immerse
EDUCATION

Immerse Education Research Journal

2025 RESEARCH SYMPOSIUM WINNING PROJECTS
MEET THE WINNERS
TIPS AND RESOURCES
JUDGES COMMENTS

SEPTEMBER 2025 VOLUME 2 NO. 1
Transformative Educational Experiences

www.immerse.education

Table of contents

About the competition

The Symposium celebrates excellence in research by high school students who have recently completed their Online Research Projects through Immerse Education.

The three shortlisted projects were chosen based on their:

- Quality and depth of research, including the use of relevant sources.
- Clarity, structure, and referencing of the written paper.
- The ability to clearly outline and summarise research and ideas.
- The ability to engage their audience with thought-provoking topics and detailed explanations of complex concepts.
- Support and guidance received from tutors as part of the research process

Immerse Online research programme

Whether you take a Group, Accredited, or classic Online Research Programme, these virtual experiences offer an unparalleled opportunity for students aiming to refine their research and study skills ahead of university. The bespoke programmes stand out by allowing participants to immerse themselves in a subject of their choice, under the guidance of esteemed tutors from top institutions.

Tailored to individual students, the programme promises an intensive academic journey. Participants engage in a rigorous academic research project, receiving one-on-one or group supervision alongside workshops aimed at enhancing academic skills like personal study, academic writing, and independent research. The objective is clear: to enable students to produce a university-level piece of work that not only demonstrates the student's ability to think critically but also their passion for their chosen field. This unique creation could range from an essay to a physical, handmade project to an interactive presentation, depending on the subject. Participants receive invaluable, subject-specific advice and detailed feedback.

immerse
EDUCATION

Key facts: Available in 20 diverse subjects

- Architecture
- Artificial Intelligence
- Biology
- Business Management
- Chemistry
- Coding
- Computer Science
- Creative Writing
- Economics
- Encryption & Cybersecurity
- Engineering
- English Literature
- History
- International Relations
- Law
- Mathematics
- Medicine
- Philosophy
- Psychology

ONLINE RESEARCH PROGRAMME (CLASSIC)

- Available to 13-18 Year Olds
- Choice of 20 subjects
- Choice of area of specialisation and focus
- Daily 1:1 contact time when it suits you
- Group programme delivered by an Oxbridge Academic
- Skills training for university-level research projects
- Academic writing tuition culminating in a 1000-word essay
- Detailed personal evaluation of your submission from your tutor
- Dedicated support from the Immerse Online Team
- Certificate of attendance

10 Hours

Best suited if you would like to have a high-impact introduction to subject-specific academic research at university-level.

ACCREDITED ONLINE RESEARCH PROGRAMME

- Available to 14-18 Year Olds
- Choice of 20 subjects
- Choice of area of specialisation and focus
- Daily 1:1 contact time when it suits you
- Accredited for 8 UCAS points OR 3 college credits
- Tailored programme delivered by a trained expert, typically a trained Oxbridge Academic
- Skills training for university-level research projects
- 8 dedicated sessions on research skills and essay writing
- Academic writing tuition culminating in a 1000-word essay
- Detailed personal evaluation of your submission from your tutor
- Dedicated support from the Immerse Online Team
- Certificate of attendance

15 hours

Ideal for students looking for an extensive and tailored 1:1 academic research experience that will offer them additional UCAS points for UK university applications.

GROUP ACCREDITED ONLINE RESEARCH PROGRAMME

- Available to 14-18 Year Olds
- Choice of 5 themes covering a wide range of subjects
- Group programme delivered by a trained expert typically from an Oxbridge University
- Accredited for 8 UCAS points
- Skills training for university-level research projects
- Academic writing tuition culminating in a 1000-word essay
- Detailed personal evaluation of your submission from your tutor
- Dedicated support from the Immerse Online Team
- Certificate of attendance

15 Hours

The option for students looking to sharpen their minds and research skills with other peers.

Getting Involved: Steps to Complete an Online Research Project

1

Submit Your Enrolment

Once you have submitted your enrolment and paid a deposit, you will be sent a booking confirmation asking for more information on your academic background and goals.

2

Be Matched With One Of Our Expert Tutors

Using your academic background form, our team will match your profile with one of our expert tutors from Oxford, Cambridge and Ivy League Universities.

3

Receive Your Course Induction Pack

Once we've found your tutor, confirmed your timetable and received your full fees, you will receive final instructions containing details about your programme, such as a course overview, how to access your virtual classroom, as well as any additional material from your tutor.

4

Start Your Course

Choose from a 10 – 20 hours programme with 1:1 tutorials each week. You will also be required to research and prepare your project in your own time.

5

Graduate

At the end of the course, your academic research project will be independently assessed and you will receive a certificate of completion, as well as a detailed evaluation from your tutor.

Tutor Profiles

DR AAKASHI BHATT - MEDICINE

Dr Aakashi Bhatt MBBS, MS, MSc (Oxon), MCh, MPhil, DPhil (Oxon), is a General Surgeon specialising in Robotic Surgery. A top 1% MBBS graduate, she trained in India and completed an MSc and DPhil at Oxford, focusing on advanced genomic techniques for IVF and ovarian cancer research.

She has also been an Online Research Project and Academic Insights tutor for Immerse Education for several years, combining her passion for teaching with mentoring future medical professionals.

LAURA HAAS - PSYCHOLOGY, LAW

Laura is a PhD candidate in Criminology at the Faculty of Law at the University of Oxford. Her doctoral thesis explores the effects of military experience on prison staff in the UK. One of her main areas of interest is the effect of PTSD on former armed forces personnel working as prison officers. She also explores the impact of military experience on prison staff culture, their identity, and their help-seeking behaviour and coping mechanisms.
Prior to her PhD, Laura completed two Masters - the MSc in Criminology and Criminal Justice at the University of Oxford and the MSc in Legal Psychology at the Medical School Berlin, in which she focused on sexual offending.
Laura has worked for Immerse since Summer 2022. In addition to working as an Academic Tutor for Immerse, she has also worked as an Associate Lecturer at Oxford Brookes University, teaching the Criminology modules “Theories of Crime” as well as “Dealing with Drugs”.

Testimonials

I found the Online Research Programme classes very interactive. I was able to work one on one with my tutor, which meant that I could ask the questions which I found most important, and allowed me to go more in-depth into what I was most interested in.

My tutor had economics experience from university, which meant that I was able to experience what studying economics at university would be like. I found it was very personal to me because it allowed me to go into my own interests rather than taking a course that would cover a whole variety of economics.

- **SHREYA G**

I’m planning on pursuing medicine and cell biology in both A-level and university, so the programme showed me what it would be like to be taught at a higher level.

I found it very surprising how helpful my tutor was and how accommodating they were. They explained a lot of things over and over, and especially in one-to-one sessions beforehand, you got quite a bit of time to ask them questions about what you didn’t understand.

My tutor was very specialised in cell biology, which I found was very helpful because even in the lessons, if something wasn’t mentioned, they were able to use their own knowledge and explain it, which I found was very interesting because I learned some extra things along the way, too.

- **SHRADA G**

Fraser Pandit

FRASER'S BIO:

Fraser is an alumnus of the Business and Economics Online Research Programme and is currently completing his final year at SHORE School in Sydney. He hopes to pursue a career in corporate strategy, building on his interest in law and business, while remaining actively engaged in team sports especially cricket.

How has globalisation affected the Australian and Chinese economies?

ABSTRACT

Globalisation, defined as the increasing integration of economies through trade, capital flows, labour mobility and technology (Stiglitz, 2002), has been a transformative force in economic development. This paper presents a comparative analysis of globalisation's impact on the Australian and Chinese through a triadic framework of economic growth (EG), income inequality, and environmental sustainability. By examining literature, empirical data, and case studies, the analysis highlights the divergent strategies employed by these nations to leverage opportunities while mitigating risks associated with. Findings underscore the importance of tailored polices addressing unique vulnerabilities while capitalising growth prospects.

INTRODUCTION

China and Australia demonstrate distinct economic models and implementation strategies shaping their respective development and global integration. China has propelled its "Socialism with Chinese characteristics" through state-driven strategies and Deng Xiaoping's 1978 economic reforms, which facilitated China's entry into the global market by enhancing trade, financial flows, and technological exchange. Conversely, Australia has embraced liberal market-orientated reforms, fostering a diversified economy closely integrated into global markets.

While both countries have experienced strong EG due to globalisation, their approaches have diverged, particularly regarding income distribution and environmental sustainability. China has grappled with rising income disparities and environmental degradation, prompting initiatives such as the 'Prevention of Air Pollution Plan'.

In contrast, Australia has achieved relatively high-income equality relative to OECD standards through its 'transfer payment system and implemented environmental management strategies to lower CO2 emissions. Yet, challenges continue to persist through Australia's resource exports-iron ore, LNG, and coal-being highly elastic to global demand, with economic reliance intensified by China's dominance as its principal trade partner.

LITERATURE REVIEW

Globalisation impact on EG is well-documented, but standardised policies risk increasing economic instability through structural inequalities Stiglitz, 2002). The primary tenet of Stiglitz's book Globalization and Its Discontents (2002) is: pro-globalisation policies yield significant benefits when tailored to a nation's context. Conversely, poorly conceived policies that adopt a 'cookie cutter model' risk imposing substantial economic and social costs. Similarly, Dani Rodrik's "globalisation trilemma" highlights the trade-offs between economic integration, national sovereignty and democratic governance, advocating for "smart globalisation" that balances comparative advantage with heterodox approaches (Rodrik, 1998). He suggests hyper-globalisation, marked by rapid trade liberalisation and capital mobility, erodes domestic policy autonomy and exacerbates inequality.

Milanovic (2005) proposes that globalisation exacerbates income inequality both within and between nations. He introduces the "globalisation paradox" where integration raises income for middle-class workers in emerging markets via capital accumulation yet depresses wages for low-skilled workers in developed economies.

In turn, he emphasises the need for progressive taxation, redistribution mechanisms, and social safety nets to offset inequality, ensuring inclusive growth. Sachs (1998) also contends that globalisation spurs inequality, particularly within developed nations. He comments that wage stagnation and job displacement among low skilled workers are exacerbated by offshoring and automation - tools of globalisation. However, he advocates that it has spurred poverty alleviation and growth in developing countries through trade liberalisation, capital inflows and technology diffusion.

On environmental sustainability, Grossman and Krueger (1995) identify three channels of globalisation's: technology transfer, composition effects, and scale effects. Using the Environmental Kuznets's Curve (EKC), an inverted U-shape relationship between EG and environmental degradation, they argue initial growth intensifies pollution due to scale effects, but at higher income levels, technological advancements and structural shifts towards service industries reduce environmental degradation. Further, Stagl (1999) links the composition effect to environmental benefits, but argues that early growth stages see the scale effect dominating, degrading environmental quality, as reflected in the EKC, where the relationship between growth and environmental degradation is initially positive before reversing.

DATA AND METHODOLOGY

Data is collected from multiple sources. GDP and FDI data for China and Australia are sourced from the World Bank's World Development Indicators, while Gini coefficient data is obtained from the World Bank and national statistics. Environmental data, including carbon emissions, is sourced from the Global Carbon project. By combining these data sources as well as domestic bank reports, from the four majors – Commonwealth Bank (CBA), National Australia Bank (NAB), ANZ, Westpac and the Reserve Bank of Australia (RBA), an analysis of the impact of globalisation is achieved.

The methodology incorporates several econometric models, including tariff diagrams to illustrate the effects of trade liberalisation, Lorenz curve and the Gini coefficient to measure income inequality, and the theory of comparative advantage to explore global trade patterns. Additionally, the EKC is used to analyse the relationship between EG and environmental degradation. A National Minimum Wage (NMW) graph is employed to assess the impact of wage -policies on income distribution.

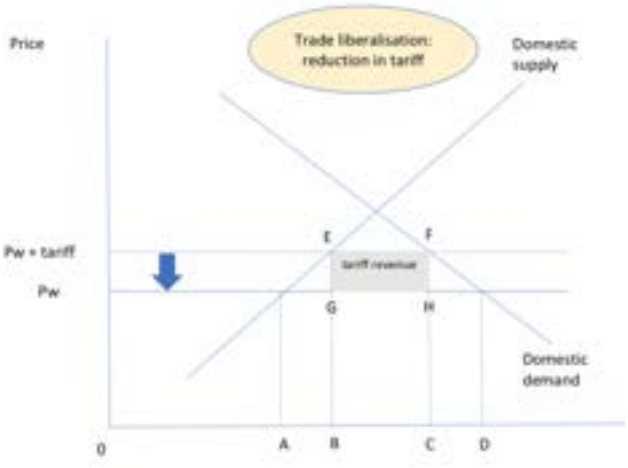


Figure 1 - Trade liberalisation: Reduction in tariff

RESULTS

China and Australia exhibit distinct EG pathways, shaped by their unique political and economic strategies rendered to the divergent impacts of globalisation. China's rise has been bolstered by the Open Door Policy, Special Economic Zones (SEZs), and trade liberalisation post-WTO entry in 2001. This free trade stance is illustrated on the tariff diagram below, wherein a reduction in tariffs from Pw + tariff to Pw increases imports from BC to AD, and subsequently reduces domestic supply from OB to OA, prompting businesses to enhance technical efficiency.

The introduction of SEZs drove a 250% surge in foreign direct investment (FDI), sustaining an annual growth of nearly 10% from 1979 to 2017. Globalisation enabled China to harness its productive capacity in targeted industries by utilising the Ricardian theory of comparative advantage, enabling its expansion into global export markets, contributing $3.4 trillion (T) to annual GDP ($17.96 T) in 2023. The progress towards free trade in China can be seen in the average tariff decreasing from 35% in 1988 to 3.39% in 2019 highlighting the positive impact of globalisation on economic growth. Although the focus of China's policy makers has changed towards a domestic consumption focus (now 58.8% of GDP), major globalisation programs such as "One Belt One Road" are still being implemented with reading success. The benefits of global trade stem from the efficiency gains of free trade, which reallocates resources toward industries with the greatest comparative advantage, boosting global output, EG, and employment. These gains are amplified through specialisation and economies of scale. China, moving beyond its role as the 'world's factory,' manufacturing declining from 32% to 26% of GDP since 2007, has shifted towards 'high value' sectors such as solar panels and EVS. In doing so, they leverage a 70% rise in average schooling years since 2000 to align with its evolving comparative advantage.

In contrast, Australia has followed a path of financial and trade liberalisation, notably through microeconomics reforms in the 1980s deregulations, notably the floating of the AUD. Australia's comparative advantage in natural resources has enabled a record trade surplus and a current account surplus of 1.5% of GDP. The positive impacts of globalisation have enabled Australia to effectively use fiscal and monetary policy as macroeconomic tools fostering sustainable economic growth over the last 3 decades by implementing counter-cyclical measures. The Reserve Bank of Australia's (RBA) inflation target of 2-3% has enabled it to simultaneously achieve its 3 goals, by changing the OCR through the interest rate corridor, affecting market rates via the transmission mechanism. Additionally, the government's use of fiscal policy in tandem with monetary policy has strengthened economic growth whilst simultaneously reallocating resources to prevent market failure in the economy. However, the downside of financial liberalisation has been vulnerability to global economic fluctuations, particularly in trade relations. Whereas China, under the People's Bank of China, mixes growth promotion with financial stability, often involving significant state intervention. Both nations, however, continue to benefit from deepening global economic ties, despite the complexities of trade disputes and geopolitical tensions. China has also kept exchange rates artificially low over an extended period reducing the cost of its exports to gain global market share. Moreover, China's focus on EG through globalisation in coastal zones via the 'Open Doors Policy' has outpaced development in rural western regions exacerbating income inequality. The Gini coefficient, rose from 0.23 in 1980 to 0.44 in 2010. A lack of development and resources left western regions impoverished, prompting government intervention that improved the Gini to 0.38 by 2019.

Xi Jinping's 2021 'Common prosperity Agreement' built on earlier, less effective strategies like the 'Western Development Strategy' and successive '5-year plans,' enhancing income equality through job creation and infrastructure improvements that raised average real wages by 15%. Additionally easing 'hukou system' restrictions encouraged migration to SEZs, decreasing unemployment and the Gini coefficient. Despite these efforts, the impact of globalisation on income inequality in China remains pronounced, with urban areas earning 2.5 times more than rural regions. This inequality is compounded by environmental damage and uneven development, as evidenced by the development gap between Tibet (HDI 0.608) and Beijing (HDI 0.904). Additionally, the introduction of globalisation has further deepened these disparities, as the Gini coefficient rose to 0.481, reflecting widening income inequality between SEZs and non-SEZs.

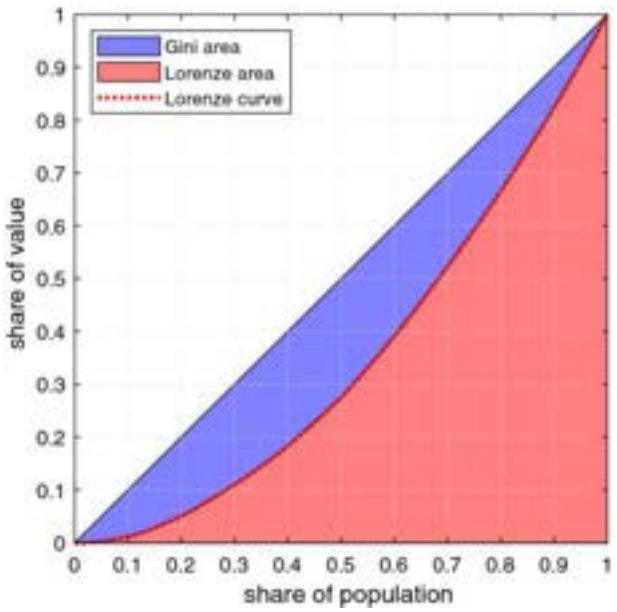


Figure 2 - Gini Coefficient: where 0 signifies perfect equality and 1 signifies perfect inequality

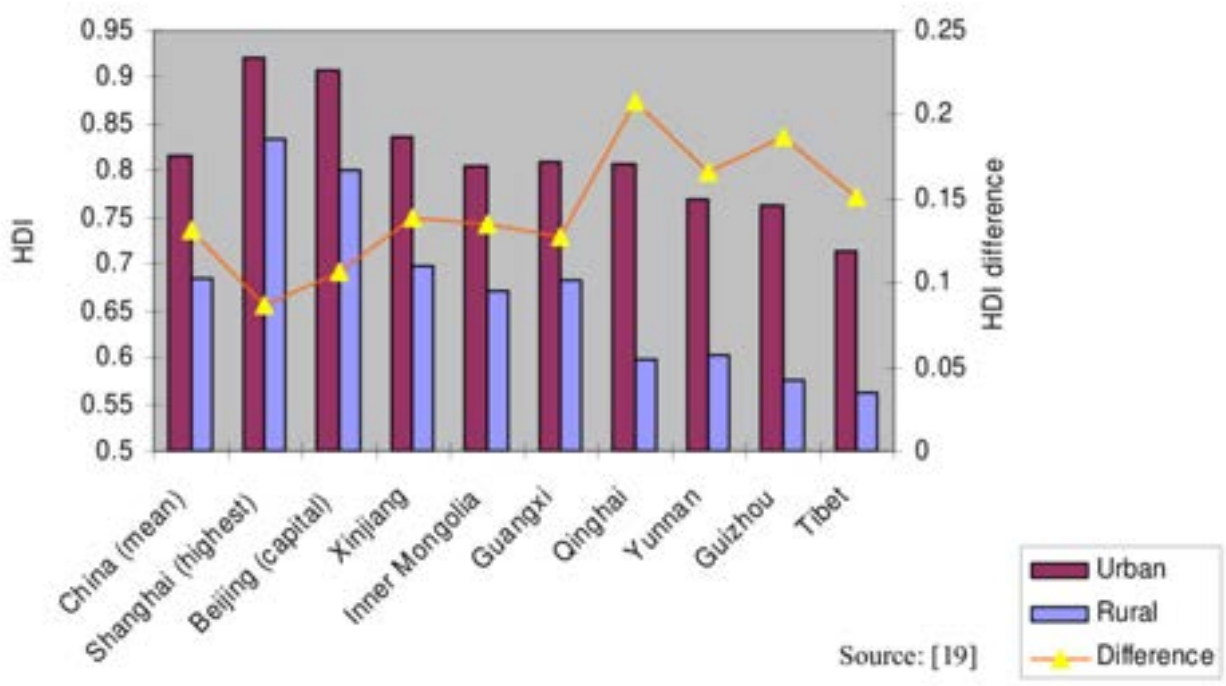


Figure 3 - Rural and Urban human development index (HDI) for Chinese provinces

In Australia, globalisation has influenced income distribution both directly and indirectly through its impact on market wages and government policy. Market wages, shaped by global competitiveness, have traditionally increased through individual and collective bargaining, exacerbating income inequality. However, recent increases to the National Minimum Wage (NMW) and award wages of 8.6% and 5.75% respectively, effective from July 2023, have improved income equity. The NMW functions price floor, ensuring wages for the lowest earners surpass market equilibrium thereby, reducing income inequality by raising wages for the most vulnerable workers. (W1 → NMW).

Globalisation has also expanded Australia's revenue base through increased trade and economic integration, enabling greater redistribution efforts. With 50% of government revenue from Pay As You Go (PAYG) tax and 40% of expenditure directed towards welfare, these funds primarily benefit the lower 20% of earners. Investments in public health, education, and affordable housing further support lower-income groups. Additionally, Australia's progressive tax system, where higher earners pay more, helps redistribute income. Despite the recent stage 3 tax cuts reducing progressivity, the overall system effectively reduces income inequality by adjusting tax thresholds and rates to favour lower earners. While globalisation has contributed to the widening wage disparities for some, these government measures demonstrate a commitment to addressing its negative effects and ensuring an equitable distribution of income.

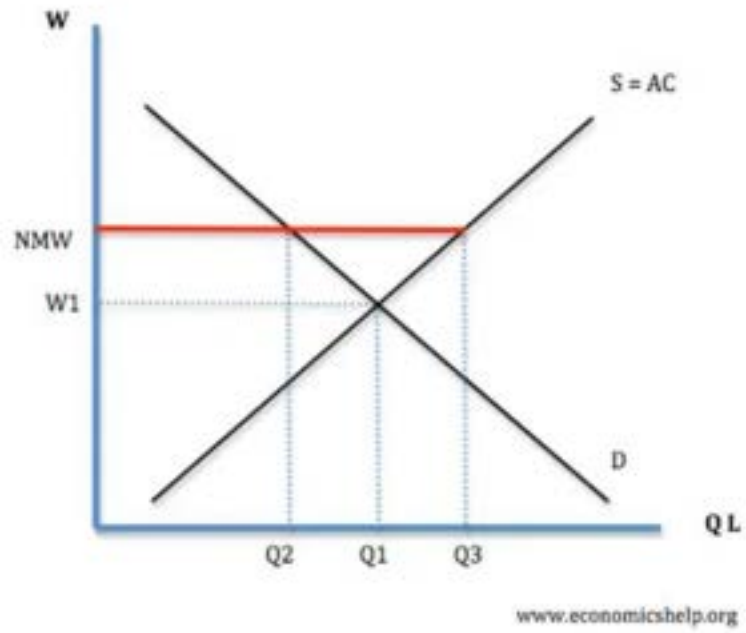


Figure 4 - NMW price ceiling graph

Furthermore, rapid economic growth in China, driven by globalisation and lenient environmental regulations, has led to severe environmental challenges. The World Bank noted in 2013 that China had 16 of the world's most polluted cities, with air pollution causing over a million premature deaths annually and reducing GDP by approximately 0.7% due to lowered productivity and agricultural yields. China's "pollute first, mitigate later" approach aligns with the environmental Kuznets curve, which posits that environmental degradation increases with economic growth up to a certain income level before improving.

However, China has yet reached such turning point, projected around 2030. Globalisation has intensified these environmental pressures, as China's role as the 'world's factory' has increased carbon emissions, making it the largest polluter, responsible for 23.5% of emissions in 2019. Efforts like the 2013 Prevention of Air Pollution Plan and partaking in the Paris Agreement (2015) aim to boost renewable energy production, which now accounts for 29% of electricity generation. Despite these advances, significant challenges persist with peak emissions anticipated by 2030.

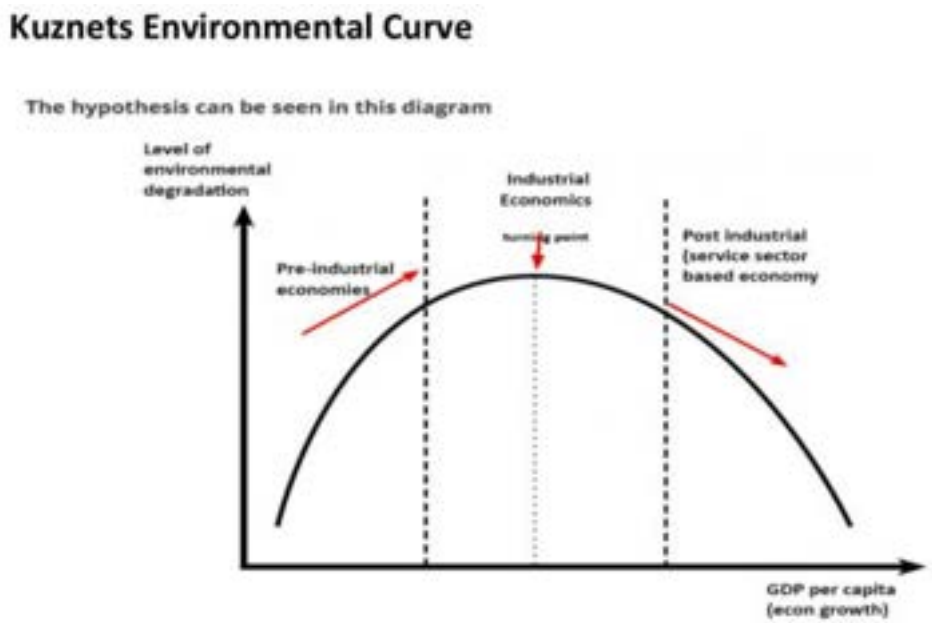


Figure 5 - EKC graph

Australia, as one of the world's highest per capita CO2 emitters, has utilised globalisation's influence to advance environmental sustainability through policies aligned with international agreements such as the Kyoto Protocols, Paris Agreement and Glasgow Pact. These commitments, driven by global economic integration, target a 43% reduction in emissions below 2005 levels by 2030 and net-zero by 2050. The EKC underpins this trajectory, suggesting that economic growth facilitated by globalisation enables greater investment in environmental protection, wherein AUS has achieved a 25% reduction in CO2 emissions from 2004. The government has effectively utilised tax incentives and subsidies to encourage the adoption of renewable technologies, notably in the solar energy sector. By taxing CO2-emitting processes and subsidising solar installations, both small-scale residential and large-scale industrial, Australia harnesses economic mechanisms to drive down emissions, showcasing a commitment to sustainable economic practices.

CONCLUSION

Globalisation has profoundly reshaped the economic trajectory of China and Australia, highlighting the contrasting strategies in achieving growth, equity and sustainability. While China's state driven model has spurred industrialisation and integration, it faces persistent inequality and environmental degradation. Conversely, Australia's market-oriented approach has achieved greater income equity and environmental progress but remains vulnerable to fluctuating global demand for exports. These contrasting outcomes underscore the critical importance of context-specific strategies in navigating globalisation and fostering sustainable development.

BIBLIOGRAPHY

Rodrik, D. (1998). Why do more open economies have bigger governments? Journal of Political Economy, 106(5), 997–1032. https://doi.org/10.1086/250038

Stiglitz, J. E. (2002). Globalization and its discontents. W.W. Norton & Company.

World Bank. (2023). World development indicators database. https://databank.worldbank.org

International Monetary Fund (IMF). (2023). World economic outlook. https://www.imf.org/en/Publications/WEO

Milanovic, B. (2005). Worlds apart: Measuring international and global inequality. Princeton University Press.

Piketty, T. (2014). Capital in the twenty-first century. Harvard University Press.

Organisation for Economic Co-operation and Development (OECD). (2023). Income inequality database. https://stats.oecd.org/Index.aspx

Ravallion, M. (2001). Growth, inequality, and poverty: Looking beyond averages. World Development, 29(11), 1803–1815. https://doi.org/10.1016/S0305-750X(01)00072-9

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. Quarterly Journal of Economics, 110(2), 353–377. https://doi.org/10.2307/2118443

Stagl, S. (1999). Delinking economic growth and environmental degradation? A literature survey on the environmental Kuznets curve hypothesis. European Commission Environment Directorate-General. https://ec.europa.eu/environment

Global Carbon Project. (2023). Global carbon budget report. https://www.globalcarbonproject.org

Australian Bureau of Statistics (ABS). (2023). Economic indicators. https://www.abs.gov.au

National Bureau of Statistics of China (NBS). (2023). Statistical communiqué. http://www.stats.gov.cn

Reserve Bank of Australia (RBA). (2023). Statement on monetary policy. https://www.rba.gov.au

People's Bank of China (PBoC). (2023). Annual report. http://www.pbc.gov.cn
United Nations Conference on Trade and Development (UNCTAD). (2023). World investment report. https://unctad.org

World Trade Organization (WTO). (2023). Trade statistics. https://www.wto.org

Paris Agreement. (2015). United Nations Framework Convention on Climate Change. https://unfccc.int

Australian Government Department of Climate Change, Energy, the Environment and Water. (2023). Australia's climate policy framework. https://www.dcceew.gov.au

China's Ministry of Ecology and Environment. (2023). Policy reports. http://www.mee.gov.cn

BIBLIOGRAPHY

Garnaut, R. (2008). The Garnaut climate change review. https://garnautreview.org.au

Krugman, P. (1995). Growing world trade: Causes and consequences. Brookings Papers on Economic Activity, 1995(1), 327–377. https://www.brookings.edu

Stern, N. (2007). The economics of climate change: The Stern review. Cambridge University Press.

Wei, S.-J., & Zhang, Z. (2011). The competitive saving motive: Evidence from rising sex ratios and savings rates in China. Journal of Political Economy, 119(3), 511–564. https://doi.org/10.1086/660887

Garnaut, R. (2020). Reset: Restoring Australia after the great crash of 2020. Black Inc.

Stiglitz, J. E., & Stern, N. (2021). The sustainability imperative: International lessons on policy, growth, and environmental cooperation. World Bank Publications.

JUDGE'S FEEDBACK:

Fraser showed a clear grasp of Australia's economic situation and its relationship to the global and Asian economies. He contributed a sophisticated response to a task on the negative effects of globalisation. His final project gave an overview of key historical texts and summarised arguments from Stiglitz and Rodrik, as well as insights from Australian economists.

FRASER'S TIPS:

- Don't try to read everything, instead dig deep into a few great sources instead of skimming dozens. Slowing down with one complex idea can actually take your research way further than gathering a heap of quick quotes.
- Make your notes messy and honest. Jot down what you agree with, what confuses you, and any random thoughts that pop up. It's not just about collecting facts, it's about figuring out what you actually think.
- If you hit a moment where nothing makes sense or you start questioning everything, that's not a bad sign. Some of the best insights show up when you're unsure or slightly uncomfortable, so stick with it and see where it takes you.

Oriane Mboua

ORIANE'S BIO:

My research explores the phenomenon of microtrends, a byproduct of the fast fashion industry characterized by rapid production and disposal of clothing. With the rise of digital platforms like Instagram and TikTok, trends have gained widespread exposure, influencing consumer behavior and shaping the way fashion is consumed. The paper examines the intersection of globalization, digital connectivity, and consumer behavior, highlighting the economic and social implications of our evolving relationship with clothing.

The Wash, Rinse, Repeat Cycle of Consumerism: Understanding Micro Trends

ABSTRACT

Microtrends, a byproduct of the fast fashion industry, have emerged as a cyclical phenomenon characterized by rapid mass production and even swifter disposal of clothing items. Although fashion has historically been an outlet for self-expression, its function has undergone a dramatic change in the last few decades. Accessibility has always been a key factor in the way we consume clothing; technological advancements have allowed for the broadcasting of these trends to larger audiences. Social media platforms such as Instagram or TikTok have allowed for the massive exposure of trends to consumers. By examining the intersection between globalization, digital connectivity, and consumer behaviour, this paper aims to shed light on the economic and social implications of our rapidly evolving relationship with clothing and style.

By examining the intersection of globalization, digital connectivity, and consumer behaviour, this paper sheds light on the economic and social implications of our rapidly evolving relationship with clothing and style. Utilizing secondary research, it examines the ease of impulsive purchases, a defining characteristic of microtrend consumption, through digital platforms and globalized supply chains. Fast fashion companies like Shein, Zara, and H&M exploit this behaviour by leveraging advanced logistics and cost-efficient production models to flood markets with affordable, trend-driven products. While these practices democratize fashion, they also perpetuate overconsumption, environmental degradation, and unsustainable business models.

The trade-offs encountered by customers who value current trends above long-lasting, high-quality goods are also examined in this paper. This emphasizes the necessity of structural change in the fashion industry as well as increased consumer consciousness to strike a balance between environmental responsibility and cultural trends.

Keywords: consumerism, consumer behaviour, microtrends, fast fashion

THE WASH, RINSE, REPEAT CYCLE OF CONSUMERISM: UNDERSTANDING MICRO TRENDS

Microtrends are the phenomena in which the cycle of trends is accelerated and short-lived. In our current society, this tendency is mostly prominent within the fashion industry. Trends within the fashion industry may be traced back to ancient times, or the 14th century; yet this gradual decrease relating to the life spans of these trends has mainly amassed acknowledgement in the 20th century. Fashion began to shift from a convenient necessity to a method of self-expression around this time period. This shift in consumer behaviour catalyzed increased demand for diverse, rapidly produced clothing, leading to a process known as fast fashion.

Fast fashion prompts overconsumption, a form of excessive consumerism that directly interconnects with the rise of microtrends. The issue with these rapid cycles is their impact on our methods of consumption and on our external environment. Microtrends encourage individuals to purchase based on trendy status items instead of an actual need; they also push out this instinctual need to fit in and keep up with others. Individuals frequently pursue these trends seeking instant gratification and external validation, diverging from fashion's intended purpose of self-expression and personal style. Simultaneously, corporations contribute to perpetuating this cycle of rapid consumption and substantial waste, exploiting this consumer behaviour tendency for profit. Although there are negatives associated with this process, it may also play a beneficial role in our culture. Certain communities have used microtrends to promote sustainability. For instance, upcycling, aims to minimize waste by encouraging microtrends for the transformation of old pieces of clothing into new ones.

LITERATURE REVIEW

The previous research conducted on microtrends and its correlation to consumer behaviour highlights various concepts. Diantari (2021) claims that the fashion industry is impacted by cycles of trends. Consumers often view trends as obsolete, leading to overconsumption of fast fashion products with the latest trends, creating a need for impulsive and addictive shopping behaviour. Diantari states, "Perceived obsolescence raises the perception that the old clothes you have are no longer suitable for use when new products with the latest fast fashion trends are launched." She adds that fast-fashion, known to market ready-to-wear products to each socioeconomic class, allows for an offering of the latest trends for affordable prices. While this accessibility democratizes fashion, it also fosters impulsive purchasing habits and highlights the environmental and ethical challenges posed by the fast fashion industry. The research stresses that consumers must adopt more conscious purchasing habits and recognize the negative impacts of fast fashion on our environment.

Another research study argues that social media is the main cause behind this phenomenon, expanding on Diantari's research. Buck, Herzog, Gomez, and Barrera (2024) claim that fast fashion marketing and social media are large factors influencing consumer behaviour regarding fashion overconsumption. The length of fashion trends has increased with platforms such as Instagram or TikTok.

Certain demographics are more likely to engage with this form of consumption, with Generation Z being the main target encouraged to interact with this system through influencer marketing and advertisements. COVID-19 has sparked consumerism online rather than in-person shopping; now, individuals prefer online marketplaces, including Shein.

"Shein Hauls" are massive excessive hauls of clothing and accessory items typically uploaded on social media by influencers. Many engage with this content in an attempt to maintain relevancy. This pressure to abide by overconsumption leads society to participate in the promotion of unsustainable business models that utilize environmental and ethical concerns. Buck et al. (2024) state, "If a consumer has a positive attitude towards their favourite social media influencer, it is more likely that they will engage in overconsumption. Emotional attachment to fashion belongings creates a lasting bond between the garment and the consumer." The authors argue that fast fashion, in contrast to slow fashion — which builds this "friendly" relationship with consumers allowing them to decrease impulsive purchases and remain eco-conscious — instead lacks awareness regarding the social and environmental impacts of fashion, which fuels overconsumption.

There are variables on perceptions of consumption that were discovered by the authors. These include consumers' perceptions of social media influencers, emotional attachment to fashion belongings, lack of knowledge of environmental and social impacts, self-esteem, and its influence on purchasing habits. Another article labels this concept as "attention deficit fashion" (ADF) and argues that the evolution of technology is directly connected to consumption. With brands constantly attempting to reach customers, they consistently utilize micro-content. The term deficit relates to the short attention spans.

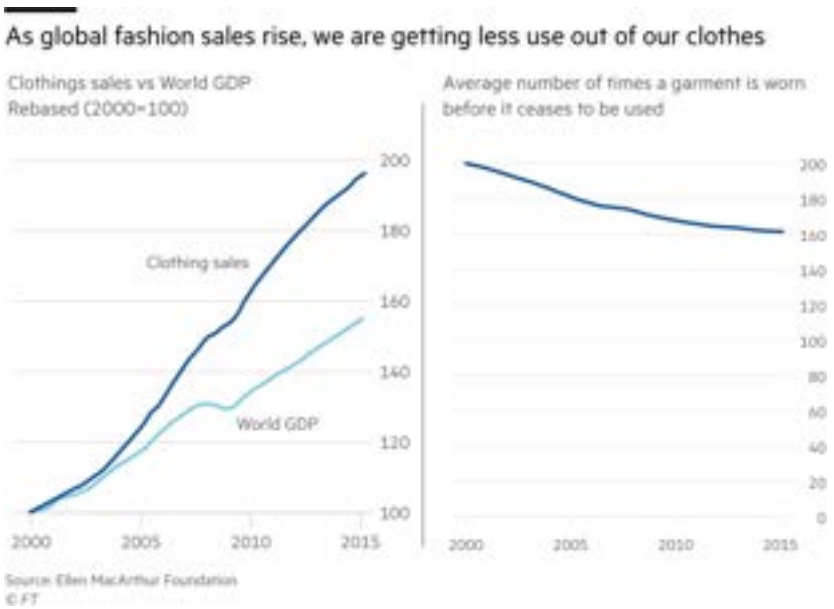
DATA AND METHODOLOGY

Secondary research is the main method utilized in this research paper. Different sources were employed, leveraging existing large datasets to reveal patterns and trends in consumer behaviour related to microtrends. The research is explanatory, attempting to convey the correlation between microtrends and consumer behaviour.

Recent statistics, created in 2023, suggest that impulsive purchasing decisions have been made by 84% of shoppers. Impulse buying is distinguished by a lack of planning, driven by the need for immediate satisfaction. Another survey discovered that Generation Z and Millennials are four times more likely to make purchases on social media than older generations. These data points display the primary demographics target by impulse purchases.

The relationship between clothing sales and how fast we discard our clothes is illustrated in graph 1. Overconsumption is exacerbated through this activity. Microtrends emerge as a result of trend cycles being significantly propelled by globalization. Digital platforms facilitate digital connectivity, allowing trends to be shared quickly and creating a growing demand for new products. Advanced logistics and technology, convoluted worldwide supply chains, and lower labour costs through production outsourcing all contribute to the cost-effective acceleration of apparel production and delivery.

Clothing can now be readily classified as out-of-date due to globalization, which encourages discarding. The wide selection of trendy garments available to consumers at affordable costs drives consumers to make regular purchases. Impulsive adoption of new trends has become easier for consumers with the existence of online shopping.



Graph 1. Graph displaying the effects of globalization on how much we use our clothes. Source: Ellen MacArthur Foundation, as cited in Financial Times (2020).

Global supply chains and internet platforms have made fashion more accessible to consumers, yet they also create economic trade-offs that oblige buyers to constantly reevaluate the benefits and opportunity costs of their choices. Individuals allocating their funds towards trend-driven purchases compared to essential long-term needs is a crucial trade-off. The opportunity cost associated with this trade-off is the potential long-term value lost by consistently choosing short-lived trendy items over durable, quality products. Consumers often face a trade-off between immediate gratification and long-term financial stability. The money spent on impulse purchases driven by microtrends could have been saved or invested elsewhere.

Solely within a perfect competition market may microtrends maintain their current rise. A perfect market is characterized by an economic model in which there are no monopolies and prices are purely based on supply and demand, with a small market share.

The fuel for these trends are the countless companies mass-producing various sorts of clothing items for cheap costs and discarding them. Shein, Zara, Forever21, and H&M are the most recognized companies in mass production. Often criticized for their disregard for sustainable production practices, these companies contribute to the manufacturing of microtrends and fill landfills with excess clothes.

Among fast fashion companies, Shein is the biggest offender in terms of unsustainable practices and environmental impact. In 2023, the company emitted 16.7 million metric tons of carbon dioxide, comparable to four coal power plants. Shein's carbon footprint is further increased by its heavy reliance on air delivery, in contrast to other well-known brands. Shein's business strategy significantly increases water pollution and textile waste. Just 6% of their textiles are recycled, and 76% of them are composed of polyester. The company's extensive use of polyester and other synthetic fibres greatly increases the pollution caused by microplastics.

Furthermore, this short-lived cycle of trends is supported by its comparative advantage. A comparative advantage, first defined by David Ricardo in 1817, occurs when one entity provides a product at a lower opportunity cost than another. Utilizing their comparative advantage, businesses may rapidly adapt to and profit from microtrends. Fast fashion stores, such as Shein, have a competitive advantage in creating fashion apparel at cheaper prices, allowing them to respond to new microtrends. Businesses with a comparative advantage in data analysis and trend forecasting are better able to spot and react to microtrends than their rivals, which gives them a competitive edge in the quick-changing fashion industry.

RESULTS

In summary, the connection between consumer behaviour and microtrends can be understood through various key factors. These include the impact of influencers and public figures, the effects of globalization such as reduced labour costs and increased accessibility, the role of advanced technologies, consumers' limited awareness of environmental and social consequences, and issues related to low self-esteem. These elements influence the connection between rapidly changing trends and consumer purchasing patterns.

BIBLIOGRAPHY

Adams, C., Alldredge, K., & Kohli, S. (2024, June 10). State of the consumer 2024: What's now and what's next. McKinsey & Company. https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/state-of-consumer

Balchandani, A., Rölkens, F., D'Auria, G., Barrelet, D., & González Méndez, P. (2024, November 11). The state of fashion 2025: Challenges at every turn. McKinsey & Company. https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion

Buck, C., Herzog, M., Gomez, A., & Barrera, A. (2024). Factors driving overconsumption amongst fashion consumers. https://scholarworks.calstate.edu/downloads/70795g794

Chomsky, R. (2023, September 12). Is Shein sustainable? A deep dive into fast fashion and ethical practices. Sustainable Review. https://sustainablereview.com/is-shein-sustainable-a-deep-dive-into-fast-fashion-and-ethical-practices/

Diantari, N. K. Y. (2021). Trend cycle analysis on fast fashion products. Journal of Aesthetics, Design, and Art Management, 1(1), 24-33. https://doi.org/10.58982/jadam.v1i1.101

Financial Times. (2020, November 13). Sustainable fashion? There's no such thing. Financial Times. https://www.ft.com/content/d174e7d7-97c4-43fc-8765-95075e5fcce7

Hush Digital. (2024, October 10). Microtrends: How culture & consumer habits are changing faster. Hush Digital. https://hush.digital/microtrends-how-culture-consumer-habits-are-changing-faster/#:~:text=Microtrends%20are%20fun%2C%20fast%2C%20and,consumer%20burnout%20and%20environmental%20issues

Invesp. (n.d.). The state of impulse buying persona – Statistics and trends 2023. Invesp - Conversion Rate Optimization Blog. https://www.invespcro.com/blog/impulse-buying/

Kitajima Mulkey, S. (2024, September 23). Shein is officially the biggest polluter in fast fashion; AI is making things worse. LAist. https://laist.com/news/climate-environment/shein-biggest-polluter-fast-fashion-ai

Lee, A. Y. (2022, February 18). Microtrends: The implications of what you see on your "For you" page. The Harvard Crimson. https://www.thecrimson.com/article/2022/2/18/microtends-fashion-think-piece-tiktok/

Mulkey, S. K. (2024, September 23). Shein is officially the biggest polluter in fast fashion; AI is making things worse. LAist. https://laist.com/news/climate-environment/shein-biggest-polluter-fast-fashion-ai

Reilly, A., & Hawley, J. (2019). Attention deficit fashion. Fashion, Style & Popular Culture, 6(1), 85-98. https://intellectdiscover.com/content/journals/10.1386/fspc.6.1.85_1

Suriarachchi, M. (2021, August 24). Micro-trends and overconsumption: Fashion consumerism in the 21st century. Cainz | Education, Network, Experience. https://cainz.org/10066/

Zhou, M. (2022, July 29). What are micro trends? How styles change faster than ever before. Good On You. https://goodonyou.eco/micro-trends/

JUDGE'S FEEDBACK:

Oriane's research project explored micro trends in consumerism and demonstrated a sound understanding of economic theory, particularly trade-off theory. Her written work showed clear engagement with issues such as globalisation's impact on the Canadian economy, including sectors like timber and mining. She effectively incorporated data and theory to analyse consumer behaviour and structural inequality, producing a thoughtful and well-organised piece of economic research.

ORIANE'S TIPS:

- Dive deeply into your research. Experiment with different keywords to streamline the process.
- Read extensively. Focus on high-quality work, analyze what makes it effective, and incorporate those insights into your own work.

Sophie Lozowska

SOPHIE'S BIO:

Sophie Lozowska is an alumna of the Immerse Education Online Research Programme in Chemistry. She is deeply interested in the psychological and biochemical foundations of human attraction and bonding. During the summer before her final year of high school, she pursued her passion for biomolecular research at Ludwig Maximilian University of Munich, where she worked with human organoids. Sophie is also passionate about educational policy, a field she looks forward to exploring further during her studies at Cornell University.

The biochemistry of human pheromones: Investigation of molecular existence

ABSTRACT

The debate on human pheromones has been an ongoing topic in research. While commonly cited human pheromones (androstenone, androstenol, androstadienone, estratetraenol) lack conclusive scientific validation due to methodological flaws and inconsistent evidence, many studies still identify a positive relationship between some human odorants and human behavior. This paper provides a critical overview of research on these 'putative human pheromones' by conducting an extensive investigation into the molecular misstatements in the methodologies of supporting studies. The research suggests that the most probable precursors of human pheromones are carboxylic acids and sulfur compounds. The main issue in testing any possible odors is their concentration, which is often disregarded and can only be accurately determined through rigorous bioassay. Only when a specific concentration that can impact behavior or physiology is established, can the reduced response to pheromones offer insights into their significance in modern social interactions.

INTRODUCTION

Pheromones are chemical cues used in communication within one species. They can be mainly split into two categories: releasers, that shape behavior changes, and primers, that influence development process by neuroendocrine responses. At the molecular level, pheromones can be structurally diverse and often consist of species-specific combinations of molecules rather than single compounds. These molecules are typically volatile, allowing them to be easily dispersed and detected by other members of the same species.

Pheromones have been discovered across the entire animal kingdom. One of the first observations in mammals came in the late 19th century when Darwin studied the breeding seasons of male goats. Pheromones play various roles depending on the species, including attracting mates, influencing mate selection, guiding trail following, and facilitating interactions between parents and offspring [2]. Nevertheless, a key aspect of pheromones is that, regardless of their specific function, the reactions they provoke appear to be "innate" within the species, despite individual variations in experience or context.

From an evolutionary perspective, it is highly likely that humans possess pheromones. Like other primates, we develop odor-producing secretions from apocrine glands during puberty, which accompany sexual maturation.

This suggests that, although our responses to pheromones may have weakened due to a lack of selection pressure, we likely still secrete them, like our closest relatives, the great apes. While great apes, like humans, don't rely as heavily on odor communication as other primates, they still have secretory glands that could produce pheromones, indicating a continued role for odors in our biology [12]. Moreover, relatively new findings claim that despite not having functional vomeronasal system believed to be specialized in pheromones detection, our main olfactory system should also enable us their recognition [8, 13]

Based on the above, over the past 50 years, many researchers have supported the existence of human pheromones through molecular findings; however, none of these studies have yet reached full scientific validity. The molecules in question include four androstene steroids: androstenone, androstenol, androstadienone, and estratetraenol. These compounds, often referred to as 'putative human pheromones,' were first presented by Monti-Bloch & Grosser at a 1991 conference sponsored by the EROX Corporation, which had commercial interests in human pheromones. While they suggested these molecules could function as pheromones, no details were provided on their extraction, identification, or bioassay, leaving no information to illustrate how these molecules were identified. The claims were built on the work of Jacob & McClintock, who cautioned that it was premature to label these steroids as human pheromones.

To address these ongoing debates and gaps in research, this paper aims to critically evaluate the current evidence supporting the existence and function of human pheromones. By examining recent studies, methodological approaches, and the molecular basis of these compounds, the objective is to provide a clearer understanding of whether these purported human pheromones play a significant role in human behavior and communication, and how their molecular mechanisms contribute to their potential effects.

CRITICISM AROUND COMMON "PUTATIVE HUMAN PHEROMONES"

The four the most often called "human pheromones" include: androstenone (5α-androst-16-en-3-one), androstenol (5 α -androst-16-en-3α-ol), androstadienone (Δ4,16-androstadiene-3-one) and estratetraenol (estra-1, 3,5 (10),16-tetraen-3-ol). According to Wyatt (2014), these molecules have been studied mostly in two waves. Between 1970-1990s, androstenone and androstenol were used as key molecules in pheromone research, but from 1991 and especially after 2000, androstadienone and estratetraenol emerged as the primary 'putative human pheromones,' based on unpublished identifications by a US corporation.

For independent onlookers or enthusiasts of science, the results corroborating pheromones existence seem highly probable as their molecular basis prompting steroid character is linked to other mammalian pheromones. Scientists seem to have experimentally proven their presence in human fluids like apocrine sweat or saliva, and what is more intriguing, different sensitivity to their concentration between female sand males [4]. Additionally, there is evidence of varying sensitivity to these compounds between males and females, and over 40 papers have reported physiological or psychological effects linked to these "putative human pheromones" since 2000 [2]. Although obtaining positive results, they have no scientific basis that could demonstrate the studied molecules as human pheromones.

Critics argue that positive results may be compromised by methodological flaws, such as small sample sizes, statistical errors, and publication bias [1]. For instance, the very low concentrations of androstenone and related steroids in axillary sweat limit generalizability, and many individuals cannot even detect these compounds.

In fact, a study by Nixon et al. (1988) found that only 10 out of 24 males had detectable levels of these steroids in their sweat. On the other hand, some studies face the lack of peer review and a paucity of cause-and-effect clarification, which may be mistaken for effects generated by non-pheromone odors that impact human mood. This has created a self-reinforcing cycle in which the popularity of androstadienone and estratetraenol in research, despite limited evidence, leads to studies and citations building upon each other, thereby perpetuating the belief in these molecules as pheromones without rigorous validation [2].

SIGNIFICANT DISCOVERIES USING OTHER APPROACHES

However, not all experiments are utterly unhelpful in the search for molecular bases of human attraction. For example, Wedekind's experiment with smelly t-shirts, where female participants rated the attractiveness of the shirts, is globally recognized as influential in evolutionary psychology. Although the term "pheromones" is not used in Wedekind's original paper, his research demonstrates that smells, particularly those related to the major histocompatibility complex (MHC), play a significant role in mate selection by influencing preferences based on genetic compatibility [19].

That is why many researchers continue to research pheromones by choosing different approaches, for example comparative anatomical studies. In 2009, using this approach scientists found out that the the humans' vomeronasal organ (VNO), also known as Jacobson's organ, compared to other animals' one is poorly developed [8]. While some people have a small structure resembling the VNO, it appears to lack the necessary neural connections to the brain and the specific receptors found in other mammals that are essential for pheromone detection.

However, despite traditional view, evidence suggests that both vomeronasal and main olfactory systems are involved in pheromonal communication, and not only Jacobson's organ. Thus, it can be concluded that humans even relying solely on the main olfactory system can perhaps detect pheromones. Furthermore, the pheromone molecules can act as ligands, binding themselves to specific receptors through a hydrophobic pocket, on the surface of sensory neurons in the vomeronasal organ or the main olfactory epithelium [20]. These receptors, such as V1Rs, V2Rs, and formyl peptide receptors (FPRs), are G protein-coupled receptors (GPCRs) specialized for pheromone detection. The binding of ligands to these receptors triggers intracellular signaling pathways, generating electrical signals that are sent to the brain, where they are processed to elicit behavioral responses.

POTENTIAL PHEROMONES CONTRIBUTING TO HUMAN AXILLARY ODOR

The precursors for potential pheromones in human axillary odor are metabolized locally and later secreted from axillary glands as odorless conjugates that are later converted into volatile odorants by bacterial enzymes. These precursors include carboxylic acids, such as 3-methyl-2-hexenoic acid (3M2H) and 3-hydroxy-3-methyl-hexanoic acid (HMHA), which are linked to a glutamine residue; sulfur compounds, released as odorant sulfur compounds from a cysteine–glycine dipeptide; and steroids like 5-α-androst-16-en-3α-ol, detected as a glucuronide conjugate in axillary secretions [9].

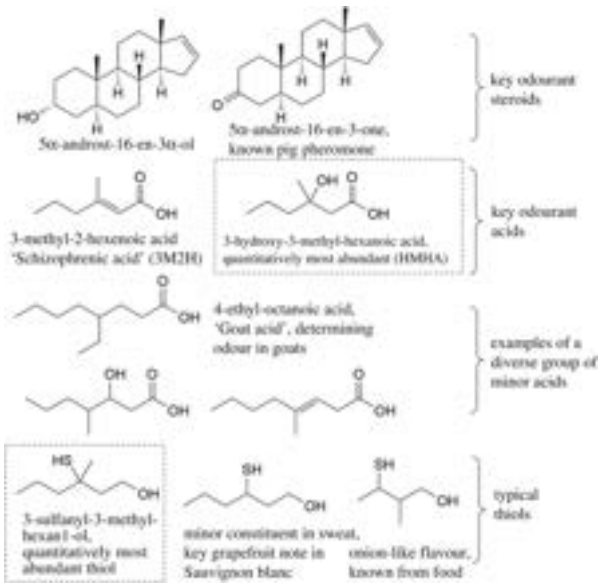


Figure 1. The structure of the known key human axilla odorants [9]

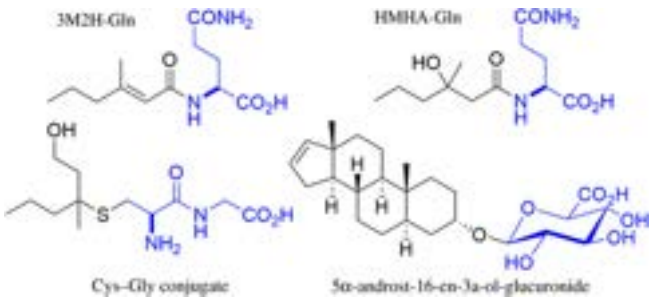


Figure 2. The structure of the three classes of odorants precursors [9]

Key odorous compounds, such as short, straight-chain fatty acids (e.g., hexanoic acid, octanoic acid, isovaleric acid), are present in sweat, but they are not the primary contributors to the characteristic axilla odor in sexually mature individuals with active apocrine glands [9]. Although initially believed that incomplete β-oxidation of long-chain fatty acids was the main cause of odor, this theory has been refuted in favor of the idea that the characteristic axillary scent is primarily linked to amino acid degradation products from bacterial breakdown of secreted proteins and dead keratinocytes. Therefore, the role of microbiome has become more notable as it synthesis these precursors into volatile fatty acids and other odoriferous compounds via enzymatic processes like hydrolysis, oxidation and fermentation.

Firstly, after being locally metabolized, odorless conjugates—such as carboxylic acids, sulfur compounds, and steroids—are transported into secretory vesicles via ABCC11, where they undergo processing by enzymes like γ-glutamyl transferase 1 (GGT1), dipeptidase, and β-lyase [9]. These enzymatic actions lead to the formation of a Cys-Gly conjugate, which is then cleaved by bacteria on the skin surface, releasing volatile sulfur compounds. Key functional groups, such as the thiol group in the GSH conjugate, play a crucial role in forming these volatile compounds, while amide groups in the glutamine side chain enhance enzyme specificity through hydrogen bonding. Once released, these low-molecular-weight thiols passively diffuse through the bacterial membrane and evaporate from the skin, forming the basis of axillary odor. The enzymes involved in this process are characterized by metal-binding domains containing zinc atoms essential for catalytic activity, with active sites featuring hydrophobic pockets that allow substrate flexibility.

TROUBLESOME METHODOLOGY

One of the main issues with previously mentioned studies advocating for the existence of "putative human pheromones" is their lack of suitable methodology. According to Wyatt (2014) the most reliable technique could be bioassay, an experimental method that helps tracking the effect of a substance to eventually determine the concentration at which a biology activity can take place. This way the established results could act as the minimum concentration at which the speculated pheromone could have any impact on a person, as it was in the case of bombykol, the first identified insect pheromone.

To accomplish that scientists would have to follow several steps just as Adolf Butenandt in 1959, when he used bioassay techniques to measure the attraction of male silkworm moths to the chemical released by females. The initial step requires observation of behavioral or physiological response that is hypothesized to be linked with a specific secreted chemical substance. Then, the bioactive molecules would have to be isolated, chemically identified and synthesized. The latter is essential to confirm that the proposed molecules, at natural concentrations, are both necessary and sufficient to replicate the original activity when tested with the initial bioassay.

Moreover, we should first stop using androstadienone and estratetraenol as stimuli, as there's no solid evidence they are 'human pheromones,' despite their common experimental use. To identify new molecules secreted among hundreds or thousands of other compounds from axillary areas, a subtractive analysis can be more effective. This approach involves directly comparing results from two or more groups of humans that differ by a specific trait, similar to how 4-ethyloctanal was identified as a key pheromone in goats despite its low concentration relative to other molecules [16].

Consequently, a promising next step in human pheromone research could involve comparing the volatile compounds emitted by adult males, females, and prepubescent children, with a focus on identifying molecules that appear with the maturation of sebaceous and apocrine glands during puberty [2].

Such study of volatile pheromones highlights the need for accurate, efficient, and non-invasive methods compared to traditional approaches like collecting odors on cotton pads. On of the primary techniques include Gas Chromatography-Mass Spectrometry (GC-MS) that separates volatile compounds through gas chromatography (GC) based on their boiling points and then identifies them via mass spectrometry (MS), which provides a molecular "fingerprint" of each compound. This method has been already instrumental in identifying key organoleptic contributors in axillary secretions [15]. Another promising approach involves identifying ligands for highly conserved human olfactory receptors (ORs), which are potentially under strong stabilizing selection due to their role in pheromone detection, though this remains largely theoretical due to limited knowledge of ligands for human ORs [18]. Furthermore, calcium imaging is a crucial technique used to study pheromone receptors by observing changes in calcium levels in response to pheromone binding, allowing researchers to track these ligand-receptor interactions in real-time [8].

DISCUSSION ON EVOLUTION

Given the speculative roles of pheromones in mate selection, kin recognition, social bonding, and health detection through axillary odor, understanding the function of the vomeronasal organ in early humans is increasingly important for the debate on the evolution of chemical communication. The dormant state of the vomeronasal organ (VNO) sheds light on how humans have become less reliant on axillary odors for social interactions and mate selection. This adaptation is evident in the ABCC11 gene mutation, particularly prevalent in East Asian populations, which affects the production of odor precursors in sweat. Cultural factors may have influenced this evolutionary shift, leading to a diminished role of body odor in social dynamics [10]. Consequently, individuals with this mutation may not have faced significant disadvantages in social interactions or mate selection, reflecting a potential loss of the adaptive advantage once provided by body odor.

It cannot be omitted that humans' responses to odors are often subtle and often context-dependent. Therefore, to prove such evolutionary theories about olfactory communication, it is pivotal to examine less culturally influenced populations, such as infants. For instance, Doucet and Montgomery's research on infant and maternal odor detection demonstrates that newborns exhibit an instinctive response to the odors secreted by any lactating mother, not just their own, highlighting the fundamental role of olfactory cues in early bonding. Thus, understanding these primal interactions can provide insights into the evolutionary significance of olfactory communication.

CONCLUSION

Despite extensive research, progress in establishing the existence of human pheromones remains limited, primarily due to methodological challenges and inconsistent findings. Although there is evidence suggesting the presence of potential human pheromones, scientific validation is incomplete. Addressing these gaps requires rigorous bioassays and advanced chemical analysis techniques, emphasizing the need to study natural behaviors and avoid assumptions based on cross-species data. However, promising avenues for future research include the identification and analysis of specific molecules, such as carboxylic acids and sulfur compounds, using refined methodologies emerges. Additionally, the evolution of human olfactory communication—evidenced by changes in the vomeronasal organ and cultural shifts in body odor perception—indicates a reduced role for pheromones in modern social interactions. By focusing on less culturally influenced populations, such as infants, researchers can gain clearer insights into the molecular basis of pheromones and their evolutionary significance in human behavior.

BIBLIOGRAPHY

1. Wyatt TD. The search for human pheromones: the lost decades and the necessity of returning to first principles. Proceedings of the Royal Society B: Biological Sciences. 2015 Apr 7;282(1804):20142994.

2. Wyatt TD. Pheromones and animal behavior : chemical signals and signatures. Cambridge, United Kingdom: Cambridge University Press; 2014.

3. Wikipedia Contributors. Richard L. Doty [Internet]. Wikipedia. Wikimedia Foundation; 2023 [cited 2024 Aug 21]. Available from: https://en.wikipedia.org/wiki/Richard_L._Doty

4.Nixon A, Mallet AI, Gower DB. Simultaneous quantification of five odorous steroids (16-androstenes) in the axillary hair of men. Journal of Steroid Biochemistry. 1988 May 1;29(5):505–10.

5. Wyatt TD. Reproducible research into human chemical communication by cues and pheromones: learning from psychology's renaissance. Philosophical Transactions of the Royal Society B: Biological Sciences. 2020 Apr 20;375(1800):20190262.

6. Monti-Bloch L, Grosser BI. Effect of putative pheromones on the electrical activity of the human vomeronasal organ and olfactory epithelium. The Journal of Steroid Biochemistry and Molecular Biology [Internet]. 1991 Oct 1;39(4, Part 2):573–82. Available from: https://www.sciencedirect.com/science/article/abs/pii/0960076091902554

7. Jacob S, McClintock MK. Psychological State and Mood Effects of Steroidal Chemosignals in Women and Men. Hormones and Behavior. 2000 Feb;37(1):57–78.

8. Tirindelli R, Dibattista M, Pifferi S, Menini A. From Pheromones to Behavior. Physiological Reviews. 2009 Jul;89(3):921–56.

9. Natsch A, Emter R. The specific biochemistry of human axilla odour formation viewed in an evolutionary context. Philosophical Transactions of the Royal Society of London Series B, Biological Sciences [Internet]. 2020 Jun 8;375(1800):20190269. Available from: https://pubmed.ncbi.nlm.nih.gov/32306870/

10. Yoshida K, Yamashita H, Conroy S, Marks M, Kumar C. A Japanese version of Mother-to-Infant Bonding Scale: factor structure, longitudinal changes and links with maternal mood during the early postnatal period in Japanese mothers. Archives of Women's Mental Health. 2012 Jun 26;15(5):343–52.

11. Robinson C. The Biochemistry of Attraction. Journal of Student Research at Indiana University East [Internet]. 2021 Jun 13;3(1):126–39. Available from: https://scholarworks.iu.edu/journals/index.php/jsriue/article/view/31822/36526

12. Stevenson RJ. An Initial Evaluation of the Functions of Human Olfaction. Chemical Senses [Internet]. 2010 Jan 1;35(1):3–20. Available from: https://academic.oup.com/chemse/article/35/1/3/305000

13. Baxi KN, Dorries KM, Eisthen HL. Is the vomeronasal system really specialized for detecting pheromones? Trends in Neurosciences. 2006 Jan;29(1):1–7.

14. Gower DB, Holland KT, Mallet AI, Rennie PJ, Watkins WJ. Comparison of 16-Androstene steroid concentrations in sterile apocrine sweat and axillary secretions: Interconversions of 16-Androstenes by the axillary microflora—a mechanism for axillary odour production in man? The Journal of Steroid Biochemistry and Molecular Biology. 1994 Mar;48(4):409–18.

BIBLIOGRAPHY

15. Cotton S. In pursuit of Bombykol [Internet]. RSC Education. 2000. Available from: https://edu.rsc.org/feature/in-pursuit-of-bombykol/2020169.article

16. Murata K, Tamogami S, Itou M, Ohkubo Y, Wakabayashi Y, Watanabe H, et al. Identification of an Olfactory Signal Molecule that Activates the Central Regulator of Reproduction in Goats. Current Biology. 2014 Mar;24(6):681–6.

17. Penn DJ, Oberzaucher E, Grammer K, Fischer G, Soini HA, Wiesler D, et al. Individual and gender fingerprints in human body odour. Journal of The Royal Society Interface. 2006 Nov 28;4(13):331–40.

18. Peterlin Z, Firestein S, Rogers ME. The state of the art of odorant receptor deorphanization: A report from the orphanage. Journal of General Physiology. 2014 Apr 14;143(5):527–42.

19. Wedekind C, Seebeck T, Bettens F, Paepke A. MHC-Dependent Mate Preferences in Humans. Proceedings: Biological Sciences [Internet]. 1995 [cited 2024 Aug 21];260:245–9. Available from: https://www.coherer.org/pub/mhc.pdf

20. Malnic B. Searching for the Ligands of Odorant Receptors. Molecular Neurobiology. 2007 Jun 19;35(2):175–81.

21. Doucet S, Soussignan R, Sagot P, Schaal B. The Secretion of Areolar (Montgomery's) Glands from Lactating Women Elicits Selective, Unconditional Responses in Neonates. Hausberger M, editor. PLoS ONE. 2009 Oct 23;4(10):e7579.

JUDGE'S FEEDBACK:

Sophie demonstrated understanding of the differences between organic and inorganic compounds, halogenoalkanes, aldehydes and ketones, amines, benzene reactivity, and laboratory techniques. Her project synthesised information from various sources and applied biochemical principles. It reflected critical thinking and tackled challenging questions. She also showed understanding of experimental chemistry techniques and reaction mechanisms.

SOPHIE'S TIPS:

- When beginning a research project, start by exploring both online and physical sources in depth. This helps you understand what has already been said and identify areas you're genuinely eager to explore. I personally find it helpful to organize all my notes in a single Google Doc, using a two-column format: on one side, I list article titles and links; on the other, I group key themes with keywords, quotes, and notes beneath them. This structure allows me to quickly see connections and shape coherent paragraphs.

- In scientific research especially, it's essential to build on existing work—acknowledge prior findings but aim to present new links and conclusions. Incorporating graphics can be incredibly useful, both to clarify your argument for visual learners and to keep your own thinking on track. Finally, always talk to your tutors! They're not only there to help but are often interested in similar topics, making conversations with them a great opportunity to learn and grow.

Niharika Gandhi

NIHARIKA'S BIO:

Niharika is a Class of 2025 student at Prometheus School with a strong interest in economics, finance, and data analytics. She has interned in data analysis, completed online courses to build practical skills, and co-founded Nazariya, a nonprofit promoting financial literacy among teens. She also serves as Editor-in-Chief of her school's Theory of Knowledge magazine. She plans to study economics and finance at university.

How do cognitive biases, such as the scarcity effect and anchoring bias, influence purchasing decisions on e-commerce platforms across different demographic groups?

ABSTRACT

This study explores the influence of cognitive biases, particularly scarcity and anchoring, on purchasing decisions across various demographic groups on e-commerce platforms.

Cognitive biases, such as those discussed by Tversky and Kahneman (1974) and further elaborated in dual-process theory, are mental shortcuts that impact consumer judgment and decision-making. The literature review highlights how biases, like the anchoring e3ect and scarcity e3ect, are leveraged by retailers to manipulate consumer behavior, as seen in common e-commerce strategies such as price discounts and limited-time o3ers.

An experiment involving 249 participants across three product categories—Bluetooth headphones, toothpaste, and casual T-shirts—was conducted to test the impact of these biases. The results revealed that scarcity was the stronger bias, significantly a3ecting the purchase intentions for luxury items like headphones, where psychological factors such as exclusivity played a crucial role. Anchoring had a noticeable but lesser e3ect, particularly on pricing decisions. Demographic factors such as age, gender, and shopping frequency influenced susceptibility to these biases.

Younger consumers were more likely to be a3ected by both biases, while older consumers demonstrated a more rational decision-making approach, focusing on practical value. This research contributes to understanding the role of cognitive biases in shaping e-commerce consumer behavior, emphasizing the need to consider product type and demographic characteristics when designing marketing strategies.

INTRODUCTION

In our increasingly complex world, individuals are bombarded with vast amounts of information daily, making it challenging to navigate decisions e3ectively. To cope with this overwhelming influx, our brains have evolved to use mental shortcuts known as heuristics. While these heuristics can facilitate quicker decision-making, they often lead to cognitive biases, systematic errors in judgment that distort our understanding of reality (Tversky and Kahneman,1974).

Cognitive biases arise from the brain's reliance on these shortcuts. They are unconscious and systematic errors in thinking that occur when people process and interpret information in their surroundings and influence their decisions and judgments (Kahneman et al., 1982).

The concepts of cognitive biases and heuristics are further illuminated by the dualprocess theory (Thinking, Fast and Slow, Kahneman). This theory distinguishes between two modes of thinking: System 1 and System 2. System 1 is fast, automatic, and often operates unconsciously, relying on heuristics to make quick judgments. In contrast, System 2 is slower, more deliberate, and analytical, engaging in deeper reasoning and critical thinking. While System 1 allows for rapid responses in everyday situations, it is also more prone to errors due to cognitive biases.

One of the common cognitive bias is anchoring effect. It occurs when individuals rely too heavily on the first piece of information they encounter (the "anchor") when making decisions. This initial value influences subsequent judgments and estimates, often leading to biased outcomes (Tversky and Kahneman, 1974).

This can be seen in pricing strategies retailers often display original prices alongside discounted prices, creating an anchor that leads consumers to perceive the sale price as a better deal, even if the discount is minimal (Zuo, 2023).

Another cognitive bias is scarcity effect, which is when people place a higher value on a product when it appears to be scarce. Research indicates that both limited-time and limited-quantity cues can significantly influence purchase intentions. Application of this bias can be seen through limited-Time O3ers, these create a sense of urgency, prompting impulsive buying behavior, particularly in live-streaming e-commerce settings (Hao & Huang, 2023). Another is limited-quantity offers, these cues enhance perceived product value and can lead to higher purchase intentions, especially when combined with promotional strategies like discounts(Kwon et al., 2016).

Understanding cognitive biases and their underlying heuristics is essential for improving decision-making and interpreting information more accurately. Awareness of these mental shortcuts provides valuable insights into human behavior, helping individuals make more rational choices. In the context of e-commerce, cognitive biases are particularly important because online shopping offers a vast array of options, often leading to decision fatigue and increased reliance on subconscious cues. E-commerce platforms leverage these biases to optimize user experiences, increase sales, and drive consumer behavior. By understanding cognitive biases, companies can design strategies that guide consumers toward certain products, influencing their decisions in subtle but powerful ways (Boyzer and Doğan, 2022).

Due to its relevance, I decided on the research question of- “How do cognitive biases, such as the scarcity e3ect and anchoring bias, influence purchasing decisions on e-commerce platforms across di3erent demographic groups?”.

LITERATURE REVIEW

Cognitive biases are not just theoretical constructs but practical tools widely applied in the real world to shape consumer decisions. Across industries, these biases are leveraged to influence behavior, with the e-commerce sector being particularly adept at integrating them into its strategies. Amazon, which is considered to be the world’s largest online retailer, also leverages such tools. It frequently displays a crossed-out higher price (the MSRP) next to the sale price of items. For example, a blender might be shown as originally priced at $200, now selling for $100. This tactic leads customers to perceive the $100 price as a significant discount. Along with this, Amazon employs several scarcity tactics, including displaying limited stock notifications (e.g., “Only 3 left in stock”) and featuring a “Today’s Deals” section with time-sensitive o3ers. This approach has been shown to create a sense of urgency among consumers, leading to higher conversion rates. According to research, this strategy has contributed to Amazon’s sales growth, with estimates suggesting that such psychological pricing strategies can increase conversion rates by up to 30% in some categories.

However, it can’t be said that everyone is impacted by these cognitive biases in the same manner. One of the influencing factors is the person’s demographics. Bozyer and Doğan’s research highlights how cognitive biases influence consumer behavior in e-commerce, revealing significant demographic di3erences, it sheds light on how factors such as age, gender, and shopping frequency impact susceptibility to biases (Boyzer and Doğan, 2022).

There are contrasting beliefs over the role of age, and their susceptibility to cognitive biased on e-commerce platforms. One of the beliefs is that older participants demonstrate lower susceptibility to herd behavior, meaning they were less likely to base their purchasing decisions on social proof, such as trends or the actions of others (Boyzer and Doğan, 2022). This finding is significant because herd behavior can lead to irrational decisions when consumers prioritize popularity over personal needs or preferences. As individuals age, they often gain more experience and confidence in their judgment, which reduces their reliance on external validation. Older consumers may have developed critical thinking skills and decision-making frameworks that allow them to evaluate products more independently, focusing on quality or utility rather than popularity.

The other belief is that, as individuals age, they often experience cognitive challenges that affect their ability to navigate complex decision-making tasks. This is particularly evident in multi-attribute choice scenarios, which are prevalent in e-commerce settings (Rydzewska et al., 2021). These tasks require comparing various product attributes, such as price, quality, and reviews, which can overwhelm older adults due to declining cognitive processing capabilities. Consequently, older consumers may struggle to make optimal purchasing decisions, often settling for choices that fail to meet their needs or preferences (Rydzewska et al., 2021). Due to these limitations, aging is associated with a heightened susceptibility to cognitive biases, which can further distort decision-making processes in online shopping environments (Shamy & Hassanein, 2018; Shamy & Hassanein, 2015). For older adults, reliance on these heuristics becomes more pronounced as cognitive effort decreases with age.

The study revealed that men were less influenced by anchoring bias than women. It is believed that gender plays an important role in influencing decision making in uncertain situations (Zou et al, 2007). This gender di3erence leads to di3erent cognitive styles, judgement criteria and anchoring e3ect (Lauriola and Levin, 2001). Men may approach decisions with a greater emphasis on systematic evaluation, while women might consider contextual and emotional factors more strongly, making them more susceptible to anchors.

Frequent online shoppers were better able to recognize and resist cognitive biases such as scarcity (e.g., "only 2 left in stock") and urgency (e.g., "sale ends in 2 hours"). These participants demonstrated more rational decision-making compared to those who shopped online infrequently. Familiarity with e-commerce platforms likely allows frequent shoppers to identify common marketing tactics and develop strategies to mitigate their e3ects. For instance, they might recognize scarcity messages as artificial pressure rather than genuine stock limitations. This suggests that experience plays a critical role in shaping consumer resilience to persuasive techniques.

METHODOLOGY

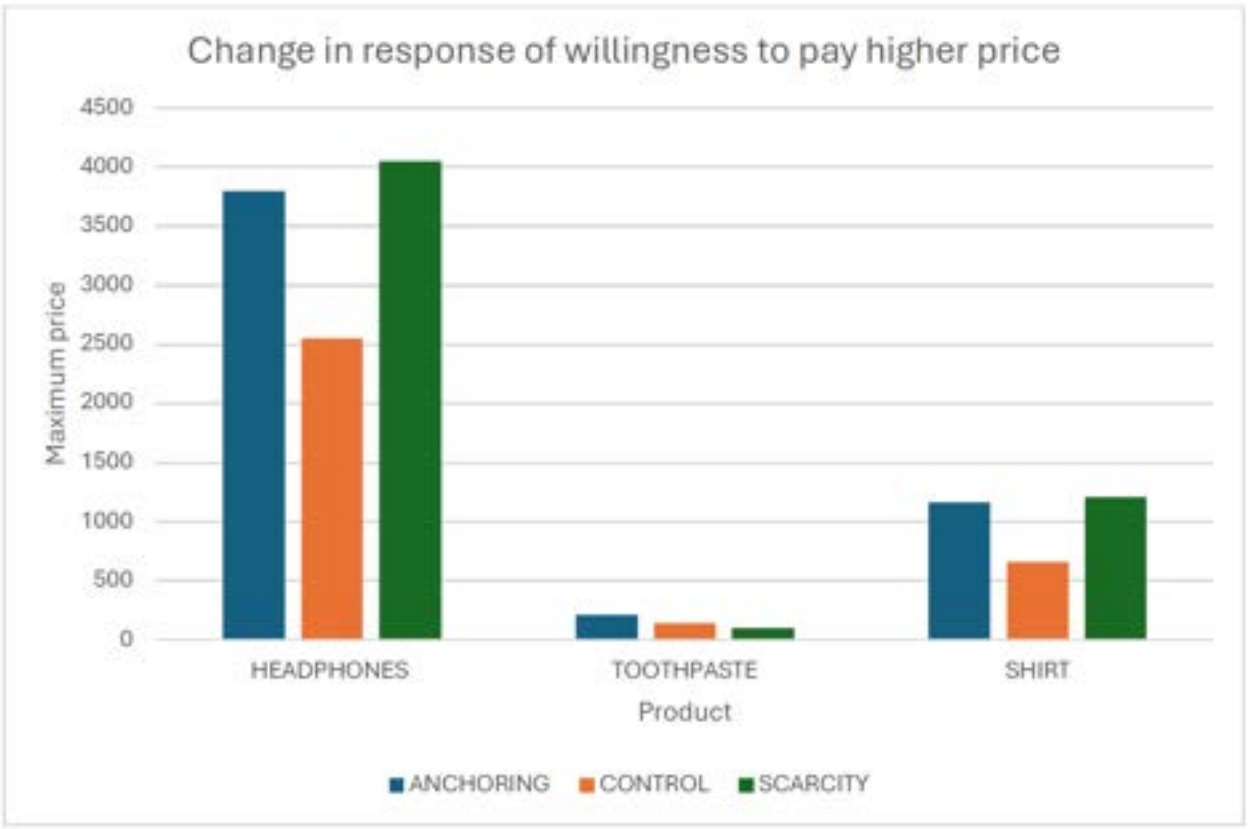
As part of my primary data collection, I conducted an experimental which had a total of 249 participants with the aim of investigating the e3ects of scarcity and anchoring cognitive biases on consumer decision-making across three product categories: Bluetooth headphones, toothpaste, and casual T-shirts. The survey was meticulously designed to gather comprehensive insights into consumer behavior by combining demographic profiling with experimental manipulation of product descriptions.

Participants were asked to provide their demographic details, including age group, gender, shopping frequency, and approximate monthly income, to understand how these factors interact with bias susceptibility.

Participants were randomly assigned to one of three experimental groups. The control group received product descriptions that were neutral and devoid of bias-inducing elements. The scarcity group was exposed to descriptions emphasizing limited availability, such as "Only 3 left in stock" or "Limited stock available." The anchoring group encountered descriptions that highlighted a discounted price framed against a higher original price, such as "Save 50%!" or "Now 30% o3!" These manipulations aimed to elicit responses reflective of the cognitive biases under investigation.

Each participant reviewed product descriptions tailored to their assigned group for all three products. Following this, they answered a series of questions to assess their consumer perceptions and behavior. These included their likelihood of purchase, urgency to buy (on a scale of 1 to 5), perceived value for money, and the maximum price they would be willing to pay. This comprehensive set of questions was designed to measure the influence of scarcity and anchoring biases on decision-making processes.

The inclusion of three diverse product categories, ranging from a high-discretionary item (Bluetooth headphones) to a necessity (toothpaste), provided a robust basis for generalizing the findings.



Graph 1: Impact of Cognitive Biases on Willingness to Pay Across Different Product Categories

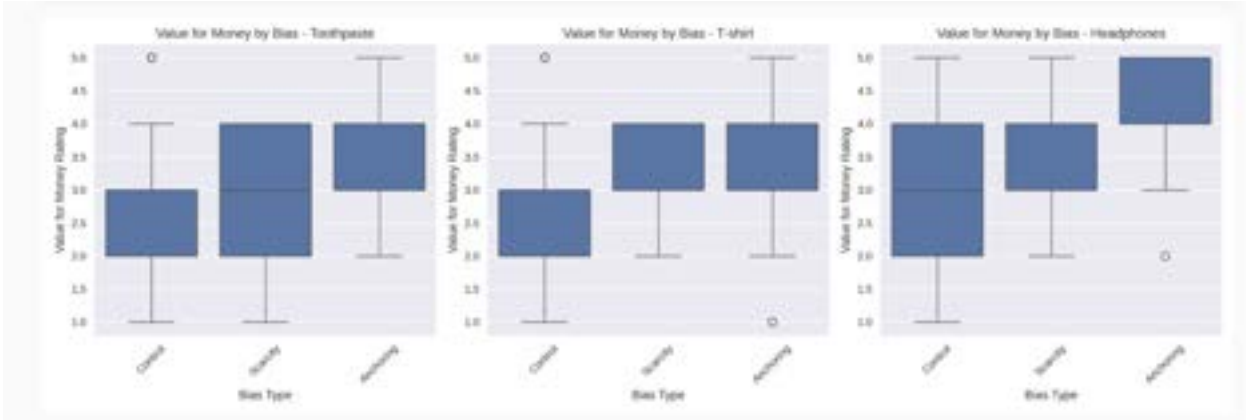
RESULTS

To understand the results of the survey better, they have been visualized in the form of Graphs.

The graph reveals important insights into how cognitive biases, specifically scarcity and anchoring, influence consumers' willingness to pay higher prices across different product categories. For headphones, which relatively high-value item considered as a luxury with a high price elasticity of demand, both scarcity and anchoring have a strong impact. This significant high impact compared to the control is because of luxury items symbolic and psychological significance.

Unlike necessity items, luxury products are often associated with status, exclusivity, and emotional gratification rather than mere utility. Cognitive biases tap into these perceptions and amplify their effect.

For instance, the scarcity effect heightens the perceived value of luxury items by creating an impression of exclusivity or limited availability. This aligns with the desire for distinction or prestige associated with luxury goods. Similarly, anchoring influences consumers by setting a high reference price, making them perceive the luxury item as more valuable compared to alternatives.



Graph 2: Impact of cognitive biases on value for money rating

These biases are particularly effective for luxury items because the decision to purchase them often involves emotional and aspirational factors, making consumers more susceptible to external cues.

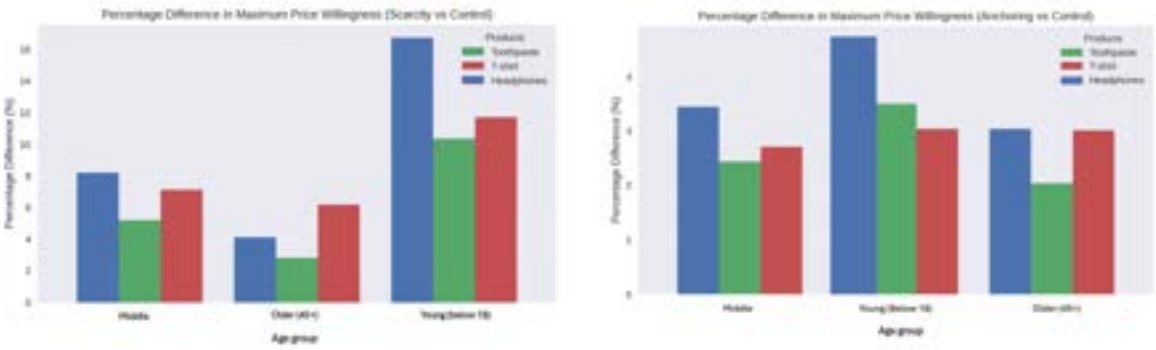
For toothpaste, a necessity product, the influence of cognitive biases appears to be much weaker. The differences in maximum price willingness between the control, scarcity, and anchoring groups are minimal. This aligns with the hypothesis that necessity items are less susceptible to external influences like scarcity or anchoring because their perceived value is largely dictated by practical need rather than psychological factors. The relatively stable willingness to pay across all groups reflects this underlying characteristic of essential goods.

In the case of shirts, which falls somewhere between necessities and luxury items, the impact of scarcity and anchoring is noticeable but less pronounced than for headphones. This suggests that while cognitive biases do affect consumer perceptions of moderately priced, non-essential items, the magnitude of the effect is less consistent and depends on the nature of the product.

Overall, as the group assigned to the scarcity effect are willing to pay a higher price, it can be said that it has a stronger e3ect than anchoring bias on the sample. This could be because the whole sample are Indian, which is considered to be a collectivistic culture.

Scarcity effects tend to have a higher impact in collectivistic cultures because these societies prioritize social harmony, conformity, and group identity. In such cultures, individuals are more influenced by societal norms and the behavior of others.

A scarcity cue, such as “only a few left,” signals not only exclusivity but also desirability within the group, prompting individuals to act quickly to secure the item before others do. This dynamic is driven by the fear of missing out (FOMO), which is amplified in collectivistic cultures where maintaining one’s standing or fulfilling societal expectations is important. Additionally, the perception of limited availability can create a social proof effect, if an item is scarce, it must be valuable or popular among others, further increasing its appeal.



Graph 3: The percentage difference in maximum price willingness between scarcity and control, anchoring and control

The value-for-money rating provides crucial insights into how consumers evaluate products under the influence of cognitive biases like scarcity and anchoring. This metric reflects not only the perceived utility of a product but also the psychological impact of external cues that shape consumer decision-making. The graph shows that products such as headphones, which carry emotional and symbolic value, are rated significantly higher for value when influenced by biases. This is because consumers see headphones as discretionary, high-involvement purchases where pricing cues (e.g., anchoring) or social cues (e.g., scarcity) play a substantial role in shaping perceived worth. A high value-for-money rating in such cases indicates that the biases e3ectively enhance the perceived quality or desirability of the product, compelling consumers to justify higher willingness to pay.

For toothpaste, the low variation in value-for-money ratings between groups underlines the functional and habitual nature of necessity items. Consumers are less responsive to biases because their primary concern is practicality, and their price sensitivity is rooted in predictable, rational evaluations. This stability in ratings demonstrates that cognitive biases have limited leverage in altering perceptions of essential goods.

This reinforces the notion that the value-for-money metric serves as a lens to understand how cognitive biases manipulate not just willingness to pay but also the underlying consumer perception of product worth.

Both the graphs paint a fascinating picture of how different age groups respond to scarcity messaging and anchoring when deciding how much they're willing to pay for various products. It's clear that age, combined with the type of product, plays a big role in shaping consumer behavior.

Younger consumers, for instance, are the most susceptible to the cognitive bias, especially when it comes to headphones. Luxury items such as headphones often carry a sense of identity or status, and the idea that they might miss out triggers a strong desire to act quickly. Even for something as basic as toothpaste, young shoppers seem to react to scarcity cues and anchored prices, likely because they're more impressionable and drawn to the urgency these messages create.

For middle-aged consumers, the response is more balanced. They still react, but their decisions seem more thought-out. Headphones grab their attention the most, perhaps because they see them as valuable tech investments.

T-shirts spark some interest, though not as much, as they likely weigh practicality alongside urgency. Necessities like toothpaste, however, barely nudge this group, reflecting a more rational, needs-first approach to shopping.

Older consumers, on the other hand, are the least influenced. Their buying decisions seem to be guided by experience and a focus on value rather than urgency. They're less swayed by the "limited stock" messaging for headphones and T-shirts, likely seeing these items as either replaceable or non-essential. For toothpaste, their response is minimal, underscoring their resistance to being rushed into purchasing something they view as a simple, functional product.

Across the board, headphones stand out as the product most influenced by scarcity, showing how aspirational and tech-driven purchases tap into emotional decisionmaking. T-shirts fall somewhere in between, appealing to a mix of emotions and practicality. Toothpaste, a basic necessity, consistently resists the pull of scarcity marketing, showing that for some things, urgency just doesn't work. These patterns show how deeply human factors like age, values, and emotions shape the way we shop.

RESULTS

The results of the experimental survey, which involved 249 participants from diverse demographic backgrounds, illustrate the influence of cognitive biases—scarcity and anchoring—on purchasing decisions across different product categories and age groups.

For high-value discretionary items like Bluetooth headphones, both scarcity and anchoring biases had a strong impact on consumers' willingness to pay, aligning with previous research on luxury goods (Zhou, 2023).

The scarcity effect, such as "Only 3 left in stock," significantly increased perceived value, tapping into the emotional and aspirational factors that drive purchasing behavior for luxury items. Similarly, anchoring tactics, like displaying original and discounted prices, made the sale price appear more attractive, reinforcing the biases identified by Tversky and Kahneman (1974). This pattern confirms that cognitive biases are particularly potent when products are associated with status or exclusivity, as seen in Amazon's pricing strategies (Boyzer and Doğan, 2022).

In contrast, necessity products like toothpaste were less influenced by either bias. The minimal differences in willingness to pay between the experimental groups and the control group reflect the findings of Rydzewska et al. (2021), which suggest that essential goods are evaluated more rationally and are less susceptible to external psychological influences. Consumers' primary concerns for necessity items appear to center on practicality and need, rather than emotional or social factors.

Moderately priced, non-essential items like casual T-shirts showed some susceptibility to both biases, though the impact was less pronounced compared to high-end items like headphones. This aligns with the notion that consumers' responses to cognitive biases depend on the nature of the product, with discretionary items being more strongly affected (Hao & Huang, 2023).

Demographic analysis revealed that younger consumers were the most influenced by both scarcity and anchoring biases, particularly for luxury items. This is consistent with the literature suggesting that younger shoppers, being more impressionable, respond strongly to urgency cues and perceived exclusivity (Shamy & Hassanein, 2015).

Middleaged consumers exhibited more balanced responses, with their decision-making likely guided by experience and practical considerations. Older participants, in line with Shamy & Hassanein (2018), were the least susceptible to these biases, especially for nonessential items, as they prioritized value over urgency and emotional cues.

Overall, the results support the literature on the psychological mechanisms underlying consumer behavior, highlighting how cognitive biases interact with product type and demographic factors to influence purchasing decisions.

BIBLIOGRAPHY

1. Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. Science, 185(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

2. Judgment under Uncertainty. (1982). In Cambridge University Press eBooks. https://doi.org/10.1017/cbo9780511809477

3. Kahneman, D. (2011). Thinking, Fast and Slow. http://ci.nii.ac.jp/ncid/BB2184891X

4. Xiaobo, Zhou. (2023). Analysis of Consumer Decision-making from the Perspective of Anchoring E3ect. Advances in Economics, Management and Political Sciences, doi: 10.54254/2754-1169/29/20231361

5. Shuaikang, Hao., Ling, Huang. (2023). How the time-scarcity feature of livestreaming e-commerce a3ects impulsive buying直播电商的时间性稀缺特征如 何影响冲动购买. Service Industries Journal, 43(11-12):875-895. doi:10.1080/02642069.2023.2185231

6. Wi-Suk, Kwon., Sang-Eun, Byun., Je3rey, S., Katz., Gopikrishna, Deshpande., Sandra, Forsythe. (2016). Scarcity E3ects on Consumers' A3ective, Cognitive, and Conative Responses: Moderating Role of Shopping Orientation. 73(1) doi: 10.31274/ITAA_PROCEEDINGS-180814-1502

7. Sinem, Bozyer., Seyhun, Doğan. (2022). The Cognitive Biases in E-Commerce and Effects on Consumer Decisions. Bartın üniversitesi iktisadi ve idari bilimler fakültesi dergisi, 13(26):195-219. doi: 10.47129/bartiniibf.1181624

8. Scarcity Effect | Convertize | Neuromarketing Glossary. (2024, December 16). Convertize. https://www.convertize.com/glossary/scarcityeffect/#:~: text=The%20Scarcity%20Effect%20is%20the,that%20is%20available%20i n%20abundance.

9. Tsipursky, G. (2023, July 12). Amazon Uses These Psychological Tricks To Take Your Money on Prime Day. Entrepreneur. https://www.entrepreneur.com/living/amazon-uses-these-psychological-tricks-to-takeyour-money/455494

10. Baddeley, M. (2009). Herding, social influence and economic decision-making: socio-psychological and neuroscientific analyses. Philosophical Transactions of the Royal Society B Biological Sciences, 365(1538), 281–290. https://doi.org/10.1098/rstb.2009.0169

BIBLIOGRAPHY

11. Klara, Rydzewska., Justyna, Pawlowska., Justyna, Pawlowska., Radoslaw, Nielek., Adam, Wierzbicki., Grzegorz, Sedek. (2021). Cognitive Limitations of Older E-Commerce Customers in Product Comparison Tasks.. 646-656. doi: 10.1007/978-3-030-85613-7_41

12. Nour, El, Shamy., Khaled, Hassanein. (2018). The Impact of Age and Cognitive Style on E-Commerce Decisions: The Role of Cognitive Bias Susceptibility. 73- 83. doi: 10.1007/978-3-319-67431-5_9

13. Nour, El, Shamy., Khaled, Hassanein. (2015). The Influence of Cognitive Biases and Decision Making Styles on Older Adults' E-Commerce Decisions.

14. Zou, D. Q., Wang, G., Zhao, P., & Wang, Y. (2007). The impact of functional value and symbolic value on brand loyalty: the moderating e3ect of gender differences and brand di3erences. Nankai Manag. Rev, 10, 4-12.

15. Lauriola, M., & Levin, I. P. (2001). Relating individual di3erences in attitude toward ambiguity to risky choices. Journal of Behavioral Decision Making, 14(2), 107-122.

JUDGE'S FEEDBACK:

Niharika entered the course with prior research experience and a clear topic in mind. She contributed insights from her previous projects. Her discussion of gentrification in New York demonstrated understanding of racial and socioeconomic demographics. She also discussed globalisation and its impact on India's economy, particularly its uneven benefits. In one presentation, she described two cognitive biases clearly.

NIHARIKA'S TIPS:

- Start with a clear research question: Ensure your paper has a focused and specific objective to guide your work.
- Thoroughly review existing literature: A solid understanding of previous research will help position your work and highlight its contribution.
- Stay organized: Create an outline before you start writing to keep track of key points and structure.
- Revise and seek feedback: Editing is crucial, prepare your doubts before the session with your mentor and make use of your mentor's expertise.
- Be curious and adaptable: Research often takes unexpected turns. Embrace new ideas and adapt your approach as needed.

Yash Karia

YASH'S BIO:

Yash Karia is a Year 11 student at Oshwal Academy Junior High in Nairobi, Kenya. As a national-level swimmer, he has demonstrated resilience and dedication through his achievements in competitive swimming. He is also a passionate public speaker, having delivered a TEDx Talk that reflects his curiosity and global outlook.

Yash is deeply interested in emerging technologies like quantum computing and nanotechnology, particularly their potential in medicine and artificial intelligence. He balances academic excellence and athletic achievement with a strong drive to make a meaningful impact on the world.

Quantum-based AI Transistor and Nanotechnology: Pioneering the Future of Next-Generation Computing

ABSTRACT

The rapid evolution of computing technology is challenging the limits of classical transistor-based methods. In response, quantum-based AI transistors and nanotechnology are emerging as transformative innovations poised to transcend these boundaries. This paper delves into the principles underlying quantum transistors, their applications in artificial intelligence (AI), and the pivotal role of nanotechnology in advancing computational capabilities. By integrating quantum mechanics with nanotechnology, unprecedented computational power can be achieved, opening the door to neuromorphic systems that mimic human brain functions. However, significant challenges, including technical, ethical, and societal implications, must be addressed to fully harness the potential of these next-generation technologies.

INTRODUCTION

For decades, Moore's Law predicted the exponential growth of transistor density on microchips, driving continuous advancements in computing power. This exponential growth has been the cornerstone of the technology industry's expansion, enabling increasingly sophisticated applications across various fields.

INTRODUCTION

However, as transistors shrink to the nanometer scale, issues such as quantum tunneling, heat dissipation, and energy consumption become more pronounced. These challenges indicate that traditional silicon-based transistors are approaching their physical limitations, necessitating the exploration of new computing paradigms that can sustain the trajectory of technological advancement.

PURPOSE

As the demand for computational power, particularly for AI applications, continues to surge, traditional hardware struggles to keep pace. AI systems require vast resources to perform tasks like deep learning, natural language processing, and big data analytics. Quantum-based AI transistors and nanotechnology offer promising solutions to these challenges by enhancing processing power, reducing energy consumption, and enabling new forms of computation that were previously unimaginable. The convergence of these technologies could lead to breakthroughs in computational efficiency, enabling more sophisticated AI models and real-time processing of large datasets.

SCOPE

This paper explores the potential of quantum-based AI transistors and nanotechnology to revolutionize computing. It covers the foundational principles of these technologies, examines their integration, and discusses their future prospects. The paper also addresses the challenges that must be overcome to realize the full potential of these innovations, including technical hurdles, ethical considerations, and societal impacts.

PRINCIPLES OF QUANTUM MECHANICS

Two key principles are central to the operation of quantum transistors:

- **Superposition:** In classical computing, bits are in a state of either 0 or 1. In contrast, quantum bits, or qubits, can exist in a superposition of states, where they represent both 0 and 1 simultaneously. This ability to process multiple states at once allows quantum transistors to perform parallel computations, vastly increasing computational power and enabling the solution of complex problems that are intractable for classical computers.

- **Entanglement:** Entanglement is a phenomenon where particles become interlinked so that the state of one particle directly influences the state of another, regardless of the distance separating them. This property allows for faster and more efficient information processing and has the potential to revolutionize fields such as cryptography, communication, and AI.

QUANTUM-BASED AI TRANSISTORS

Quantum Dots

Quantum dots are semiconductor particles only a few nanometers in size that exhibit distinct quantum mechanical behaviors. These particles can confine electrons in all three spatial dimensions, leading to discrete energy levels, making them highly suitable for use in transistors.

Single-Electron Transistors (SETs)

Single-electron transistors function by precisely controlling the movement of individual electrons. This is achieved using a quantum dot or a small conductive island, allowing SETs to operate with exceptionally low power consumption while offering high sensitivity.

Superconducting Qubits

Superconducting qubits are built on superconducting circuits capable of maintaining quantum states for extended durations. These qubits form the foundation of some of the most advanced quantum computing systems under development today.

Fabrication and Integration

The production of quantum-based AI transistors requires cutting-edge nanotechnology techniques, including:

Electron Beam Lithography

Electron beam lithography (EBL) is a technique used to create highly intricate patterns essential for quantum transistors. By employing a focused electron beam, EBL achieves nanometer-level precision in patterning substrates.

Atomic Layer Deposition

Atomic layer deposition (ALD) involves the sequential deposition of thin films, one atomic layer at a time. This method is critical for fabricating high-quality, uniform layers necessary for quantum devices.

NANOTECHNOLOGY IN COMPUTING

Nanomaterials and Devices

Nanotechnology employs a variety of nanomaterials which offer superior electrical, thermal, and mechanical properties compared to bulk materials:

- **Carbon Nanotubes (CNTs):** CNTs are cylindrical nanostructures with remarkable electrical conductivity and mechanical strength. These properties make them ideal for use in transistors, and interconnects. CNT-based transistors, for example, have the potential to operate at higher speeds and lower power consumption than traditional silicon-based transistors.

- **Nanowires:** They are one-dimensional structures with diameters in the nanometer range, typically made from semiconductors or metals. Their properties make them suitable for use in transistors, and sensors. Nanowires can be precisely controlled during fabrication, allowing for the creation of ultra-miniaturized devices with superior performance characteristics.

- **Nano-Sensors:** Nano-sensors leverage the vast surface area and remarkable sensitivity of nanomaterials to detect minute physical, chemical, and biological changes with exceptional precision.

MINIATURIZATION AND PERFORMANCE

Nanotechnology enables the creation of ultra-miniaturized components that operate at lower power levels while delivering higher performance. As transistors shrink to the nanometer scale, precise control over material properties allows the development of transistors that switch faster, consume less power, and generate less heat. This miniaturization is critical for maintaining the pace of innovation predicted by Moore's Law and for continuing the advancement of computational power in the face of the physical limitations of silicon-based technologies.

INTEGRATION OF QUANTUM-BASED AI TRANSISTORS AND NANOTECHNOLOGY

Synergy

The integration of quantum-based AI transistors with nanotechnology creates a powerful synergy that could redefine the future of computing. Quantum transistors, when enhanced by nanotechnology, could lead to the development of quantum processors that are not only powerful but also practical for widespread use. This integration could enable the creation of new computing architectures that combine the best aspects of both quantum and nano-scale technologies, resulting in systems that are faster, more efficient, and capable of tackling problems that are currently beyond the reach of classical computers.

Neuromorphic Systems

One of the most promising applications of this integration is in the development of neuromorphic systems—computing architectures designed to mimic the human brain. Quantum-based AI transistors, combined with nanotechnology, could enable the creation of neuromorphic systems with unprecedented computational power and efficiency. These systems could process information similarly to biological neurons, leading to significant advancements in AI, such as more efficient pattern recognition, learning, and decision-making processes. Neuromorphic systems could revolutionize fields such as robotics, healthcare, and autonomous systems by enabling machines to process and respond to information in ways that closely resemble human cognition.

APPLICATIONS AND FUTURE PROSPECTS

The potential applications of quantum-based AI transistors and nanotechnology extend across numerous fields, including:

Artificial Intelligence:

Quantum-based AI transistors have the potential to revolutionize AI by enabling significantly faster data processing and supporting more complex computations. This advancement could lead to the development of more sophisticated machine learning algorithms and transformative AI applications.

Medicine:

The integration of nanotechnology and quantum computing in medicine could revolutionize medical diagnostics, drug discovery, and personalized treatment plans. These technologies promise more accurate, efficient, and tailored healthcare solutions.

Communications:

Quantum communication systems, leveraging the principles of quantum entanglement, could dramatically enhance data transmission by providing unparalleled security and speed. This innovation has the potential to transform encryption and secure communications.

Environmental Monitoring:

Nano-sensors, with their exceptional sensitivity, could be employed to detect pollutants and monitor environmental changes. This capability would greatly enhance efforts in environmental protection and management.

CHALLENGES

Fabrication Complexity: The precise creation of quantum and nanoscale devices demands advanced techniques and specialized equipment, making fabrication a highly intricate process.

Scalability: Expanding quantum-based systems to functional, large-scale applications presents a substantial challenge that researchers are actively addressing.

Stability and Error Correction: Ensuring the stability of quantum states and developing robust error correction methods are essential for the dependable operation of quantum computing systems.

ETHICAL CONSIDERATIONS

Privacy and Security

Quantum computing could transform data processing but also threatens current encryption methods, making sensitive information more vulnerable. New encryption standards and security measures are needed to protect against potential cyberattacks and privacy breaches as quantum-based AI systems become more common.

Societal Impact and Job Displacement

The rise of quantum-based AI and nanotechnology may lead to job losses, especially in sectors reliant on data processing and automation. Strategies like reskilling programs and social safety nets are necessary to address job displacement and ensure that the benefits of these technologies are widely shared.

Environmental Impact

The production of nanotechnology and quantum-based systems can impact the environment, due to resource use and waste. Using rare or hazardous materials raises sustainability concerns. Researchers and manufacturers should focus on eco-friendly practices and recycling to minimize environmental harm.

CASE STUDIES

Several research initiatives highlight the potential of integrating quantum transistors and nanotechnology:

- IBM's Quantum Computing Research: IBM's work on quantum computing exemplifies the strides being made toward practical quantum-based AI systems. Their research focuses on developing scalable quantum processors and improving qubit stability, which are critical for the widespread adoption of quantum computing.

- Intel's Silicon-based Quantum Processors: Intel's research into silicon-based quantum processors is another significant development in this field. By leveraging their expertise in silicon technology, Intel aims to create quantum processors that are compatible with existing semiconductor manufacturing processes, paving the way for more accessible quantum computing.

- Stanford University's Carbon Nanotube Transistors: The development of carbon nanotube transistors at Stanford demonstrates the potential of nanotechnology in creating ultra-miniaturized devices that could be integrated with quantum computing technologies. These transistors offer higher performance and lower power consumption than traditional silicon-based devices, making them ideal candidates for next-generation computing systems.

Conclusion

As we stand on the brink of a new computing era, the revolutionary advancements in quantum-based AI transistors and nanotechnology are poised to transform the capabilities of technology. These innovations are set to revolutionize a wide range of industries, from healthcare to telecommunications, and beyond. The journey to next-generation computing is complex and challenging, but the vision of a smarter, faster, and more efficient technological landscape propels progress forward.

Continuous research and development are crucial in shaping the future of computing.. These technologies promise significant advancements in speed, efficiency, and miniaturization, and are likely to be pivotal in the evolution of computing systems.

References

1. "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang
2. Sahoo, S., Kontos, T., Furer, J., Hoffmann, C., Gräber, M., Cottet, A., & Schönenberger, C. (2005). Electric field control of spin transport. Nature Physics, 1(2), 99-102.
3. Akinwande, D., Huyghebaert, C., Wang, C.-H., Serna, M. I., Goossens, S., Li, L.-J., ... & Koppens, F. H. L. (2019). Graphene and two-dimensional materials for silicon technology. Nature, 573(7772), 507-518.
4. Dresselhaus, M. S., Dresselhaus, G., & Avouris, P. (Eds.). (2001). Carbon Nanotubes: Synthesis, Structure, Properties, and Applications (Vol. 80). Springer Science & Business Media.
5. Quantum Dots for Quantum Computing" by G. Goldstein et al
6. Single-Electron Transistors & Quantum Computing: An Overview by J. E. Mooij et al
7. Google Scholar
8. ChatGPT
9. arXiv.org
10. MIT OpenCourseWare
11. ACM digital Library

JUDGE'S FEEDBACK:

Yash produced a review paper that was well written and clearly conveyed the research purpose. He demonstrated understanding of the research's objectives and key questions. His literature review and methodology supported this. He selected appropriate research methods, used relevant journals and sources, and structured his essay clearly. He paraphrased and explained ideas well, and avoided plagiarism.

YASH'S TIPS:

- Choose a topic you're genuinely curious about—your enthusiasm will carry you through the toughest parts of the research process.
- Stay organized from the beginning. Keep track of sources, ideas, and deadlines in a research journal or digital planner.
- Don't hesitate to reach out to mentors or peers—collaboration and feedback are invaluable.
- Balance depth with clarity—a well-researched paper should also be readable and engaging.
- Reflect often on what you're learning and how it connects to the bigger picture.

Gabriela Guadalupe Ledezma Hidalgo

GABRIELA'S BIO:

As a senior at Kanata School, Gabriela is passionate about STEAM, with a focus on research in nanoengineering and nuclear physics. She has furthered her knowledge through prestigious programs such as the National Youth Science Camp. Gabriela leads a STEAM initiative supported by the Universidad Mayor de San Andrés (UMSA) called Nuclear Youth Club. She plans to study software engineering at university next year to drive innovation that creates sustainable and meaningful change.

How is nanoengineering enabling advances in numerous technologies shaping the future of industries?

ABSTRACT

A basic ramification of engineering is nanoengineering, which focuses on the creation, utilization, and design of structures. By manipulating matter at the atomic or molecular level, this field integrates ideas from chemistry, physics, and engineering to advance in the nanoscale dimension across various industries, including electronics, materials science, medicine, etc. [1]

Our analysis explores the potential in multiple areas and its impact in various fields through innovative applications and future developments that hold immense potential. [2] Finally, we can expect significant advancements that will improve product performance and contribute to sustainability efforts globally; however, it is important to research and discuss the revolutionary applications. [3]

INTRODUCTION

The purpose of this review is to provide a comprehensive review of how nanoengineering is enabling advances that shape the future of industries. We explored the impact on multiple industries, from biomedical to nanomaterial solutions, based on developing new materials and processes, covering challenges and gaps that our society faces today. [4]

The history of nanoengineering spans significant milestones from ancient to modern times, starting from the Lycurgus Cup, which utilized nanoparticles to create color-changing dichroic glass, is the first example of this, dating back to the fourth century. [5]From the sixth to the fifteenth century, stained glass windows in cathedrals were colored with gold chloride nanoparticles. From the 13th to the 18th centuries, Damascus saber blades were made using techniques that created nanotubes. In the modern era, Victor La Mer and Robert Dinegar created methods for creating colloidal materials in the 1950s, while Richard Feynman's 1959 deal unveiled the basic concepts of molecular manipulation. The scanning tunneling microscope (STM), developed in 1981, made it possible to observe atoms, and Sumio Iijima's discovery of carbon nanotubes in 1991 proved their power. [6]The College of Nanoscale Science and Engineering at SUNY Albany was established in 2004 as the first dedicated program in the U.S. More recently, robotic nanoscale assembly tools for 3D DNA structure creation were created by Nadrian Seeman's group. [7]All things considered, nanoengineering has advanced dramatically, influencing numerous sectors and inspiring cutting-edge uses today. [8]

MAIN BODY

The biomedical and building materials sectors have been greatly impacted by the development of nanoengineering, mainly due to the application of molecular dynamics (MD) simulations. To improve efficiency and dependability, these simulations serve as a "computational microscope," allowing researchers to investigate the atomic-level principles controlling material behavior.[9] By increasing modeling accuracy, incorporating artificial intelligence (AI) and MD simulations promotes developments in both areas. There are still some significant gaps, though, namely the lack of extensive databases for machine learning applications, concerns about the safety of revolutionary nanomaterials, and challenges increasing production procedures. To take full advantage of nanoengineering's promise of creating safer biomedical applications and improving long-lasting building materials, these problems must be solved. [10]

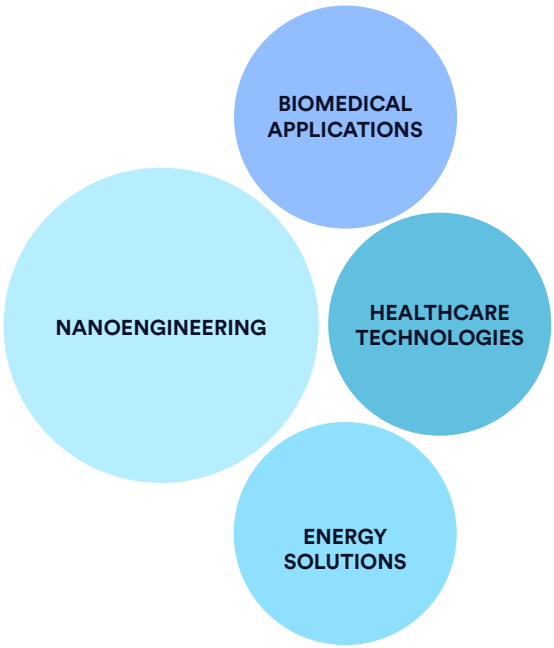


Figure 1: Nanoengineering and its applications. [12]

2: Unleashing the Power of Artificial Intelligence for Revolutionary Discoveries. [13]

By providing more natural motion and control, the use of nanoparticles in prosthetics and implanted delivery systems has improved the quality of life. [11] Although nanoparticles have good cellular interactions, they reveal certain gaps, namely long-term biocompatibility, ethical issues, cost accessibility, practical efficacy, manufacturing difficulties, and integration with new technology, which are constraints. To improve user efficiency, these challenges must be addressed.

In addition to addressing manufacturing scalability and safety concerns, nanoscale drug delivery systems (NDDS) require a thorough understanding of the factors determining drug release characteristics. Despite their potential for flexible release mechanisms, clinical use of synthetic polymeric nanoparticles is hampered by inflammatory reactions from breakdown products.[1] Developing NDDS to reduce patient discomfort and increase approval rates relies on efficient knowledge transfer from academia to industry.

Since they are so effective at solving energy and environmental problems, solid oxide fuel cells, or SOFCs, are seen as possible alternatives for fossil fuels.

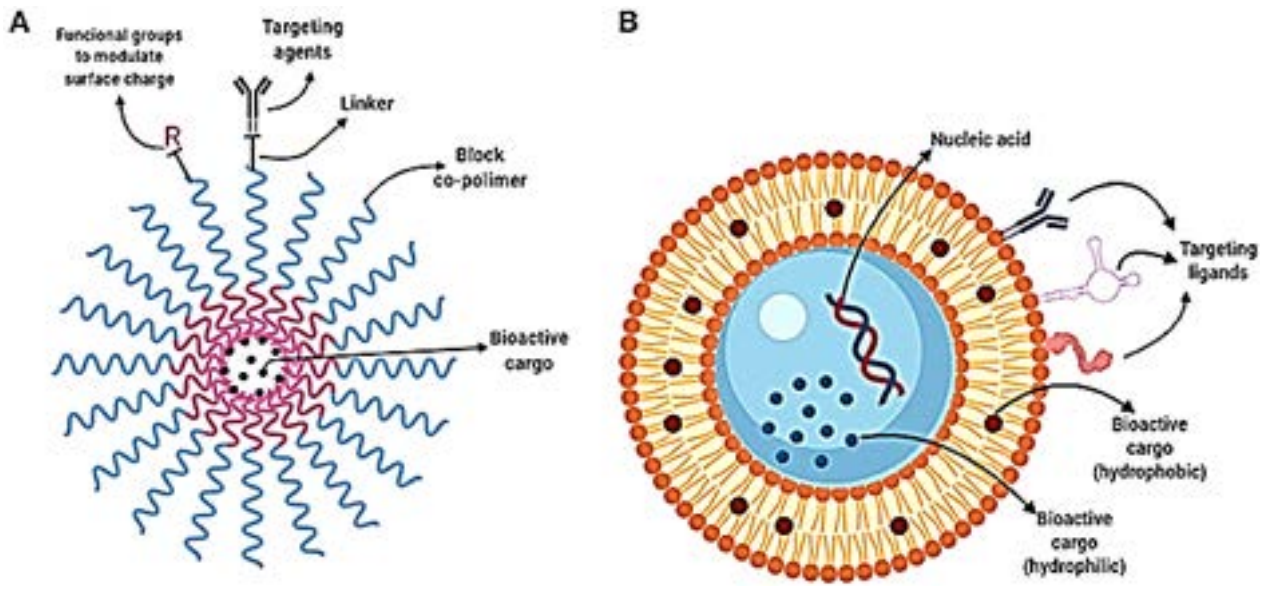


Figure 3: The Intersection of Biological Engineering and Technology. [14]

By producing high-performance thin-film cathodes, nanoengineering has effectively enhanced the electrochemical performance of SOFCs. [2]Even though remarkable current densities of roughly 2.2 A/cm² at 650 °C and 4.7 A/cm² at 700 °C have been achieved, there are still several important commercialization limitations, namely material stability, thermal cycle concerns, manufacturing scalability, navigating regulations, and approval from the public. [3]Furthermore, it faces several challenges in achieving stable performance at lower operating temperatures and ensuring long-term durability against material degradation and gas sealing issues. [4]

Wearable health monitoring has been revolutionized by nanomaterial-based sensors in bioelectronics nanoengineering, allowing for continued and customized healthcare. [5] The sensitivity of identifying biomarkers in bodily fluids at low concentrations is improved by materials, namely carbon nanotubes, graphene, and quantum dots. [6]

Their flexibility increases comfort and biocompatibility while enabling smooth integration into wearable technology. These sensors additionally offer wireless connectivity, which is required for transmitting data in real-time to manage chronic illnesses [7].

The development of extensive databases for nanomaterials to aid machine learning initiatives, the standardization of safety evaluation procedures for new materials to reduce safety concerns, the investigation of scalable manufacturing methods such as 3D printing to improve production quality, the execution of long-term stability studies to bolster confidence in medical applications, the resolution of privacy issues through creative data security measures in wearable technologies, and the integration of artificial intelligence into sensor design to optimize performance and real-time monitoring capabilities. By pursuing these directions, the full potential of nanoengineering can be unlocked, leading to safer biomedical applications, improved energy solutions, and enhanced quality of life through innovative healthcare technologies.

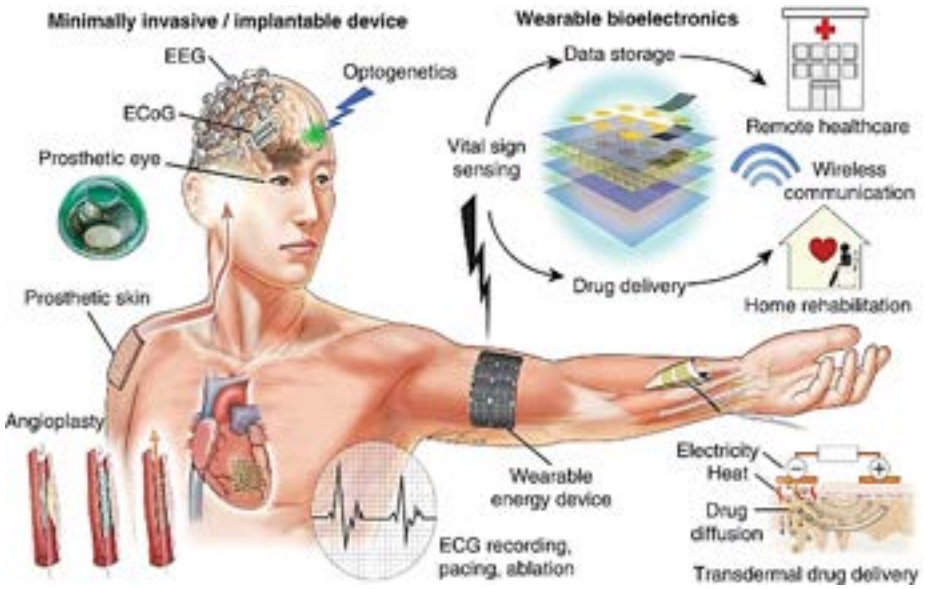


Figure 4: Nanotechnology for Environmental Sustainability. [15]

Conclusion

To sum up, nanoengineering is a spurring innovation across various fields, particularly in electronics, materials science, and healthcare technologies. Among the significant innovations made possible by the ability to work with materials at the atomic and molecular level are sensitive nanomaterial-based sensors for wearable health monitoring and nanoscale medication delivery devices. [8]However, there are still challenges that need to be overcome, like the need for large databases for machine learning, established safety protocols for new nanomaterials, scalable manufacturing techniques, and effective translation of research into practical applications. [9]

Addressing these gaps is crucial for nanoengineering to achieve its full potential. Lastly, the ongoing challenges in putting these technologies into practice must be tackled. Further investigation and collaboration in this field promise to improve product performance and support global sustainability initiatives, ultimately revolutionizing technology and healthcare. [10]

References

[1] RDWorld Online. “What Is Nanoengineering?” RDWorld Online. Accessed Accessed December 28, 2024. https://www.rdworldonline.com/what-is-nanoengineering/.

[2] Walsh Medical Media. “Nanoengineering: Pioneering the Future Through Miniaturization and Precision.” Walsh Medical Media. Accessed December 28, 2024. https://www.walshmedicalmedia.com/open-access/nanoengineering-pioneering-the-future-through-miniaturization-and-precision.pdf.

[3] UCR Engineering Online. “What Is Nanoengineering?” UCR Engineering Online, 2023. Accessed December 27, 2024.. https://engineeringonline.ucr.edu/blog/what-is-nanoengineering/.

[4] De Gruyter. Key Findings in Nanoengineering. 2020. Accessed Accessed December 23, 2024.. https://www.degruyter.com/document/doi/10.1515/ntrev-2020-0053/html.

[5] Google Books. Key Findings in Nanoengineering. Accessed Accessed December 28, 2024. https://books.google.com.bo/books?hl=es&lr=&id=3Q-dBAAAQBAJ&oi=fnd&pg=PP1&dq=key+findings+in+nanoengineering&ots=8Qlwdv8C2N&sig=FLebyCR50Jp7hjO4vmPOD89QITc#v=onepage&q=key%20findings%20in%20nanoengineering&f=false.

[6] ScienceDirect. Key Findings in Nanoengineering. 2014. Accessed December 24, 2024.. https://www.sciencedirect.com/science/article/pii/S0928493114002410.

[7] Google Books. Key Findings in Nanoengineering. Accessed December 26, 2024. https://books.google.com.bo/books?hl=es&lr=&id=C8lAIlob9Q8C&oi=fnd&pg=PR5&dq=key+findings+in+nanoengineering&ots=hibBLRIo2A&sig=TUnf9t-xwtlicaLsuLCTP6ynRI0#v=onepage&q=key%20findings%20in%20nanoengineering&f=false.

[8] DLPress. Key Findings in Nanoengineering. Accessed Accessed December 21, 2024. https://publications.dlpress.org/index.php/jcha/article/view/25.

[9] Tandfonline. Key Findings in Nanoengineering. Accessed Accessed December, 24, 2024. https://www.tandfonline.com/doi/full/10.2217/17435889.1.4.383.

[10] Robertazzi, Arturo. “Is Molecular Dynamics the Future of Nanoengineering of Construction Materials?” Arturo Robertazzi, 2024. Accessed Accessed December 20, 2024. https://www.arturorobertazzi.it/2024/05/is-molecular-dynamics-the-future-of-nanoengineering-of-construction-materials/.

[11] ScienceOpen. Key Findings in Nanoengineering. 2024. Accessed December 21, 2024. https://www.scienceopen.com/hosted-document?doi=10.57197%2FJDR-2024-0019.

[12] Ledezma, Gabriela. Nanoengineering and Its Applications. Date unknown. Digital image. Accessed February 10, 2025. https://photos.fife.usercontent.google.com/pw/AP1GczOKcybjw1fhXXhRpvjaa98FqYNZSnIf9oi9GEvYyFBgs0ZSWXDczZDf=w487-h393-s-no-gm?authuser=0.

[13] Unknown Artist. “Innovating Molecular Simulations: Unleashing the Power of Artificial Intelligence for Revolutionary Discoveries.” CBIRT, accessed February 9, 2025. https://cbirt.net/innovating-molecular-simulations-unleashing-the-power-of-artificial-intelligence-for-revolutionary-discoveries/.

[14] Unknown Artist. “Bioengineering and Biotechnology: The Intersection of Biological Engineering and Technology.” Frontiers in Bioengineering and Biotechnology, accessed February 9, 2025. https://www.frontiersin.org/journals/bioengineering-and-biotechnology/articles/10.3389/fbioe.2020.00079/full.

[15] Unknown Artist. “Chapter 9: Nanotechnology for Environmental Sustainability.” Springer, accessed February 9, 2025. https://link.springer.com/chapter/10.1007/978-3-662-59600-5_9.

[10] Robertazzi, Arturo. “Is Molecular Dynamics the Future of Nanoengineering of Construction Materials?” Arturo Robertazzi, 2024. Accessed Accessed December 20, 2024. https://www.arturorobertazzi.it/2024/05/is-molecular-dynamics-the-future-of-nanoengineering-of-construction-materials/.

[11] ScienceOpen. Key Findings in Nanoengineering. 2024. Accessed December 21, 2024. https://www.scienceopen.com/hosted-document?doi=10.57197%2FJDR-2024-0019.

[12] Ledezma, Gabriela. Nanoengineering and Its Applications. Date unknown. Digital image. Accessed February 10, 2025. https://photos.fife.usercontent.google.com/pw/AP1GczOKcybjw1fhXXhRpvjaa98FqYNZSnIf9oi9GEvYyFBgs0ZSWXDczZDf=w487-h393-s-no-gm?authuser=0.

[13] Unknown Artist. “Innovating Molecular Simulations: Unleashing the Power of Artificial Intelligence for Revolutionary Discoveries.” CBIRT, accessed February 9, 2025. https://cbirt.net/innovating-molecular-simulations-unleashing-the-power-of-artificial-intelligence-for-revolutionary-discoveries/.

[14] Unknown Artist. “Bioengineering and Biotechnology: The Intersection of Biological Engineering and Technology.” Frontiers in Bioengineering and Biotechnology, accessed February 9, 2025. https://www.frontiersin.org/journals/bioengineering-and-biotechnology/articles/10.3389/fbioe.2020.00079/full.

[15] Unknown Artist. “Chapter 9: Nanotechnology for Environmental Sustainability.” Springer, accessed February 9, 2025. https://link.springer.com/chapter/10.1007/978-3-662-59600-5_9.

JUDGE’S FEEDBACK:

Gabriela demonstrated a deep understanding of research methodology and the review writing process. Her final paper clearly established the purpose of her research and was well-organised and articulate. She analysed the research objectives effectively, identified appropriate methods, and selected reliable sources. Her essay incorporated reference books, journals, and other relevant materials, and she paraphrased and synthesised information clearly.

GABRIELA’S TIPS:

- Your research will have direction, authenticity, and purpose from the start if you know why your topic is important to you and the rest of the world.
- Always seek advice and comments from your tutor. Their assistance is essential for helping you organize your work, hone your concepts, and maintain focus.
- Every time, take notes on every stage of your investigation. You can stay organized and consider how your ideas have evolved by recording your ideas, discoveries, and difficulties at each step of the process.
- Write a little every day. Writing as you go improves time management and lessens the sense of overwhelm associated with the process.

www.immerse.education