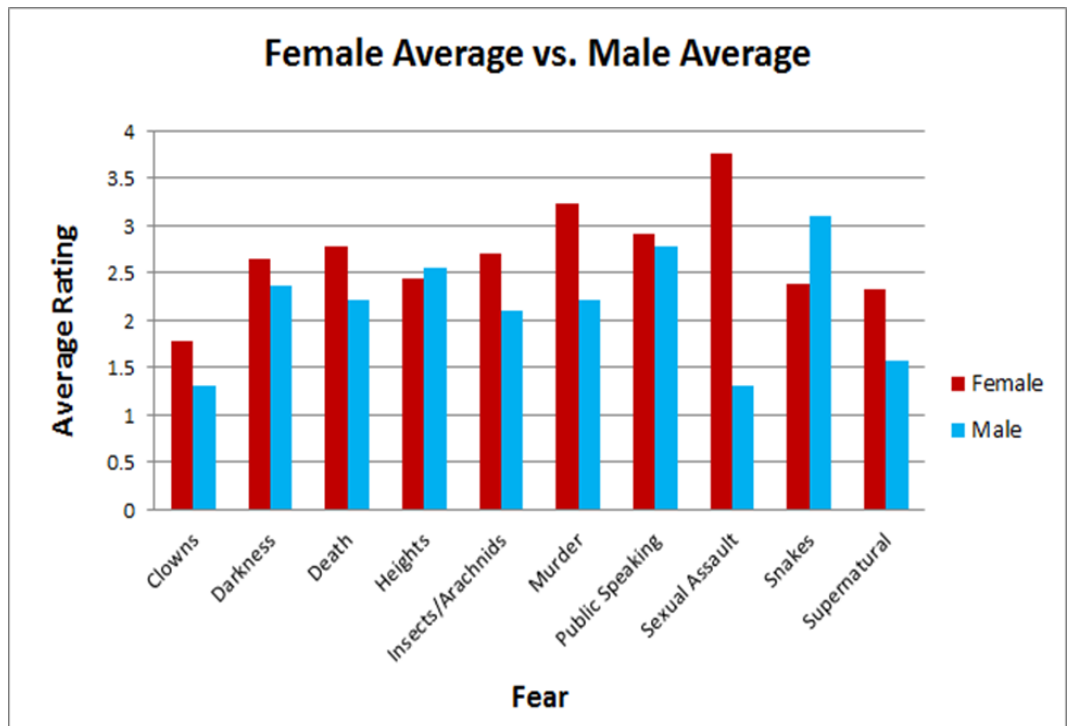
Methods

To test the hypothesis that women feared sexual assault, insects, arachnids, the supernatural and the dark while men feared snakes, heights, clowns, death, and public speaking more than the opposite gender, a survey was put into place. This survey was worded as simply as possible in order to avoid a written bias cropping up in some of the results. Men and women taking the survey were asked to rate their fears of certain objects from one to five, with one being the lowest amount of fear and five being the highest.

This survey was distributed to the researcher's contacts on social media websites as well as other forms of communication to spread knowledge of the survey to as many people as possible. Participants of the survey were asked to confirm that they were eighteen or older. They were also asked to give an age range as well as their gender. The range of age was originally going to be used to see if certain fears were more prominent or less prominent depending on how old the participant was, but this was cut out from the experiment because it was felt that it detracted from the focus on gender-based fears. The results may be reviewed later on to see if different age groups fear the same thing with different severities as a different experiment.

The survey was posted on a website that is dedicated to the different and current ongoing psychological studies. Participant's results were recorded by the website. Personal information was not given, and the survey was completely anonymous to all who chose to partake in the survey. The information was gathered and placed together, separating the women's results from the men's and placing each thing they were asked to rate together to better analyze the results.

<u>Fear</u>	<u>Females'</u>	<u>Males'</u>
Clowns	1.787	1.316
Darkness	2.650	2.368
Sexual As-	3.766	1.316
Public	2.913	2.789
Snakes	2.391	3.105
Murder	3.234	2.211
Insects/	2.702	2.105
Supernatu-	2.326	1.579
Death	2.783	2.211
Heights	2.444	2.556



In order to get a better understanding of the results, the chi squared method was used. This method helps to get the statistical significance of the results achieved through the survey. The

equation is
$$\sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$
. This equation shows the statistical significance of the results, granted the number created by this equation is 3.84 or greater. If it is lower than this, the number calculated is too similar to put too much thought into what the results could mean. If it is 3.84 or greater, deeming it statistically significant, there is a 95% certainty to the results.

Results

The data table and the graph shown above depict the results that were found in the survey conducted. As seen, the fears of men and women are generally very close. In the majority of fears they rate similarly, though women tend to feel slightly more afraid. This trend signifies that people fear relatively the same, regardless of gender, because it is something they find equally menacing. The most prominent difference shown is the fear of sexual assault. Men averaged a rating of 1.316 while women averaged a rating of 3.766, a difference that is much larger than any other result. This, as indicated by previous research, is likely because it is a fear directed prominently towards women. While men can still experience sexual assault, it is far less likely for them to experience it than a woman would be.

There are a few potential issues seen with this research. Because it was difficult to inform others about this survey, as the researchers had limited ways to contact others, many of the people participating in this study are local to Washington State. A large portion of the participants were women. Fewer

men took the survey, leading to a smaller and therefore less accurate reading of what they feared. Extending the time period and different people taking the study would give more accurate results. Within the time frame of the study, these results are fine, but it would be best to get more participants.

In order to determine the statistical significance of these results, the chi squared equation was used. Using this equation, results of 3.84 or higher are statistically significant with certainty of 95%.

As shown, there is only one fear with a number at 3.84 or above, making it the only statistically significant difference. Sexual assault is numbered at 4.563 with the chi squared equation, showing that it is the only fear that has a large gap between genders. This is most likely due to the societal norm of sexual assault being directed towards women rather than men. Other than this, the fear felt between each stimuli was very similar between men and women.

Conclusion

The data above shows that many common fears are common among both sexes, with a very minimal difference in fear between the two genders. Many threats perceived by men are also perceived by women, as they do not live in completely separate regions and cultures from each other. While there are differences, the amount of fear is predominantly the same. An exception to this is sexual assault. While many perceived fears are similar among men and women, the latter feels a much greater amount of fear of sexual assault. Using the chi squared equation, the result was 4.563, a statistically significant difference. This is because women have a much larger chance of being sexually assaulted than men, and it is something often portrayed in the media and throughout

<u>Fear</u>	<u>P Value</u>
Clowns	0.167
Darkness	0.034
Sexual Assault	4.563
Public Speaking	0.005
Snakes	0.213
Murder	0.474
Insects/Arachnids	0.169
Supernatural	0.354
Death	0.144
Heights	0.005

American culture. Because it is such a pressing matter in the country, many women are very aware of the issue and as a result their fear of sexual assault is higher. Men, who are rarely included in campaigns against sexual assault and who speak up about what occurred less often fear this less because they feel it is not as prevalent to them.

The hypothesis stated was that women are more likely to fear sexual assault, insects and arachnids, the supernatural, and the dark, while men are more likely to report a higher fear of snakes, heights, clowns, death, and public speaking. This was predominantly proved wrong, as many of the statistics show that men and women generally feel the same amount of fear towards insects, arachnids, the supernatural, the dark, snakes, heights, clowns, death, and public speaking. The hypothesis was correct about sexual assault, as women feared this much more than men did.

Something possible to look into is whether or not other socially pressed matters are commonly feared among the sex they are directed predominantly towards. Another study that could be conducted is the impact of age on certain fears. For this survey, everyone participating was over the age of eighteen. Young children, teenagers, young adults, adults, and the elderly may fear completely different things from each other because different things are more relevant to their particular age group, whether this is solely based upon cultural matters or not.

Throughout this study, it was learned that men and women for the most part fear similar amounts. The thought that women are more afraid than men was not proven, other than a fear that is culturally directed towards women specifically. Men may possibly fear certain things with a statistical significance if these fears were faced majorly by men rather than women. Fear is something felt by all humans, as it is a mechanism used to help homo sapiens survive and thrive. Without fear, many people would not survive and the population would be greatly decreased, if not extinct entirely. Because of fear, humans are more cautious and tend to live more successful and safe lives.

Men and Women Really Are Different." *Gender Biology*. Information Television Network. ITV, 2008. Web. 27 Oct. 2013.

Regitz-Zagrosek, Vera. "Sex and Gender Differences in Health." *EMBO Reports*. 14.13 (2012): 596-603. Web. 27 Oct. 2013.

Dzierzak, Lou. "Factoring Fear: What Scares Us and Why." *Scientific American*. 2008. Web. 27 Oct. 2013.

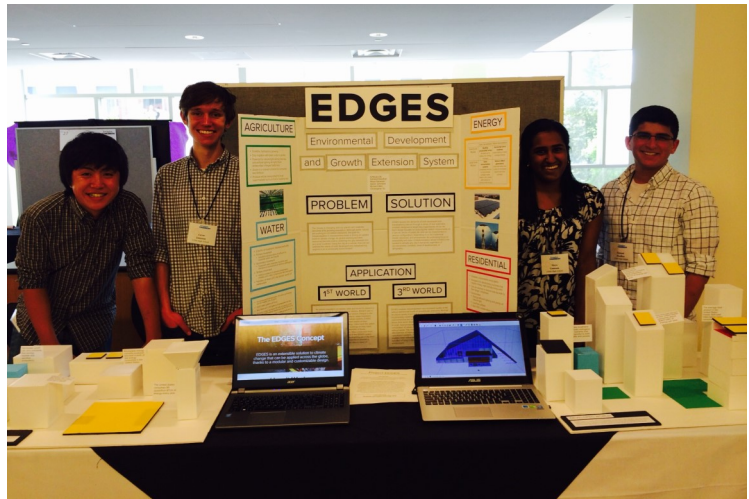
Reid, Lesley W. and Konrad, Miriam. "The Gender Gap in Fear: Assessing the Interactive Effects of Gender and Perceived Risk on Fear of Crime." *Sociological Spectrum*. 24.4 (2004): 399-425. Web. 29 Oct. 2013.

Hilinski, Carly M., Neeson, Kindsey E. Pentecost, and Andrews, Heather. "Explaining the Fear of Crime Among College Women, in their own Words." *The Southwest Journal of Criminal Justice*. 8.1 (2011). Web. 29 Oct. 2013.

Works Cited

EDGES: Environmental Development and Growth Extension System

Kanaad Deodhar, Maya Ganesan,
Aaron Johnston, Richard Wen,
and Christopher Yu



*Christopher Yu, Aaron Johnston, Maya Ganesan and
Kanaad Deodhar*

Question

The climate is changing, and our planet can't meet the demands of its growing population. Although some nations are working to cut carbon emissions, the push for industrialization in impoverished areas is driving an upward trend in climate change. As global warming worsens, resources become scarce, widening the gap between rich and poor countries. Using the city as a canvas, how can we address the needs of both developed and industrializing regions in an economically sound model?

Solution

EDGES tackles the demands of both developed and industrializing nations through a series of four extensible modules designed to target key requirements of city life. Each design focuses on reducing the carbon requirements of a specific sector of public life, and can be implemented in various configurations depending on a city's individual needs, resources, and environment. An underlying focus on adaptability and ease of implementation allows EDGES to be applied in virtually any city in the world, regardless of socioeconomic condition, level of development, or geography.

Water

The water module incorporates three stages of wastewater treatment, all stacked vertically to allow for maximum utilization of minimal space. Primary treatment (gravitational separation of

solids and liquids) and secondary treatment (treatment with anaerobic bacteria and membranes to remove pathogens) are required by law; tertiary treatment (passing water through an artificial wetland to absorb nutrients and hormones) is essential in allowing water to be purified enough for human consumption. The water module allows water to be recycled within a city, while also protecting external marine ecosystems into which the water is channeled out. An average water module would handle at least 220 city blocks' worth of wastewater.

Agriculture

The agriculture module utilizes scalable, hydroponic growing, with plant roots in perlite and drip irrigation to conserve water. The module will be powered by natural light during the day and artificial lighting at night (from photovoltaic-charged batteries), and crops will be grown in a nutrient solution to consume less fertilizer. Produce will be transported to local supermarkets and distribution centers by a truck from a loading bay. The module allows people to eat locally-grown produce and be more connected with the food they consume.

Residential

The residential module is a scalable, expandable living space that can be stacked either vertically or horizontally to form larger complexes. It's designed especially with developing countries in

mind, where cheap, high-density living units are required, but it can also be equally adaptable in a first-world metropolis. It incorporates energy-efficient lighting and plenty of natural light, as well as low-flow utilities and non-VOC construction materials.

Energy

Four energy modules are offered to fit an area's specific needs, incorporating both wind and solar technology. For a small-scale module, the solar technology involves a rooftop photovoltaic array that is hooked up to a battery for energy storage; the wind technology involves horizontal wind turbines that are extensible to meet energy needs. For a large-scale module, the solar technology involves solar concentration systems that use mirrors to concentrate sunlight and heat a water tower to turn a turbine; the wind technology involves Venturi effect generators that channel wind into a pipe to increase its speed and turn a turbine. The energy modules are adaptable based on an area's environment and size constraints.

Application

1st World

As global population increases, cities are forced to expand in order to provide for an influx of new citizens. EDGES uses a comprehensive plan that targets four sectors integral to the functioning of a city: housing, agriculture, water treatment, and energy production. With this modular system, EDGES can be incorporated into existing cities based on their specific issues and current technology. Cities have the option to purchase only as many modular buildings as they need, saving funds and increasing the availability of these sustainable alternative technologies. Mass production from widespread use of each component of the EDGES system will also drive down costs, ultimately enabling use in the third world. Therefore, EDGES has the potential to provide a relatively cheap system to first world cities in need of expansion.

3rd World

EDGES enables industrialization and increased quality of life without detrimental levels of greenhouse emissions. Modular structures tackle 4

principal areas of resource usage in an incrementally implementable fashion, offering a comprehensive and economical approach to clean fuel that drives third world development. By providing these services in small, mass-produced units, communities with any combination of needs can implement the relevant modules without waste. This small-scale approach combines the cost effectiveness of mass production with the efficiency of customized solutions. Through its flexible system that enables clean industrialization, EDGES can raise the standard of living in the third world while protecting the environment.

How Varying Ratios in Dynamic Range Compression of Music Affect Listener Preference

Hunter Gordon

Abstract

Excessive clipping and dynamic range compression of music are used widely at much greater levels today than ever before. If a greater ratio in dynamic range compression is employed upon a track, does this create a more preferred song than the uncompressed original? Four different songs were chosen, each given compression ratios of 1:1, 1:2, 1:10, and 1:25. Participants were brought in and were not told of how songs were altered. Four different compressions of a song (each compression called a track) were played one after another in a random order. Listeners detailed their favorite to least favorite track using the numbers 1 to 4 (4 meaning best) and how strong their preferences were (very weak, weak, strong, or very strong). The data presents an average increase of 0.6 of all songs' preference values from 1:1 to 1:2 and a decrease of 0.5 from 1:2 to 1:10. Somewhere between the 1:2 and the 1:10 ratios is where each song begins to diverge from the average. It appears that the greatest preference across all songs lies between the 1:1 and 1:10 ratio. The preference strength, however, amounted to a "weak" for three songs and "very weak" for one song, meaning listeners are not too finicky over compression differences between 1:1 and 1:25. Between 1:10 and 1:25, preference values vary from the mean as much as 0.4, so compression ratios up to 1:10 and beyond may or may not amount to a better sounding song.

Overview

What is dynamic range compression, exactly? Dynamic range compression, not to be confused with data compression [3], makes the louder parts of an audio signal quieter and the quieter parts louder. The ratio in particular influences



Hunter Gordon

how much "push" there is upon a signal to achieve this effect.

Scientific research available on the topic includes a phenomenon of increased compression in music often titled "The Loudness War". This overview by Earl Vickers, aptly titled "The Loudness War: Background, Speculation and Recommendations" [7], details the phenomenon as a whole, noting speculation of why it occurs and if increased dynamic range compression (noted as lower dynamic range values, in this case) led to higher record sales. The latter statement can be answered as "no", though not the opposite. A small negative correlation between dynamic range and sales had been found, with a very weak relationship between dynamic range and sales. Many people, however, may hear the album or tracks of the album from online sources, such as Youtube, prior to purchasing the album. This online source could have compression unlike compression present on CD or digital formats. Youtube at many times has songs with less compression than their CD counterparts. The online source *entices* them to buy the product, but they do not receive an equal product in return.

Questions and Possible Implications

This research project, titled "How Varying Ratios in Dynamic Range Compression Affect Listener Preference" measures just that. This experiment can help find the ratio amount (independent vari-

able) that would make a song the most desirable to listeners (dependent variable). Music in the 80's utilized much less compression than today. Are we leading towards better-sounding music, or have we traveled away from it?

It's safe to assume that most record companies want to thrive and survive, grow and expand, sell records a plenty. It's also fine to believe better-sounding records sell better than worse-sounding records. Knowing just how much compression sounds the best would help one of these companies understand what the public wants.

Variables

The independent and dependent variables of this experiment are the size of the ratio and the song preference of the listener. The four chosen songs of the experiment are "Hell Is Round the Corner" by Tricky [6] (Song 1), "Are You Gonna Go My Way" by Lenny Kravitz [5] (Song 2), "La Cienega Just Smiled" by Ryan Adams [1] (Song 3), and "Unbelievable" by EMF [2] (Song 4). Each Song had a dynamic range [8] of 11 before dynamic range compression (to develop a baseline). All sound bytes, originals or otherwise, were encoded in FLAC or WAV formats. Songs are cut to 30 second intervals starting at 50 seconds and ending 1 minute 20 seconds. Tracks have a constant attack of -1.0 milliseconds and a constant release of 175.5 milliseconds, under the threshold of -25 dB. As compression lowers the RMS (root mean square), or the average sound pressure of the song, makeup gain was applied to compensate. Tracks with the ratio of 1:1 were given a 0 dB amplification, 1:2 had a 7.0 dB increase, 1:10 had a 13.4 dB increase, and 1:25 had a 14.3 dB increase. The compressions were put in a random order that remained constant throughout the experiment, which is mentioned below.

Compression Values on Section Number (1:Value)				
	Sec- tion 1	Sec- tion 2	Sec- tion 3	Sec- tion 4
Song 1	2	1	25	10
Song 2	2	25	10	1
Song 3	10	1	25	2
Song 4	25	1	10	2
Master Vol- ume:	-17 dB			

Figure 1: Compression ratios of each section, ordered randomly before the experiment.

Section number refers to the order in which the tracks are played.

To keep the placebo effect in place, consent forms advertised the project with a title of "Processing Music and User Preference". The form notified data would be collected anonymously. Participants ages 13 to 18 had been organized through such announcement of the event and had arrived on their own.

Procedures

Methods and procedures were conducted at the Old Fire House Recording Studio. The available speakers were used to play the music in an otherwise quiet environment. All forms of visual output in the room that are caused by sound played through the equipment, such as bars that show volume, were hidden from participant view. The master volume of playback was to remain constant and was recorded in the Data Table for Compression Values. Participants also had been instructed not to converse with one another. Participants were told to fill out a questionnaire stating their preferences of the tracks. The numbers 1-4 allowed participants to give their sections of a song from least (1) to most (4) preferred. Participants were also motioned to state how large their preference was from their least to most preferred, with very strong, strong, weak, very weak as choices [4].

Data & Conclusions

Compression Values on Average Preference				
	1:1	1:2	1:10	1:25
Song 1	2.444	3	2.22222 2	2.33333 3
Song 2	1.889	2.88888 9	2.44444 4	2.77777 8
Song 3	2.556	2.88888 9	2.66666 7	1.88888 9
Song 4	2.222	2.77777 8	2	3
Average	2.278	2.88888 9	2.33333 3	2.5

Figure 2.1: Average Compression Preference; further detailed in 2.2

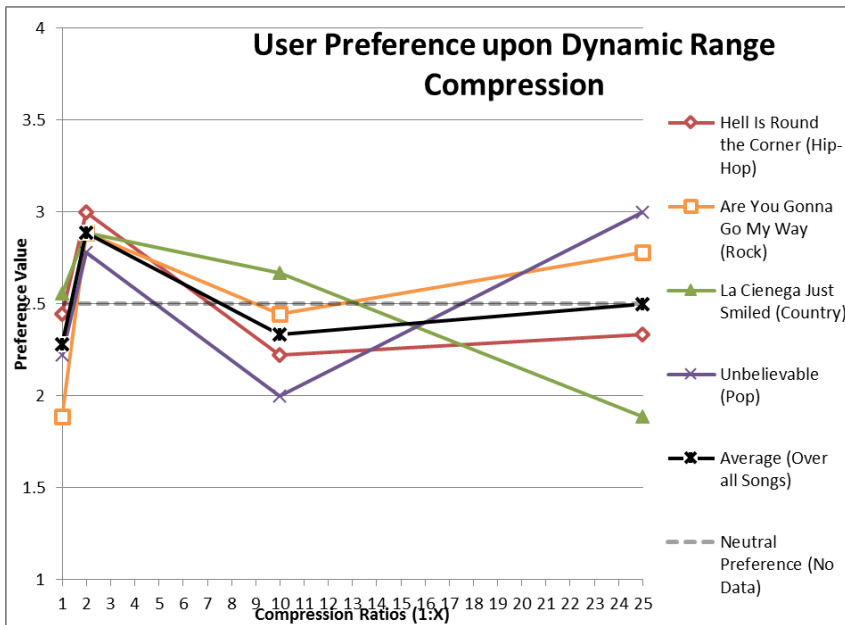


Figure 2.2: Mean Preference of the nine subjects in the study. Points are connected only to express differing preference over various compression ratios. "Neutral Preference" refers to the mean of 1 and 4, signifying a better or worse sound above or below the line, respectively.

Preference Strength					
	Song 1	Song 2	Song 3	Song 4	Average
Strength	1.556	1.333	1.778	1.625	1.573
Equates to	weak	very weak	weak	weak	weak

Figure 3: Average preference strength of the nine participants, in which "very weak", "weak", etc. had been converted to 1, 2, and so on.

This culminating data presents an average increase of 0.6 of all songs' preference values from 1:1 to 1:2 and a decrease of 0.5 from 1:2 to 1:10. Somewhere between the 1:2 and the 1:10 ratios is where each song begins to diverge from the average. It appears that the greatest preference across all songs lies between the 1:1 and 1:10 ratios. The preference strength, however, amounted to "weak" for three songs and "very weak" for one song, meaning listeners are not too finicky over compression differences between 1:1 and 1:25, calling back to the record sales mentioned in "The Loudness War" [7]. Between 1:10 and 1:25, preference values vary

from the mean as much as 0.4, so compression ratios up to 1:10 and beyond may or may not amount to a better sounding song.

Error Analysis and Suggestions:

One important point that would help in determining why one track sounds better than another would be to have participants note what they think was different between the tracks. At one point one of the participants hypothesized that "pops and clicks" may have been added to make "Hell Is Round the Corner" (Song 1) sound differently.

To help eliminate other variables such as outside sound and the position of the listener during the experiment, it would help to use headphones for all participants. As participants were different distances and angles away from the speakers, the audio input *they* received varied very slightly from person to person. Each participant should be aside from other participants to further ensure they do not converse their opinions. This experiment used the same equipment (of high quality) to play the sound files, so that remained (and should remain) constant. Small details between the sound files that may not be evident through speakers could reveal themselves in this approach.

The size of the data set gets put into question. Only nine teenagers were able for participation. The User Preference upon Dynamic Range Compression graph shows enough trend to verify the data, but a larger sample is always more viable. This is especially true if investigating the area between 1:1 and the 1:10 ratios, as the differences between the compressions would be very minute.

Further analysis in-between the 1:1 to the 1:10 ratios would determine where the "best" amount of compression lies on average. In addition, compression far beyond the 1:25 ratio would reveal at what points the preference peaks, unable to sound worse through all greater ratios.

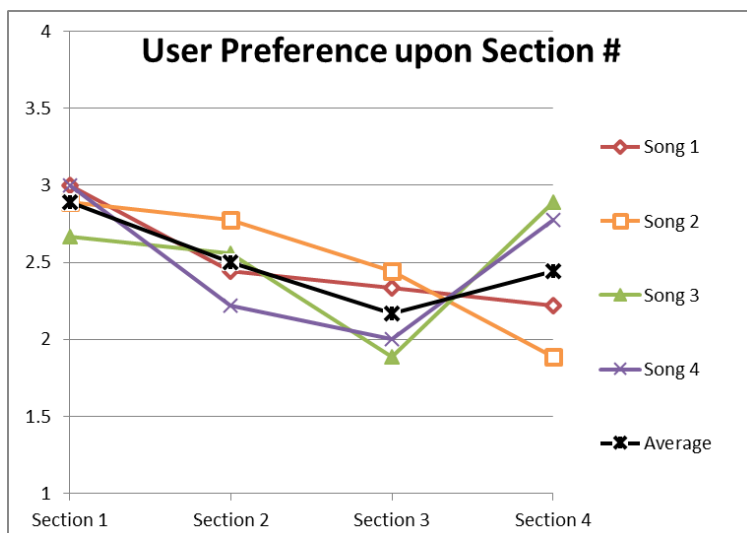


Figure 4: Mean listener preference; lines are connected only to show growth or decline in preference.

The order of the tracks was checked to see if it influenced the preference level and it had not; there is no trend in the data. Although the graph appears as if preference decrease is caused by Section # increase, this does not account for the preference change from Section 3 to Section 4. The preferences in Section 4 vary wildly, also negating this theory.

Standard Deviation				
	1	2	10	25
Song 1	1.013794	1.224745	1.092906	1.224745
Song 2	1.054093	0.781736	1.236033	1.301708
Song 3	0.726483	0.927961	1.414214	1.269296
Song 4	1.092906	1.20185	1.224745	0.866025
Average	0.971819	1.034073	1.241974	1.165444

Figure 5: Standard Deviation of the nine subjects in the experiment. Results indicate data falls close to the mean, with the greatest deviation of 1.414.

Important Points

Some important points that may not be evidently mentioned as important in the experiment include the file type of the songs, the dynamic ranges of the file originals and how much participants need to listen to the tracks.

The file type for this experiment, FLAC, is one of

many "lossless" file types for audio files (WAV is also an example), meaning that original data can be perfectly reconstructed from compressed data. "Lossy" file types, while smaller than FLACs, can only approximate the original data. Keep in mind that this type of compression refers to data, not the dynamics range of a song. This "lossy" compression may add artifacts to the mix. iTunes MP3, for example, creates pink noise from its compression [3]. All in all, increased compression of these types of files could amplify these artifacts, giving a misjudged representation of the experiment if such artifacts impact the listener.

Similar dynamic ranges of the original sound excerpts can very easily be overlooked. Obviously songs compressed a lot prior to this compression would have much greater changes compressed again than would compressing a song barely compressed at all. Songs in the experiment before compression have a DR, or dynamic range, of 11.

Participants need to listen until they form a preference, or else their data slips from reputability. Derived from an experiment by David B. Hawkins [4], this assures that participants had enough time to form their opinions, and to listen again if they are on the fence. The "strength of preference" portion of the document could not be finished by the participants if this is not executed.

Works Cited

- Adams, David R. "La Cienega Just Smiled." By David R. Adams. Rec. 2001. *Gold*. Ryan Adams. Lost Highway/UMG Recordings, 2001. CD. Catalog Number: 088 170 256-2
- Atkin, James. "Unbelievable." By EMF. Perf. EMF. Rec. 1990. *Unbelievable*. EMF. Ralph Jezzard, 1990. CD. Catalog Number: E2-56210
- Corbett, Ian. "What Data Compression Does to Your Music." *What Data Compression Does to Your Music*. Sound On Sound, Apr. 2012. Web. 27 Nov. 2013.
- Hawkins, David B., and Sharmala V. Naidoo. "Comparison of Sound Quality and Clarity

with Asymmetrical Peak Clipping and Output Limiting Compression." *Journal of the American Academy of Audiology* 4.4 (1993): 221-28. Print

Kravitz, Leonard A. "Are You Gonna Go My Way." By Leonard A. Kravitz and Craig D. Ross. Rec.1992. *Are You Gonna Go My Way*. Lenny Kravitz. Leonard Kravitz, 1992-1993. CD.Catalog Number: 0777 7 86984 2 5

Thaws, Adrian. "Hell Is Round the Corner." *Maxinquaye*. Tricky. Tricky, Mark Saunders, Howie B, Kevin Petrie, 1994-1995. CD. Catalog Number: 314-524 089-2

Vickers, Earl. "The Loudness War: Background, Speculation and Recommendations." *SFXMachine.com*. N.p., 7 Nov. 2010. Web. 27 Nov. 2013.

Vickers, Earl. "Metrics for Quantifying Loudness and Dynamics." *SFXMachine.com*. N.p., 7 Nov.2010. Web. 30 Nov. 2013.

Bibliography

Adams, David R. "La Cienega Just Smiled." By David R. Adams. Rec. 2001. *Gold*. Ryan Adams. Lost Highway/UMG Recordings, 2001. CD. Catalog Number: 088 170 256-2

Atkin, James. "Unbelievable." By EMF. Perf. EMF. Rec. 1990. *Unbelievable*. EMF. Ralph Jezzard, 1990. CD. Catalog Number: E2-56210

Corbett, Ian. "What Data Compression Does to Your Music." *What Data Compression Does to Your Music*. Sound On Sound, Apr. 2012. Web. 27 Nov. 2013. <<http://www.soundonsound.com/sos/apr12/articles/lost-in-translation.htm>>.

Figueiredo, Ricardo Rodrigues, Andreia Aparecida De Azevedo, Patrícia Mello De Oliveira, Sandro Pereira Vasconcellos Amorim, Artur Guedes Rios, and Vanderlei Baptista.

"Incidence of Tinnitus in MP3 Player Users." *Brazilian Journal of Otorhinolaryngology*

(2011): 293-98. *SciELO.org*. Scientific Electronic Library Online, June 2011. Web. 27 Nov.2013. <<http://www.scielo.br/pdf/bjorl/v77n3/v77n3a04.pdf>>.

Hawkins, David B., and Sharmala V. Naidoo. "Comparison of Sound Quality and Clarity with Asymmetrical Peak Clipping and Output Limiting Compression." *Journal of the American Academy of Audiology* 4.4 (1993): 221-28. Print

Kravitz, Leonard A. "Are You Gonna Go My Way." By Leonard A. Kravitz and Craig D. Ross. Rec. 1992. *Are You Gonna Go My Way*. Lenny Kravitz. Leonard Kravitz, 1992-1993. CD.Catalog Number: 0777 7 86984 2 5

Thaws, Adrian. "Hell Is Round the Corner." *Maxinquaye*. Tricky. Tricky, Mark Saunders, Howie B, Kevin Petrie, 1994-1995. CD. Catalog Number: 314-524 089-2

Vickers, Earl. "The Loudness War: Background, Speculation and Recommendations." *SFXMachine.com*. N.p., 7 Nov. 2010. Web. 27 Nov. 2013. <http://www.sfxmachine.com/docs/loudnesswar/loudness_war.pdf>.

Vickers, Earl. "Metrics for Quantifying Loudness and Dynamics." *SFXMachine.com*. N.p., 7 Nov.2010. Web. 30 Nov. 2013.<http://www.sfxmachine.com/docs/loudnesswar/metrics_for_quantifying_loudness_and_dynamics.pdf>

Aquifer Education

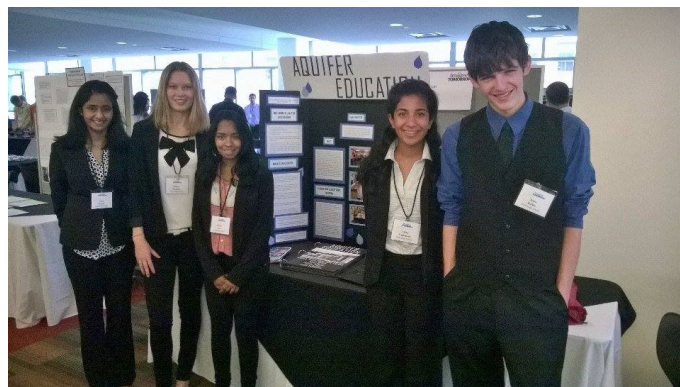
Vibha Vadlamani, Sonia Murthy,
Juliana Seymour, Jason Ruffin and Pavitra Siva

Background

Our school, Tesla High School, was built on top of an aquifer's recharge zone that supplies over 2 million gallons of water to surrounding residents. The Union Hill Water Association, which is the owner of the aquifer, required our school to be built according to particular specifications that would maintain the original quality of the water. To help maximize water input into the aquifer and reduce the amount of pollution, engineers in charge of designing our school implemented the use of permeable sidewalks, which would allow all run-off to enter storage tanks to be released into the aquifer, and the use of swales, a system which gathers water from the parking lot and removes pollutants through the use of native, cost-efficient, drought resistant plants.

Education Plan

To help better the understanding of how aquifers function and what residents can do to minimize the amount of pollution they release, we designed and conducted an elementary-school education program that was presented to the 4th and 5th graders of Alcott Elementary. In this program, students were engaged in an interactive presentation that taught them about aquifers and water tables, as well as how aquifers are polluted and the impact an individual can have to maintain the quality of water produced from the aquifer. Students were also presented with a taste test to differentiate the quality of certain water. Six students were given three water samples, one aquifer water sample, one Arrowhead bottled water sample, and one Kirkland Signature water sample. The question was asked as to which water sample tasted the purest, and out of the six children, five answered that the sample from the aquifer seemed the least polluted and the other two samples tasted metallic and salty. At the end of the lesson, students were eager for more information and teachers gave their feedback of being extremely impressed and gave their invitation to allow us to come back and further educate their students more about aquifers.



*Sonia Murthy, Juliana Seymout, Pavitra Siva,
Vibha Vadlamani and Jason Ruffin*

Public Outreach

To help convey our information to the public, we created pamphlets and distributed them to adults who resided in the communities receiving the UHWA water. In addition, posters were created to hang up in the seven signboards on the Tesla High School campus. Each poster conveyed different information that could be easily interpreted by students and parents as they entered the building. The topics of each poster included groundwater collection and how the swales work, information on the UHWA Aquifer, landscaping features that help make the swales able to remove pollutants from the water, EPA water standards that regulate the amount of pollutants in drinking water, common sources of pollution/contamination that can reduce groundwater quality, ways that an individual can reduce the amount of pollution they release and ways they can save water at home, and finally, an explanation of why this issue is relevant to our society today.

Future Goals

To reach more communities, we have constructed an education plan that is adaptable to different problems and regions where aquifers are located. Our goal is to make this program available to different classrooms, communities, water associations and corporations to better educate the public on ways that water can be conserved and treated effectively.

Our Purpose

Though many people associate the use of water to create energy, many don't realize that the in-

verse is true. It takes energy to deliver water to taps through both methods of transportation and treatment. Energy and the consumption of fossil fuels must be used to move water through pipes, especially if that area is drought riddled and must gain access to water from external sources. Treatment of water releases energy through the process of filtration and the creation of chemicals to help remove pollutants. In methods such as desalination, energy is used to remove salt from water. Our purpose is to inform the public to view aquifers as a local source of water that can be used effectively if maintained properly. To keep in mind the idea of “prevention, not mitigation”, we can reduce the energy and fossil fuel consumption required to transport and treat our water which can help mitigate one aspect of global climate change.

Project Sustain

Andrew Chronister, Nikko Rush,
Caeli MacLennan, Amy Zhang,
Matthew vonAllmen, Teri Guo, Adrian Pang
and Eli George

What if there were games that let you understand the challenges of sustainable development? Not by listing off facts, but by allowing you to experience the challenges that are faced in the real world during the development of a city, and arrive at decisions of your own accord.

Our Approach

From the outset, we wanted to make a fun and interactive experience that also conveyed a key idea. Why do people make the decisions that they make about sustainable design? We wanted our end product to convince the player of the value of looking at long-term value rather than short term benefits.

Our approach took two paths. The first was a video game. We felt an interactive medium was the ideal way to convey our principles, and more and more of our interactions are taking place on computers. A video game afforded us a sense of realism and immediacy without having to abstract away the important core ideas. The second was a board game. As the video game developed, we began shifting the target towards younger audiences. To fill the gap, we decided on a more traditional game that could appeal to older players who might not be as familiar with computer interfaces, or who can better grasp an abstraction of the core ideas.

Video Game

Our computer simulation capitalized on the advantages of the medium: a world that responds to and informs the player's actions without the need for a dice throw. The game models everything from weather conditions to pollution levels to the city's economy in real time. The player can build anything within their budget, which fluctuates according to incomes and expenses. The game is designed such that use of the more Sustainable practices—buildings that promote energy efficiency and produce little pollution—get you more in the long run.



Nikko Rush, Andrew Chronister, Eli George, Teri Guo, and Caeli MacLennan

The game was incredibly well-received by our testing groups. Interviews show that the game conveyed its core concepts fluently as well, and testers left knowing more about sustainable design.

Board Game

Like the video game, the board game tasked players with creating a city using sustainable practices. However, it focused more heavily on the interaction between cities in a multiplayer setting. It introduced random events, exploration, trade, and limited resources that players must compete over, like nations do in the real world. The board game broadens the scope beyond a single city, modelling the effects of these decisions on the rest of the world.

This game was also well-received among target audiences. Players praised its beautiful art and clever integration of the core concepts. Like the video game, it effectively communicated these and players left feeling a deeper understanding of world politics.

The Effect of a Digital Medium on Test Performance

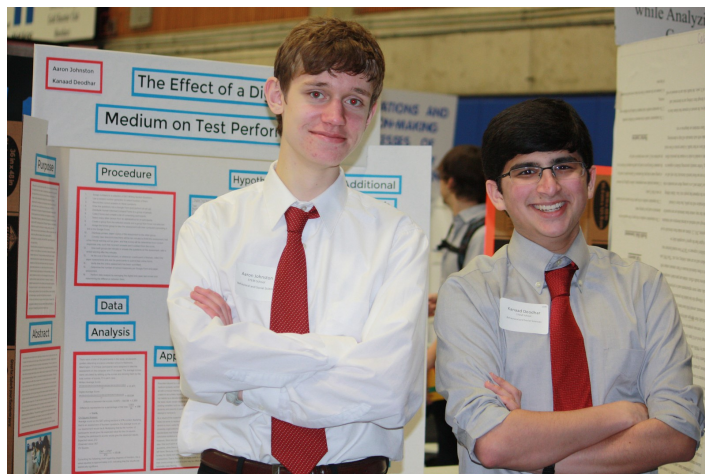
Kanaad Deodhar & Aaron Johnston

Abstract

As society moves ever further into the digital age, schools continue to adopt electronic tests to replace the traditional pencil and paper. Although easier to administer, a digital medium must not impact student performance to provide a viable alternative. Previous research has indicated that students perform better on computer tests in Speed Reading and Proofreading, while writing and essay-based tasks produce better results on paper and pencil tests. A major part of standardized testing, however, is composed of multiple choice questions. This study sought to determine the effect that computers have on student performance on a multiple-choice writing assessment, with the hypothesis that the written version of a test would yield greater accuracy. The participants that consented to the experiment were randomly divided into two equal groups, and one group was given the fourteen-question assessment with questions randomly selected from previous SATs on the computer, while the other group was given the same test in paper form. The data show that the average score for paper tests was 11.24 out of a total of 14, while test takers on the computer scored an average of 10.06. The difference between performances was 1.18 points, or 8.43% of the total possible points – a statistically significant difference. This experiment suggests that while digital tests are easily administered and can automatically check answers, they do not accurately represent the abilities of test takers and that schools should therefore be cautious about using computerized testing mediums with the expectation of fully predicting a student's aptitude.

Introduction

Although the specific tests may differ, it is an almost universal ritual for students that have taken



Aaron Johnston and Kanaad Deodhar

a standardized assessment to ponder the impact that one miniscule score will have on their futures. In today's world, standardized testing forms a student's primary determinant for intelligence and aptitude, making the accuracy of such results more crucial than ever. Every year, the PSAT is administered to thousands of students nationwide to assess their scholarly aptitude and to determine their eligibility to receive a National Merit Scholarship. Meanwhile, thousands of students also take the MSP, the Measurement of Student Progress, a test taken to determine a student's proficiency in reading, writing, and math. While these two tests are administered at different grade levels, the overarching difference between them is that the MSP is administered on a computer, while the PSAT uses entirely pencil-and-paper testing.

Students, teachers, and parents all have an interest in discovering whether or not the difference in test medium creates an incongruity between test scores. This study examines eleventh grade, upper-middle-class high school students with extensive technological experience and their test performances with both computer and paper-based assessments. In a nation faced with an increasing movement towards digital testing and online examination, this study seeks to determine whether or not this divergence from previous practices will alter students' performance. In essence, it seeks to establish baseline data for school districts and education programs throughout the nation in order to determine which method of testing would be preferred. Each test method offers its own benefits and disadvantages, especially that digital tests are easier to administer and distribute to a large number of people;

however, this study seeks to determine how each method affects performance, a major factor in determining which test method to use. After conducting research to find a difference in test scores between otherwise identical written and digital tests, it is predicted that written tests will show a higher average, based on prior research.

Background Research

Although numerous studies have sought to find a link between digital tests and student performance, no common consensus has emerged over their effects. While a number of the studies have reported that paper based testing does indeed produce better assessment performance than its digital equivalent, others either show no correlation or indicate that digital testing causes students to *feel* better about the test, even though they may not perform better (Russell 3). A group of students in Oregon, for example, were assigned to take the Oregon State Reading Exam either on the computer or on paper. Instead of assessing their performance, however, the students were asked to rate how confident they felt about the test. Students ranked the computer test as easier and that they felt better taking it, yet their performance was worse than their paper counterparts. The large number of external, uncontrollable factors drastically affects the results of such studies, but data must continue to be collected.

As education technology increasingly shifts its focus to the digital classrooms and online learning, the difference between test results could potentially have vast consequences on the end product of these tests, the ranking of students based on their knowledge and ability to learn (Horkay 1). However, digital testing offers a great many benefits over its traditional counterpart, especially that it is easier to distribute, administer, and score. Furthermore, digital testing “can provide almost immediate feedback” and “has the potential to be far cheaper than its printed counterpart” (Tech’s Answer 9). Many schools have already switched to the newer option for some standardized testing, and any potential consequences of this method may adversely affect the accuracy of the scores, to the detriment of the students. As such, it is important to determine the effect of digital testing on student scores, because as digital testing gains

more and more ground, efforts need to be made to ensure that standardized testing remains an accurate measurement of student capability. Digital testing, of course, has drawbacks as well. Many students across the nation do not have regular access to a computer; without experience using a computer, digital testing consequently is a far more alien and unnatural method of testing than the traditional pencil and paper (Robinson 1). While every student knows how to “operate” a paper, many students may not have the skills necessary to perform their best on a digitized test. Standardized tests are meant to measure a student’s aptitude or proficiency, not their mastery of a certain test interface. Because digital testing has a large number of unknowns and confounding variables, steps need to be taken to further understand how digital tests change and affect a student’s performance. Scores that are used to represent a student’s ability without proper understanding of how those scores may change depending on the type of test that is administered is simply unfair. This is especially true because, though there is no distinct overall difference between the two, the tests differ significantly in specific areas (Tech’s Answer 8). Previous studies have shown that Speed Reading and Proofreading are subjects in which students taking digital tests outperform their pencil and paper counterparts, while traditional testing produces far better scores than digital with writing and essay-based tasks (Noyes 2). For example, a study in Massachusetts had eighth and tenth grade students respond to two essay prompts. Half the students had to respond to the prompts on the computer, and half had to hand-write their essays. With both grades, the students consistently performed better when asked to hand-write the essays, though the difference was more noticeable with eighth graders. There exist many studies similar to this one that study the effect of computers on students’ writing. What hasn’t been studied thoroughly before, however, is student performance on multiple choice writing questions. Many studies have been done on essay tasks as well as mathematical and reading comprehension, yet there is a scarcity of studies done on multiple choice writing questions (Russell 4). The SAT, the nation’s premier college aptitude test, derives one third of the composite score from writing assessments - one essay, but mainly multiple choice. With increasing digitization, it will not be long before some or all

parts of the SAT are administered digitally. Determining the effect that digital testing has on writing-based multiple choice questions will assist in keeping scores fair and accurate for students across the nation and the globe.

Methods and Procedures

In order to determine the effect of a digital medium on student performance, the experiment manipulated the type of test given to two groups of students, and then analyzed the difference between the groups' scores. The groups were randomly selected to be representative samples of eleventh-grade English students at a STEM school, meaning that these students had above-average experience with technology. One group was given the test on paper, while the other group was given the same test on a digitized Google Form. The difference in the average score between two groups was the primary effect of the difference in testing methods. The subjects were all 11th grade English students at a STEM school, and were asked if they wanted to participate in the experiment, while being incentivized with Twix candy bars. Those who responded and consented to the experiment were randomly divided into two groups by counting every other person from an alphabetical list of participants.

The questions on the assessment were chosen by means of a random number generator and a selection of questions from old SAT Writing Section questions. The randomly generated number corresponded to a question number - whichever number was generated, that question was selected for the test. The test was both printed out and rendered in a Google Form to be administered digitally. One of the previously selected groups was given the paper version to complete, and the other group was told to use their district-provided laptops to answer the questions on the Google Form. A total of ten minutes were given for participants to complete the fourteen-question assessment. After the ten minutes were up, the paper-based assessments were collected and the Google Forms submitted.

Data

Once data was collected from the experiment, it was processed and checked for statistical significance in order to form a conclusion. Before any

other data analysis could occur, the raw answers from test takers were matched against the correct answers, thus determining the percent of each test that was correct. For each group, consisting of either entirely written tests or entirely digital tests, all scores in the category were averaged together to yield the average score for each type of test overall.

After data analysis was conducted, the average score for paper tests was found to be 11.24 out of 14.00 possible points. This data was based on a sample size of 17 test takers. Figure One portrays the distribution of paper-based test takers (See Fig. 1).

In addition, the average digital test score was found to be 10.06 out of 14.00 possible points, also with a sample size of 17 test takers. The difference between these two scores is 1.18, or 8.43% of the possible points. Figure Two portrays the distribution of digital test takers (See Fig. 2).

Figure Three illustrates a direct comparison between the scores of the written and digital test takers (See Fig. 3).

Once all results were calculated and the averages had been compared, their relationship was analyzed using a chi-square test in order to determine if the numbers were statistically significant or merely the result of random variations in the testing sample groups. The chi-square test demonstrated a p value of 0.04, indicating that the data is significantly different and likely represents a valid correlation-based relationship between the variables.

In addition to the numerical results from the tests, each group was analyzed to find non-numerical trends that might give insight into the effects that a digital medium has on test performance. Of particular note was the omission of answers to certain questions on multiple tests taken in written form, which caused the scores of multiple test takers to drop. In each case, the test taker would have had a 20% chance of improving their score by guessing, so no reasonable motivation exists for leaving questions blank intentionally. Therefore, it can be concluded that these questions were left blank unintentionally, highlighting an important difference between digital and written mediums: mechanisms for verify-

ing that answers have been given. In the case of digital testing, which included a progress bar and notified the test taker when a question was missed, there were no questions left blank. However, without an automatic program checking over the results, multiple questions were accidentally missed on the written portion. This suggests that, although written tests have a higher average score, they lack a method by which a test taker's answers may be verified and confounding variables such as accuracy in spotting unanswered questions may be removed from the data.

Conclusion

The data show that students taking written tests performed at a higher level than students taking the same test on an electronic platform. Students taking the written test outperformed the other group by an average of 1.18 points of a possible 14. This confirmed the hypothesis that students taking digital tests would perform worse than the students taking the same test on paper, and these results are corroborated by a sizable number of previously conducted studies. These results indicate that digital testing may not be providing an accurate enough measurement of student aptitude and therefore may not be an ideal choice for testing on Writing subjects. Previous studies which suggest that digital tests are especially unsuitable for essay-based tasks confirm that writing is not a suitable subject to be tested on through a digital medium. This affects the development of future educational tests as it suggests that digital or online tests may not be effective measurements of student aptitude or performance. Further experimentation would be needed to determine the cause of the decreased performance, in order to put measures into place to decrease the discrepancy between scores from the two kinds of tests.

Appendix I: Graphs

Figure 1: Distribution of Test Takers in Written Scores

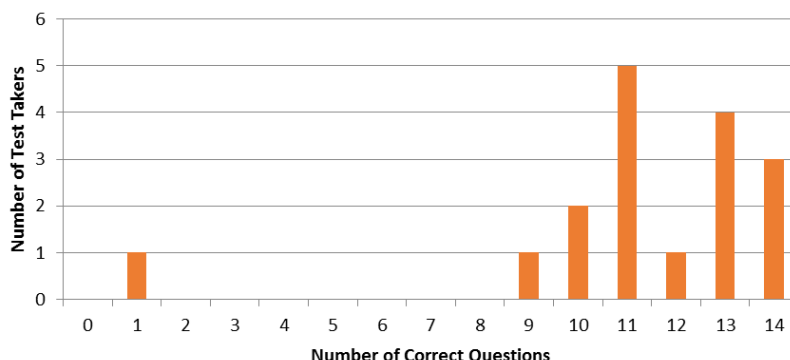


Figure 2: Distribution of Test Takers in Digital Scores

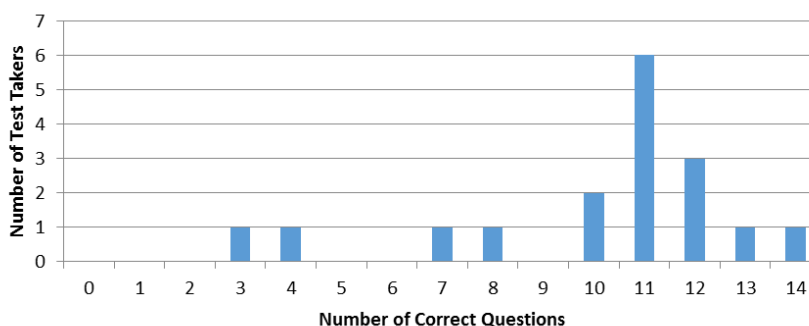
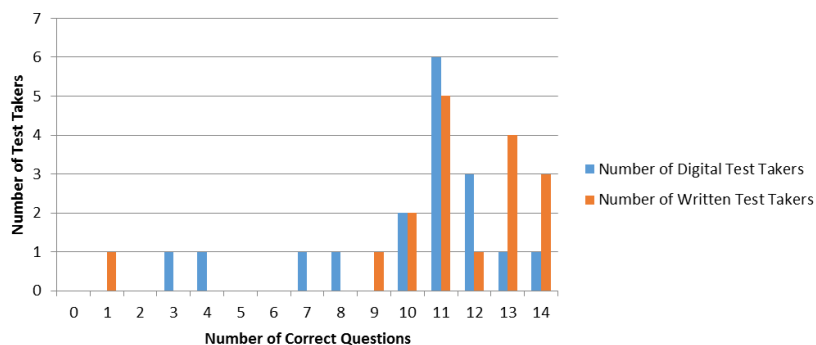


Figure 3: Comparison of Written and Digital Distributions of Test Scores



Works Cited

Horkay, Nancy, Randy Elliot Bennett. "Does It Matter If I Take My Writing Test on Computer?" *Journal of Technology, Learning, and Assessment* 5.2 (2006): 3-38. *JTLA*. Technology. Web. 5 Nov. 2013. <<http://files.eric.ed.gov/fulltext/EJ843858.pdf>>.

Published in the *Journal of Technology, Learning, and Assessment*, this report examines the differences in performance on digital and written essay prompts given to eighth grade students. After experimentation, no significant difference was discernible between the scores of the two groups, although students that took both tests generally performed better in one category over the other. As a published study from a scientific organization specializing in education research, this source carries weight and scientific validity in addition to an overall lack of bias. Although our study will target multiple choice testing, as opposed to the essay given in this study, it is still useful for proven methods and background information about previous experiments in educational research. From this source, which details a previous study done to determine a similar effect in a younger group of students for writing tests, we can find mistakes or weaknesses in the procedure that we can attempt to avoid in our own experiment and establish a background to the topic.

Noyes, Jan M., Kate J. Garland. "Computer- vs. Paper-based Tasks: Are They Equivalent?" *Ergonomics Volume 51, No. 9*. Taylor & Francis Group, Sept. 2008. Web. 3 Nov. 2013. <http://www.princeton.edu/~sswang/Noyesa_Garland_computer_vs_paper.pdf>.

Featured in a study of test-taking procedures by Princeton University, this article details the differences and, moreover, similarities between paper and digital media for various tasks. Testing is a major focus of the piece, which concludes that while no significant difference can be ascertained between digital and written tests

in the majority of cases, tasks such as speed reading and proofreading show greater accuracy in paper testing. Due to the scientific nature of the source's composition and its promotion by a reputable institution, it likely contains only neutral, scientific data. After reading this source, we have determined that it provides a summary of various experiments relating to different tasks performed on the computer and in a written medium, which will help narrow our experiment's focus and provides a jumping-off point for further research into specific tasks.

Robinson, Nick. "Computerized GRE Scores Vs. Written." *Synonym Classroom*. Demand Media, n.d. Web. 3 November 2013. <<http://classroom.synonym.com/computerized-gre-scores-vs-written-3572.html>>.

Nick Robinson's article does not mention a specific study, but talks about performance on the GRE on the computer versus on paper. The source also talks about the effects of taking the test in familiar versus unfamiliar locations, and how students are far more comfortable with a paper test and in a familiar setting, although actual performance is not tested. This information is relevant because it adds another factor into consideration of the scores: comfort level. However, few sources seem to perform this sort of experiment on high-school aged groups with significant experience with computers. Overall, this source simply contributes to a greater understanding of the previous research done on this topic.

Russell, Michael, Tom Plati. *Effects of Computer Versus Paper Administrations of a State-Mandated Writing Assessment*. Rep. Boston: Technology and Assessment Study Collaborative, 2000. *In* TASC. Technology and Assessment Study Collaborative, June 2000. Web. 5 Nov. 2013. <<http://www.bc.edu/research/intasc/PDF/ComputerVsPaperStateWriting.pdf>>.

This source describes a study performed on eighth and tenth graders in Massachu-

setts, where the students were given two essay prompts either on the computer or on paper. The results showed that paper testing scored higher than computer testing in both grades, though the difference was greater in eighth graders. The source was free of bias, as it simply reported on the data from the study. This information is relevant to our research because it yields results from previous studies against which to examine our data, namely to determine whether or not our data support those from other studies.

"Tech's Answer to Testing." *Education Week Volume XXII* 8 May 2008: 8-10. *Education Week*. Editorial Projects in Education. Web. 5 Nov. 2013. <<http://www.edweek.org/media/ew/tc/archives/TC03full.pdf>>.

This source explains an experiment in which the Oregon State Reading Exam was given to two groups of students, one group on the computer, and one on paper. Instead of assessing their performance, however, the study asked them to rate their confidence on the test - students continually felt more confident about the computer tests, while performing worse. The source contains little to no bias as it is simply reporting on the data and not offering many opinions on what can be done with it. This source is relevant to our research because it give insight into an additional factor in computer vs. paper-based testing, that of student confidence. It gives us additional information as a lens with which to look through at our results, to see if the data can lead to any further conclusions.

Effect of Physical Exercise on Symptoms of Autism

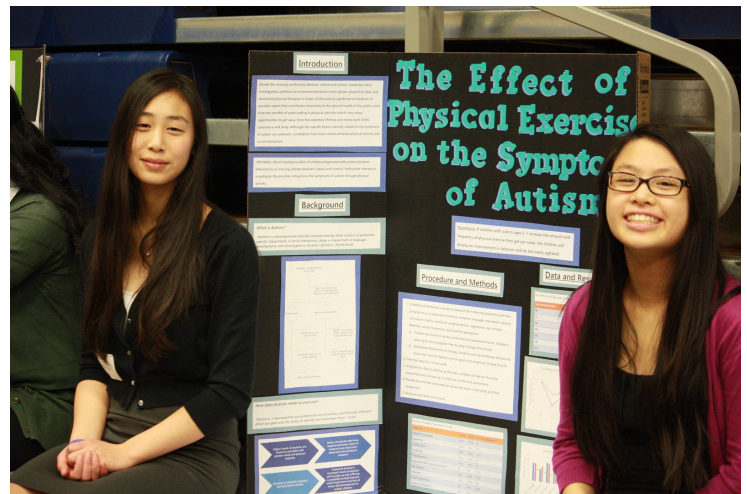
Lynsey Liu and Jennifer Yeh

Abstract

As the number of children diagnosed with autism continues to increase rapidly, the necessity of finding effective treatments and a possible cure are vital. Consequently, the purpose of this experiment was to investigate the effect of physical exercise on the symptoms of autism through a week-long study of exercise for 10-20 minutes each day. Searching for methods to minimize the intensity of the nature of autism, surveys were distributed to parents of children with autism who recorded the changes in their child's behavior after having him/her exercise each day of the week. The surveys consisted of initial and final assessments that demonstrated the overall change in behavior over time in terms of receptive language, expression, sensory stimulation, aggression, eye contact, attention, social interactions, and auditory perception. Additionally, the daily log kept track of the different forms and times of exercise, comparing step-by-step the changes in their child's behavior through each symptom. The data show that the week of exercise helped create a very slight improvement in each aspect of behavior. Generally, the results show a decrease in aggression/self-injurious behavior and an increase in eye contact, attention, and social interaction. The average initial assessment score is 19.5 while the average final assessment score is 23.4, showing a considerable improvement. Essentially, physical exercise helps calm the senses, creating a greater focus and allowing children to improve eye contact, attention, and social interaction. Ultimately, this research can contribute to further studies that may begin to recommend exercise as one possible option for improving the symptoms of autism.

Introduction

Over the past 60 years, the pendulum of public and scientific opinion on the etiology of autism



Lynsey Liu and Jennifer Yeh

has swung between two extreme positions: that autism is caused by some specific genetic abnormality, and that autism is the result of a specific environmental factor or condition (Lane). Amidst the ensuing controversy between nature and nurture, researchers have investigated a plethora of environmental factors from gluten-wheat free diets, and structured physical therapies in hopes of discovering significant correlations.

A possible aspect that contributes immensely to the general health of the public come from the benefits of participating in physical activities which carry many opportunities to get away from the sedentary lifestyle and renew each child's conscience and body. Although the specific factors directly related to the symptoms of autism are unknown, correlations have been shown between physical activity and social interaction. Ultimately, the increasing number of children diagnosed with autism has been followed by an ensuing debate between nature and nurture, fueling the interest to investigate the possible mitigations to the symptoms of autism through physical activity.

Background Information

Autism is a developmental disorder characterized by three clusters of symptoms: specific impairments in social interactions, delay or impairment in language development, and stereotyped or ritualistic behavior (Rutherford). There are many different types and varieties of autistic disorders, ranging from mild or high-functioning autism, such as Asperger's syndrome, to more se-

vere disorders. High-functioning autism is applied to those with a “higher cognition level” or typical IQ above 70, though the latter qualification is very loosely based; the defining characteristics include a delay in the development of speech and language skills, sometimes leading to social impairment. Asperger’s syndrome, a common form of high-functioning autism, is defined by similar characteristics of deficit in communication, emotional recognition, and social interaction, but also specifically by obsession with a singular task or object (Baron-Cohen). On the other end of the spectrum is severe autism, which is marked by sensory dysfunction, sometimes inability to use spoken language, and other physical disabilities. These labels are by no means definitive because of the wide range of autistic symptoms, and categorization of the different syndromes is impractical because of the many different types and forms in which autism appears; however, autism as a whole is identified by developmental social, language, or behavioral difficulties.

There is no definitive or known cause for autism, and the impacts of nature versus nurture in the disorder have become largely contested. Scientists still struggle to pinpoint the specific genetic or environmental factors that lead to autism, after considering a search for the “autism gene” and performing numerous tests of different diets and parenting styles. There have, however, been speculations of parental emotional detachment or infant institutionalization playing an adverse role in autism (Lane). Shown in animal case studies, young who are isolated in critical stages of development display social and motor impairment later on, similar to autistic symptoms. According to other theories of environmental impact, increased toxic exposures and use of Thimerosal vaccinations have also been cited as causes for symptoms such as delayed response, digestive issues, or ultra-sensitivity (Corbier). Support for a hypothesis of a greater nurture role in autism is seen in studies that show that affected monozygotic twins do not exhibit similar autistic characteristics any more so than dizygotic twins (Lane). This result infers that identical genes do not necessarily result in identical degrees of autism, implying outside factors as having a significant effect. On the nature side of the spectrum, previously conducted research reveals genes encoding for neuronal cell-adhesion

molecules as genetic markers for autism, though to a small degree; the discovered functional class of autism-associated genes is regulated by neuronal activity that both genetic variation and non-genetic experience may contribute to. Thus, taking both sides into account multiple genetic and environmental factors may be responsible for the appearance of autism.

Another major theory is that development of autism in relation to genetics models interaction, rather than separate impact, between DNA and the environment. In many functional systems, the emergence of a properly wired neural system is contingent upon exposure to appropriate stimuli in the external world, pointing to epigenetics as a determining factor (Carlisle). Epigenetics refers to the reversible but significant changes that surroundings can have on DNA both during and after the fetal stage (Francis). The variation in autism symptoms in identical twins also supports speculations of the involvement of epigenetics; the twin study implies not only environmental impacts, but also slight chemical or physical differences in the surroundings of the twins in the womb, resulting in subsequent differences in disorder after birth. This theory applies to involvement of physical exercise in that according to the suggested mechanisms, exercise would serve as a secondary outside cue, after genetics, in shaping the symptoms of autism.

Despite whether autism is derived from nature, nurture, a mix of both, or an interaction of both through epigenetics, because of the intertwined nature of genetics and environmental factors on autism, the best therapy applies information from both neurological and psychiatric perspectives for treatment (Corbier); physical exercise for autistic children combines the perspectives of both genetics and environment. The experiment would observe how physical exercise has an effect on these symptoms and the degree of this effect as part of a more comprehensive therapy method. Based on two main correlations, the use of physical exercise as a treatment for autistic symptoms optimizes prior research by taking into account the different theories and categories of factors that have an impact.

One correlation that bridges the theories is the connection between oxytocin levels and appearance of autism symptoms. Essentially opening

doors towards reversing the social ineptness of autistic behavior, “oxytocin, a neuropeptide associated with social memory and learning, enhances direct eye gaze and the ability to identify and remember faces” (Lane). According to Kerstin Uvas-Moberg, PhD., oxytocin is naturally released during walking, swimming, and other physical activity, showing a possible correlation between physical activity and social behavior. Higher levels of oxytocin are shown to correlate with greater social and physical capacity, specifically direct contact and face recognition, and brains of animals who have experienced lower levels of maternal care have been observed to be lacking in this neurotransmitter. With increase in physical activity, levels of oxytocin increase as well, connecting the neuroscience aspect with a physical way to decrease symptoms such as social impairment and lack of advanced motor skill development in autistic children.

As well, children with autism generally live a sedentary lifestyle because of their social and behavioral limitations that prevents them from engaging in physical activities and interacting with other kids. This isolationism is reminiscent, though to a much lesser degree, of previously observed correlation between autism symptoms in young animals and social separation or neglect. Thus, physical activity can by extension lead to positive self-esteem, behavior, happiness, and intellectual, and social outcomes in youth (Frey). Considering the importance of exercise in the lives of children today, it is essential that even children with behavioral disabilities fulfill this need as well. Encouragement of activity that increases physical and social interaction with the outside world may benefit autistic children in development of both areas. By encouraging exercise and physical activity among children with autism, these possible correlations can be tested to investigate the effect of exercise on symptoms of autism in children.

Our Experiment

To study this correlation, a survey was created to compare an autistic child’s behavior in terms of receptive language, expression, sensory stimulation, aggression, eye contact, attention, social interactions, and auditory perception and its progression over time as a response to daily exercise. These surveys were distributed to parents

of children with autism who filled out an initial and final assessment on the first and last days of the week. Throughout the week, children were encouraged to exercise 10-20 minutes a day and parents kept a daily log on their child’s behavior.

Unfortunately, the experiment in some aspects is extremely limited because “exercise” cannot be operationally defined for parents as each child’s personal case of autism can differ immensely. Some children are simply physically incapable of withstanding even ten minutes of walking or jogging or playing because they lose focus, interest, or patience to complete an activity. Furthermore, the effect exercise has on the symptoms of autism is extremely difficult to measure because each child naturally is more sensitive in different areas. For example, the survey distributed inquired about receptive language, expression, sensory stimulation, aggression, eye contact, attention, social interactions, and auditory perception. One child may naturally experience a higher level of sensory stimulation in terms of tactile sense, while another child may experience more vestibular stimulation. Additionally, many cases of autism are accompanied by other disorders such as Down syndrome, and epilepsy which also affect how these children respond to exercise because of the role these other disorders play on their health and behavior. Essentially, the initial and final assessments are intended to demonstrate the progress of their behavior in response to the 10-20 minutes of exercise each day, while taking into account the changes are per case rather than an overall generalization amongst all the children.

Results

Upon receiving the surveys back from the parents, we observed that any change at all between the final and initial assessments was extremely minimal with the levels of each symptom only changing by one degree. Some basic trends we saw throughout the daily logs were slow progressions of improvement in terms of the degree of each symptom. Conclusively, the data ultimately show that the week of exercise showed very slight improvement in each aspect of behavior. Comparing the initial and final assessments, the data showed a decrease in aggression/self-injurious behavior and an increase in eye contact, attention, and social interaction. Sensory

stimulation generally stayed the same, but some cases showed a slight bit of improvement in tactile stimulation particularly. The average score on the initial assessments turned out to be 30 while the average score on the final assessments was 35, showing a considerable degree of improvement. Essentially, physical exercise helps calm the senses, creating a greater focus and allowing children to improve eye contact, attention, and social interaction. Furthermore, the exercise helps release uncontrolled energy that can result in aggression or self-injurious behavior. Ultimately, this research can contribute to further studies that may begin to recommend exercise as one possible option for improving the symptoms of autism.

Conclusion

Since the data show a decrease in aggression/self-injurious behavior and an increase in eye contact, attention, and social interaction, it can be concluded that exercise has a positive effect on autism by minimizing the severity of each symptom and calming the senses. In the future, extensions of this study may contribute to easy solutions that doctors can recommend to parents to help reduce agitation in kids with autism to help them improve their behavior. Current solutions include a wide variety of pills and strict gluten-wheat-free diets which interfere with a child's digestive tract and pose burdens on what they can and cannot eat. With exercise, there are no further limitations or drawbacks, especially because all human beings need exercise to survive and live a healthy life.

Nonetheless, the study still needs a bit of fine-tuning to receive more reliable results which can be achieved through extending the study from one week long to three months long. Perhaps the minimal change in symptoms was due to the short period of time the experiment was carried out in while in actuality, the long-run benefits could be astonishing. Overall, the implications of this quick study are quite promising; as the number of children born with autism continues to increase, they deserve to live life away from the points and the stares for their "unusual" behavior.

Annotated Bibliography

Baron-Cohen, Simon. "The Autism Spectrum Quotient (AQ)." *Journal of Autism and Developmental Disorder* 1.5 (2001). Web.

Through his study of autism, Baron-Cohen attempts to classify and describe the various types of the disorder according to the "autism spectrum quotient." From mild to severe forms of symptoms, the different kinds of autism are thoroughly explored and categorized by the author and contributed to an understanding of both the range of the disorder and the generalities of it. This analysis of autism symptoms helped to define what the experiment is attempting to treat and provide a further understanding of the various forms it can take.

Carlisle, Paul C. *Beyond Nature and Nurture: A Systems Approach to Autism*. New York, New York: Nova Science Publishers, 2007. Print.

In this analysis of the different factors of autism, Carlisle examines the impacts of both nature and nurture, and proposes, instead of a mixture of the two perspective, that the development in relation to genes interacts with the environment. He states that the emergence of a correctly wired neural system is dependent upon exposure to external stimuli--that when synapses are lost, environmental control and cues take over. This source applies to involvement of physical exercise in that according to the suggested theory, exercise would serve as a secondary environmental cue, after genetics, in shaping the symptoms of autism.

Corbier, Jean-Ronel. *Solving the Enigma of Autism*. Selma, Alabama: Ufomadu Consulting & Publishing, 2004. Print.

Corbier seeks in *Solving the Enigma of Autism* to combine medical, historical, and cultural methods in an inclusive understanding of autism as a disorder and how to treat it. Using a variety of perspectives, she asserts that the most effective diagnosis and therapy of autism includes both

psychiatric and neuroscience approaches together. She also tackles the nurture and environment side of autism factors, citing toxic exposures and increased vaccinations as causes for symptoms such as delayed response, digestive issues, or ultra-sensitivity. The experiment would observe how physical exercise has an effect on these symptoms and the degree of this effect as part of a more comprehensive therapy method.

Francis, Richard C. *Epigenetics: How Environment Shapes Our Genes*. New York, New York: W. W. Norton & Company, 2011. Print.

This book discusses epigenetics, the interaction of environment with genetics, a relatively new field of genetic research. Although autism is only briefly mentioned in the author's discussion, a comprehensive understanding of how surroundings can affect genetic switches was key in supplementing the theory of the role of epigenetics in autistic symptoms. In relation to the experiment, this source connects the therapeutic aspects of physical exercise to the epigenetics theory.

Frey, Georgia C. and Chien-Yu Pan. *Physical Activity Patterns in Youth with Autism Spectrum Disorders*. Bloomington, Indiana: Springer Science & Business Media, 2006. Web.

This source summarizes Frey and Pan's study of the effect of physical exercise on an age range of 10 to 19-year-olds with autism. Split in elementary, middle, and high school categories, the subjects and their progresses were tracked by accelerometers and seven-day questionnaires. The study was based on the lack of opportunities for physical exercise for autistic children due to social and behavioral deficits. In the results, Frey and Pan revealed that physical activity decreased risk of chronic diseases and caused an overall improvement in general health as well. Subjects were also observed to be happier and behaving more positively by the end of the study, implicating the merits of exercise as an effective therapy for au-

tism.

Lane, Strathearn. "The Elusive Etiology of Autism: Nature and Nurture?" *Frontiers in Behavioral Neuroscience* 3.11 (2009). Web.

In this source, the author explores the origins and manifestations of various types of autism. Although he fails to "uncover a core psychobiological deficit" for autism, Strathearn speculates that the disorder at its core is caused either by a specific genetic abnormality or by an environmental condition. He further proposes that social development and lack of physical experience contribute to the social development problems commonly associated with autism and in addition, and oxytocin levels, which are known to increase with physical exercise, are lower in autistic children leading to a decrease social interaction skills and ability to remember faces.

Reid, Greg, and Teri Todd. "Increasing Physical Activity in Individuals with Autism." *Focus on Autism and Other Developmental Disabilities* 21.3 (2006): 167-176. Web.

The study in this article directly relates to the experiment in that it investigates correlation between physical exercise and autism. In the study, three male secondary school students diagnosed with autistic disorders participated in a six month outdoor physical activity program. The results suggested that interventions can be developed to promote sustained participation in physical activity for individuals with autism, and observations further showed an increase in motor abilities by the end of the program. Over the six months, the subjects' physical skills and ability to focus on given tasks increased significantly, providing grounds for speculation of the same improvement in younger children with autism through exercise.

Student Awards

American Association of University Women (AAUW) Awards

Mathematics: Maya Ganesan

Science: Kaimyn O'Neill

Technology: Alka Pai

Association of King County Historical Organizations (AKCHO)

Anand Nambakam

Kevin Nakahara

Ethan Perrin

Central Sound Regional Science and Engineering Fair

Behavioral and Social Sciences

3rd Place: Benton Schutz and Cam Nagel

Honorable Mention: Lynsey Liu and Jennifer Yeh

Computer Science

2nd Place: Tiago Ferreira, Devansh Kukreja and Cameron Mackenzie

Electrical and Mechanical Engineering

3rd Place: Clark Schaeffer, Usman Jamil, and Tristan Heywood

Energy and Transportation

3rd Place: Christopher Yu and Pavan Kumar

Honorable Mention: Mrigank Bhardwaj, Srikar Murali, Abhishek Sangameswaran

Environmental Management and Environmental Science

3rd Place: Maya Ganesan and Madison Minsk

Honorable Mention: Julia Rettig and Claudia Nguyen

Medicine and Health Science

1st Place: Meena Meyyappan, Daaniya Iyaaz and Saakshi Dulani

3rd Place: Audrey Hyem, Warisha Soomro and Marisa Messina

Honorable Mention: Kaimyn O'Neill, Dipti Dhond and Kelsey Drake

Inspiring Excellence Awards

Jeremy Harrison, Vineeta Parupudi and Reksha Rathnam

Alexandra Mititean and Kyra Nichols

American Meteorological Society Award

Madison Minsk and Maya Ganesan

District Solo/Ensemble Competition

1+ Rating

Jennifer Yeh - Violin

1 Rating

Caeli MacLennan - French horn

Adrian Pang - Cello

Future Business Leaders of America State Competition

Agribusiness

1st Place: Sonia Murthy

Business Ethics

1st Place: Sonia Murthy & Sophia Tevosyan

Intro to Business

3rd Place: Sonia Murthy

Intro to Business Communication

2nd Place: Sonia Murthy

Intro to Parliamentary Procedure
 1st Place: Sonia Murthy
 Business Calculations
 4th Place: Udit Ranasaria
 Business Communication
 4th Place: Aaron Johnston
 Marketing
 1st Place: Aaron Johnston, Maya Ganesan and Pranav Vasudha
 Business Communication
 Maya Ganesan
 Future Business Leader
 1st Place: Maya Ganesan
 Business Procedures
 3rd Place: Maya Ganesan
 Insurance and Risk Management
 3rd Place: Maya Ganesan
 Business Law
 3rd Place: Jenna Oratz
 Business Math
 5th Place: Sophia Tevosyan
 Business Ethics
 1st Place: Sophia Tevosyan & Sonia Murthy
 Business Math
 2nd Place: Dinesh Parimi
 Client Service
 5th Place: Chris Yu
 Job Interview
 1st Place: Chris Yu
 Creed
 2nd Place: Shravya Kuklamarri
 Management Information Systems
 4th Place: Teri Guo and Karisma Kulknari
 App Development
 3rd Place: Apoorv Khandwal

Imagine Tomorrow Environmental Science Competition

Technology Division

1st Place: *Reimagining the Electric Car*: Abhishek Swangaresan, Mrigank Bhardwaj, Madison Minsk, Anand Nambakam, Pranav Vasudha, Srikar Murali, Aashray Anand, and JD Daly
 2nd Place: *Step on Carbon*: Jennifer Yeh, Lynsey Liu, Catherine Yao, Hana Keller, and Christina Dias
 3rd Place: *Solar Light Tower*: Daniel Torres, Jacob Lee, Hari Kuduva, Andreas Hindmen, and Weston Oden'hal

Biofuels Division

1st Place: *Cellulosic Ethanol: A New Look at the Transition to Renewable Energy*: Ethan Perrin, Andrew Wang, Isaak Nanneman, Pavan Kumar, and Oisin Doherty
 4th Place: *Yeast DNA Splicing*: Saakshi Dulani, Reksha Rathnam, Meena Mey, and Daaniya Iyaz

Design Division

4th Place: *EDGES*: Kanaad Deodhar, Maya Ganesan, Aaron Johnston, Richard Wen, and Christopher Yu

National History Day Regionals

Documentary, Senior Division

1st Place: Hana Keller, Aaron Johnston, and Lynsey Liu: *Hetch Hetchy* (Water Rights and the Responsibility to the Environment)

PTSA Reflections Winners

Literature Award of Excellence

Brittany Quan: *Ambiguous Words*

Music Composition Award of Merit

Adrian Pang: *Believe*

Visual Arts Award of Merit

Sonia Murthy: *Beyond My Wildest Dreams*

Technology Student Association State Competition

Technology Bowl

4th Place: Naveen Sahi and Surya Cimbadi

Career Preparation

3rd Place: Alka Pai

Promotional Graphics

4th Place: Alka Pai

Essay on Technology

4th Place: Anjali Sribalaskandarajah

Prepared Presentation

1st Place: Meena Meyyappan

Animatronics

4th Place: Abhishek Sangameswaran, Jay Tayade, Pavan Kumar and Srikar Murali

Biotechnology

4th Place: Pooja Ghelani, Reksha Ratham, Saakshi Dulani and Divya Cherukupalli

Fashion Design

5th Place: Pooja Ghelani, Reksha Ratham, Saakshi Dulani, Divya Cherukupalli, and Meena Meyyappan

On Demand Video

4th Place: Srikar Penumaka, Tristen Donyes and Hunter Gordon

Open Source Software Development

2nd Place: Patrick Mao and Aditya Kumar

Open Source Software Development

1st Place: Abhishek Sangameswaran, Pranav Vasudha, Jay Tayade, Mrigank Bhardwaj, Andrew Chronister

Scientific Visualization

1st Place: Mrigank Bhardwaj, Madison Minsk, Pranav Vasudha, Andrew Chronister

Video Game Design

1st Place: Andrew Chronister, Alka Pai, Alex Hoar

VEX Quantum Robotics Awards

917A: Aashray Anand, Mrigank Bhardwaj, JD Daly, Madison Minsk, Pranav Vasudha, Andrew Wang, Nikko Rush

Tournament Champions, Washington Jump Start Tournament

Tournament Champions, Yakima Valley Winter Tournament

Judges Award, Western Washington VRC Championship

VRC Game Design Animation Challenge, 3rd Place: Tower Hoist

917B: Sai Gandham, Alex Hoar, Devansh Kukreja, Udit Ranasaria, Brian Liao (LWHS), Joseph Zhong (Lakeside)

Tournament Champions, Lake Washington VRC Tournament
 Excellence Award, East Valley Vex Tournament
 Robot Skills Winner, East Valley Vex Tournament
 Tournament Finalists, Cavelero Cup VEX Robotics Tournament
 Tournament Champions, Central Washington VRC HS Championship
 917C: Kanaad Deodhar, Christina Dias, Aaron Johnston Hana Keller, Lynsey Liu, Christopher Yu
 Design Award, Washington Jump Start VRC Tournament
 Excellence Award, Yakima Valley VRC Winter Tournament
 Tournament Finalists, Yakima Valley VRC Winter Tournament
 Amaze Award, Western Washington VRC Championship
 917R: Atul Madhugiri, Anand Nambakam, Will O'Brien, Edward Johnston (RHS)
 Judges Award, Washington B Team VRC Tournament
 Design Award, Cavelero Cup VEX Robotics Tournament
 917S: TJ Hori, Alex Ilias, Schawn Lin, Daniel Mar, Sriram Natarajan
 Tournament Finalists, Washington B Team VRC Tournament
 Tournament Champions, Cavelero Cup VEX Robotics Tournament
 Tournament Champions, Central Washington VRC High School Championship
 Robot Skills Winner, Central Washington VRC High School Championship
 Ranked 3rd in Washington State for Robot Skills
 917X: Andreas Hindman, Hari Kudava, Pavan Kumar, Srikar Murali, Sera Narumoto, Yash Pahade, Abhishek Sangameswaran, Jay Tayade
 Tournament Champions, Cavelero Cup VEX Robotics Tournament
 Tournament Champions, Western Washington VRC Championship
 917Z: Divya Cherukupalli, Saakshi Dulani, Meena Meyyappan, Alka Pai, Jennifer Yeh
 Judges Award, Cavelero Cup VEX Robotics Tournament

Verizon Innovative App Challenge

Best in State

Isaac Jensen, Baptiste Debuire, Asaf Axelrod, Matt Culver, Maheck Jerez-Terceros, Margo Nanneman, and Sami Siddiqui & Ms. Melissa Wrenchey

Washington State Aerospace Scholars

Clark Schaefer

Pavitra Siva

Washington State Science and Engineering Fair

Health and Medicine, Senior Division

1st Place: Daaniya Iyaz, Meena Meyyappan and Saakshi Dulani

Behavioral Science, Senior Division

1st Place: Jeremy Harrison, Reksha Rathnam, and Vineeta Parupudi

Computer Science, Senior Division

1st Place: Cameron Mackenzie, Devansh Kukreja, and Tiago Ferreira

Wolfram Alpha Mathematics Award- \$80,000 scholarship to Ohio Wesleyan College

Cameron Mackenzie, Devansh Kukreja, and Tiago Ferreira

Environmental Management, Senior Division

2nd Place: Claudia Nguyen and Jeannie Kwak