A Collection of

Literature Reviews

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youthstem journal club

Subject Groups

YSJC Biology	**YSJC Chemistry**	**YSJC Physics**
The biology group spent our 4 weeks exploring the tardigrade, an organism adapted to tolerate harsh conditions such as radiation and temperature. For our literature review, we focused on the TDR1 gene, a mechanism that aids the tardigrade with robust and novel DNA repair, providing insight on gene repair for humans as well.	*The chemistry group spent our 4 weeks investigating microplastics, tiny plastic particles that contaminate drinking water and pose emerging risks to human and environmental health. For our literature review, we focused on bottled water contamination, characterizing the abundance, size, and polymer types of microplastics that people may unknowingly ingest*	*The physics group spent our 4 weeks examining cool roof coatings, materials engineered to reflect sunlight and reduce heat absorption on building surfaces. For our literature review, we focused on cool roof albedo and temperature reductions, evaluating how different commercial coatings mitigate urban heat and improve thermal performance.*
Mentor: Jadon Li **Scholars**: Suraj Andra, Anika Chandra, Aditya Ghate, Vidhi Jindal, Charlotte Liu, Eshwar M, Serena Qu, Anya Virmani	**Mentor**: Ashley Kang **Scholars**: Tanishi Chokshi, Elsa Deng, Sanskruth Gopinath, Mahanyasri Karthik, Hardit Kumar, Anya Virmani	**Mentor**: Ashley Kang **Scholars**: Rajvir Sharma, Aditya Ghate, Eshwar Muthunagaswamy
YSJC Mathematics	**YSJC Computer Science**	**YSJC Psychology**
The mathematics group spent our 4 weeks exploring the Fibonacci and Lucas sequences, number patterns that appear in both theoretical mathematics and nature. For our literature review, we focused on combinatorial proofs, using tilings and discrete arguments to reveal elegant identities and structural properties of these sequences.	*The computer science group spent our 4 weeks studying path planning, the problem of finding efficient routes for agents moving through complex environments. For our literature review, we focused on comparing algorithms like Dijkstra's, A* and RRT on the PathBench platform to evaluate their performance across 2D and 3D maps, real cities, and video game worlds.*	*The psychology group spent our 4 weeks investigating motor response inhibition, the brain's ability to stop or withhold actions in time. For our literature review, we focused on striatal D1- and D2-type dopamine receptors, examining how their availability in different brain regions relates to individual differences in stopping behavior.*
Mentor: Veer Mahajan **Scholars**: Kavan Dai, Advith Godavarthi, Vidhi Jindal, Alvin Lin, Jelissa Tao	**Mentor**: Satyaki Maitra **Scholars**: Rajvir Sharma, Aishi Bag, Vaibhav Vijaay, Sanskruth Gopinath, Advith Godavarthi, Monalee Bhattacharya, Arnav Agarwal	**Mentor**: Brian Lu **Scholars**: Tanishi Chokshi, Mridhula Kumar, Elsa Deng

YSJC Biology

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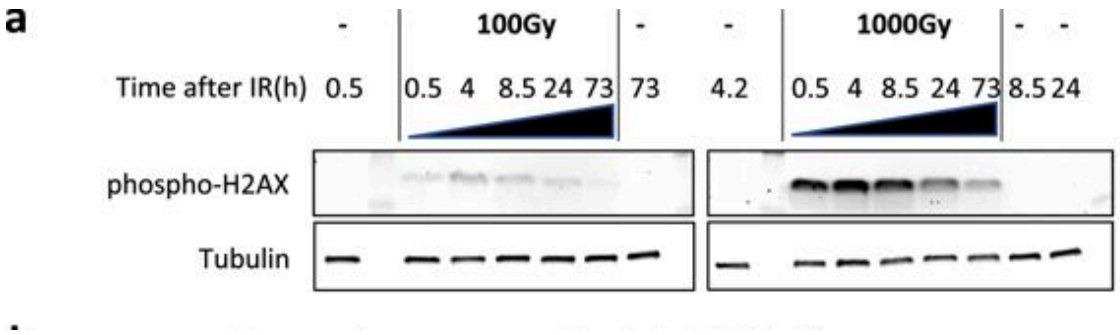
Literature Review: *Comparative transcriptomics reveal a novel tardigrade-specific DNA-binding protein induced in response to ionizing radiation*

Suraj Andra, Anika Chandra, Aditya Ghate, Vidhi Jindal, Charlotte Liu, Eshwar M, Serena Qu, Anya Virmani
Mentor: Jadon Li

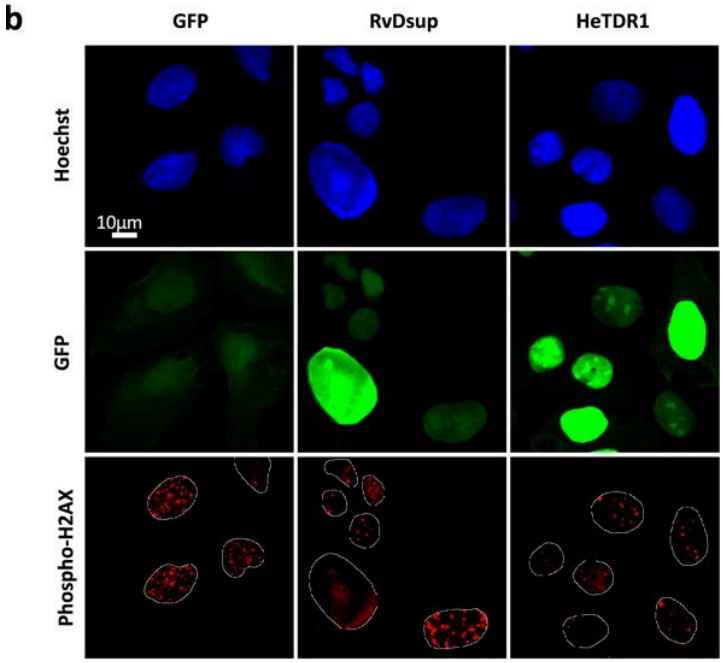
Tardigrades are microscopic creatures known for their unique ability to survive even the strongest of conditions. One of these conditions is an absurd amount of radiation, up to 4000+ Gy, an amount capable of shredding human DNA. Their ability to survive has kept them alive for millions of years and could help with future space travel and medicine, prompting scientists to dive deep into the secrets of the Tardigrade.

The researchers in this study were trying to find out how tardigrades survive extreme doses of ionizing radiation that can shred DNA. They wanted to know what genes made this possible and what type of DNA protection this was — shielding or repairing? This is significant because understanding the genes in tardigrades helps researchers figure out how they can survive harsh conditions. Learning how these genes work helps their understanding of how fast DNA repair is and how effective Dsup shields the DNA when radiation strikes a tardigrade. TDR1 is a novel gene that protects tardigrades from even the most extreme conditions. This could help humans in the future in risky situations such as space travel and cancer treatments.



In diagram A, the tardigrades were targeted with 100 and 1000Gy of ionizing radiation (IR), with results from a group where DNA breakage is shown with phospho-H2AX (a biomarker) and from the control group, which is shown from the diagram with Tubulin. The more phospho-H2AX there is (the darker the bands are), the more DNA breakage there is. In the diagram with 100Gy, we can see that the bands get slightly darker and then get more faint, which shows that there was DNA breakage when IR was introduced but then there was less breakage as time progressed. Similarly when 1000Gy was used, the DNA breakage was very strong but then cleared after some time. In both diagrams the damage peaks 4 hours after IR is introduced and mostly improves after around 24 hours. Tubulin was used as a loading control to ensure equal

protein concentration across all lanes, confirming the changes observed in phospho-H2AX is reliable and accurate.



In diagram B, they tested Dsup and TDR1 in human cancerous cells because they multiply very quickly, which makes testing quicker and more efficient. The labels for the rows are different dyes and biomarkers that make the features of the cells easier to see under a microscope. Hoechst is used just so we can see the shape of the cells, GFP shows how much Dsup (which acts as a shield against IR) or TDR1 (which binds broken DNA together, making it much easier to repair) is present (the more brightly colored the cells are, the more Dsup or TDR1 is expressed), and Phospho-H2AX shows how much DNA breakage there is. The first column is the control group, where there were no genes that were added. There was very little glowing color (GFP), meaning that there wasn't much radio-resistance. In that column we can also see that there were a lot more red spots in the phospho-H2AX image, which means that there was high DNA breakage since there wasn't any Dsup or TDR1. In the second column, the Dsup protein was added to the cells. In the third column, the TDR1 protein was added to the cells. In both of these there is much more GFP shown in the images because there is more neon color. Therefore, we can also see that for these columns there are less red spots (phospho-H2AX), indicating that there's less DNA breakage because there was more Dsup and TDR1, which implies that Dsup was able to shield the radiation, and TDR1 was able to bind the broken DNA together for repair. This study demonstrates that Dsup and TDR1 can be used in humans and can have the same effect in humans as in tardigrades.

By measuring the y-H2AX at 30 minutes, 4 hours, 8.5 hours, 24 hours and 73 hours, the scientists found out that tardigrades repair their cells quickly instead of protecting them from radiation. They continued measuring y-H2AX over several days, and noticed that it slowly

returned to almost-normal levels, and realized that, even after facing 1000 Gy of radiation, most of the DNA damage done to the tardigrade was repaired within 24-73 hours. This demonstrates the tardigrades' unusually efficient DNA repair systems. By using whole-mount immunolabeling to visualize y-H2AX inside different tissues and compare the tardigrade's body cells with its gonad cells, the scientists figured that most of the tardigrades' body cells recover, with the exception of its reproductive cells. The researchers reckon this explains why heavily irradiated tardigrades survive, but become sterile. They observed that y-H2AX remained high in gonads 72 hours after 1000 Gy and compared this with previous observations that irradiated tardigrades become sterile. This means that cells trying to copy their DNA were more vulnerable to the radiation, because it can interfere with the replication process. Hence, DNA repair is powerful, but cannot restore every single cell.

This research is important because the protein, TDR1, repairs DNA damaged due to radiation. When TDR1 was put inside human cells, it had fewer DNA breaks. This can be beneficial to humans because it can be used to save them from dangerous amounts of radiation, too. It can help astronauts stay safer from radiation in outer space. Also, if tardigrade repair proteins were added to human cells, the healthy cells will be protected from radiation used to destroy cancer cells. This study further enhances research of biology and genes, and opens up new doors.

In this research paper, many new discoveries were made, such as the DNA shield Dsup and a new protein found only in tardigrades called TDR1, which helps in bunching up broken DNA until they can be repaired. When exposed to ionizing radiation, the tardigrade's DNA repair genes went into overdrive, being overexpressed after being hit with the ionizing radiation. This seems interesting, as it establishes that repairing broken DNA is the key to radiation survival, even if it doesn't completely block out all damage. Scientists also implemented these genes into human cells, which increased resistance to radiometric drugs, showing that implementing these proteins and genes into human cells is a valuable tool . It could also be studied and replicated into pharmaceutical drugs, but for any use in humans we must understand all effects that implementing these genes may have on the body. Surprisingly, a protein that destroys remaining DNA repair proteins after their job is done called RNF146 is found in tardigrades as well as humans. This shows that humans also have DNA repair genes, however they are nowhere near strong enough to give us efficient radiation survivability. Overall, Humans have potential for DNA repair to maintain a damage control system for ionizing radiation, as seen with the few DNA repair genes we have, but genetic modification or specific drugs are necessary to harness the full potential of DNA repair.

YSJC Chemistry

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Literature Review: Occurrence and characterization of microplastics in bottled drinking water

Tanishi Chokshi, Elsa Deng, Sanskruth Gopinath, Mahanyasri Karthik, Hardit Kumar, Anya Virmani

Mentor: Ashley Kang

In the paper "Occurrence and Characterization of Microplastics in Bottled Drinking Water" by Pathissery John Sarlin, Sancia Morris, Gayathry Savitha, Archa Gopan, and E. K. Radhakrishnan (2024), the authors employed stereomicroscopy and μ-Raman spectroscopy to analyze samples from ten popular bottled water brands. They detected an average of 9 ± 1.00 MPs/L, predominantly fibers, with particles under 500 μm in size and polymer types including polypropylene (PP) and polystyrene (PS). The study attributes many microplastics to bottle caps, packaging materials, and secondary sources such as synthetic fibers from clothing production. Though small, these particles raise serious concerns for human health through ingestion, potentially causing inflammation and chemical exposure, while also polluting oceans and entering the food chain, harming aquatic life and humans alike. This research underscores microplastics as a major environmental and public health issue.

Microplastics represent a major component of global plastic pollution. These tiny particles (<5 mm), originating from the breakdown of larger plastics and everyday sources such as clothing fibers, cosmetics, and packaging, pose significant risks when ingested by humans and wildlife. The paper addresses the research question: Are microplastics present in commercially available bottled drinking water, and what are their characteristics, sources, and potential exposure levels? This question is important because bottled water is widely consumed as a "pure" and safe option, yet widespread microplastic contamination could contribute to chronic human exposure through ingestion. To investigate this, the researchers collected samples from ten popular brands sold in Kerala, India. They processed the water using hydrogen peroxide to digest organic matter, isolating the microplastics for analysis. Stereomicroscopy and μ-Raman spectroscopy were then used to identify, count, and characterize the particles. The study found microplastics in every brand tested, with an average abundance ranging from 3 to 9 MPs/L. All particles were smaller than 500 μm, predominantly fibers (≈59%), and composed mainly of polypropylene (PP) and polystyrene (PS), along with other polymers. Sources were linked to both raw water contamination and packaging materials, especially bottle caps and synthetic fibers from clothing production. The authors estimated that an average adult could ingest approximately 153 microplastics per year from bottled water alone.

This paper has several strengths and weaknesses. One notable weakness is that the water samples could have been contaminated during transportation or handling. In contrast, one of the paper's key strengths is the authors' thorough approach, which enabled them to generate specific, easy-to-understand metrics and values for readers. The researchers examined thirty bottles from ten different brands, using a fine filter to capture particles, which they then measured and counted. Employing Raman spectroscopy, they successfully identified the polymer types. However, the study has some limitations, including the relatively small sample of only ten brands, which may limit the generalizability of the results. Despite this, the paper presents many noteworthy findings. It highlights that clothing fibers are a major source of microplastics in bottled water, a pressing issue that demands immediate attention. The implications of this research are significant: by detailing the presence, characteristics, and origins of microplastics, the study

can inform strategies to mitigate exposure, ultimately supporting improved human health and future solutions.

In conclusion, microplastics are present in bottled drinking water, though the concentrations vary across brands. These particles can contribute to various health complications in humans. Since microplastics were detected in every brand tested, consumers should consider limiting their intake of plastic-bottled water. Given their tiny size and potential to cause significant health issues, companies should prioritize efforts to eliminate microplastics from their products. Through Raman spectroscopy, the researchers determined that fiber-shaped microplastics primarily originated from clothing, with polypropylene (PP) and polystyrene (PS) being the two most common polymer types identified.

YSJC Physics

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Literature Review: Experimental Analysis of Cool Roof Coatings as an Urban Heat Mitigation Strategy to Enhance Thermal Performance

Rajvir Sharma, Aditya Ghate, Eshwar Muthunagaswamy
Mentor: Ashley Kang

In the paper titled “Experimental Analysis of Cool Roof Coatings as an Urban Heat Mitigation Strategy to Enhance Thermal Performance” by Cheuk Yin Wai, Hing-Wah Chau, Prudvireddy Paresi, and Nitin Muttil, the authors investigate cool roof technologies to combat rising urban temperatures. Albedo, a scientific measure of a surface’s ability to reflect sunlight that ranges from 0 for a perfectly black surface that absorbs all heat to 1 for a pure white surface that reflects nearly all light, plays a central role in this research. Rapid urbanization has intensified the Urban Heat Island Effect, in which cities experience significantly higher temperatures than surrounding rural areas due to the prevalence of heat-absorbing materials such as dark pavements and traditional roofs. In response, strategies such as cool roofs, which maintain higher albedo values, offer an effective, technologically advanced solution. Unlike many other mitigation approaches, cool roofs provide substantial benefits for both thermal performance and public health, helping to reduce heat-related risks amid ongoing urban development.

Cool roofs can significantly lower building temperatures. On a larger urban scale, widespread adoption of cool roofs could help cool entire cities while reducing electricity costs associated with air conditioning. Additionally, because cool roofs operate without mechanical systems, they remain effective even during power outages on extremely hot days. This reliability can help prevent heat-related illnesses, such as heat stroke, which pose serious public health risks. To evaluate the performance of cool roof coatings, the researchers applied six different commercial brands to an experimental roof on an office building in Melbourne, Australia. Surface temperatures of both coated and uncoated tiles were measured using a thermal infrared camera during peak heat hours (12:00-3:00 PM) on hot, sunny days. The coatings achieved an average temperature reduction of approximately 20°C. While the average ambient temperature was around 27°C, the cool roofs helped maintain substantially lower internal building temperatures. Brand 4 delivered the strongest performance, reducing the surface temperature to 34.3°C (a 45.5% reduction) from a peak of 62.9°C. Brand 5 showed the smallest improvement but still achieved a meaningful 15.8°C (25.1%) reduction. The results demonstrated that cool roof coatings effectively reduced surface temperatures across all tested brands. The coatings achieved temperature reductions ranging from at least 8.7 °C to as much as 34.2 °C, corresponding to percentage reductions of 13.2% to 53.6% from the uncoated maximum surface temperature. Brand 4 performed the best overall, lowering the surface temperature to 34.3 °C (a 45.5% reduction) when the uncoated peak reached 62.9 °C. Brand 5 was the least effective but still provided a meaningful reduction of 15.8 °C (25.1%). These findings confirm the potential of cool roof coatings as a practical and reliable strategy for mitigating urban heat.

One strength of the paper is that it evaluates the effectiveness of cool roof coatings under varying weather conditions, including different sky conditions (overcast, partly cloudy, and clear), rather than limiting the analysis to a single scenario. However, a key limitation is that the coatings were tested only on concrete tiles; results may differ when applied to other roofing materials. Additionally, measurements were taken only during peak hours (12:00-2:00 PM), so performance at other times of day remains unexamined. Notably, the study observed significant temperature differences between coated and

uncoated surfaces under both warm and cooler conditions. Overall, this research is significant because cool roofs offer an eco-friendly, cost-effective, and sustainable alternative for building cooling, with strong potential to shape future urban heat mitigation strategies.

In summary, the study by Wai et al. (2025) demonstrates that cool roof coatings are a highly effective strategy for mitigating the Urban Heat Island Effect. By increasing surface albedo and reducing heat absorption, the tested coatings achieved substantial temperature reductions of 8.7-34.2 °C (13.2-53.6%) across various weather conditions, with Brand 4 delivering the strongest performance. These findings highlight cool roofs as a reliable, low-maintenance, and machinery-free solution that can lower building energy consumption, reduce cooling costs, and help prevent heat-related health risks, even during power outages. While limitations such as the focus on concrete tiles and peak-hour testing exist, the research provides valuable real-world evidence supporting the broader adoption of cool roof technologies. Ultimately, integrating cool roofs alongside other sustainable practices offers a practical pathway toward cooler, more resilient, and environmentally friendly cities.

YSJC Mathematics

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Literature Review: *The Fibonacci Numbers -- Exposed More Discretely* (Benjamin, Quinn)

Kavan Dai, Advith Godavarthi, Vidhi Jindal, Alvin Lin, Jelissa Tao
Mentor: Veer Mahajan

Researched by Arthur T. Benjamin from Harvey Mudd College and Jennifer J. Quinn from Occidental College and published on June 1st, 2003, *The Fibonacci Numbers -- Exposed More Discretely* is a paper that discusses various proofs within the Fibonacci and Lucas sequences through an intuitive, discrete series of arguments while also generalizing it. This review offers insights on the key ideas, methodologies, and results of the research.

Figure 1: Identities combinatorially proved by Benjamin and Quinn.

$$F_n = F_m F_{n-m+1} + bF_{m-1}F_{n-m}$$

$$(a+b-1)\sum_{i=1}^{n} F_i = F_{n+1} + bF_n - 1$$

$$a\left(b^n F_0^2 + b^{n-1}F_1^2 + \cdots + bF_{n-1}^2 + F_n^2\right) = F_n F_{n+1}$$

$$F_{n-1}F_{n+1} - F_n^2 = (-1)^n b^{n-1}$$

$$\gcd(F_n, F_m) = F_{\gcd(n,m)}$$

$$L_n = aF_n + 2bF_{n-1}$$

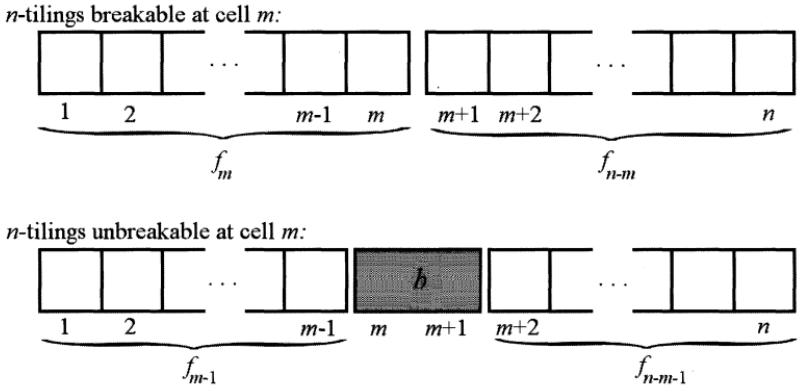
$$L_n = F_{n+1} + bF_{n-1}$$

This research paper's primary aim is to inform the readers about the unique properties of the Fibonacci and Lucas sequences and convey the idea of unity in mathematics by applying combinatorial methods to complete proofs.

This paper is significant because it explains a new method to explaining the patterns previously observed in the Fibonacci and Lucas sequences. Applying a discrete approach, it virtually eliminates the need for algebra or complex mathematics, instead focusing on intuitive, logical, and visual representations. Similar to how $\binom{n}{k} = \binom{n}{n-k}$ can be proved algebraically but also by answering the question of choosing k from n or not choosing $n - k$ from n, the discrete approach developed is used to prove each of the identities shown in Figure 1.

The key visual representation employed by the authors is of counting combinations of tilings with length n (Benjamin & Quinn, 2003, p. 183). This method replaces the algebraic approach of a Kalman and Mena paper that had inspired them to make for a more intuitive approach and illustrate how different approaches often yield the same results in mathematics. Each tiling is composed of 1×1 squares, each of which has a possible colors, or 1×2 dominoes, each of which has b possible colors. Recursion is used to generate a tiling of length n, denoted F_n, in terms of smaller tilings; for instance, since F_n ends in either a square or domino, it can be broken by casework into $F_{n-1} \cdot a + F_{n-2} \cdot b$, yielding the equation $F_n = aF_{n-1} + bF_{n-2}$, which matches the general Fibonacci sequence, and matches the famous case when $a = b = 1$.

Figure 2: From the paper, this model is a visual representation of how breakability is defined..



Breakability is used to extend the previous idea. In short, breakability is the concept of how many n-colored tiles can be split at cell m and how many cannot (Benjamin & Quinn, 2003, p. 183). To be breakable, the tiling is made up of colored m-tiling followed by a colored $n - m$ tiling, meaning that there are $F_m \cdot F_{n-m}$ such possible tilings . To be unbreakable at the m-th cell, the tiling has a colored $m - 1$ tiling followed by a colored domino on m and $m + 1$ and an $n - (m + 1) = (n - m - 1)$-tiling; there are $b \cdot F_{m-1} \cdot F_{n-m-1}$ such tilings when we consider that the domino may be of any of b colors. Combining the two cases forms the identity. To demonstrate the second identity above, the summation identity, the authors consider a tiling partition based on white squares, picking the last non-white square and summing the results. The idea is generalizable, considering not only non-white squares, but squares that are not of any of c different colors (Benjamin & Quinn, 2003, p. 184). Figure 2 provides a visual description of the breakability idea.

Building off breakability, the authors then define faults, where two stacked tilings are simultaneously breakable, and implement a tail-swap (switching ends at the final fault) to prove Cassini's identity. The tail-swap mechanism turns two length n tilings into an $n - 1$ and $n + 1$ length tiling; adding an error term to account for a not-fully-one-to-one relation (Benjamin & Quinn, 2003, p. 186), this arrives at Cassini's identity, which states $F_n^2 = F_{n-1}F_{n+1} \pm (-b)^{n+1} = F_{n-1}F_{n+1} \pm (-1)^{n+1}(b)^{n+1}$; keep in mind that this reduces to simply $F_{n-1}F_{n+1} \pm (-1)^{n+1}$ for the Fibonacci sequence with $a = b = 1$. This is easy to verify; for instance, $F_7 = 13, F_8 = 21$, and

$F_9 = 34 \Rightarrow 21^2 = 441 = 442 - 1 = 13 \cdot 34 - 1$, as expected.

The greatest common denominator (gcd) property, also proved in the paper through combinatorics, states that the gcd of any two Fibonacci numbers will be another Fibonacci number, one with index equal to the gcd of the two elements' indices. Stated mathematically, this yields $\gcd(F_n, F_m) = F_{\gcd(n,m)}$, which is supported by simple examples such as

$\gcd(5, 8) = \gcd(F_5, F_6) = F_{\gcd(5,6)} = F_1 = 1$ and $\gcd(1548008755920, 498454011879264) = \gcd(F_{60}, F_{72}) = F_{\gcd(60,72)} = F_{12} = 144$. For known values and indices of the sequence, this offers a path to trivially finding common factors and reduces computations.

Lucas Numbers are approached by the authors in a largely similar way, through bracelets. These extend the tiling strategy to a circle and have properties of being in- and out-of-phase that are analogous to the linear tilings' breakability property.

In addition to $a, b \in \mathbb{Z},\ a, b \geq 0$, Benjamin and Quinn also extended the sequences to more generalized values. Through the consideration of a random, infinitely long tiling, they were able to prove Binet's formula, $F_n = \frac{1}{\sqrt{5}}\left[\left(\frac{1+\sqrt{5}}{2}\right)^n + \left(\frac{1-\sqrt{5}}{2}\right)^n\right]$ (Benjamin & Quinn, 2003, p. 192).

This paper provides a deeper layer of appreciation of the sequences, and mathematics in general, by revealing how two wholly different approaches converge to the same elegant results. In the context of the Fibonacci and Lucas sequences, Benjamin and Quinn are able to make properties memorable and understandable, intuitive in a way that previous proofs were not.

YSJC Computer Science / AI

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Literature Review: Systematic Comparison of Path Planning Algorithms using PathBench

Rajvir Sharma, Aishi Bag, Vaibhav Vijaay, Sanskruth Gopinath, Advith Godavarthi, Monalee Bhattacharya, Arnav Agarwal
Mentor: Satyaki Maitra

Path Planning is an optimization problem to create the shortest path from place to place. The father of Path Planning, Edsger W. Dijkstra once said, “What’s the shortest way to travel from Rotterdam to Groningen?” Many algorithms have been made to solve this path planning problem, like Dijkstra’s, A*, RRT, and RRT Connect, and more research is ongoing to create new algorithms. Google Maps uses A* to find the shortest path from place to place. Autonomous vehicles rely on Path planning algorithms, like RRT and RRT Connect. Also, Minecraft uses A* to navigate mobs to the player. The paper “Systematic Comparison of Path Planning Algorithms using PathBench”, written by Hao-Ya Hsueh, Alexandru-Iosif Toma, Hussein Ali Jaafar, Edward Stow, Riku Murai, Paul H.J. Kelly, and Sajad Saeedi, compares different path planners on the novel PathBench, with platform-specific maps, real-world maps, and video game maps.

The main path planning algorithms we cover are Dijkstra’s Algorithm, A*, RRT, and RRT connect. Dijkstra’s algorithm is effective at moving in a tree-like pattern through adjacent paths. It then finds the shortest path out of all of them. The main limitation of Dijkstra’s is that it is very expensive to compute and apply. On the other hand, A* is a path algorithm that finds possible paths *in the direction of the destination*. A* also estimates the cost of moving from the starting point to the final goal, increasing efficiency compared to algorithms like Dijkstra’s. RRT creates a tree on a random point that creates branches with the goal of a branch reaching the endpoint (where branches can create more branches, and so forth). RRT-connect is widely considered to be the more efficient version of RRT, because it creates two separate starting branches: one from the starting point and one from the ending point. RRT-connect’s branches’ goal, unlike RRT’s branch’s goal of reaching the end point, is to eventually connect somewhere in the middle.

The paper itself aims to test PathBench, a platform that can use 2-dimensional and 3-dimensional spaces and tests with a 3D map, a PathBench map, and a game path. The main path planning algorithms we cover are Dijkstra’s Algorithm, A*, RRT, and RRT connect. Dijkstra’s algorithm is effective at moving in a tree-like pattern through adjacent paths. It then finds the shortest path out of all of them. The main limitation of Dijkstra’s is that it is very expensive to compute and apply. On the other hand, A* is a path algorithm which finds possible paths *in the direction of the destination*. A* also estimates the cost of moving from the starting point to the final goal, increasing efficiency compared to algorithms like Dijkstra’s. RRT creates a tree on a random point that creates branches with the goal of a branch reaching the endpoint (where branches can create more branches, and so forth). RRT-connect is widely considered to be

the more efficient version of RRT, because it creates two separate starting branches: one from the starting point and one from the ending point. RRT-connect's branches' goal, unlike RRT's branch's goal of reaching the end point, is to eventually connect somewhere in the middle. Out of these, A* shone as a clear winner for the most efficient planner, with Dijkstra being a close second and third, respectively, for their success rates. PathBench allows us to test and use software that can be useful in 2-dimensional and 3-dimensional environments. It also allows us to figure out which software is the best one for everyday use in video games and real environments. The results showed that out of all the software, A * was the most efficient and fastest one. It had a 99.4 % success rate, and its speed was 0.106 seconds on PathBench. In the real city environment, it had a 100% success rate and took around 3.816 seconds. In the video game environment, it also had a 100% success rate, but it took around 31.567 seconds. Dijkstra has similar success rates, but took much longer. However, only for video games, d-sPRM performed similarly to Dijkstra, having an average performance in PathBench and in the city environment. Interestingly, d-RRT performed the worst in all three environments in terms of success rate and time taken, while d-RRT-connect performed quite well and matched some of Dijkstra's performance.

The paper clearly explained how they conducted experiments using PathBench by providing details in both words and detailed graphs and illustrations. A* is the benchmark testing algorithm for all the PathBench maps because of its efficiency. The ways that we can usechePathBench vary greatly, but the main use of testing different algorithms in varied environments is to evaluate and compare different algorithms across different environments, as the results may differ with each environment. (e.g., Even though A* is used in each map to find the fastest route, in 3D maps A* takes much longer to find the best path because it has to explore more nodes than in 2D maps.) The results can be used to further improve online services that implement these algorithms, such as A* for GPS services, RRT types for motion planning simulations, and Dijkstra's for maze solvers. This matters for path planning and beyond as it helps to find the most overall efficient algorithm, its conclusion providing information improving services that use such algorithms.

Path planning's biggest strength is its many algorithms being able to be used for many cases with different algorithms. Some use cases include self-driving cars finding their way around the city, or an NPC in a video game navigating its surroundings. These algorithms can also be used for different problems. In many cases, certain algorithms are more useful than others. For example, A* was the quickest and most efficient out of all them. In a real city and video game environment, A* had a 100% success rate. A* was also much faster than the others, like Dijkstra's, even though they had similar success rates. Another example is d-RRT, which performed the worst out of all the algorithms in both categories. On the other hand, d-RRT connect performed well and matched average-performing algorithms like Dijkstra's, which is why it is considered superior to d-RRT.

PathBench's flexibility allows people to test planners in both two-dimensional and three-dimensional environments using only one platform. This removes the need of having to

switch between different platforms to test different environment types, creating a consistent testing place. The results showed that each planner completed navigating a PathBench environment in under 10 seconds, which is significantly faster compared to how the planners performed in the other environments (where completion times averaged to about 20 seconds). The faster navigation speed in PathBench environments allows researchers to evaluate planners' performance across both 2-dimensional and 3-dimensional spaces more efficiently and, in turn, on a larger scale. Overall, PathBench is one of, if not the most effective, platforms for uniform, large-scale experimentation with path planning.

YSJC Psychology

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Literature Review: Striatal D1- and D2-type dopamine receptors are linked to motor response inhibition in human subjects

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In the paper "Striatal D1- and D2-type Dopamine Receptors Are Linked to Motor Response Inhibition in Human Subjects," written by Chelsea L. Robertson, Kenji Ishibashi, Mark A. Mandelkern, Amira K. Brown, Dara G. Ghahremani, Fred Sabb, Robert Bilder, Tyrone Cannon, Jacqueline Borg, and Edythe D. London, researchers used Positron Emission Tomography (PET) imaging to test the role of dopamine receptors in human response inhibition. Motor response inhibition is the essential ability to suppress inappropriate or premature actions. This mechanism is guided by complex neural circuits involving dopaminergic transmission. Additionally, deficits in this inhibitory control show hallmarks of psychological disorders like ADHD and substance use/addiction. While prior animal studies point to distinct roles for D1- and D2-type receptors, human studies hadn't yet evaluated D1-type receptors in this specific stopping mechanism. Taking this into account, this study analyzes how the individual variability in D1- and D2-receptors leads to varying levels of behavioral control.

The purpose of this study is to determine whether individual differences in D1- and D2-type dopamine receptor availability in the striatum are related to motor response inhibition in humans, and whether these receptors function in opposing ways across different brain regions. This research is highly important because understanding how dopamine influences behavioral inhibition could lead to improved treatments for disorders involving impulsive behavior, such as ADHD and substance addiction. To investigate this, the researchers recruited 31 healthy adult volunteers to participate in the study. Each participant completed two specialized neurobehavioral computer tasks: the Stop-Signal Task (SST) and the Continuous Performance Task (CPT), which were used to measure the different aspects of motor response inhibition. Participants also underwent structural MRI scans to identify and outline specific regions of the brain, specifically dividing the striatum into its functional subdivisions: the limbic, associative, and sensory-motor regions. Furthermore, PET imaging was performed using the targeted radioligands [11C]NNC-112 (for D1-type) and [18F]fallypride (for D2-type) to measure the exact binding potential and availability of these dopamine receptors.

The study demonstrated that Stop-Signal Reaction Time (SSRT) had a significantly negative correlation with both D1- and D2-type receptors in the whole striatum. Because a lower SSRT indicates a faster stopping speed, this negative correlation means that a higher receptor availability

directly predicts faster, more efficient stopping speeds. Crucially, the researchers discovered that the link between the movement and the D1- and D2-type receptors was highly localized only in the dorsal striatum (the sensory-motor and associative sub-regions) and was not found in the ventral striatum (the limbic sub-region). Furthermore, they found that there was no significant correlation between dopamine receptor abundance and performance on the Continuous Performance Task (CPT). This reveals that higher receptor abundance specifically in the dorsal striatum predicts better stopping metrics, while different tasks measuring "inhibition" actually utilize entirely separate neurological and neurochemical pathways.

In this experiment, there were notable time lapses averaging 17 months between when participants completed their initial behavioral tests (SST, CPT) and when they underwent the PET imaging procedures. During this time, participants' D1- and D2-receptor abundance may have increased or decreased, potentially weakening the accuracy of the study. However, despite this limitation, the researchers conducted multiple re-testings on a subset of the participants 40 months later to prove that their observations and the participants' neurobehavioral metrics were highly reliable and stable over time. Furthermore, the relatively small sample size of 31 healthy volunteers may have been too small to draw large-population conclusions. Nevertheless, a noteworthy strength of the paper is that both receptor subtypes contribute similarly to the stopping metric. This suggests that motor control depends on a delicate balance between phasic (D1) and tonic (D2) dopaminergic activity, rather than acting in strictly opposing ways.

In conclusion, both D1-type and D2-type dopamine receptors are explicitly linked to motor response inhibition in humans. Dopamine mainly controls your ability to stop an action in the brain's movement center (the dorsal striatum) rather than its reward center (the ventral striatum). This happens because the two different receptor types showed similar relationships with stopping tasks, proving that a balance between D1 and D2 activity pathways is crucial for behavioral control. While response inhibition capacity can vary heavily across individuals, these tasks capture completely distinct neurological profiles. Therefore, researchers must selectively and carefully choose behavioral tasks when assessing clinical impulsivity in patients. Ultimately, this study is important because identifying this specific dopamine receptor distribution allows localized neurochemical pharmaceutical therapies to be developed to aid individuals struggling with clinical impulsivity and behavioral disorders, like ADHD or Parkinson's Disease.

To conclude this journal, we would like to acknowledge all the individuals and communities who made this effort possible.

To all the students, thank you for your dedication to learning, your diligence throughout the program, and your intellectual curiosity. Your thoughtful engagement and contributions have been greatly impressive and inspiring. We hope you carry forward the knowledge you've gained here, continue to pursue your scientific passions, and find success and fulfillment in your prospective paths.

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We deeply appreciate the support and efforts of everyone involved to bring this opportunity to life, and we wish you all the best in your future endeavors.

Best,

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