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Featuring:

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A Letter from the Editorial Team

Welcome to the Third Edition of the BISV Research Journal! After two successful editions last year, we are extremely excited to announce the first publication in the 2023-24 school year. This will also be our second edition since transitioning to an interdisciplinary research journal that can represent the interests of every student in our community.

In this edition, you will see several articles written by the editorial board of the Research Journal Club that discuss significant — or interesting — advances in STEM in recent times. We decided to include this section in our edition to provide a diverse perspective on the research being done in the wide field of science and to share our — the editorial board — scientific interests with the rest of the community.

Aside from the articles sent in by students, we have also received incredible support from Mr. Meyerowitz and his Colonialism and Post-Colonialism class from the 2022-23 school year. In this edition, we also include some of Bobcats' written works on historical research that competed for National History Day 2023.

Always looking forward,

Dr. Karen Allendoerfer - BISV Science Research Journal Club Advisor

Jeonghyun An - Co-Editor-in-Chief

Ellie Xi - Co-Editor-in-Chief

Iris Li - Senior Editor

Caroline Tian - Senior Editor

Aanya Gupta - Senior Editor

Vedh Reddy - Senior Editor

Science in the News

Speech Prosthesis That "Reads" Your Mind

Jeonghyun An

Speech disabilities plague millions worldwide, and several causes, such as neurological trauma, can lead to the permanent loss of verbal communication in patients. This grows to be a much more significant problem when the patient is also paralyzed, unable to control other muscles in their body, which prevents them from utilizing popular speech aids or other devices to aid communication.

Speech neuroprosthesis is an engineered solution to these medical crises: a tool that utilizes the signals from the nervous system to interpret verbal intentions. For the past couple of decades, several developments have been made in order to make this technology possible. Researchers have found that brain signals — electrical signals measured through microelectrode arrays — could be interpreted to signify words with meaning. However, this technology was unable to be fully implemented, due to lower accuracy and a limited number of words that it could interpret. While other engineered devices, such as fMRIs, were also tested for speech prosthesis, yielding astounding accuracies and diverse vocabularies, they were impossible to implement for clinical usage due to the size and cost of the machine.

This study[1] by the research group at UCSF, under Dr. Edward Chang, MD., titled "A high-performance neuroprosthesis for speech decoding and avatar control" designed an electrocorticography pipeline for the decoding of speech in paralyzed patients. Electrocorticography, or ECoG, is a sub-invasive neuroimaging modality that measures electrical activity through microelectrodes laying on the cortex of the brain, which offers much greater spatial resolution than other recording technologies such as electroencephalography, functional magnetic resonance imaging, and magnetoencephalography.

Researchers covered the ECoG array over regions associated with speech production and language perception. ECoG signals were then transferred to a computer running several functions to extract semantic meanings from the electrical signals. Specifically, a recurrent neural network first classified each phone (a phonetic unit: any distinct speech sound or gesture). Then, these phones were further analyzed through classification loss functions, phone-to-text conversions, and language models to output sentences that the patient intended to say. After 13 days of recording training data, the patient was able to "speak" with a 1024-word vocabulary and a median word error rate of 25.5%. All at an astounding speed of 78 words per minute, whereas a healthy individual would be able to speak at a rate of 110-150 words per minute.

This technology is still not at the point of clinical implementation for all paralyzed patients with speech loss. ECoG arrays require surgical procedures for the initial setup and several days of training to achieve the level of dexterity and accuracy documented in this paper. However, this study indicates that the field is one step closer to a technology that could fully assist paralyzed patients who have no other means to communicate with the people and the world around them.

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Viable offspring derived from fetal and adult mammalian cells

Ellie Xi

On September 10, 2023, Sir Ian Wilmut, Professor Emeritus at the University of Edinburgh and the scientist behind "Dolly the Sheep,"[1] the first mammal cloned from adult somatic cells in history, passed away[2]. Prior to this project which brought him worldwide recognition, Sir Wilmut initially focused his research on the cryopreservation of animal embryos, which became the backbone of his 1971 PhD thesis that described a method of thawing and freezing boar spermatozoa or motile sperm cells. Then, when he arrived at the Roslin Institute at the University of Edinburgh, he began to study how to genetically engineer sheep, creating Tracy, a sheep designed to secrete the human enzyme α1-antitrypsin in its milk[3], and Megan and Morag, the first animals cloned from differentiated cells[4].

In 1997, these predecessors would lay the foundations for Dolly, who was introduced to the world in a groundbreaking article published by Nature Journal titled, "Viable offspring derived from fetal and adult mammalian cells."[1] In this paper, Wilmut and his team derived three populations of cells from a day-26 fetus, a pregnant 6-year-old ewe's mammary gland, and a day-9 embryo. Reconstructed embryos from the cells were then transferred to ewes. Out of 61 ewe recipients, only eight gave birth successfully, though one weak baby lamb died soon after without any detected abnormality. One sheep out of the surviving offspring was subsequently named Dolly.

In total, 12.5% of the lambs passed away after birth, which was deemed similar to the 8% statistic found among natural lambs. Unfortunately, 62% of all fetuses were lost, a significantly higher percentage than the 6% estimate for natural mating. The scientists at Roslin Institute concluded that nuclear transfer-based embryo development depends upon "the maintenance of normal ploidy and the conditions for developmental regulation of gene expression," which are further influenced by the cell-cycle stage of donor and recipient cells. During this study, donor cells in mitosis and the G1 phase showed greater development than cells in the G2 and S phases, though the paper did emphasize that further analyses must be conducted to fully understand the underlying mechanisms and interactions between each phase.

Though his work was met with criticism from proponents of animal rights at first, Sir Ian Wilmut was known to be an advocate for the ethical use of genetic engineering, firmly opposing human embryo cloning technologies due to his understanding of genetic risks from his studies with animals. Sir Wilmut's presence will be missed by the scientific community and his legacy will forever be remembered.

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Data Equity in GenAI Models

Vedh Reddy

Generative AI is built on data, resulting in a better model. Data allows the generation of the next “best” word, which is the basis of all language models like ChatGPT and Bard. However, we run into data inequity when we use large amounts of data. Not as much data represents certain groups of people, leading to biases and errors in our models. This paper[1] explores different data equity problems and how we can identify/solve them.

First, some definitions. Artificial Intelligence is a broad field that encompasses computers to emulate human behavior. Machine Learning is a sub-field within AI that utilizes patterns in datasets. Generative AI is a branch of ML capable of producing patterns and replicating relationships within data. Foundation models are large models trained on large amounts of diverse data. Large Language Models are models that are specifically text-based. They work with textual data and usually generate language.

To begin, there are four types of data equity. First, feature equity. This focuses on the accurate representation of different groups. Access equity is based on the accessibility to diverse data. Outcome equity focuses on the equity in results. Representation equity deals with enhancing traditionally oppressed and discriminated against groups of people.

Within the types of equity, they fall under input, output, and algorithmic data equity. Input data equity is data that is fed into the model, the output is the result the model generates, and algorithmic equity is data that is specifically needed for the algorithmic process of the model.

The study was able to identify 8 main problems within data equity. These were divided into types of challenges. Unique ones and exacerbated ones. Within the unique problems, there lie scale and volume of data, generalizability vs specificity of data, creation of novel content, and scale of impact. Within the exacerbated problems, there are opacity and complexity, feedback loops, reproducibility/accountability, and internationalization of the dominant culture.

After this, the paper dives into the people responsible for eliminating data inequity. The paper divides the responsibility between three groups. First, AI-creating organizations must work to create equality and create data privacy/transparency. The AI-using organization must use AI responsibility and make sure to notify all impacted communities. The government must create ethical AI regulations to try to fight discrimination.

Finally, the paper talks about groups like civil society groups, the public, and communities using AI responsibly. AI can impact these communities with data inequity and biases in multiple ways, so each community must treat AI responsibly and respectfully. This technology is very powerful, and that’s why we have to be so careful with data equity since extreme inequity could lead to very harmful responses from the model.

In conclusion, data inequity is a problem that is very prevalent in generative AI, yet it is being explored and mitigated right now. The public needs to be informed about data equity because they might be victims of GenAI biases, and they should be able to recognize this to create a safer environment for all.

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Selective Deconstruction of Mixed Plastics

Iris Li

Plastic is an essential material in our society, however with the high production use of plastic comes unrecovered energy, economic hardship, and a high carbon footprint. Recycling is also limited due to the hardship of recycling mixed plastics, in which every type of plastic has its own organocatalyst and must be separated in order to deconstruct. Deconstruction of plastics gives us valuable chemicals that can be used. Organocatalysts are organic molecules that speed up reactions. This study[1] finds a versatile organocatalyst for the selective decomposition of diverse consumer plastics and materials that were previously unrecyclable (such as cotton and polyester) into valuable chemicals.

The study found that TBD:TFA, an efficient PIS(Proton Ionic Salt) organocatalyst, which is ideal for the deconstruction of condensation polymers, worked much better than the old organocatalyst TBD:MSA. TBD:MSA has been the most efficient in the deconstruction of PC and PET individually and their mixture. The new organocatalyst, TBD:TFA, works by selectively deconstructing condensation polymers(two different components combined) at a specific temperature. This will result in a significant reduction in greenhouse gas emissions and energy input, opening a new circulation system for plastic which leads to a net-zero carbon society.

TBD:TFA can be used to selectively and sequentially deconstruct PC, PET, PU, and PA - all different types of plastics. Using TBD:MSA was much more unconventional, as the different types of plastics had to be separated and deconstructed with their specific catalyst. Using

TBD:TFA is much more efficient and versatile than mechanical recycling and selective chemical recycling as less labor goes into the process.

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Summary of the 2023 Chemistry Nobel Prize

Caroline Tian

Things get complicated when it comes to the quantum realm, but the unexplored areas of this field are sure to open technology to more possibilities. The Nobel Prize in Chemistry Winners: Moungi G. Bawendi, Ph.D. (Massachusetts Institute of Technology), Louis E. Brus (Columbia University), and Alexei I. Ekimov (Nanocrystals Technology Inc.) perfected their development of quantum dots, nanoparticle semiconductors that are so minuscule that tiny variations in size determine their properties[1]. This is possible due to quantum phenomena, events that occur when objects reach nano-dimensions. Because each singular quantum dot is zero dimensional, it can have more states than objects of higher dimensionality, resulting in more optical properties.

The quantum dots that were developed by these chemists were of the same composition but could produce different colors. They also had vibrant hues that wouldn't dull as fast as other materials or substances. A light would be shone on the dots and depending on its size, a color would be produced. Differing shapes lead to differing colors, so to produce a desired color one just had to tweak the size of the dot. The larger particles that are around 550 nm look red, and the smaller particles that are around 400 nm look purple. Other color emitting devices always have energy loss due to intrinsic inefficiency; quantum dots will significantly reduce this energy loss as it emits light at a narrower wavelength, which minimizes reabsorption. Quantum dots also convert more blue light into visible light which can make LED lights more effective in luminosity.

This technology proved to be immensely useful in the creation of better, higher-quality television screens as well as other LED products. Because of its versatility, long lifespan, and energy efficiency, it has also come to be used in helping doctors and biologists better map biological tissue. Such optical bioimaging is most often based on traditional dyes, but the dyes come with their drawbacks. For one, the dyes can lead to background autofluorescence which increases the intensity of the natural light emitted by molecules such as Flavins and NADH. This occurrence makes reading captured images more difficult and thereby makes the process of bioimaging less efficient.

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Summary of the 2023 Nobel Prize in Physiology or Medicine

Aanya Gupta

COVID-19 rocked the globe, and many were lost as to how the world would ever recover from the pandemic. The first step had to be some sort of vaccine, but the virus seemed invincible. When Moderna and Pfizer came out with their vaccines, it almost seemed magical, and hope was renewed. For the research behind this world-saving innovation, Katalin Karikó, along with her collaborator Drew Weissman, won the Nobel Prize in Physiology and Medicine. Their journey to success is a testimony to human perseverance and decades of groundbreaking scientific research.

Historically, there are several different types of vaccines. Each type is designed to teach your immune system how to fight off a certain kind of pathogen. There are several types of vaccines, including inactivated vaccines, live-attenuated vaccines, and messenger RNA (mRNA) vaccines. Most licensed antiviral vaccines available today are produced with traditional techniques based on

weakened or inactivated whole viruses. With more advancements in molecular biology, opportunities for more targeted vaccine approaches arose. Developments in molecular biology also allowed the engineering of carrier viruses encoding antigens, which are receptors on the cell membrane used specifically by the immune system. These encoded antigens are then produced, providing the cell some protection in case the actual virus attacks the host cells. However, both traditional whole virus-based vaccines and viral vector-based vaccines require cell culture-based manufacturing facilities which makes them slow and labor intensive.

Nucleic acid-based vaccines solved a lot of the issues associated with protein-based vaccines. The first demonstrations that nucleic acid-based immunizations could work date back to the early 1990s when DNA vaccines and mRNA vaccines were first tested in mice. There were several potential advantages with these nucleic acid-based vaccines including ease of production and target flexibility, since the sequence can be easily changed to encode different antigens. Amongst nucleic acid-based vaccines, scientists figured early on that mRNA vaccines were better than DNA-based ones since mRNA vaccines only need to gain access to the cell cytoplasm (versus the nucleus for DNA) where translation, the process of ribosomes decoding mRNA to manufacture proteins, takes place, making delivery easier. An additional advantage of mRNA vaccines is that the delivered nucleic acid cannot integrate into the host genome, adding an important safety aspect to this platform. Despite these advantages, there was lots of skepticism about the usefulness of the approach since mRNA was considered too unstable for medical applications. In parallel another important research area focused on delivering transcribed mRNA directly into cells and tissues.

All the above discoveries substantially increased the potential of mRNA-based vaccines. mRNA could now be used as vaccines or to treat human diseases by delivering mRNA to replace defective genes. Around this time, a Hungarian research scientist at the University of Pennsylvania, Katalin Karikó, experimented with different forms of RNA with the ambition to optimize the expression of therapeutic proteins. Karikó rigorously investigated different components of in-vitro transcribed mRNA to identify requirements for optimal protein expression in cells and tissues. In the late 1990s, Karikó teamed up with Drew Weissman, a physician-scientist with an interest in basic immunology and vaccine development. With Weissman's background in immunology and Karikó's expertise in RNA biochemistry, the two scientists complemented each other well and shared a passion for exploring the use of mRNA in medical applications.

Weissman had previously worked on dendritic cells, noticing that they had the unique ability to sense pathogens and "prime" immune cells by showing antigens, preparing them for the actual viruses beforehand. This would elicit a greater and more efficient response by the body since the immune cells knew earlier, therefore showing how dendritic cells had the potential to play a very diverse role in the immune system. Karikó and Weissman showed that dendritic cells pulsed with in vitro transcribed mRNA imitated the responses of T cells that had encountered the virus before and so now had protection. Dendritic cells also express some specific receptors, which recognize distinct molecular structures of pathogens and start intracellular signaling that proves an effective warning system against incoming pathogens. Despite these major milestones in their mRNA research that showed how dendritic cells could be used to improve the body's ability to combat pathogens, the team failed for years to develop an effective nucleic acid-based vaccine. The main problem was that the mRNA was delicate, so that when it was introduced to cells, the cells instantly destroyed it. Mice injected with mRNA often became sick or died because the immune system interpreted it as a pathogen, attacking it. Eventually, in 2005, Karikó and Weissman made a breakthrough in this field.

They discovered that cells protect their own mRNA with a specific chemical modification. When they tried making the same change to mRNA synthesized in the lab before injecting it into cells, it worked, and there was no immune response. Now mRNA could be altered and delivered effectively into the body to activate a robust response of the protective immune system against a specific antigen only, without any other adverse effects or live virus required.

When the COVID-19 pandemic struck, many companies chose to use mRNA with modified bases to quickly develop and deploy vaccines, building on the discoveries by Karikó and Weissmann. Both Pfizer/BioNTech and Moderna built highly effective mRNA-based vaccines to protect against severe illness and death from the virus. In the United States alone, mRNA vaccines make up more than 655 million total doses of SARS-CoV-2 vaccines that have been administered since they became available in December 2020. The visionary laboratory research by these two scientists from 15 years ago, laid the foundation for critically important developments that have saved humanity during the COVID-19 pandemic.

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National History Day Projects

The Final Frontier: The Space Race and the Construction of a New Imperial Apparatus

Sidhant Chaliha

2023 Santa Clara County National History Day: Senior Individual Historical Paper Category

By 1930, many aspects of what we consider modern society had already begun forming, but over the course of the next decade various massive changes were on the horizon: the boundaries of science were expanding into new frontiers as the greatest physicists of the twentieth century began probing the structure of the atom, and at around the same time, in Europe, fascism and authoritarianism were on the rise. Within 10 years, these movements which seemed disconnected and slow would come to a violent head and with the Second World War would result in a true explosion of scientific development and an emergent geopolitical minefield - the atomic bomb. For a brief time, the United States was in its golden age as the sole power of the world, but that would not last forever: in under a decade the USSR would have nuclear weapons, beginning the game of scientific armament and ostentatious shows of superiority that would characterize the late twentieth century - the Cold War. The Cold War was fought across many battlefields, from over the chess board, in proxy wars, and over ideological battlefields - and, perhaps most visibly and publicly, the Space Race.

The Space Race was a tipping point in the global balance of power, ushering in a new world order in which geopolitical status was predicated on scientific superiority, rewarding rapid technological development and leaving behind all who were unable to keep up, creating institutions of power that are still entrenched to this day. In many ways, the Space Race acted as a microcosm for the larger world order, its trajectory mirroring the rise and fall of Soviet technology in comparison to US technology, and Soviet influence compared to US influence. The Space Race pushed the world through various frontiers: geopolitical, breaking down old empires and establishing new ones, scientific, as governments were willing to fund more and more scientific research, and even physical, as humanity plunged into the vastness of space itself.

Despite its eventual victory, the United States was not the first country to be interested in considered to be a failure[1]. Everything changed in 1957, when, thanks in large part to the work of the brilliant rocket physicist Konstantin Tsiolkovsky, the USSR launched Sputnik I - the first spacecraft to reach orbit. Sputnik's victory took the world by storm - the scientific community at large, regardless of nationality, saw Sputnik as one of the greatest technological achievements of the twentieth century, and it seemed like a sign that it would be the Soviets that would take the world to a new frontier and into space, with Joseph Kaplan, a prominent US government physicist, stating "I am amazed, [given] the short time which they had to plan... They did it and they did it first,"[2] a quote that was printed and reprinted many times, including in Science Magazine. The Soviets certainly saw this as an opportunity to crow about the success of their system of science (and supposedly, by extension the success of their system of government), explicitly saying in a behind-doors conference of Communist Party leaders[3]:

> "In propaganda to foreign countries make especial note of the great historical significance of the world's first space flight of a Soviet man for progressive humanity and peace in the entire

world, stress that the successes of socialism in the USSR gave rise to this outstanding feat, and that it reflects the very great gains of the Soviet system in all fields of the economy and culture, science and technology, public education and the Communist upbringing of the Soviet people."

Fears that Sputnik represented Soviet scientific superiority (and therefore ideological superiority) began to play in the American consciousness and incited a general anxiety, backed by the notion that space was the most important frontier of the twentieth century and that if the Soviets had a better space program, they were a more advanced civilization. The poem "Sputnik,"[4] facetiously written at the time by Governor Williams from Michigan to President Eisenhower (the "golfer" in the poem), criticizing him for his lackluster effort on the space program, perhaps exemplifies the growing American dissatisfaction best, with its language of the "Commies" taking the sky in this new world while Uncle Sam sleeps:

Oh little Sputnik, flying high
With made-in-Moscow beep,
You tell the world it's a Commie sky
and Uncle Sam's asleep.

You say on fairway and on rough
The Kremlin knows it all,
We hope our golfer knows enough
To get us on the ball.

Nowhere is it more apparent that humanity at this time viewed the Space Race as its greatest frontier yet as in the rapid about face in attitude that the US underwent as the threat of Soviet superiority loomed[5]. Kennedy's famous speech in front of Congress in 1962, in response to the Soviet space program, was one of the earliest sources of the American fervor - he demonstrated the rapid progress of human society by condensing the past millennium into a mere century, concluding his speech about the human spirit by famously saying "We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard... because that challenge is one... which we intend to win."[6] We can see from this the two primary facets of the American obsession with the Space Race in the 60s embodied: the spirit of exploration, and, perhaps even more importantly, the spirit of competition. This almost romantic notion of space as the next great land (giving it almost Manifest Destiny-like quality) swept across much of the literature, culture, and even academia of the time; in many ways, just the very idea of space being a frontier gave rise to frontiers being pushed all across the arts and sciences. Donald Menzel, considered one of the founders of theoretical astrophysics, at the time referred to space as "the new frontier"[7] and that rejecting the Space Race represented not just backwardness and lack of foresight but a "defeatist attitude" that would lead the US down a path of stagnancy and allow the USSR to take the reins and determine the nature of the new world.

The combined factors of anti-Soviet paranoia and the general romanticism of the unknown soon contaminated the public and was visible through a lot of the media of the 50s and 60s. In contrast to the science fiction of the early twentieth century, much of the popular media of this era was characterized by a brief but ample output of idealistic content riding off of this romantic wave.

One need look no further than the very earliest Star Trek show, with its famous opening monologue[8]

> Space: the final frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds. To seek out new life and new civilizations. To boldly go where no man has gone before!"

in order to get a glimpse of the way in which Space Age era media depicted a space-based future, as we move through a new frontier in history ("where no man has gone before"). The central organization of the show, Starfleet, represents an utopian, united version of what the governments of the world could look like if we could voyage out into space, the exemplary "best version" of mankind.

Of course, the idyllic views of the new utopian future that space exploration would bring were not coincidental - rather, they were carefully engineered, particularly in the West, as the US saw an opportunity to both promote its own activities, gaining political capital, and undermine its enemies and critics by showing that space exploration was indeed an important priority for the future. To take the example of Star Trek from above, modern analyses agree[9] that the "technocratic liberalism" of the original series was a thinly veiled, very direct endorsement of the way the US was handling the space program and certain aspects of its Cold War response at the time (and in particular Kennedy's leadership and foreign policy). It wasn't just niche media; Walt Disney famously partnered up with the German - former Nazi - physicist Wernher von Braun to produce several episodes of his show Disneyland which were educational docushorts that expounded upon the the science of space travel, which helped popularize it by portraying space exploration as an almost Wild West-esque continuation of American expansionism[10].

It wasn't even just popular media, either - for nearly a decade, every time the headlines weren't plastered with the Vietnam War or the civil rights movement, they were instead plastered with the Space Race and crowing its glories. Take for instance these headlines from the Springfield Daily News from shortly after Apollo 8 lands in December 1968, as the headlines declare triumphantly "US Explorers Etch Their Names In History" and "Move Over Columbus, Here Come the Astronauts."[11] A reporter at the time, Joseph Whelan, criticized the headlines surrounding the space race, claiming how it was nothing but propaganda, and that in "fast-moving process of newspaper publishing,"[12] the watchdog media had failed to uphold its duty in delivering news accurately and objectively in favor of producing sensationalist content and peddling propaganda. Others, for example in the scientific community, shared this distrust for what they saw as a faux frontier - in Science magazine, JT compares the US's very public involvement in space to the economic idea of a Veblen good[13]- not necessarily having any intrinsic value of its own, but with its value derived from the "conspicuous" showing of it, in this case the propagandizing of it.

Regardless of whether or not the continuous propagandization and commercialization of space was justified or not, a debate that still goes on today, eventually the United States' efforts paid off in a big way in July of 1969. Over half a decade after Kennedy's bold proclamations at Rice Stadium, after the US had lost several key milestones in the Space Race to the Soviets, and after waning public support and decreasing efficacy of propaganda made scientists worry they would have to abandon the project, the first manned trajectory towards the moon was plotted. On July 20, 1969, 193 years and 16 days after Independence Day, after over a decade of various abstract frontiers of one kind or another, Neil Armstrong finally stepped onto the surface of the Moon and famously said, "That's one small step for [a] man, one giant leap for mankind."[14] (Despite the fact that without the "a" added in the

annotations by Neil Armstrong, the quote is somewhat nonsensical, it is often repeated without the addendum, showing the power of frontier-breaking moments etched in history to overcome even logic). The Soviet space program (the CCCP), unlike NASA, failed quite dramatically in their moonshot program, and never really recovered from it; although Apollo 11 did not mark the end of the Cold War or even the end of tensions between the US and USSR in space, it did mark the final great victory in the Space Race and arguably the turning point of the Cold War. Speaking of the resolution of the moon race and other matters of the decade, Assistant AG Roger Wilkins said, "And it was over... the whole thing was over. The whole period of lift and hope and struggle - it was all over."[15] The Boston Globe headline that day read "World Gets Guided Tour: Beautiful, Magnificent Desolation"[16] and claimed it was the "dawn of a new era in human evolution."

Like many aspects of the Cold War, the Space Race left a lasting legacy on the power structures of the world. The placing of a flag on the Moon by Buzz Aldrin was more symbolic than anything else[17]- the same symbol of territorial acquisitions that the conquistadors of old used to mark the new boundaries of their frontiers. After having lost its exclusivity of nuclear weapons, by emerging victorious in the battle of scientific superiority, winning the race to the final frontier, the US solidified its position as the global superpower of the world for the next few decades, and through the spirit of competition pushed itself as much through the technological frontier of innovation (leading to critical developments such as the laptop, memory foam[18], and even the Internet) just as much as through the geopolitical frontier of establishing itself as a cultural and imperialistic hegemon. Analyzing the geopolitical and scientific ramifications of the Space Race is especially relevant today, as it appears the world is headed to a new Space Race[19] and therefore new frontiers as the roles of battling world governments are replaced by those of billionaire-headed corporations seemingly aiming to establish an analogous hegemonic apparatus.

In some ways, the Space Race was a frontier of frontiers: it was both the culmination of the frontiers that came before (from the explosion of modern physics to the meteoric rise of fascism) and a spawning point for the frontiers that came afterwards (from the dawn of the modern age of information to the the rapidly accelerating commercialization of space). It pushed the world through the technological frontiers that allowed it to to come to the place it is today, through the social and geopolitical frontiers that set up the current world order, and pushed humanity into the farthest physical frontier it has ever reached. Therefore, it was far from the final frontier - the Space Race was merely the frontier that led to the modern frontiers we are able to witness today, as can be seen in this photograph[20] of Earth rising above the Moon's horizon (taken by the oft-forgotten third crew member of Apollo 11, Michael Collins), showing how far, physically and metaphorically, humanity had come in the past few decades.

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Ping Pong Diplomacy: How Sport Ended the Détente Between China and US

Aneesh Raghavan

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The year was 1971. It was the height of the Cold War. The US and the Soviet Union, the two superpowers were enmeshed in violent proxy wars in various parts of the globe, polarizing the world into two ideological camps and pushing the world to the brink of nuclear warfare. In the Soviet camp was Communist China, a regional giant and a rising global power which was once an ally of the US during World War II against the Japanese but was now in conflict with the West in many series geopolitical conflicts. In such turbulent times, who would have imagined that a simple sport like Ping Pong would break barriers between US and China and usher in a new era of peace between the two nations, even act as a catalyst to bring an end to the Cold War? After decades of suffering a frozen, hostile relationship, post the communist revolution in China in the Forties, both superpower US and rising power China were looking for ways to end the détente, but it was the encounter between two Table Tennis players, Glenn Cowan of the US national team and Zhuang Zhedong of the Chinese national team in April 1971 leading to a series of friendly matches between the two national teams in China, later dubbed by the media as "ping pong diplomacy", that served as a spark which thawed

diplomatic relationships between the two countries and started a new era of people-to-people understanding and cultural exchanges.

In the years since Mao Zedong's communist revolution in 1949[1], relations between the People's Republic of China and the United States had been clouded by Cold War propaganda, trade embargos, diplomatic silence, and even actual hostilities. In the early Fifties, Soviet-backed North Korean People's Army invaded South Korea. The US and UN came to South Korea's aid, but when their troops approached its borders, China got into the fray in support of the North Korean Communist forces. In the violent war that unfolded, over four million people lost their lives.[2] In 1953, the People's Republic of China shelled the Quemoy and Matsu islands in Taiwan Strait leading the US to sign a mutual defense treaty with the Chinese Nationalist government in Taiwan. Soon after the First Taiwan Strait Crisis, the US threatened mainland China with nuclear attacks[3]. Later, in 1959, there was widespread uprising in Lhasa after years of China's assertion of control over Tibet, and thousands were killed in consequent crackdown by Chinese forces. The US severely condemned Chinese violation of human rights in Tibet and secretly commissioned the CIA to arm Tibetan resistance [4] By the time the Sixties ended, the two nations were again in a serious quagmire in Vietnam, with the US supporting the South Vietnamese, and the Chinese, along with the Soviet Union backing the Viet Cong in the North. In the long years since the communist revolution in China, the two military giants had met on the battlefield several times, but no official American delegation had set foot in the People's Republic in over 20 years.

By 1971, however, both nations were looking to open a dialogue with one another. As the challenging Sixties came to an end, the US was facing a perfect storm of issues including an unpopular war in Vietnam, domestic angst against the establishment, and a stalemate with the Soviets over nuclear disarmament. President Nixon, and Henry Kissinger, his National Security Adviser, came to the view that opening up a new frontier of peace with China would help solve problems with the Soviets and with the North Vietnamese. In 1967, Nixon had written, "We simply cannot afford to leave China forever outside the family of nations." [5] Surprisingly, they were to find a willing partner in China, although the Chinese had their own self-centered motivations to seek peace with the US. The Chinese were worried about the burgeoning power of Japan to their east. In general, the large nation was beginning to look outwards after decades of inward looking caused by political unrest and wide-spread famines [6]. Additionally, although they shared the same communist ideology, the Chinese were growing wary of the Soviets. Over the Sixties, the Soviets had flexed their military muscle against China, hoping to gain territory over its Asian neighbor. Small scale border skirmishes were turning into all out wars. "Nixon and Kissinger cooked up this idea of pitting the Soviet Union and China against each other with the United States as a third corner of the triangle to create a stable balance of power," says Evan Thomas, journalist and author of Being Nixon: A Man Divided. "'The enemy of my enemy is my friend' was a very Nixonian idea." [7].

The two countries eventually opened secret communications, but the real breakthrough came courtesy of a public encounter between a pair of ping-pong players. Of all tools, Table Tennis, a simple sport at which the Chinese were the best and the US was not even in the top twenty nations for, seemed the least likely to achieve a new frontier in the frozen relations between the two belligerent nations. During the 1971 World Table Tennis Championships in Nagoya, Japan, 19-year-old U.S. player Glenn Cowan hopped on a shuttle bus carrying the

Chinese national team, seemingly an accident by all accounts[89]. While the other players looked on at the long-haired American with suspicion, Zhuang Zhedong, the Chinese team's captain, stepped

forward to befriend Cowan. Talking to him through an interpreter, Zhedong presented Cowan with a beautiful silk art piece depicting the magnificent Huangshan Mountain range of China. Many years later in an interview with the Reuters news agency, Zhuang said he told Cowan through an interpreter: "Although the US government is unfriendly to China, the American people are friends of the Chinese. I give you this to mark the friendship from Chinese people to the American people."[10] Cowan returned the gesture the following day by giving Zhuang a t-shirt emblazoned with a peace symbol and the Beatles' lyric "Let It Be." Media caught the incident on film, and soon this chance encounter between the two table tennis players became a point of conversation all around the table tennis world. When Mao heard about the gift exchange, he saw a political opportunity for China. "Zhuang Zedong is not just a good table tennis player," he observed, "he's a good diplomat as well." A few days later, as the U.S. team was preparing to leave Nagoya, Mao shocked the world by inviting them to make an all-expense paid visit to China. Was this pivotal meeting of two Table Tennis players an accidental encounter or was it orchestrated? Before the Nagoya championship started, Roy Evans the head of the International Table Tennis Association was visiting in China, and he had an opportunity to meet

Premier Zhou Enlai. When Zhou wanted to know how the Chinese Table Tennis team, which was considered the top team in the world, could integrate better into the world of Table Tennis, Evans suggested that China might want to invite international teams playing in Nagoya to China after the tournament [11] Cowan's hailing the Chinese bus may have been an accident, but perhaps, some of the Chinese players had been instructed to be friendly to the Americans. But on the American side, the event certainly seemed like a chance meeting. When President Nixon was informed about this development, he was amazed that the Chinese team would reach out to the American National team. Table Tennis may have been a national pastime in China and a sport at which the Chinese excelled at a level well beyond their closest competitors, but it was a low profile, basement sport in America. "They have been dropping little hints...at the various embassies, and for months we've been expecting some thaw," Nixon said, according to the transcript of a White House recording provided by the Richard Nixon Presidential Library and Museum. But it happened in a way few foresaw. "You never can predict how the Chinese are," [12] Nixon said. "I was as surprised as I was pleased," President Nixon later wrote in his memoirs. "I had never expected that the China initiative would come to fruition in the form of a ping-pong team." Purely accidental, or partially orchestrated, at least by the Chinese, the visit began on April 10, 1971, when the American team of fifteen players crossed a bridge from Hongkong into mainland China. US passports had to be modified to allow the Americans to visit a communist state [13]. The US team was a rag-tag team of the self proclaimed hippie Glenn Cowan, a Guyanese immigrant, college professor, and a couple of high school-age girls. They were the best in America, but on the world stage, America did not even feature in the top 20 countries for Table Tennis. The team spent ten days traveling through Beijing, Shanghai, and Guangzhou absorbing new experiences, something that few Americans had had an opportunity for. "Everything was different from anything I'd ever seen," player Tim Boggan later told the New York Times. "The streets were different, the food was d ifferent. The people, of course, were different. The bicycles were different." [14] Posters of Mao Zedong seemed to be everywhere. After visits to the Great Wall and the Summer Palace, the Americans were invited to play a series of exhibition matches with Chinese players held under the slogan "Friendship First and Competition Second." It was clear that the world-class Chinese players understood their true mission. They won the majority of the contests

easily, but let the Americans take the occasional game . “I knew I was not only there to play,” Chinese competitor Zheng Minzhi told the New York Times, “But more important, to achieve what cannot be achieved through proper diplomatic channels.” [15] [16]. Finally, the American team met Premier Zhou Enlai in Beijing’s Great Hall of the People. Zhou congratulated the players on opening “a new chapter in the relations of the American and Chinese people .” The American table tennis team would leave China on April 17, arriving back in Hong Kong to a sea of news-hungry reporters. By then, American and Chinese governments had already opened new back channel communications with one another - the “ping heard round the world,” as Time Magazine had called it, was already bearing results. On April 14, the same day that the American players met with Zhou Enlai, President Nixon had announced that the US was easing its travel bans and trade embargos against China . Later, in response to the American trip, the Chinese sent their table tennis t eam to the United States for an eight-city tour [17] Ping-Pong diplomacy had achieved a new frontier in normalizing US China relations that no coercive military action or formal government to government contact had been able to accomplish.

The biggest result of Ping-Pong diplomacy was, of course, President Nixon’s February 1972 visit to the People’s Republic. On July 15, 1971, Nixon announced to Americans over a public TV broadcast that he had accepted an invitation to visit China. This was a remarkable announcement because the American public viewed China as the most hostile enemy of the US after the Soviet Union. “I have taken this action because of my profound conviction that all nations will gain from a reduction of tensions and a better relationship between the United States and the People's Republic of China,” said Nixon in his address [18]. Nixon had calculated that he needed China as a foil against the Soviets and wanted to use the trip to announce to the world that the US would now welcome China into the society of nations as the third superpower. He arrived in China to great fanfare, and almost immediately his company was sought by Mao himself, the aging chairman of the Chinese communist party who was ill by this time. Cameras of news agencies around the world caught the smiles and friendly gestures of the two world leaders [19]. At a state banquet, Zhou Enlai hailed Nixon’s visit to China as a “positive move,” observed that “the gate to friendly contact had finally been opened,” and said the great differences between the two nations “should not hinder China and the United States from establishing normal state relations.” [20]. Year later, writing about the visit years later, Nixon noted that the Chinese leaders “took particular delight in reminding me that an exchange of ping-pong teams had initiated a breakthrough in our relations. They seemed to enjoy the method used to achieve the result almost as much as the result itself.”[21]

Nixon’s historic visit to China, triggered by that fateful encounter between Table Tennis players Glenn Cowan and Zhuang Zhedong, was not just a public relations success – it helped usher in a new era of global peace. The visit helped the US realign the balance of power on the global stage. The Soviets, who had previously turned down calls for limiting their nuclear arsenal, came back to the negotiating table after Nixon’s China visit. Just a couple of months after his China trip, Nixon visited Moscow where he met with Leonid Brezhnev to sign the Strategic Arms Limitation Treaty (SALT) and made plans for a joint U.S.-U.S.S.R. space flight in 1975 [22]. Even more significant than the peace achieved between US and China was the recognition that people-to-people exchanges can diffuse intractable geopolitical issues. Years later, the U.S. Department of State’s Sports Diplomacy Division was established in the wake of 9/11 as a means of reaching out to youth in the Middle East through soccer. In a larger sense, the Ping-Pong diplomacy of 1971 had become a template for people-to-people connections supplanting more formal channels of connecting nations.

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Student Publications

Impact of Traffic Induced Air Pollution on Apricot Tree Health

Aneesh Raghavan (aneeshraghavan2005@gmail.com), Jane Packard

Advisor: Dr. Jane Packard, Chairperson of the Los Altos History Museum's Orchard Commons Committee, jmpackard@earthlink.net

Abstract

The Los Altos Heritage Orchard, a cherished urban space, looks unhealthy, with many bald spots on the ground and an overwhelming number of sickly trees. This observational study is valuable as understanding the factors that adversely impact tree health can help us find solutions to create a thriving, healthy orchard. Upon completing an inventory of the apricot trees, we evaluated if tree health is affected by air pollution because of the proximity of some of the sections to San Antonio Road. The hypothesis was that trees closer to the street would have poor health as they are more exposed to vehicle exhaust. The result of the study showed a strong correlation between tree health and proximity to the street: trees in sections closer to San Antonio Road were less healthy by our viability measures

Introduction

The historic old Los Altos Heritage Orchard represents an interplay between conservation of our natural environment and urban development. The one twenty-year-old 10-acre land with 259 apricot trees nestled in the suburbs of Los Altos next to San Antonio Road, a main thoroughfare, makes for an opportunity to study the relationship between these two competing forces. Upon taking an inventory of the trees in the orchard, we found that trees closer to the road experienced more brown rot (brown leaves), canker (sap dumplings), and other signs of poor health in comparison to trees farther from the road. A research question emerged from this: is the health of these trees affected by air pollution a product of their proximity to traffic on San Antonio Road? We hypothesized that if sections of the orchard are closer to the road, they will experience greater air pollution from cars, impacting their health negatively. Our research question was supported by scientific work done by Meineke et. al., 2022 in their paper, "Vehicle pollution is associated with elevated insect damage to street trees", the authors argue that vehicle pollution is a pervasive aspect of change across rural and urban habitat, and the most common emissions - carbon or nitrogen-based pollutants - may impact diverse interactions between plants and insect herbivores [1]. The purpose of this research was to understand factors that lead to poor tree health. Understanding these factors will help us find ways to improve their health not only to ensure delicious produce but also to preserve a historic city landmark that ties the community together. While the impact of sunlight, water, soil, and nutrients on tree health is well understood, less studied is the effect of air pollution induced by traffic. Using rigorous statistical analysis, we found a strong correlation between tree health and proximity to the street: trees in sections closer to trees were less healthy. However, a causal relationship can't be confirmed because this is an observational study. Indeed, we suspect that tree age is a confounding variable in the study.

Materials and Methods

The study area is the Los Altos Heritage Orchard, located in Los Altos, California (37.3814° N, 122.1140° W), which was established in 1901. This region is characterized by a Mediterranean climate of warm summers and wet winters. The orchard contains apricot trees, Prunus armeniaca.

The orchard was divided into 5 sections (A: Library, B: Middle, C: Parking Lot, D: San Antonio City Hall, E: San Antonio Library). Sections A, B, and C are relatively farther away from San Antonio Road than Sections D and E. There were additional sections G and F, but they were not used in the study due to their separation from other sites and lack of trees. A site number was assigned to every location where a tree could be planted (1 through 443). Each tree was then given a unique ID based on a coordinate grid system (Ab01: Section A, Row b, tree site 01). Each apricot tree was measured on the following variables: diameter (as a surrogate for age) as small, medium, or large using a measuring tape, height using a measuring pole, viability or measure of the state and health of the tree as stumps, dead, dying, unhealthy, or healthy. Additionally, specific diseases like brown rot, canker, and squirrel damage were noted.

Results

Sections A, B, and C had the greatest proportions of small and young trees with 21, 27, and 74 young trees respectively. Sections D and E contained a greater proportion of large, old trees with 11 and 8 old respectively. Sections A, B, and C had a greater proportion of healthier trees while Sections D and E had a greater proportion of unhealthy trees. Additionally, 42% of all trees in the orchard were healthy, 37% had wilted leaves, 55% had sap dumplings present, 44% had squirrel damage, and 59% of the orchard space was being utilized with trees.

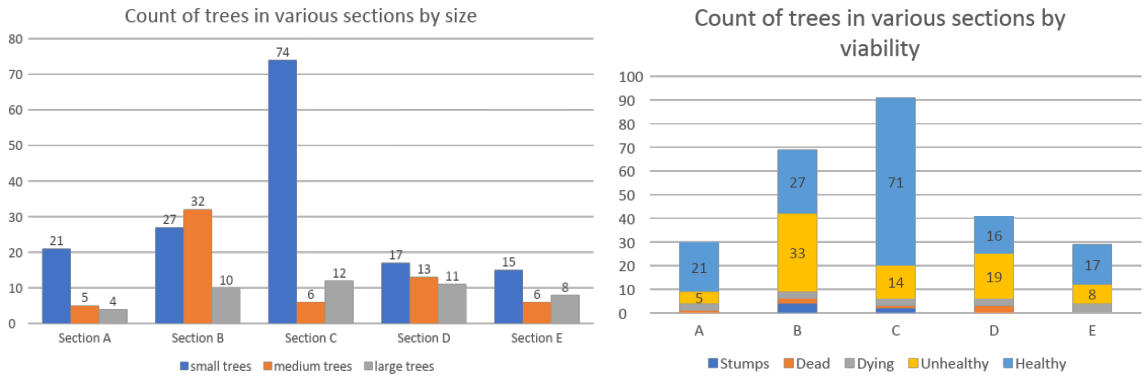

Figure 1: (A, *left*) Number of trees classified as small, medium, or large by diameter per section; (B, *right*) Count of trees in viability measures per section

Figure 2: Percentages of various statistics, such as health, wilting, sap, squirrel damage, and capacity on the orchard in totality

With this data, we used a Chi square test of independence to measure the strength of the association between tree health and proximity to the streets (as a surrogate for traffic induced air pollution).

Healthy?

	Yes	No
Trees near the street (D,E)	33	34
Trees Far from the street (A,B,C)	119	61

Figure 2: Observed Counts

	Healthy?	
	Yes	No
Trees near the street (D,E)	41.23	25.77
Trees Far from the street (A,B,C)	110.77	69.23

Figure 3: Expected Counts (all values are greater than or equal to five):

Our null hypothesis was that there was no association between trees' proximity to the streets and their health. Our alternate hypothesis was that there was an association between trees' proximity to the streets and their health.

The Chi squared value was 5.86 with one degree of freedom. The p-value was 0.015 and is less than alpha (0.05). This means that we can reject the null hypothesis, and that there is convincing evidence to support the alternate hypothesis that there is an association between the two variables.

Moreover, our results support our alternate hypothesis as shown by the stacked bar chart (Graph 2): Sections A, B, and C were farther from the streets and had a lower proportion of unhealthy trees while Section D and E were closer to the streets and had a higher proportion of unhealthy trees.

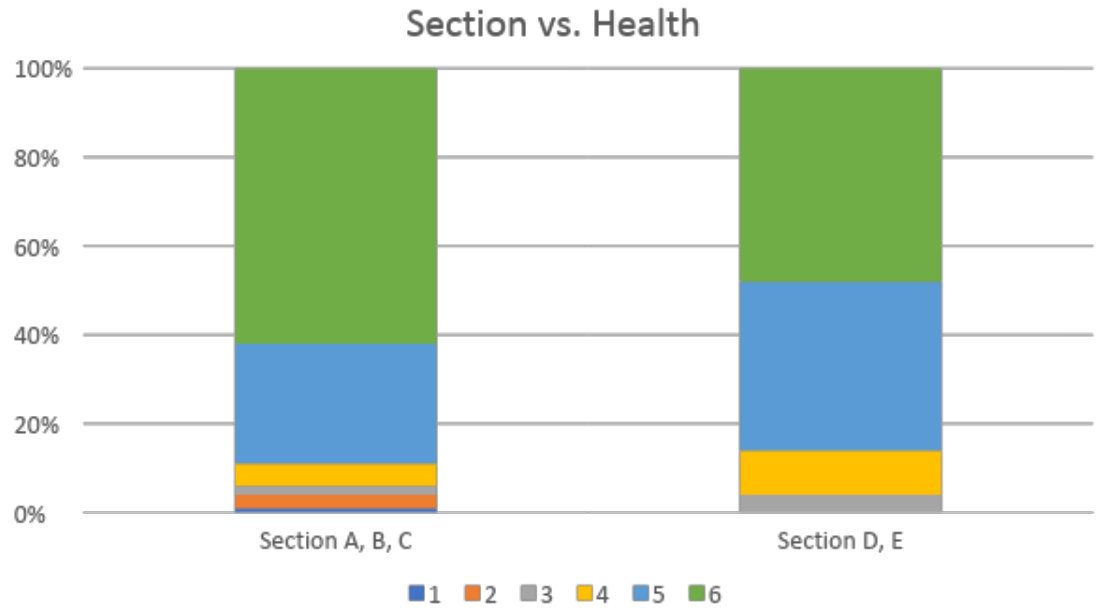

Figure 4: Stacked graph chart compares differing proportions of tree health in Sections A, B, and C vs. Sections D and E (1: Stump removed, 2: stump, 3: dead, 4: dying, 5: unhealthy, 6: healthy)

Discussion

After taking an inventory of 259 apricot trees at the Los Altos Heritage Orchard, we did a statistical analysis on the effect of air pollution on apricot tree health. We found a strong, positive correlation between health and proximity to the streets - trees in sections closer to San Antonio Road tended to be unhealthier while trees in sections further from the road tended to be healthier.

Despite this strong association, causality between the two cannot be determined. We found a strong association between the size (age) of the tree and its health. We also found a strong association between section and tree size, meaning that sections farther from the streets had smaller, younger trees. This introduces age as a confounding factor.

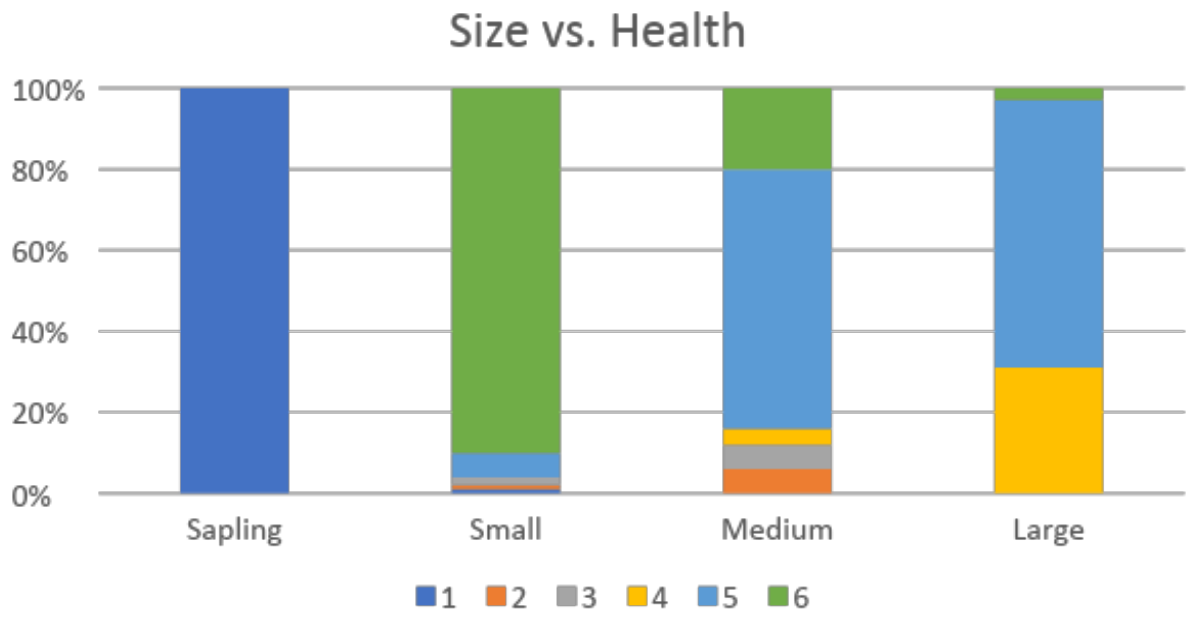

Figure 5: Comparison of distribution of viability measures in small, medium, and large trees (1: Stump removed, 2: stump, 3: dead, 4: dying, 5: unhealthy, 6: healthy)

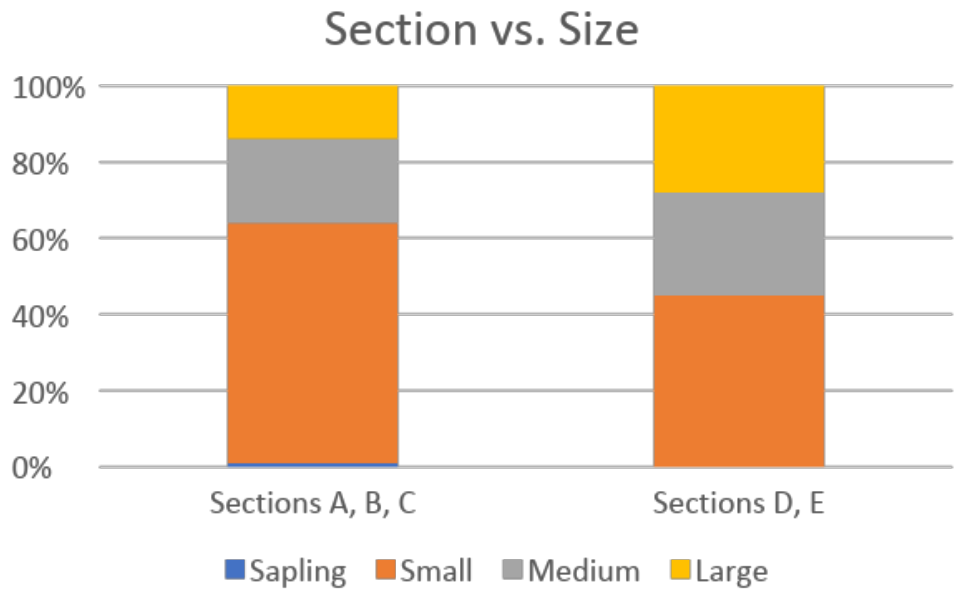

Figure 6: Comparison of distribution of small, medium, and large trees in Section A,B, and C vs. Sections D and E

Further analysis is required to eliminate the impact of age in our analysis. This means that we need to conduct an experiment that controls for possible confounding variables or using a longitudinal observational study.

Disclosures

The inventory and analysis were completed by AR and JP. The publication was written by AR. The results and conclusions were discussed by AR and JP

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Methods of Sustainable Transportation: Poly-anthraquinone Air Filtration System

Wania Chanveer

Abstract

All over the world people are dealing with rising air pollution problems, holes in the ozone, and climate change. Is there a simple idea we have overlooked when making the jump from gas-powered vehicles to clean energy? We all know that global warming is changing our perspectives on how we act and have acted in the past. But as the growing concerns for preservation increase, innovations are necessary to counteract the harm done. Mankind has made some of its more technologically advanced breakthroughs in science in the past decade but is it enough to stop our impact on the earth? The innovation we are thinking of is a filter to help propel us toward clean energy. That way we could separate the pollutants (CO2, N2) from the gas coming out of engines.

The world today is ever-changing and with growing concerns about carbon emissions from vehicles in our environment, we have created some new and brilliant ideas. The electric car portrays stunning use of clean energy, but what about lower-income families that also strive to help the environment? They want quick transportation, but the public provides little transportation that is also eco-friendly. So the question we have to ask ourselves is: Is it possible to make a car electric without having to rebuild it? To answer this question one must think outside the box. And instead of rebuilding, think about improving. How can we improve our past to make way for the future? Big companies don't care about the environment if it costs them more money. We need something that is cost-friendly, environment-friendly, and practical. I propose a filter that is designed for the emissions released from tailpipes. This filter utilizes a chemical substance known as polyanthraquinone, which is essentially a magnet for carbon ions. As we continue to make big waves in reversing the harm done to the earth, we still must take those baby steps of small ideas that could turn out to be something bigger and greater.

The production and disposal of cars have long been associated with significant resource waste and environmental pollution, making it a pressing concern that demands immediate attention.

As California takes a stance in combating climate change, the recent law mandating all new cars sold after 2035 to be electric holds immense potential for mitigating these issues. The manufacturing process of automobiles involves the extraction of finite resources such as iron ore, aluminum, and petroleum, which not only deplete valuable reserves but also contribute to ecological pollution. Furthermore, the disposal of old and obsolete vehicles adds to the burden, as they often end up in landfills, releasing harmful chemicals and pollutants into the environment. The average lifespan of a car is 12 years or 200,000 miles which after 2035 will mean nothing. All the cars being manufactured now cause all the companies to make a giant change that may end up with more cars ending up in landfills. The transition to electric cars causes demand for these resources can be significantly reduced, leading to a more sustainable and resource-efficient automotive industry. But electric cars are the opposite of cost-friendly and lower-income families will have to resort to other, less desirable, means of transportation. We can help everyone foster a cleaner and greener future for generations to come.

When considering the target customers for the innovative filter solution, shipping companies such as U-Haul, FedEx, US Mail, and others, along with everyday citizens reliant on automobiles for transportation, emerge as important players. These individuals and organizations collectively contribute to a substantial portion of carbon emissions globally. Notably, the United States, China, and Russia, as the top three CO2-emitting countries, account for a staggering 45.2% of the world's carbon emissions. By specifically targeting these customers and countries, the filter solution can make a remarkable impact in mitigating global warming and reducing environmental harm. Whether it's the transportation of goods from state to state or the daily commute from work to home, grocery shopping, or dropping children off at school, these activities heavily rely on carbon-emitting vehicles. By implementing filter technology in their fleets and personal vehicles, these target customers can effectively minimize their carbon footprint, contributing to a significant reduction in greenhouse gas emissions and steering the world towards a more sustainable future.

The actual product itself addresses emissions from car engines, harnessing the power of cutting-edge technology to combat environmental pollution. The product will have two features of protection, an arm clasp and sliding gates, which allow it to securely attach to a car adding to its effectiveness throughout the journey. The product utilizes a magnesium battery, which is considered more eco-friendly than its lithium counterparts, reducing the environmental impact associated with energy storage. The magnesium battery is 100% recyclable and dissolves naturally, leaving no trace of the metal. The chemical compound poly-anthraquinone, acting as our "magnet" for carbon ions, can separate the bad from the good. The emissions from the tailpipe consist of 71% nitrogen, 14% CO2, and 13% water vapor. The harm of CO2 on the earth is well known but what about the large 71% of N2? When nitrogen reacts with the O2 in the air it creates a compound called NOx. NOx is rain with an unusually low pH level. Normal rain has a pH of 5.6 but when NOx mixes with the water vapor to create acid rain the pH ranges from 4.2-4.4. This can be very detrimental to society and wildlife. Animals have little to no protection against rain, let alone rain that has the potential to dissolve solid rock. This is why integrating a holed wall in the filter, with a diameter of 300 pm, will trap the N2 with the CO2 but allow the H2O to escape. Through its innovation, this product surpasses the limitations of previous filtration methods, including face masks, blade tailpipe exhaust filters, and even natural processes like a plant's cellular respiration, offering an advanced and comprehensive approach to reducing car emissions and preserving our environment.

In conclusion, the innovative filter solution represents a beacon of hope on our journey for a sustainable and environmentally conscious future. By tackling the resource waste and pollution associated with traditional car manufacturing and disposal, this product aligns perfectly with the visionary goals set forth by California's new law mandating electric vehicles. By targeting shipping companies and individuals who heavily rely on automobiles for transportation, we can make significant strides in reducing global carbon emissions and combating climate change. The product itself, with its resourceful technology, showcases a remarkable advancement in emissions filtration. This revolutionary filter creates an opportunity to reshape the automotive industry and pave the way for our future. Right now we have created our theoretical solution. But moving forward laboratory testing, practical testing, and publishing of our final product will have to be made. The road to the final solution isn't over yet but after facing challenging obstacles we can finally say we are making progress. As Mahatma Gandhi said, " The future depends on what we do in the present." We can only move forward from this point on and we are. By embracing this technology, we take a giant leap toward preserving our planet for generations to come.

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