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It is hoped that by publishing this special issue the scholarship on display will reach a wider specialist and non-specialist audience and generate feedback and a scholarly profile for the authors. Every paper in this collection has gone through a rigorous review process.

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What is The Most Common Human Factor That Threatens Marine Species in The North Atlantic Ocean Region?

By Alex Yu

Alex Yu is a 16 year old junior at Boston Latin School in Boston, Massachusetts. He is an enthusiastic participant in many activities including playing the trumpet in Pep Band and Jazz Band, dancing at Korean Dance Club, and playing on the Boston Latin Volleyball Team. Outside of school, Alex likes to volunteer within his community through community development projects with Asian Voices of Organized Youth for Community Empowerment, helping out teachers at Newton Chinese Language School, and managing and coaching his school's girls volleyball team. Academically, he is interested in Environmental Science and how it can relate to Engineering. Alex hopes to study Environmental Science or Mechanical Engineering in college.

ABSTRACT

In the North Atlantic Ocean Region, the greatest human threat to marine species is ship strikes. The many different species that reside in the ocean are affected greatly by various human factors such as pollution, ship traffic, infrastructure in the water and net entanglement. In this paper we establish that ship strikes cause the most damage to species in the North Atlantic region. We found that ship traffic affects many species greatly, from being the cause of death for 53% of the 40 Right whales autopsied between 1970 and 2006, to hundreds of sturgeon across three distinct regions killed by this method. Ship strikes are the most damaging factor, especially to the larger marine animals in the ocean such as whales and sturgeon. Our results not only show how one factor harms these species to a great extent, but how humans, through many different forms, greatly threaten the survival of other species. We conclude that these factors will continue to harm and threaten the well-being of species unless concerted action is taken to mitigate the effects.
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INTRODUCTION

According to the International Union for Conservation of Nature (2022), the number of endangered species in the world right now is 16,364 (International Union for Conservation of Nature [IUCN], 2022). In the last two decades, the number of endangered species has gone from 2,614 to 16,094. Even though some of these species are endangered because of natural reasons, most of these species are being threatened by humans through factors like pollution, entanglement, hunting, poaching and commercial fishing. In the North Atlantic region, many marine species are harmed by all the threats caused by humans in this region. This region presents a demographic of different types of marine animals from small sized fish like salmon, to huge sea mammals like whales.

Research Goal and Method

By analyzing four species, the Atlantic salmon, Atlantic sturgeon, Sei whale, and Right whale, I will try to find what the most common human created threat is to marine organisms in the North Atlantic. I picked these species as they demonstrate the diversity of species in the North Atlantic region. These species, on one hand, show how huge sea mammals are affected by humans in deeper waters, and on the other, show how small fish are affected by humans more inland. In this paper, I will first list the common threats caused by humans I found in the four selected species from two agencies' websites, the International Union for Conservation and the National Oceanic and Atmospheric Administration. Then, I will explain why or why not death by ship strike is the most common factor between all of the species. The four factors that I chose to base my research on were human infrastructure, ship strikes, pollution and entanglement. To find the most common, I had

to find how many species are affected by the factors and how severe these factors are to the species as a whole. Finally, I will explain the process in which I determined which factor was the most common. I will do all this to answer the question: What is the most common human factor that threatens marine species in the North Atlantic Region?

Materials

In my research, I used data from one national and one international agency. The first was the International Union of Conservation of Nature. This agency focuses on threatened species. Established in 1964, The International Union for Conservation of Nature's Red List of Threatened Species (https://www.iucnredlist.org/) has evolved to become the world's most comprehensive information source on the global conservation status of animal, fungi, and plant species. The second is NOAA, also known as the National Oceanic and Atmospheric Administration (https://www.noaa.gov/), an American scientific and regulatory agency that monitors oceanic conditions, conducts deep sea exploration, and manages protection of marine mammals and endangered species in the U.S. This agency houses research about species that are threatened. By using NOAA's five-year reviews and IUCN's Red List listings, I analyzed these marine animals to find the common man made factors that threaten them.

Infrastructure

Humans have been using dam technology to redirect water to moisten their crops for millennia. Human-kind has also been building bridges across waterways to help mobilize themselves better. Even though these structures have helped humans to overcome

obstacles, the wildlife that live in these environments are harmed by them. In the North Atlantic, Atlantic salmon will migrate more inland through rivers and creeks to reach their birthplace to mate and spawn in lakes and ponds. The journey through these streams is the only route salmon can take to reach their reproduction area, and those ponds and lakes are the only place they can reproduce. These structures "continue to be a major threat to Atlantic salmon by blocking or impairing access to historic Atlantic salmon spawning and rearing habitat." (NOAA)

While these preexisting structures are damaging the North Atlantic population of Atlantic salmon, ongoing construction is affecting the domains where the North Atlantic population of Atlantic sturgeon reign. Constructions of dams, groundwater extraction, irrigation, and flow alteration all threaten these sturgeon by displacing and destroying their habitats. Through humans erecting these structures to accommodate themselves, marine species like the North Atlantic salmon and sturgeon are being endangered through migration route destruction and habitat loss. Although these species were affected by the constructions of humans, many other species in the North Atlantic do not feel the influence of these structures. For example, the Sei and the North Atlantic whale live in deeper waters far from the shore. Since Sei whales and North Atlantic whales don't swim near the shoreline or estuaries, they are not as affected by bridges and dams as much as smaller species of marine animals, since dams and bridges are usually located further inland. This means that, even though these structures are common threats to marine animals that reside in or travel inland, most marine life that live in deeper waters aren't as affected by them.

Ship Strikes

Bridges and dams have helped people travel over water, but boats are the most effective way humans have found to travel in water. Throughout the history of civilization, boats have been used to travel great distances while also bringing great amounts of cargo with them. Ships are often built to be larger and faster than their predecessors. Despite these advantages, these vessels can cause great amounts of damage to organisms that reside in the sea. In the North Atlantic, many sea animals were and are currently threatened by these large ships. Right whales appear to be one of the most vulnerable species of large whales to ship strikes. According to the IUCN Red List, "Ship strikes were found to be the cause of death for 53% of the 40 Right Whales necropsied between 1970 and 2006 and could have been responsible for up to 10 individual North Atlantic Right Whale deaths per year."(Cooke, 2020) Right whales continue to face the risk of being struck by vessels throughout their range.

Another species of whale that is affected by ship strikes is the Sei whale. There are records of ships striking sei whales, but it is unclear whether they account for a significant source of mortality. Because of the Sei whales' offshore distribution, most ship strikes could go unnoticed.

Another species frequently affected by ship strikes in the North Atlantic is the Atlantic sturgeon. In NOAA's five-year reviews, they analyzed the three different distinct populations of the Atlantic sturgeon(National Oceanic and Atmospheric Administration, NOAA, 2022). These distinct populations were inhabitants of three different areas such as the Chesapeake Bay, New York Bight, and the Gulf of Maine. According to the Chesapeake Bay Distinct Population Segment of Atlantic Sturgeon 5-Year Review, ship strikes are a main threat to the species. More than 100 Atlantic sturgeon carcasses have been salvaged in the James River, a Virginia river that flows into the Chesapeake

Bay, since 2007, and additional carcasses were reported but could not be salvaged. Many of the salvaged carcasses had evidence of a fatal vessel strike. Also according to the New York Bight Distinct Population Segment of Atlantic Sturgeon 5-Year Review, vessel strikes were considered a primary threat to the New York bight distinct population when NMFS, National Marine Fishing Services, listed the distinct population as endangered. On the other hand, in the Gulf of Maine Distinct Population Segment of Atlantic Sturgeon 5-Year Review, new information confirms that vessel strikes are a threat to the Gulf of Maine's distinct population albeit with fewer discovered carcasses compared to the Hudson, Delaware, and James rivers. Even though ship strikes overall are a huge cause of mortality to the Atlantic sturgeon, different populations in different regions feel the effects of this threat differently. All in all, ship strikes are a very common threatening factor caused by humans in the North Atlantic.

Pollution

Another threat that ships cause is pollution. According to National Public Radio (NPR), the amount of carbon dioxide released in the air by cargo ships is about 1 billion metric tons(NPR, 2021). Just by these statistics, we can see how much pollution is caused by humans. We can see pollution everywhere, from litter all over the ground, clumps of trash in the ocean, and smoke from factories. This causes a lot of problems for many land and marine animals in the world. These problems include microplastic being ingested as food, green-house gasses releasing chemicals causing climate change, and the oceans becoming more acidic. In the North Atlantic, many organisms are affected by pollution from humans. One example is the Atlantic salmon. According to NOAA's Five-Year Reviews, "In 2016, a climate vulnerability analysis for 82 managed species of

fish and invertebrates in the Northeast United States concluded that Atlantic salmon, along with other sea-run fish, are among the most vulnerable species to climate change."(NOAA, 2020) In the case of the Sei whale, due to the inherent uncertainties outlined above and recent research findings, it remains unclear whether reduced prey abundance due to climate change is a threat to them. The magnitude of threats from anthropogenic noise to Sei whales is highly uncertain. Another whale in the North Atlantic that is affected by common polluting factors is the North Atlantic Right whale. According to the IUCN's Red List, "[l]ow-frequency in-water noise from shipping activity has been linked to physiological stress (increased glucocorticoid levels) in North Atlantic Right Whales."(Rolland et al. 2012) In the case of the Atlantic sturgeon, contaminants, primarily from industrial sources, contribute adversely to individual fish health and population declines. In conclusion, even though pollution causes climate change, which affects these marine animals, this effect is only minor as the research or the size of which it affects these species is minimal.

Entanglement

Fishing in the modern world also brings up a problem. The fishing industry's method of trawling does get more fish for less power, but it usually leads to some side effects. In the North Atlantic, many different species get caught and entangled in these nets, which leads to injury and sometimes death. Large animals such as sturgeons and whales usually get entangled in the nets used for trawling. For example, Sei whales may swim for long distances with gear attached, resulting in fatigue, compromised feeding ability, or severe injury. Recently, Right whale entanglement events appear to be increasing in both frequency and severity. A further 30 deaths were recorded during 2017–19

of which 21 were in Canadian and nine in US waters (Pettis et al. 2020). Chronic entanglements are one reason scientists think that female Right whales are having fewer calves and are taking longer to have calves. Therefore, many whales in the North Atlantic are being heavily threatened by entanglement from fishing nets. Even though this is a big concern and threat for these larger animals, smaller marine animals are less affected by being entangled in these huge nets.

Discussion

In both NOAA's five year reviews and IUCN's Red List, I found that the most common factors that threaten marine species in the North Atlantic are human structures' obstruction of migration paths, ships strikes, pollution, and entanglement. From my research, the most common factor that threatens species in the North Atlantic Ocean is ship strikes because of how many species are endangered by ship strikes and how deadly these strikes are to the population. For factor 1, human structures' obstruction of migration paths, even though this affected the Atlantic salmon and Atlantic sturgeon greatly, many species that don't migrate to fresh water like Sei and Right whales aren't affected a lot by these structures. For factor 2, ship strikes, most marine animals researched were affected. The Atlantic sturgeon, North Atlantic Right whale, and Sei whale all are greatly threatened by ships striking them, but smaller organisms like Atlantic salmon aren't as threatened by ship strikes. For factor 3 and 4, pollution and entanglement, most species were affected by this factor, but the amount that it affects the species is either small or unknown.

Conclusion

From my research, I learned about not only what factor threatens these species the worst, but I have also learned about how great other animals are threatened by humans. Even though I consolidated all of these factors into a few pages, there are still thousands of ways humans harm other species' populations. The one overarching lesson I have learned is that humans cause great harm to animals. Even though humans do cause so many problems, I believe there are some ways to help these species. One way to stop obstructing migration paths of Atlantic salmon and sturgeon is to just stop building in areas where salmon and sturgeon spawn or travel to spawn. For this to work, I believe governments should step in and impose strict regulations on what can be built in these areas. For ship strikes, one way to reduce them is to have less ship traffic in areas where whales are mostly located. This means that ships that do not have to go through areas where whales and sturgeons are most commonly found can just go around them. And finally, to be able to stop whales and fish from getting entangled into trawling nets, fishermen have to watch where they are trawling and monitor what fish are being caught in their nets. In these ways, we can preserve the populations of these species and make sure that they do not become extinct. In the end, finding the most common factor is a fundamental step, but the most important step is to make plans to combat these factors to better help the conservation of these species.

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Donde Comen Dos, Comen Tres: Investment Discrimination Against Latino-Owned Businesses

By Thomas Catalano

AUTHOR BIO

Thomas Catalano is a senior at Loyola High School of Los Angeles. He is highly passionate about the field of economics and plans to study it in college. Thomas is also interested in the intersection between economic principles and behaviors with his Latino identity. He is involved in extracurricular activities at his high school, including Co-Editor-In-Chief of the newspaper, Co-Editor-In-Chief of the yearbook, Co-Captain of the Public Forum Debate Team, Chapter President of Junior State of America, and a member of the Varsity Tennis Team. He is currently engaged in an independent research capstone project on cultural narratives of Latino people found in literature.
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ABSTRACT

The paper addresses the systemic underinvestment of Latino-owned businesses in the United States. The research examines the disparity in access to capital for Latino-owned businesses, the mechanisms through which this disparity is rooted and persists, and the impacts that this early-stage disparity plays on the future success of businesses. The work employs comparative data between Latino-owned businesses and white-owned businesses to empirically establish the investment disparity.

Keywords: *Latino-owned businesses; disparity; investment disparity; United States.*

INTRODUCTION

Investing in Latino-owned businesses in the United States is an opportunity that is missed by early-stage investors, which systematically underfund such companies. According to the most recent report by Bain & Company in collaboration with the Stanford Latino Entrepreneurship Initiative, US Latinos had an economic output of $2.7 trillion in 2019, which makes them the world's seventh largest economy. Although Latinos made up only 19% of the total US population, they were responsible for 82% of the growth in the US labor force from 2010 to 2017 and approximately 50% of net new small business growth from 2007 to 2017. Employment at Latino-owned businesses grew at twice the rate of non-Latino-owned businesses from 2014 to 2016. Despite the rapid economic growth of the Latino population in the US, Latino-owned businesses (LOBs) are massively underfunded compared to white-owned businesses (WOBs) with similar profiles. If investors funded LOBs equitably, they would generate $1.4 trillion in additional revenue today and $3.3 trillion in additional revenue by 2030 (Saenz et al., 2021).

While some may argue that this disparity in investment across racial groups is a result of the investment potential of the companies, LOBs exceed WOBs in revenue growth across companies of all sizes. Rather, the structures encoded in investment culture and in the Latino economic community systemically disadvantages LOBs in the investment stage of startups. The landscape of investment in the United States is primarily controlled by investors (angel groups, venture capitalists, private equity, etc.) and includes LOBs as well as their white counterparts.

This paper seeks to answer the following question: In the United States, to what extent do early-stage investments by angel investors and venture capitalists create a systemic advantage for WOBs over LOBs? The following research examines the disparity in access to capital for LOBs, the mechanisms through which this disparity is rooted and persists, and the impacts that this early-stage disparity plays on the future success of businesses.

Obtaining Capital

Minority-owned businesses face significant difficulty in obtaining capital to fund their startups. One study found that Black and Hispanic-owned businesses experience higher rates of rejection and smaller size investments by investors (Lee & Black, 2017). Another study found that while 40% of WOBs obtained the investment capital they sought, only 20% of Hispanic-owned businesses obtained the investment capital they sought (Small Business Credit Survey, 2021). According to the aforementioned 2021 report by Bain & Company (in collaboration with the Stanford Latino Entrepreneurship Initiative), less than 1% of funds invested by top venture capital and private equity firms are directed towards Latino-owned enterprises. For example, LOBs only received $680 million of $487 billion invested by the largest venture capital and private equity firms. Less than 2% of investment in the seed/angel round is given to LOBs. The founder diversity of venture capitalist-backed businesses breaks down to 77% white and 2% Latino. Additionally, LOBs have to enlist double the amount of investors to reach the same level of investment as their white counterparts. On average, WOBs receive three times more funding per private equity investor and two times more per venture capitalist than LOBs. Mature employer LOBs are 30 to 50 percentage points less likely to have funding needs sufficiently met by angel investors and 16 percentage points less likely for national banks than WOBs; small employer LOBs are 19

percentage points less likely to have funding needs met by local banks (Saenz et al., 2021).

As a result of their limited access to funding, LOBs typically must resort to less conventional ways to fund their startups, such as personal savings, grants, and payday loans. Small LOBs are 1.3 times more likely to invest personal wealth into their companies than small WOBs; larger LOBs are 1.4 times more likely to rely on friends and family (Saenz et al., 2021). According to the Stanford Latino Entrepreneurship Initiative, the three most common sources of funding for these businesses are personal savings, credit cards, and friends, compared to the sources of personal savings, commercial loans, and personal bank loans for non-Latino owned businesses (MacBride, 2015). These less stable alternatives to traditional early-stage investment lead to higher costs and more risk for LOBs, which "sets a vicious cycle in motion, forcing LOBs to turn to expensive forms of debt, including hard-money lending, and creating challenges with cash flow, profitability, and obtaining later equity investments as these businesses seek to scale" (Saenz et al., 2021).

Disparities

The primary root behind the disparities in the investment landscape for minority-owned companies is the personal wealth and assets statistically typical of Latin Americans. While the mean family wealth of white families is $983,400, the mean family wealth of Hispanic families is $165,500 (Bhutta et al., 2020). The racial disparity in wealth translates to the gap in access to capital as a business owner: "Latinos have one-eighth the wealth of White households, making a Latino entrepreneur's access to friends and family financing severely limited in comparison to White entrepreneurs. As a result, debt may be among the only startup financing options available" (Orozco and Furszyfer, 2021).

Low levels of personal wealth limit investment opportunities for Latino entrepreneurs. Low levels of assets account for one-quarter of the gap for business entry for Mexican Americans (Fairlie and Robb, 2010). Differences in home equity are one example of an asset that causes the investment discrepancy across racial groups: "Less than half of Hispanics and African Americans own their own home compared with three-quarters of non-minorities. The median equity of Hispanic and African American homeowners is also substantially lower than for non-minorities ($49,000 for Hispanics, $40,000 for blacks, and $79,200 for whites). Homes provide collateral and home equity loans provide relatively low-cost financing. Without the ability to tap into this equity many minorities will not be able to start businesses" (Fairlie and Robb, 2010). The differences in home equity are especially important because Latinos are required to pay more collateral than white people on average (Orozco and Furszyfer, 2021). The racial differences in personal wealth and assets are a major mechanism through which the cycle of systemic underfunding of Latino businesses is created and persisted.

Another reason for the disparities in access to startup investment is racial discrimination in lending practices. A study conducted by the Minority Business Development Agency of the U.S. Department of Commerce found that "African Americans, Hispanics, and Asians were all more likely to be denied credit, compared with whites, even after controlling for a number of owner and firm characteristics, including credit history, credit score, and wealth" (Fairlie and Robb, 2010). The investment industry also systemically discriminates against immigrants, which make up one-third of LOBs. Because employment history, credit history, and other records are more difficult to evaluate for immigrants, investors often reject immigrant entrepreneurs seeking funding for their

businesses (Orozco and Furszyfer, 2021). Bain & Company also found that "cultural expectations, language gaps, and loan approval processes" can play a role in LOBs getting funded. In addition, the research found that "Latino business owners may struggle navigating the current structures and processes of the financing world and face challenges packaging a loan application or business data in ways likely to maximize the odds of being funded" (Saenz et al.,2021). The cultural and structural components of the investment industry create a pervasive and persistent disadvantage for Latino businesses, perpetuating a system of discriminatory investment practices.

Consequences

The consequences that this systemic disparity inflicts upon the Latino economy are devastating to the prospects of long-term entrepreneurial success. Early stage investment from angel investors, venture capitalists, private equity firms, and private investors is "a critical enabler of growth for businesses," but the underrepresentation of Latinos in the investments presents a significant barrier for Latinos seeking to grow their businesses (Saenz et al., 2021).

As a result of the lack of access to capital, LOBs are often forced to reduce operational capacity or shut down altogether. Between February and April 2020, for example, the number of Latino business owners dropped by 32% and the number of immigrant business owners dropped by 36% (Fairlie, 2020). The rare, inconsistent flow of capital to LOBs is most apparent as these companies approach the $1 million revenue mark. This period represents the critical window for investment, as firms at this size typically struggle with profitability and cash flow as they attempt to scale. LOB growth often decelerates as WOB growth accelerates in this stage; however, the few LOBs that are able

to reach the $5 million revenue mark experience growth at nearly double the rate of WOBs, a testament to the viability of LOBs when they receive equitable investment (Saenz et al., 2021).

The disproportionate investment across racial groups creates a vicious cycle that often leaves LOBs with no options other than to turn to expensive forms of debt, leading them to more challenges with cash flow, profitability, and receiving future investment (Saenz et al., 2021). Research conducted by the Stanford Graduate School of Business found that while Latinos start new businesses more often than the general population, their businesses are often smaller in size and revenue than their non-Latino competitors (MacBride, 2015). The systemic underinvestment of LOBs wreaks devastating consequences on Latino entrepreneurs seeking a prosperous and stimulating economic endeavor, or at least an equal opportunity as white entrepreneurs to get there.

Conclusion

This paper establishes the disparity in the investment of LOBs compared to WOBs using empirical, comparative data on the frequency and sizes of investment. There are socio-economic and political mechanisms through which this disparity is rooted and perpetuated, including the personal wealth and assets of business owners, racial discrimination against Latinos, and cultural barriers to navigating the structures of the investment industry. This investment disparity has devastating effects on the potential for success among LOBs. The investment landscape of the United States is a discriminatory landmine for Latino entrepreneurs; beneath each step is an explosive device of systemic rejection.

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The Neurological Mechanisms and Possible Treatments of Sporadic Alzheimer's Disease

By Jason Zhang

AUTHOR BIO

The author of this paper is Jason Zhang, a grade 12 student who is interested in STEM, especially neuroscience. He currently studies in Mulgrave School. As a Canadian, he spent approximately 15 years in Shanghai and moved back to Vancouver with his family in 2020. In middle school, he was exposed to the complexity of the brain and decided to dive deep into the field of memory and neuro-diseases. In the future, he hopes to pursue a career studying neurodegenerative diseases and become a neuroscience researcher.

ABSTRACT

Alzheimer's disease (AD) is one of the most common neurodegenerative diseases, accounting for sixty to seventy percent of all causes of dementia. Though Alzheimer's Disease has been discovered for more than 116 years, the disease still lacks effective treatment. This paper presents the history of Alzheimer's disease since 1907, when it was first discovered. As a literature review, the paper explores a wide range of studies conducted by global researchers. The major focus of this paper is to illustrate the specific neurological mechanisms of sporadic Alzheimer's disease by looking into the two most predominant theories: Amyloid Beta Plaques, and Neurofibrillary Tangles. This paper compares and contrasts the two theories and discusses possible directions that could be considered in future studies. This paper also illustrates the potential impact and changes Alzheimer's Disease could have on the brain from a neurology perspective. Besides the pathology of the disease, this paper also reviews possible treatments and ways to prevent Alzheimer's Disease in a variety of areas including lifestyle, diet, hormones, and FDA-permitted medicines.

INTRODUCTION

Dementia is the general terminology used to describe a set of symptoms including poor memory and difficulty learning new information. In most cases, dementia is associated with damaged brain cells which can be caused by a variety of diseases. Alzheimer's disease (AD) is one of the most common neurodegenerative diseases that starts slowly, but progressively worsens over time. It accounts for sixty to seventy percent of all causes of dementia (Alzheimer's Association, 2022). AD could directly cause degeneration or loss in neurons in the cortex of the brain.

In 1907, German psychiatrist and neuropathologist Alois Alzheimer reported a case in which a 51-year-old female patient exhibited a variety of symptoms of early dementia. This included loss of recent memory, difficulty performing familiar tasks, and some psychiatric disturbance. Four years after the case was reported, the patient died, and this disease was named "Alzheimer's disease." (Castellani, 2010). By 2022, approximately 44 million people worldwide have been diagnosed with AD, and this number will likely triple to 132 million people by 2050 (Alzheimer's Association, 2022). In the United States of America, AD and other dementia-related diseases cost around 321 billion dollars per year. Therefore, AD not only leads to detrimental health outcomes in the patients, but also imposes an economic burden on society. In this paper, I will explore the neurological mechanisms as well as possible treatments of the type of Alzheimer's now known as sporadic.

Two Types of Alzheimer's Disease

After Alzheimer's disease (AD) is discovered in patients, the disease is categorized into one of two clinical conditions based on the different ages of onset. The two clinical conditions have very different impacts on individuals, and the age of onset indicates the possible causes of AD and needs to be treated differently in terms of pharmacology. In the case of the 51-year-old female patient discussed above, due to the early age of onset, this was recognized as the "presenile" type. This type of AD is mostly familial, suggesting that the causing factor of AD can be inherited from ancestry. In contrast, the more common, older age of onset after 65 years old is recognized as the "senile" or "sporadic" type. This type differs from the presenile type by the older age of onset and its low probability of inheritance; thus, sporadic AD is also the more common type (Rolston, 2010).

In terms of clinical presentation, evidence such as memory loss or impairment in at least one other cognitive domain, as well as evidence of social or occupational function disturbance, is required for the diagnosis of AD. More specifically, patients tend to exhibit symptoms based on the time and brain regions affected, such as deteriorating speech ability, personality, judgment, or sometimes vision. Unfortunately, despite all available treatments, clinical AD continues to advance. (Smith, 2010) Over months and years, progressive memory loss continues resulting in a disoriented personality, judgment dysfunction, speech abnormalities, and apraxias. Over time, patients' ability to care for themselves deteriorates. In most cases, pneumonia is the proximate cause of death. This is a devastating illness that strips the patient of their personality and dignity (Castellani, 2010).

Furthermore, AD's impact varies depending on many other factors, such as sex. Females tend to have a higher risk of developing AD and dying from the disease. This is due to the production of estrogen and testosterone (Andrew, 2018). These hormones have

neuroprotective mechanisms that help to counter most neurodegenerative diseases. The male tends to have a higher level of estrogen production than female after females experience menopause which results in this different prevalence rate (Tierney, 2018).

Pathology of Alzheimer's Disease

Although the cause of sporadic AD is not fully understood, the majority of pathology discussion focuses on two theories: the Amyloid-Beta Plaques theory and the Neuron Fiber Tangles theory. These two theories are both well supported by the observation of patients' brain scans.

Amyloid-Beta Plaques Theory

Amyloid precursor protein (APP) is an integral protein that is found in numerous neuron synapse tissues. It is a cell membrane receptor that regulates synapse formation, brain plasticity, antimicrobial activity, and iron export. APP is encoded by the APP gene and is controlled by substrate presentation. After this protein is used, it usually gets broken down and recycled for future use. However, during the process of breaking down the used amyloid precursor protein, different secretases are utilized to break down the APP (Huang, 2012) In normal situations, the APP is broken down into a secreted amyloid precursor, a protein alpha, and an 83 amino acid fragment named CTF 83. This process is catalyzed by the enzyme named alpha-secretase or α secretase. Later, the CTF 83 compound is further cleaved by gamma-secretase, which is made up of PEN-2, Aph 1, NCT, etc. (Hansson, 2004). This cleavage results in an APP intracellular domain, which is an AICD domain that enters the nucleus and drives the neuroprotection pathways. The remaining sAPPα is secreted from the neuron and enables learning and memorizing (Castellani, 2010).

In contrast, AD patients go through a different process. For patients with AD, instead of alpha-secretase, beta-secretase is used to cleave the amyloid precursor protein into CTF 99 (carbon terminal fragment). The gamma-secretase cuts the CTF 99 compound into an AICD domain and an Abeta 40/42 peptide. The Abeta 40/42 peptide, together with APOE, forms insoluble amyloid-beta plaques(Murphy, 2010). Formed outside of neurons, these plaques block the neuron signaling interaction, which impairs memory ability. The plaques then result in inflammation that damages surrounding neurons and eventually becomes a neurodegenerative disease (Castellani, 2010).

Neurofibrillary Tangles and Tau Protein Theory

In contrast to the Amyloid-Beta Plaques Theory, the Neurofibrillary Tangles and Tau Protein Theory (TAU) suggests that the trouble might be within the neurons instead of outside the neurons(Castellani, 2010). Microtubules help transport nutrients and maintain the shape of the neurons, and Tau proteins are a collection of six highly soluble proteins that play an essential role to maintain the integrity of these cellular microtubules (Arendt, 2016). In the case of AD, after amyloid-beta plaques are built, the enzyme kinase is activated and it phosphorylates the Tau protein. The Tau protein then leaves the microtubule and starts to clump up with other phosphorylated Tau proteins which eventually results in neurofibrillary tangles. In AD patients, due to the absence of Tau protein in the microtubules, the microtubules can no longer transport nutrients around neurons (Rolston, 2010). This leads to apoptosis (programmed cell death). As more neurons start the apoptosis process, neuron signaling is significantly

impaired and the gyri shrink, which results in severe AD.

External Factors Associated with Alzheimer's Disease

There are numerous external factors that could lead to AD. Though these hypotheses have not been fully proven, these risk factors show a high correlation to the presence of sporadic AD. As previously mentioned, despite the genetic factors that affect the possibility of getting AD, the most significant factor is still age. Between the ages 60-65, AD tends to affect 1% of the total population. The risk increases to nearly 50% of the age group over 85. Using France as an example, in 2019, around 5800 citizens within the age range of 55 to 64 were diagnosed with AD. The number increased to 34800 confirmed cases in the age group of 65 to 74 and reached 404,000 cases in the age group of 75 to 84 (Ameli, 2021).

The second factor is the genetic component of AD. Genetics play very different roles in sporadic and familial AD. In terms of early-onset, presenile or familial cases, the genetic components focus on chromosomes 21, 19, 14, and 1 (Castellani, 2010). These chromosomes are inherited from the ancestry history of the family. In contrast, sporadic or senile AD are usually affected by the e4 allele of the apolipoprotein E gene (APOE 4). APOE gene is a cholesterol gene that usually has three forms. The first form is APOE 2, which appears to reduce the risk of AD. The second form is APOE 3, which does not affect the risk of AD. The third form is known as APOE 4, which seems to increase the risk of AD. The three proteins have different sequences by amino acid substitution at different residues(Huang, 2012). Single inherited APOE 4 slightly increases the risk of AD, while two inherited APOE 4 increases the risk of AD to a greater degree. APOE 4 carries the least cholesterol to the

neurons in the three forms of apolipoprotein. In addition, APOE 4 degrades quicker, and its ability to clean amyloid-beta is weaker(Mucke, 2012). As a result, the presence of APOE 4 potentially leads to a higher amount of amyloid-beta plaques.

Treatments of Alzheimer's disease

Though AD was discovered around 115 years ago, there is still a lack of effective treatment. As mentioned above, Alzheimer's disease tends to be a progressive disease whereby once the patient starts exhibiting symptoms of AD, it is usually at a very late stage that synapses function is largely impaired. Thus, most drug developers aim to make drugs or treatments that prevent Alzheimer's disease from progressing into late stages, which also means targeting the formation period of Amyloid Beta Plaques. On the other hand, much of modern pharmacology attempts to slow the progress of the disease. An example of such a treatment is Aducanumab. These types of drugs delay the clinical decline by targeting beta-amyloid plaques and removing ABP to slow down the rate of forming clumps and inflammation. This can successfully delay the formation of amyloid-beta plaques, which leads to a delay in clinical decline (Alzheimer's associations, 2021). By removing some of the amyloid-beta plaques formed around the neurons, the synapse signals will be able to transfer from dendrites to dendrites and perform basic cognitive functions.

The other approach is to treat the symptoms of AD. This alternative approach can temporarily mitigate some symptoms of AD. FDA has also approved drugs that focus on the two categories of symptoms, one being cognitive symptoms, including memory and thinking, and the other being non-cognitive symptoms, including behavioral and psychological symptoms. In terms of cognitive symptoms,

FDA has approved drugs like cholinesterase inhibitors and glutamate regulators to treat symptoms related to the cognitive system(Alzheimer's association, 2021). These cholinesterase inhibitors can prevent the breakdown of acetylcholine and support the neurotransmission process. Glutamate regulators on the other hand improve cognitive systems by regulating glutamate, which is a chemical messenger that helps to process information in the brain(Alzheimer's association, 2021).

Despite the pharmacological treatments that were approved by FDA, there are many other treatments or therapies available now that seem to have an impact on AD. One example is hormone replacement therapy. As mentioned above, estrogen tends to lower the risk of AD because of three processes. Estrogen helps to maintain cerebral blood flow, reduce oxidative stress and decrease the formation of amyloid-beta(Andrew, 2018). Population-based studies (Castellani, 2010) have suggested such hormone replacement therapy may delay the onset of Alzheimer's disease.

Another treatment, or method, to reduce the risk of Alzheimer's disease is known as the Mediterranean diet. Many studies have shown that this diet tends to correlate to the risk of AD. The Mediterranean diet is well known for its "high intake of vegetables, fruit, and cereals; low to moderate intake of saturated fat, high intake of fish and low intake of dairy products and a moderate amount of ethanol" (Rolston, 2010). Many theories and studies have suggested that vitamin deficiency could potentially result in a higher risk of AD. Thus having high levels of vegetable intake, such as kale, could help people avoid vitamin deficiency, resulting in a lower risk of AD.

Another possible approach is anti-inflammatory drugs, sometimes referred to as non-steroidal anti-inflammatory drugs. As previously mentioned, when amyloid-beta plaques progress to the state of interrupting neurotransmission, inflammation in neurons damages surrounding blood vessels. Recently, there have been many observations (Smith, 2010) that there is a lower than expected prevalence rate of Alzheimer's disease in patients with rheumatoid arthritis. As observed, the long-term treatment of anti-inflammatory drugs might be protective against the development of Alzheimer's disease. The anti-inflammatory treatments can reduce the decline of microglia, astrocytes, and the production of amyloid-beta plaques. According to the Cache County Study on Memory Health and Aging (2013), treatments like NSAIDs could potentially prevent cognitive function decline at a relatively earlier age of onset. On the other hand, in most trials, NSAIDs did not showcase a significant positive impact on the development of sporadic Alzheimer's disease cases. In short, the extent to which anti-inflammatory drugs are effective remains a controversial question that future research could focus on (Castellani, 2010).

Conclusion

In conclusion, though sporadic Alzheimer's disease was discovered over 100 years ago, modern neuroscientists have not yet discovered any effective treatment that targets this disease. The greatest hindrance is a lack of knowledge about the causes of the disease. Until now, there are only hypotheses like Neurofibrillary Tangles and Tau Protein Theory and Amyloid Beta plaques. These hypotheses have been supported in numerous experiments, research, brain scans, and studies, but the methods of treating TAU tangles and Amyloid Beta plaques remain a mystery. Since 1985, most neuroscientists have focused on the amyloid-beta plaques theory. However, they have failed to conquer the disease by only targeting amyloid-beta plaques. In the future, research should begin to shift its focus towards

TAU tangle theory. If this attempt also fails, other treatments will have to be considered.

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The State of Financial Literacy and Financial Education in the United States

By Jeff Zhou

AUTHOR BIO

Jeff Zhou is currently a senior at the San Francisco Waldorf High School. As of August 2022, he is 17 years old. He is interested in social entrepreneurship, business, and finance. At school, he is the president of the finance club, where he invites finance professionals to teach at club meetings. In his free time, he runs a website that provides personal finance resources and opportunities for other high school students. He also enjoys photography, playing basketball, reading, and traveling. In his first time writing a literature review, Jeff chose to research the literature on financial education in the hope of gaining a comprehensive understanding of its current state in the United States and its importance.

ABSTRACT

The world we live in is more complex than ever. We can now transfer money through mobile payment apps such as Venmo, budget through online services such as Mint, and invest in the stock market through free-trading apps like Robinhood. As a result, teenagers and young adults can easily spend and accumulate debt without ever seeing paper money change hands. Without these physical barriers to spending and the vast subscription services and online shopping opportunities, people are more susceptible to losing control of their personal finances. Due to new financial technology and globalization, personal finance has become increasingly complicated in the United States and throughout the world. This paper reviews the literature on the current state of financial literacy in the United States, including the efforts to improve financial education. This paper will also discuss how financial literacy is measured in the existing literature and consider whether financial education improves adult financial literacy or personal finance outcomes. Finally, this paper will outline a few proposals for future research. learning.

INTRODUCTION

In recent years, the concern over the lack of financial literacy in the United States has increased. Previous studies discussing financial literacy tend to agree that "consumers lack the financial literacy to make important financial decisions in their own best interests" (Mandell & Klein, 2009). Moreover, Lusardi and Wallace (2013) reported that young adults between the ages of 23 and 25 usually have the lowest level of financial literacy. Although these levels are low in every subgroup of the population, it is especially concerning among teenagers and young adults who are just starting to make financial decisions that will significantly impact their lives, suggesting that it is increasingly important to educate citizens at a young age on the basics of financial concepts.

The majority of concern over financial literacy is due to the transition from defined benefit to defined contribution pensions, leaving many people today more responsible for figuring out how to save for their retirement and how much they should invest in their chosen plan (Bumcrot, Lin, & Lusardi, 2013). If new forms of investment are constantly emerging, preparing citizens for their financial future could be essential as they face increased responsibility for their savings and investing.

Defining Financial Literacy

Before determining if high school personal finance courses result in higher financial literacy among adults, it is essential to understand precisely what financial literacy is. While one study claimed "financial education is the knowledge that helps people make sound, informed financial decisions" (Valentine & Khayum, 2005, p. 1), another researcher suggested defining it as "a combination of awareness, knowledge, skill, attitude, and behavior necessary to make sound financial decisions and ultimately achieve individual financial wellbeing" (Cameron et al., 2014, p.13). As McCormick (2009) pointed out, despite its growing popularity, there is no single, uniform definition of financial literacy. However, existing literature generally regards financial literacy as a combination of knowledge and ability, which are the two essential factors that an individual should possess to manage their personal finances responsibly (Huston, 2010; Lusardi, Mitchell, & Curto, 2010). In this paper, "financial literacy" is defined as having both the knowledge and ability to make informed personal finance decisions.

Current State of Financial Literacy Among Youth (K-12) in the US

One of the most comprehensive measurements of financial literacy among young individuals in the U.S. is the OECD Program for International Student Assessment (PISA), which assesses the knowledge and skills that 15-year-old students have acquired in several critical areas. Since 2012, PISA has designed a module on financial literacy to measure three different dimensions: knowledge and understanding of basic financial topics, cognitive processes related to students' ability to recognize and apply relevant financial concepts, and the breadth of contexts in which financial knowledge, skills, and understanding are applied. In addition to financial literacy scores, the assessment includes information on each student's cultural, educational, and socioeconomic background.

Findings from the most recent PISA assessment (2018) suggest that, like their adult counterparts, many high school students in the U.S. lack basic financial knowledge and skills. For example, on a 1,000-point scale, the average score for U.S. students was 506. These levels of

financial literacy are low, and they have been quite resistant to progress since the initial assessment. According to the study, U.S. students' scores were statistically the same since the first assessment in 2012.

Some Financial Literacy Determinants

Studies show that other determinants besides educational instruction may affect one's financial knowledge. Some researchers believe there are "considerable differences among demographic groups" (de Bassa Scheresberg, 2013, p. 10). The characteristics of race and sex are considered factors that affect one's financial literacy. One group of researchers suggested that "there is now fairly robust evidence confirming that many women do not do well in financial calculations." Their study also found that "white people were more likely than Black and Hispanic respondents to answer financial literacy questions correctly" (Lusardi, Mitchell, & Curto, 2010, p. 367). Though these findings are discouraging, they show us the specific groups of people who benefit from financial education the most. A larger argument lies in the role of educational attainment as a factor in youth's financial literacy. Valentine and Khayum (2005) showed that plans to pursue post-secondary education significantly improve a student's overall financial literacy score. Students with professional goals may already be more able to understand and apply financial topics and appreciate their importance. Data also suggests that college-educated parents have more financially literate children (Lusardi, Mitchell, & Curto, 2010, p. 363). Parents with a higher education level are more likely to instill financial knowledge in their children and encourage higher education. It is seen that overall, education plays a prominent role in financial literacy.

Issues when Incorporating Financial Education into High Schools

While incorporating financial literacy into high school curricula should be attainable, understanding the issues ahead allows us to understand better how to implement the proposed solutions. Unfortunately, potential problems arise when studying the correlation between high school education and personal financial literacy. One common problem discussed among researchers is that the effectiveness of the curriculum may be compromised if the teachers are not adequately trained. One researcher suggested that "teachers may have inappropriate or inadequate qualifications (Bernheim, Garrett, & Maki, 2001, p. 436)." Another claimed that "mandate effectiveness could also be compromised if mandates create negative learning environments or if teachers are untrained in the subject area (Tennyson & Nguyen, 2001, p. 242)." It will be challenging to increase students' financial knowledge if teachers are not educated as well. Training teachers and providing them with the proper tools to educate students is crucial when incorporating a financial course into a curriculum.

Student interest and engagement are additional issues in education. Bernheim, Garrett, and Maki (2001) argued that "students may fail to take the material seriously." Though this is a possibility, as with any other subject, some students have expressed a desire for financial education, which decreases the chances of this occurrence. Also, if a personal finance course is a graduation requirement and the importance of the class material is stressed, they will be able to fall back on this knowledge later. However, one researcher said, "there is substantial variation in personal finance curriculum mandates across the states" (Tennyson & Nguyen, 2001, p. 246). This suggests a more standardized curriculum needs

to be created so that students across the nation have the same exposure to financial education and more equal opportunities to succeed.

Efforts to Improve Financial Literacy

The lack of financial literacy has stimulated the development and implementation of various educational programs to improve financial literacy. At high school level, 21 states incorporate personal finance standards, courses, or exams as a graduation requirement (CEE, 2022). Current attempts to address financial literacy in the U.S. are generally categorized into three groups: early education or adoption, mitigation, and retirement planning. The early education efforts focus on developing a baseline understanding of money and economic forces, covering topics like the fundamental definition of currency and its role in society to mathematics and finance. Such early educational initiatives, and the required curriculum modifications, are often dictated by education standards boards and vary state by state. On the other hand, mitigation efforts aim to reactively address the negative impacts of financial illiteracy through education and alleviative tools. These tools can come from loan consolidation, personal financial advisory, and general education to make up for poor or nonexistent early education. Lastly, retirement planning solutions focus on helping individuals set retirement goals and identifying the necessary measures and decisions to achieve those objectives.

These initiatives are undertaken primarily by the U.S. government, non-profit organizations, and for-profit enterprises. The U.S. government focuses mainly on resources dedicated to educational programs, while sometimes receiving assistance from non-profit organizations for additional resources and for-profit enterprises for funding. Non-profit programs usually prioritize qualifying issues of

financial illiteracy, such as burdening debt, poor credit, and interest consolidation, while the private sector typically addresses retirement planning education. However, outside the K–12 classroom, most of these efforts are autonomous, lacking meaningful coordination and collective effort across platforms and topic areas.

With a better grasp of what current research shows about the effects that high school courses have on young adults and an understanding of other possible factors and problems, there is a strong case in favor of required personal finance courses. As Figure 1 displays, economic education has been taught more in high school classrooms over the past two decades. However, the presence of specifically designated personal finance courses is still low (CEE, 2022).
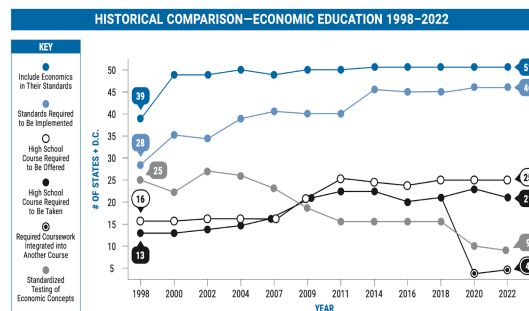
Source: Council for Economic Education (CEE). (2022). Survey of the states' economics, personal finance, and entrepreneurship education in our nation's schools 2022. New York: CEE.

Conclusion

With our current understanding of the definition of financial literacy, its current role in high schools, and the potential problems that may exist, we can evaluate the most effective solution. While previous research has shown a positive correlation between receiving personal finance education in a high school setting and having a higher adult financial literacy (Fan & Chatterjee, 2018), future studies should consider the factors that impact financial literacy. Furthermore, future financial literacy assessments should test students before and after

completing a course to see if their financial literacy has actually improved. It would also be helpful to test students across the United States to compare regional differences and to determine whether teaching methods would produce different results. Young adults and teenagers are becoming more responsible for their financial outcomes, so it is important to understand how society can help them make informed decisions.

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a Field Experiment in Singapore.

SCHOLARLY REVIEW

Comparing Primary Distance Indicators

By Tiffany Zhang

AUTHOR BIO

Tiffany Zhang is a junior at Great Neck South High School and has been part of her school's research program since freshman year. She is interested in astrophysics, computer science, and math. She is the co-founder, website manager, and instructor at AlphaMath, a non-profit organization that hosts free online sessions to make learning math more accessible and fun during the pandemic. She actively participates in her school's Women in STEM club 'SHE' by hosting events and organizing fundraisers. She interned in the ReWild Long Island Summer Program to promote biodiversity, climate change resilience, and food security by reintroducing native plants to attract a variety of animals, following organic and regenerative practices of recycling and composting, and donating grown fruits and vegetables to the hungry. She qualified for AIME, represented her school in various math competitions, and has participated in physics and programming competitions. Acknowledgement: The author thanks Dr. Shyamal Mitra, Arnav Sharma, and Eleanor Liu for their feedback and constant support.
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ABSTRACT

Measuring distances to astronomical objects is crucial for collecting and analyzing their properties. Different distance methods form the distance ladder, in which methods for shorter distances calibrate methods for larger distances. Parallax, main sequence fitting, variable stars, and red clump stars form the lower portion of the distance ladder. Reviews on these methods were compiled and evaluated. The distance methods played a significant role in astronomical discoveries (especially parallax), though controversies and discrepancies limit their reliability (especially for red clump stars). Red clump stars are not a firmly established distance indicator because of varying strengths in the relationships of specific photometric bands, or passbands, with other stellar properties between studies. These discrepancies are likely due to contamination of the data and the heterogeneous nature of red clump stars; hence, future research should explore different ways to isolate the red clump for more accurate and decisive data analyses on whether red clump stars are a plausible distance indicator.

Keywords: *distance indicator, distance ladder, parallax, main sequence fitting, HR diagram, star clusters, variable stars, Cepheids, RR Lyrae, period-luminosity relation, red clump, metallicity.*

INTRODUCTION

In an expanding universe, distances to astronomical objects become a barrier to observing these objects' properties, so consistent recalibration of distance methods is needed to increase their accuracies. However, each method has a limited range in which it is applicable because the distance indicator might not be present within a certain distance or become too faint outside a certain distance, so farther distance methods rely on closer distance methods for calibration in the distance ladder.

Parallax lies at the bottom of this ladder, as it is the only method for measuring absolute distance. Main sequence (MS) fitting is on the next rung of this ladder, relying on known distances calculated from parallax for calibration. The distance indicators of Cepheids and red clump stars are on the subsequent rung of this ladder and rely on distances calculated from either parallax or MS fitting to these objects for calibration. The reliance on shorter distance methods to calibrate farther distance methods continues on the subsequent rungs. As our understanding of cosmology and evolution progresses, studying farther astronomical objects becomes more important to clarify and confirm the findings, emphasizing the need for increasingly accurate distance measurements.

Despite recent advances in these distance calibrations and measurements, they are influenced by systematic errors and discrepancies left unresolved. Red clump stars are a promising distance indicator as they are luminous and prominent on the HR Diagram (HRD). This review aims to evaluate the mentioned methods of distance measurement: parallax, MS fitting, variable stars, and red clump stars. Specifically, this review outlines their history in Sections 2, 3, 4, and 5, respectively, and evaluates them in Section 6.

1. Parallax

Parallax is the only method to measure distance directly as other distance measurements rely on relative distances and recalibration. Since Earth's revolution causes angular displacement of an astronomical object with respect to background stars as shown in Fig. 1, this can be measured to calculate the distance with the small angle formula:

$$d = \frac{1}{p}$$

where d is the distance in parsecs and p is the parallax in arcseconds. However, using parallax for distance measurements is limited: as the distance of the target object increases, the observed angular displacement diminishes, becoming negligible and impossible to measure for distance calculations.
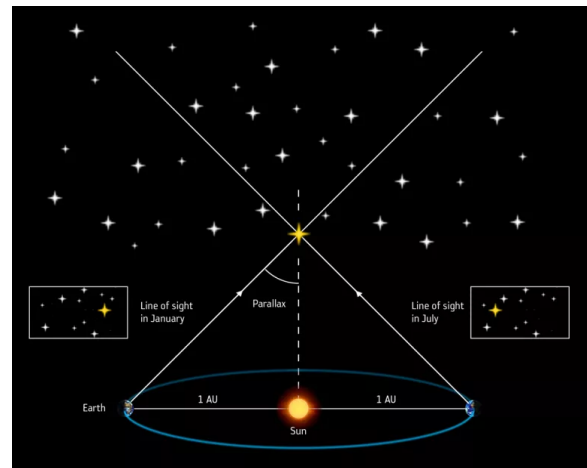

Figure 1: As the Earth revolves around the Sun, parallax motion is observed in the yellow star as its position shifts with respect to background stars with negligible parallax. This figure is from Pultarova (2022).

Gaia and Hipparcos are two significant space missions with the accurate and efficient collection of parallax measurements of 1,811,709,771 and 118,218 objects, respectively (Lindegren et al., 1997; Vallenari et al., 2022).

Moreover, they both contributed to many novel discoveries. Hipparcos aided in the confirmation of the Vogt-Russel Theorem, the hypothesis that absolute magnitude (luminosity) and color (effective temperature) are a function of metallicity, by expanding the sample size and providing more accurate distance measurements for calculating absolute magnitude (Reid, 1999). Gaia allowed for the discovery of new open clusters as it provided a large data set of proper motions and parallaxes where unsupervised machine learning can be applied (Cantat-Gaudin et al., 2019).

2. Main Sequence Fitting

Main sequence fitting relies on the Vogt-Russell Theorem and the HRD of a star cluster by assuming stars with similar colors have equal luminosities and stars in the same star cluster have equal distances (Reid, 1999). Consequently, after plotting the cluster's HRD, the amount shifted to align it with the zero-age main sequence (ZAMS) is the distance modulus, or m - M, where m and M are the apparent and absolute magnitudes, respectively. This can be used to derive the distance using the following equation:

$$m - M = -5 + 5 \log d$$

This method may be inaccurate for individual stars as there are various possible luminosities for a given color or effective temperature (for example, a red main-sequence star and a red giant with the same color or effective temperature). However, this is not a problem when analyzing the star cluster as relative magnitudes between stars become apparent. For example, Oralhan (2021) studied the properties of open cluster Berkeley 55, including distance, age, radius, star membership, and reddening. MS fitting was used to determine the distance modulus by shifting the ZAMS

vertically in increments of 0.1 mag until it is fitted with the lower edge of the MS in the bands $IJHK_S$ with the V band as shown in Fig. 2. Hence, MS fitting is widely used to calculate distances for star clusters.
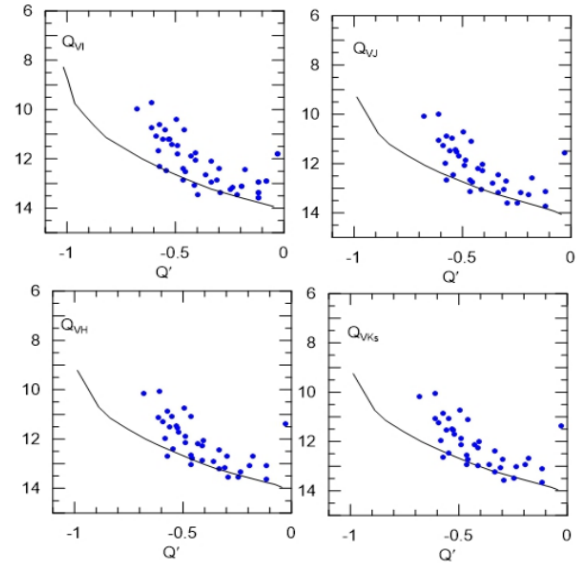

Figure 2: $Q_{V\lambda}$ versus Q' graph where Q represents reddening-independent quantities for their respective bands and λ represents the $IJHK_S$ filters. The early-type stars in the open star cluster Berkeley 55 and ZAMS are plotted as blue dots and a line, respectively. This figure is from figure 10 of Oralhan (2021).

3. Variable Stars

Variable stars fluctuate in luminosity in a regular pattern and serve as crucial distance indicators as they usually follow a relation between some physical characteristic (e.g. period, metallicity, color) and luminosity, which varies with distance. Two of the variable stars most popularly used as distance indicators are Cepheids and RR Lyrae.

Cepheids exhibit a correlation between the period of their luminosity fluctuations and their absolute luminosity described by a Period-Luminosity (P-L) relation. The light curve of Cepheid can be recorded, as shown in Fig. 3, to obtain the period and derive the absolute luminosity. Along with the measurement of apparent luminosity, the

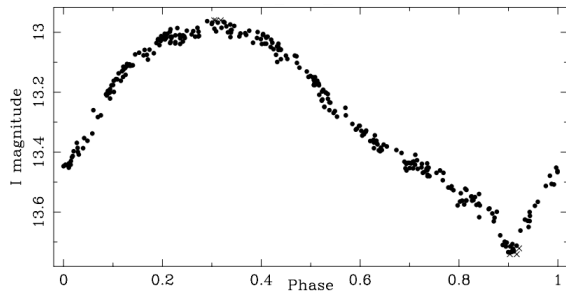equation of the distance modulus can be used to calculate the distance.

Figure 3: Light curve of a Population II Cepheid in the I band from the OGLE survey. The period of the light curve 9.94431 days. This figure is from figure 1 of Groenewegen (2008).

However, P-L relations will differ in slope or zero-point across different colors with respect to the photometric band as revealed in the calibrated P-L relations of Galactic Cepheids selected by Sandage & Tammann (2016) in the B, V, and I bands shown in Fig. 4, which are

$$M_B = -(2.692 \pm 0.093) \log P - (0.575 \pm 0.107)$$ (1)

$$M_V = -(3.087 \pm 0.085) \log P - (0.914 \pm 0.098)$$ (2)

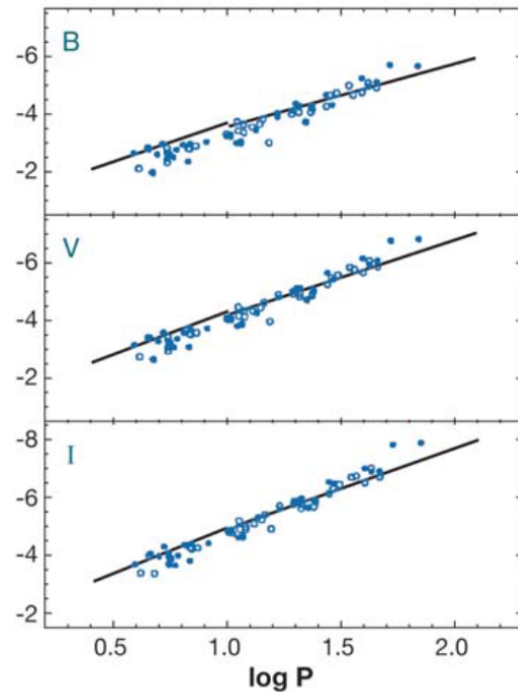$$M_I = -(3.348 \pm 0.083) \log P - (1.429 \pm 0.097)$$ (3)

Figure 4: Fitted P-L relation for Galactic Cepheids in the B, V, and I bands. These calibrations are equations (1), (2), and (3), respectively. This figure is from figure 8 of Sandage & Tammann (2016).

RR Lyrae exhibits a relation between absolute magnitude and metallicity [Fe/H] (the iron to hydrogen ratio with respect to that of the Sun), which was originally assumed to be linear. However, recent research found that a parabolic metallicity-luminosity relation demonstrated a better fit (Sandage & Tammann, 2016; and references therein). One of these relations selected by Sandage & Tammann (2016) is

$$M_V = 1.109 + 0.600([Fe/H]) + 0.140([Fe/H])^2$$

and is favored for longer distances.

4. Red Clump Stars

Red clump (RC) stars are core He-burning stars with masses below the He-flash limit M_{HeF}, or the maximum mass of a star that can have a degenerate yet He-burning

core to cause the He-flash (Girardi, 2016). Since a specific small range of masses allow for degeneracy, consistencies of RC luminosity and effective temperature. Consequently, the RC makes up ⅓ of all red giants, forming a prominent clump in the HRD as shown in Fig. 6. Moreover, high metallicity and low mass create the RC's characteristic large red convective envelope. The use of RC as a distance indicator was first suggested by Cannon (1970), and the first significant study on the RC by Paczyński & Stanek (1998) found their mean I-band magnitude with little uncertainties. Since the RC's luminosity increases as it transitions from mainly H-burning to He-burning overtime, the RC should exhibit a metallicity-luminosity relation where absolute luminosity is represented as a linear function of metallicity (Girardi, 2016). Note that metallicity is defined as the concentration of all elements heavier than He relative to the Sun. Hence, it is possible to derive a red clump star's absolute magnitude from metallicity and calculate its distance.
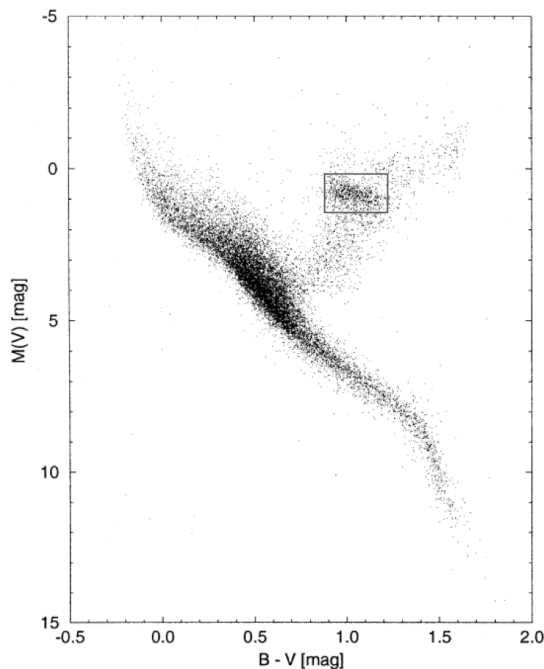
Despite their proximity to the RC in the CMD, the different structures shown in Fig. 7 have their distinct characteristics. The secondary red clump (SRC) and vertical structure (VS) are substructures of the RC: The secondary red clump (SRC) has masses between M_{HeF} and M_{HeF} + 0.3 $M_\odot$ and stretch below the RC, while the vertical structure (VS) has masses greater than M_{HeF} + 0.3 $M_\odot$, are slightly brighter than the RC, and extend above the RC as shown in Fig. 7 (Girardi, 2016). The red giant branch (RGB) bump, horizontal branch (HB), and early asymptotic giant branch (EAGB) bump are main structures in the CMD as they represent crucial points of a star's life: stars in the RGB passed the main sequence phase but haven't experienced He ignition, those in the HB passed the RGB and undergo He fusion, and those in the EAGB passed the HB and undergo fusion of heavier elements like carbon. Hence, these stars may contaminate RC data and cause inaccuracies.
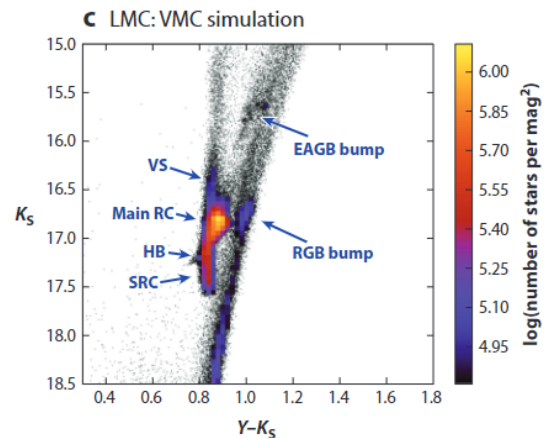

Figure 7: Color-magnitude diagrams of a simulation of the Large Magellanic Cloud (LMC). Distinctive features on the color-magnitude diagram are labeled: main red clump (RC), horizontal branch (HB), secondary red clump (SRC), vertical structure (VS), red giant branch (RGB) bump, and early asymptotic giant branch (EAGB) bump. This figure is from figure 10c of Girardi (2016).

5. Conclusion

Parallax surveys led to various significant discoveries in multiple astronomic

Figure 6: HR Diagram in the B and V bands using Hipparcos data. A box is drawn around the red clump. This figure is from figure 3 of Lindegren (1997) and edited by the author.

subfields, such as the HRD, exoplanets, proto-planetary disks, white dwarfs, the Milky Way, stellar streams, clusters, the Solar System, and active galactic nuclei (Brown, 2021; and references therein). Moreover, it contributes to the calibration of other distance indicators, including Cepheids and RC stars, allowing farther distances to be measured. However, gravitational lensing and aberration may affect the observed parallax motion by bending and blurring the observed light, deviating from the true motion of the object. These effects must be predicted to ~1 μas accuracy to consider their impact on astrometry as negligible (Brown, 2021). Hence, future surveys should investigate and refine methods to automate the recognition and correction of these effects to address this issue.

MS fitting is frequently used for distance measurements to star clusters and calibrating distance indicator relations, including the Cepheid P-L relation. However, unresolved binaries may lead to inaccuracies in the stars' absolute magnitude and color. In addition, the accuracy of MS fitting is dependent on reddening: if reddening is overestimated, the distance modulus is overestimated (Reid, 1999). Hence, future surveys should recognize and flag unresolved binaries in the data processing.

The Cepheid P-L relation is commonly used to measure distances to star clusters and galaxies. However, the P-L relations of the Milky Way and LMC differ in both zero-point and slope, and the latter even exhibits a break at the period of 10 days (Sandage, 2004). Consequently, the uncertainty in selecting an equation—calibrated with Galactic or LMC Cepheids—will influence the accuracy of distance measurements to unknown objects. One theory for these discrepancies is metallicity differences. Many studies have incorporated metallicities into their calibrations; however, no changes that can explain the inconsistencies in the P-L relation between Galactic Cepheids and

the LMC were observed (Groenewegen, 2018; Sandage & Tammann, 2016; and references therein). Future research should investigate whether metallicity plays a role in the P-L relation and analyze other differences in the features of Galactic and LMC Cepheids.

Red clump stars exhibit potential as a distance indicator because they are luminous and distinguishable on the HRD. However, they are not a firmly established distance indicator: since the first paper on analyzing this relationship of red clump stars by Paczyński & Stanek (1998), the metallicity-luminosity relationship was shown to range from a strong correlation to a weak correlation as noted by Girardi (2016). For example, Alves (2000), Grocholski & Sarajedini (2002), and Helshoecht & Groenewegen (2005) found that the K-band magnitude exhibited an insignificant correlation with metallicity. However, models suggest a significant dependence of K-band magnitudes with metallicity (Salaris & Girardi, 2002). These discrepancies are likely due to contamination of SRC and RGB stars, shown in Fig. 7 (Girardi, 2016). Asteroseismic graphs exhibit clustering that can distinguish these stars from the RC better than spectroscopic data, such as the effective temperature T_{eff} versus surface gravity log g plot. Another possible factor in the discrepancies is the heterogeneous nature of red clump stars as they span a wide range of initial masses, initial metallicities, and ages, possibly causing sample variations that weaken the metallicity-luminosity relation (Girardi, 2016). Because of the persistence of these discrepancies, repeating similar analyses will likely lead to the same inconsistencies, so the approach must be modified. Future research should address removing these contaminants, especially SRC and RGB stars, by collecting more asteroseismic data and searching for other distinguishable characteristics from the RC until their effects are near negligible. Only until then

can the reliability of the metallicity-luminosity relation be evaluated.

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OCD and its Effects on Memory

By Mina Li

AUTHOR BIO

Mina Li is a seventeen-year-old junior attending St. Mark's School in Massachusetts. She is especially interested in psychology and neuroscience, which she hopes to explore further in the future. More specifically, the connections between the two topics, including the effects of neurological functions on emotions, behaviors, and cognition. Mina is constantly involved in research at school as well as outside of school, such as her internship at Massachusetts General Hospital. When she is not busy exploring her interests in neuropsychology, she enjoys reading, painting, playing sports, traveling, and spending time with friends.

ABSTRACT

As rates of mental health disorders increase throughout the years, more and more studies have emerged to investigate their effects, such as the effects of Obsessive-Compulsive disorder on memory. Obsessive-Compulsive Disorder was first described in the Diagnostic and Statistical Manual of Mental Disorders in the 1980s.[1] It is organized into 5 main categories: checking, contamination, symmetry/ordering, intrusive thoughts, and hoarding and can be measured using the Y-BOCS. OCD is caused by genetic, neurobiological, behavioral, and environmental factors. Neuroimaging studies reveal overactivation of the orbitofrontal cortex and the basal ganglia. Scientists have discovered the effects of OCD on episodic and procedural memory. In 2004, Robert M Roth conducted a Pursuit Rotor Task with 46 participants. The results reveal that the OCD group has enhanced procedural memory, likely due to the overactivation of some parts of the brain. Furthermore, in 2011, Mika Konishi used the "directed forgetting paradigm" method on 45 participants. The results reveal reduced retrieval inhibition and difficulties in selective encoding in OCD brains, which lead to decreased memory recall performance.

Keywords: *Obsessive-compulsive Disorder, Diagnostic and Statistical Manual of Mental Disorders, Overactivation, Episodic Memory, Procedural Memory, Treatment, Selective Encoding, Memory Deficit.*

INTRODUCTION

Throughout the past few decades, rates of mental health disorders have increased dramatically in adults and adolescents worldwide. In the United States, 19.86% of adults experience a mental illness, which is equivalent to almost 50 million Americans.[2] Mental disorders are more prevalent than diabetes, cancer, and heart disease.[3] One example of a mental disorder that has increased in the rate of diagnosis throughout the past few decades is Obsessive-Compulsive Disorder (OCD). OCD is a chronic and long-term mental disorder in which a person experiences uncontrollable, recurring thoughts and behaviors they feel the need to repeat.[4] OCD affects 2-3% of adults in the United States.[5]

Symptoms of OCD can be traced back throughout history. However, the name, OCD, was not used until the 20th century. The Diagnostic and Statistical Manual of Mental Disorders (DSM) was published in 1952 in order to classify depressive disorders. Since its publication, research surrounding OCD has expanded dramatically. OCD was first described in the DSM-1 in the 1980s and was classified as an anxiety disorder.[1] Then in DSM-5, OCD was removed from Anxiety Disorders and classified as a new category: Obsessive-Compulsive and Related Disorders.[6] According to the Mental Health Foundation, symptoms of OCD are categorized as obsessions and compulsions. Obsessions that are common in people with OCD include fear of contamination, fear of harm, excessive concern with exactness, hoarding, and intrusive thoughts. Compulsions include repeated actions, repeated words, mental rituals, arranging, and repeated checking[7]. OCD is organized into 5 main categories: checking, contamination, symmetry/ordering, intrusive thoughts, and hoarding.

Recent studies have discovered that OCD can also negatively impact the memory system. Results from experiments reveal that OCD causes inferior memory performance for OCD patients.[8] Most symptoms depend on the severity of the disorder in a person. The most widely used measurement tool for assessing the global severity of OCD is the Y-BOCS. The Y-BOCS stands for the Yale-Brown Obsessive Compulsive Scale and comprises 58 items that assess two categories of symptoms: compulsive thoughts and compulsions. The scale consists of 10 questions that are scored on a scale of 0 to 40, 40 being the most severe and 0 being subclinical. A mild level of OCD is considered to be around or less than 16 points.[9] To receive a diagnosis, a patient has to reach out to a healthcare provider such as a therapist or a psychiatrist. The healthcare provider will ask the patient a list of questions in order to assess their symptoms and then present a diagnosis.

The mechanism of action for OCD

Scientists have used neuroimaging studies to research the differences in the brain activity between people who have been diagnosed with OCD, and unaffected people. Scientists were able to find that some parts of the OCD brain are more active than the brains of the control group. The most prominent parts (Figure 1) with overactivity are the orbitofrontal cortex and the caudate nucleus, which is a part of the basal ganglia.[10] The normal function of the orbitofrontal cortex in the brain is sensory integration, prediction, and decision-making, and it participates in learning.[11] The basal ganglia is primarily in charge of motor control, but it also participates in other roles like executive functions and behaviors, as well as emotions.[12] In the OCD brain, as shown in the PET scan below (Figure 2), the cortex at the top of the brain projects to the striatum, which

contains structures such as the caudate. Then, it projects down to the thalamus, which projects back to the cortex.[13] This loop is in constant overdrive in the OCD brain. Furthermore, the constant overactivation of some parts of the brain actually causes abnormally enhanced procedural memory in people with OCD.[14] This enhancement is evident in their tendency to repeat an action continuously.
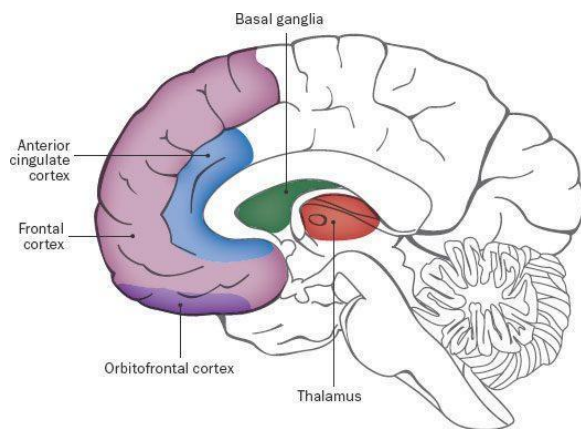

Figure 1: Diagram of the overactivated areas of the OCD brain.[13]

Figure 2: PET scans of the normal brain and the brain of the patient who has OCD.[10]

Scientists have also discovered that OCD is not only caused by neurobiological factors, but also a combination of genetic, behavioral, and environmental factors.[15] A study that was funded by the National Institutes of Health found that OCD could be associated with a rare mutation of the human serotonin transporter gene (hSERT).[16] The study reveals that genetics contributes around 45-65% of the risk for OCD[14].

Behavioral factors play an important role in developing and maintaining compulsions and obsessions. Scientists believe that compulsions are learned responses to help reduce anxiety surrounding obsessions. Therefore, due to the fact that the learned responses may temporarily reduce anxiety, the probability that the individual will repeat the response increases. As a result, the compulsive behavior may become excessive.[15]

Environmental factors also play a role in OCD by contributing to its development. For example, some severe traumatic brain injuries have been a factor in the onset of OCD.[17] Furthermore, some children exhibit sudden OCD symptoms after severe bacterial infections[15]. The infection does not directly cause OCD but triggers the disorder in people with genetic connections. Additionally, parenting styles are also environmental factors that can contribute to the development of the disorder by causing stress for a child.[18]

Treatment options for OCD

There are many types of treatments for OCD, such as medication and psychotherapy.[19] For medications, many antidepressants are approved by the FDA to treat this disorder: Anafranil, Prozac, Lexapro, Paxil, Zoloft, Celexa, etc.[20] Most medications listed above are called selective serotonin reuptake inhibitors (SSRIs). These medications are also commonly used for other mental disorders such as anxiety and depression.[21] SSRI medications reduce symptoms of mental disorders by increasing the balance of serotonin levels in a person's brain.[22]

Cognitive-behavioral therapy is a treatment that uses two scientifically based techniques to transform a person's behaviors and thoughts. The two techniques are exposure and ritual prevention and cognitive therapy.[19] In

exposure and ritual prevention therapy, people with OCD are gradually exposed to their obsessions and told not to perform the compulsions they use to reduce their anxiety.[23] Next, cognitive therapy focuses on emotions or thoughts that a person associates with certain misinterpreted experiences. Cognitive therapy for OCD is designed to assist patients in identifying these misinterpretations or unrealistic thoughts and changing their thoughts, which decreases anxiety and compulsions.[24] For example, if a patient with OCD experiences ritualistic compulsions and believes that terrible accidents will occur to their family if they do not complete the compulsions, the therapist will challenge this belief by instructing the patient not to complete the compulsion and then seeing whether an accident occurs.[25] Then, the therapist will use the results of this experiment in further discussions about other similar thoughts.

Personal experience with OCD:

I am choosing to write about how OCD affects memory mainly out of curiosity because as someone that has been professionally diagnosed with OCD, I have a poor memory and constantly forget things. I would like to learn more about the possible connections between the two. I would also like to help spread awareness of the disorder and clear up the many misconceptions surrounding OCD. Out of the 5 main categories of OCD I discussed above, I mainly fall into three categories: checking, contamination, and ordering. For me, OCD shows up through my constantly repeated checking of things: the way I constantly run back upstairs to make sure I locked the door, the way I repeatedly go through all my homework assignments to make sure I completed them all, and the way I make hundreds of lists every day, so I do not forget anything. I also wash my hands abnormally often to ensure that I am not contaminated with anything, even if I have not

moved from my seat since the last time I washed my hands. In addition, I also have ritualistic routines for common daily routines, for example, making my bed in the morning. Every person with OCD has different experiences with the disorder and different symptoms. The symptoms listed above are a few of my experiences with OCD. Therefore, not everyone with OCD experiences the same compulsions and obsessions.

The case study on effects on procedural memory

The effects of OCD on the brain is a long-debated subject among scientists. Some scientists believe that OCD causes memory impairments in the episodic memory of patients, evident in their repetitive checking behaviors.[26] Some believe that the disorder causes the abnormality of procedural memory.[27]

Procedural memory is a kind of long-term memory involving the performance of skills and actions.[28] Many scientists believe that OCD can perform differently in procedural memory[29]. In 2004, Robert M Roth and his colleagues published an experiment of theirs concerning the effects of OCD on memory. One part of the experiment focused on the effects on procedural memory. 27 patients with OCD and 29 healthy control participants were chosen for the experiment.[29] Subjects with OCD all met the diagnostic criteria for OCD defined in the DSM-IV. On the Pursuit Rotor Task, participants were told to hold a light sensor wand and follow the motion of a light emitting disk that rotates. Participants first completed 3 twenty-second trials at 4 different disk rotation speeds (15, 30, 45, 60 rpm).[29] The rotation speed at which each participant was able to track the target closest to 5s was used. Next, participants participated in 6 test blocks of 4 twenty-second trials. They received 20 seconds of rest time between trials and 60 seconds of rest time between each block.
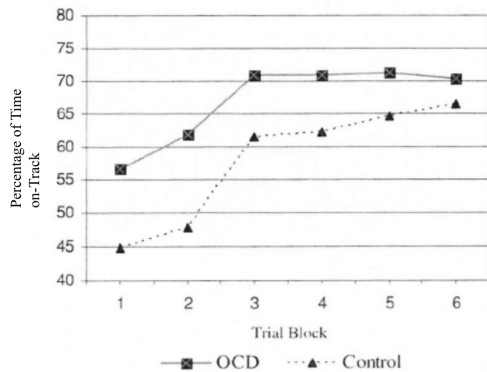
Figure 3: Graph of the percentage of time participants stayed on-target on the Pursuit Rotor Task.[29]

The majority of participants performed the tests at 60 rpm while the rest performed at 45 rpm. As shown in Figure 3, the results indicate that OCD patients stayed on-target for a longer duration than the control group for the first 3 blocks. The last 3 blocks had similar results in both groups. In summation, the results of the experiment indicate that the OCD group has better procedural memory than the control group. The enhanced procedural memory of people with OCD is likely associated with overactivation in numerous parts of the brain.[29]

The case study on effects on episodic memory

The following experiment explains the effects of OCD on episodic memory, more specifically, the encoding and retrieval process of memory in the brain. The experiment was published in 2011 by Mika Konishi and colleagues.[26] They used a method called a "directed forgetting paradigm" to examine episodic memory in relation to clinical features of OCD. A "directed forgetting paradigm" is when a subject is told to intentionally forget information they learned. The scientists believed that intentional forgetting uses a mechanism in memory to reduce intervention in processing and retrieval of important information, although unintentional forgetting can simply be a failure

to remember.[26] The "directed forgetting paradigm" depends on whether the information has been encoded into the long-term memory before the subject is instructed to forget.

In this experiment, 28 OCD patients and 17 healthy control participants from ages 16 to 68 were recruited. All of the 28 OCD patients met the DSM-IV criteria for the diagnosis of OCD. Their mean score indicates moderate severity of the disorder. The experiment uses two cue types: remember and forget. There are two conditions: List and Item. As shown in Figure 5, in the List condition, participants were shown a list of words one at a time for 5 seconds each on a computer, and told to learn as many as possible. After half the list has been shown, instructions to forget the previous words were given. Then participants were given the rest of the list to remember. In the Items condition, participants received a list of words, each followed by a "o" or "x". "O" indicated an instruction to remember (R-cued word) while "x" indicated an instruction to forget (F-cued word).
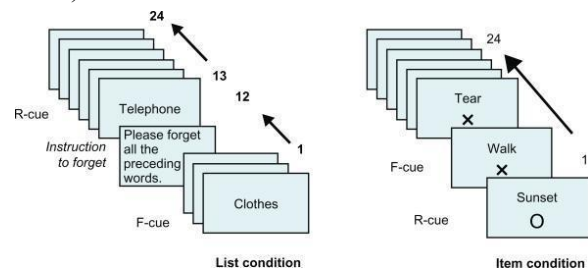

Figure 4: Illustration of List and Item conditions.[26]

As seen in Figure 5, results indicate that the control group recalled more F-cued words in the List condition than in the Item condition. The recall of R-cued words was around the same for both conditions. The results for OCD patients indicate that the OCD group remembered fewer R-cued words than the control group for both List and Item conditions. In addition, there was no group difference in the recall of F-cued words.
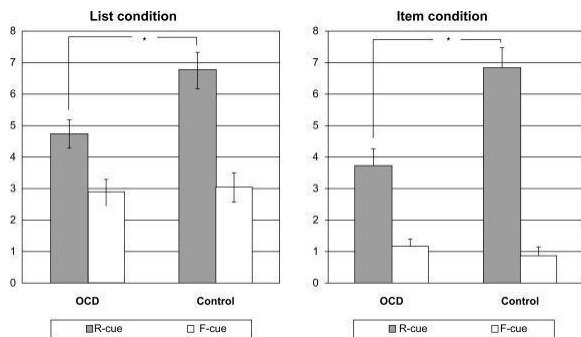
Figure 5: Graph of correct words recalled under the List and Item conditions.[26]

In the List condition, R-cued and F-cued words experience the same encoding procedure. Therefore, the method of directed forgetting should reflect successful retrieval inhibition or the suppression of F-cued words. For the Item method, since each word was followed by an instruction to either forget or remember the words, selective encoding is the essential factor underlying the effect of the directed forgetting method. As depicted in Figure 4, OCD patients recalled fewer R-cued words than control participants, while they recalled around the same amount of F-cued words as control participants. The reasoning behind this result is because the encoding and retrieval of F-cued words in OCD patients blocked the recall of R-cued words. OCD patients had impaired selective recall of important words because of the intrusion caused by the accidental recall of unnecessary words. In summary, the results of the experiment showed that OCD is distinguished by an intentional cognitive inhibition deficit. OCD patients had reduced retrieval inhibition of unnecessary words compared to control participants. In addition, OCD patients also showed reduced retrieval inhibition of neutral materials. Thus, OCD patients have reduced retrieval inhibition of irrelevant material despite any emotional significance. This amount of retrieval inhibition can be seen as frontal dysfunction. In addition to reduced retrieval inhibition, OCD patients also

exhibited difficulties in selective encoding, which can be caused by frontal dysfunction. The frontal lobe is responsible for voluntary action and higher cognitive skills, such as problem-solving, thinking and planning, and organizing[30]. Deficits in selective encoding and retrieval inhibition are most likely attributed to poor organizational skills caused by frontal dysfunction. Therefore, OCD patients likely have decreased memory recall performance due to deficient frontal-related organizational skills instead of a general memory deficit.[26]

Conclusion

As the rate of mental illnesses continues to increase across the world, more and more studies have emerged to discover the effects of those illnesses on the brain.[31] One mental disorder that scientists have focused on is OCD. More specifically, recent studies have looked into the effects of OCD on memory. Experiments using the "directed forgetting paradigm" method indicate that OCD can cause deficient frontal-related organizational skills, which contributes to decreased memory performance.[26] Furthermore, scientists have also found that OCD can enhance procedural memory, likely due to the overactivation in the brain.[29] Lastly, it is important to make a note of the limitations that may have impacted the results of the experiments. For example, both of the studies mentioned in this paper had a limited number of participants, which increases the margin of error.[32] Therefore, the small group of participants does not represent the large population of people with OCD, and their experiences may differ dramatically.

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