Student Autonomy and Agency in the Research Process

Aoba's Grade 10 Curriculum Initiative

Series 2

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Dr Jake Madden, Nathan Hensley (Eds)

Student Agency in the Research Process: Aoba's Grade 10 Curriculum Initiative

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Student Agency in the Research Process: Aoba's Grade 10 Curriculum Initiative Aoba Japan International School: Grade 10 Research Papers is produced by Aoba-Japan International School. The publication showcases restructuring the Grade 10 curriculum at Aoba Japan International School to focus on teaching students critical and creative thinking skills. The school aims to establish automated thinking skills in its students, which it sees as foundational intellectual skills necessary for success at university and work. The initiative focuses on teaching students how to learn, with the first series of research papers indicating that the initiative is heading in the right direction. The authors invite universities to join them in researching the initiative's efficacy and impact to understand its value better.

Authors

Yumiko Baba, Mao Hasegawa, Kye Pelczar, Rie Torio, Sakura N, Emily, Austin, Aoi Nagashima, Ema Matsuura, Minh Do, Mimi Okada, Lieke Poldervaart, Wings, Sakura, Nanami, Jaeeun Jeong, Diane Hubert , Eliana Edwards-EL

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For more information about this book, please contact the editors:

7-5-1 Hikarigaoka, Nerima-ku, Tokyo 179-0072

Email: jake.madden@aobajapan.jp

Phone: 03-4578-8832

https://www.japaninternationalschool.com

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From the Editors

As we stand on the threshold of another academic year at Aoba Japan International School, we are filled with a profound sense of anticipation and pride. It is with great pleasure that we introduce the second series of research papers, a continuation of our journey in redefining education and nurturing the intellectual growth of our Grade 10 students.

In the chapter titled "How is communication affected by the implied meanings of digital ideograms?", our students delve into the intricate world of digital communication. They explore the subtle nuances and implications behind the symbols we use daily, shedding light on how these ideograms shape our interactions in the digital age.

Building upon the foundation laid by the first series of research papers, we find ourselves inspired and motivated to further refine our approach to education. The challenges faced by schools in preparing students for the complexities of university and the ever-evolving world of work remain at the forefront of our educational vision.

In "What can we learn from revolutions?", our students embark on a historical journey, drawing lessons from revolutions that have shaped our world. They analyze the social and political dynamics that drive these pivotal moments in history, offering valuable insights into the forces that drive societal change.

Our commitment to educational transformation in Japan and beyond has only strengthened with time. The restructuring of the Grade 10 curriculum, aimed at enhancing critical and creative thinking skills, has continued to be the cornerstone of our efforts. We remain steadfast in our belief that automated critical and creative thinking skills are pivotal in equipping our

students with the tools needed to thrive in unfamiliar contexts, whether at university or in their future careers.

In "How is society responding to the emergence of different iPS-related biotechnological techniques?", our students explore the cutting-edge field of biotechnology. They examine how society grapples with the ethical and practical implications of revolutionary techniques like induced pluripotent stem cells, shedding light on the complex interplay between science and society.

We persistently instill in our students the invaluable skill of "how to learn." In "How does ecology affect the evolution of the brain?", our young researchers embark on a journey into the natural world, investigating the intricate relationship between ecology and brain evolution. Their findings illuminate the profound impact of our environment on the development of cognitive abilities.

As we delve deeper into this educational initiative, we acknowledge that we are still in the early stages of understanding its full impact. The second series of papers presented here is a testament to our unwavering commitment to rigorous research and continuous improvement.

In "How can the evolution of AI art generators affect the illustration industry?" our students peer into the future of creativity. They explore how advancements in AI art generators could reshape the landscape of illustration, offering both opportunities and challenges to the industry and artists alike.

While we take pride in the encouraging results achieved thus far, we humbly recognize that there is much more to explore and discover. The

journey of educational transformation is a complex and ongoing process, and we embrace the responsibility of constant evaluation and adaptation.

In "How does addiction to social media impact the adolescent brain in cognitive functioning and brain development?", our students confront a modern-day dilemma. They investigate the impact of social media addiction on the adolescent brain, shedding light on the intricate relationship between technology and cognitive development.

Collaboration and knowledge sharing have always been at the heart of our educational mission. We firmly believe that our initiative has the potential to not only benefit our own students but also contribute significantly to the broader field of education.

The potential of this initiative to revolutionize education and empower our students for success not only in Grade 11 & 12, but also at university and in their careers is a source of tremendous excitement. We remain steadfast in our dedication to ongoing evaluation and collaboration with like-minded institutions and researchers. Our quest for knowledge and improvement knows no bounds.

With these thoughts in mind, we invite you to delve into the second series of research papers with the same enthusiasm and curiosity that propels us forward. We extend our warmest invitation to you and the wider educational community to join us in this transformative journey, as together, we continue to shape the future of education.

Dr Jake Madden, Mr Nathan Hensley

How is communication affected by the implied meanings of digital ideograms?

Yumiko Baba, Mao Hasegawa, Kye Pelczar, Rie Torio

Supervisor: Benjamin Lancaster

ABSTRACT

This paper examines the extent to which emojis have impacted internet-based communication. Alongside rigorous research on their relationship, one interview session and one small-scale replication study were conducted at an international school to see how individuals perceive, interpret, and use emojis. The findings revealed that those digital ideograms can express far more than what is denoted, and they have various linguistic functions that can significantly impact the conversation. Moreover, the results allow for a further discussion of the implications and complexities of emojis.

INTRODUCTION

Emojis have become commonplace in daily online conversations — whether the receiver of the message is a friend, family member, or even a business associate. Repeatedly referred to as the "fastest-growing language" (Doble, 2015) in the world today, there are 3,664 emojis in the Unicode Standard, a character-coding system, as of February 2023 (Unicode, 2023). Emojis represent a significant factor contributing to online interactions, and their use can greatly impact the tone, meaning, and interpretation of messages.

Learning Context and Problem

Ever since the advent of emojis in 1997, the demand for iconic facial symbols has been increasing at a substantial rate, and unicode.org states that "92% of the world's online population uses emoji" as of 2021 (Daniel,

2021). While emojis can substitute for the emotions, expressions, and body language that invariably go absent in internet-based communication, they may also generate undesired implications involving cultural and contextual misinterpretations, as well as bring about controversies regarding their allusion to equivocal representations. As an example, Apple, the Unicode Consortium, and Google introduced a diverse range of emoji skin tones to promote race neutrality in 2015 — albeit their idea backfired and resulted in larger tensions concerning digital self-expression within certain communities (O'Gieblyn, 2022). Such persistent efforts are being put in by official organizations to clarify the ambiguity of the symbolistic pictographs. Through an extensive investigation of the impacts emojis have on digital communication, it is possible to obtain a deeper insight into how emojis can augment or impair what each individual wants to express and convey through digital media.

Aims and Objectives

This inquiry aims to analyze the correlation between emojis and internet-based communication and examine how emojis can complement yet also inhibit communication. Exploring the ways in which individuals use emojis while conversing digitally and gaining a deeper insight into how they perceive them when used alongside plain texts allows for an evaluation of the practicality and limitations of emojis.

Research Question

How is communication affected by the implied meanings and usage of digital ideograms?

Digital ideograms, specifically emojis, are permeating online communication faster than ever before, and individuals are seeking new ways to replace plain text with them. While those icons allow for literal interpretations, they can also be polysemous, meaning that they can have

multiple functions and provide subtexts to a given context (Godman, 2022). This feature gives rise to the possibility of unintended miscommunication on an interpersonal level, and the abstraction caused by the emojis may ultimately result in a discrepancy in the perceived meaning between the sender and receiver of the ideogram. As society further adopts emojis as a part of online communication, the need to investigate the obscured functions and implications of such ideograms increases at a substantial rate.

Background

Emojis went through immense changes in their form, function, meaning, and usage since their emergence approximately 30 years ago. Shortly after SoftBank, formerly known as J-Phone, released its first 90 simple monotone emojis in 1997, Shigetaka Kurita invented the second colored set for the "ease of communication on a nascent mobile internet system developed by Japanese telecom giant NTT DoCoMo" (CNN, 2018). His creation turned out to be a great success, and it virtually replaced emoticons, an ideogram that served as a precursor to modern emojis.

The importance of emojis in digital communication is also reflected in Albert Mehrabian's 7-38-55 Communication Model (see Fig. 1). This rule demonstrates that the personal communication that takes place every day is 7% verbal, 38% vocal, and 55% nonverbal (Mehrabian, 1972). In light of this, it is possible to conclude that approximately 93% of human communicative skills are negated when communicating through text — fortunately, emojis have the ability to fill in such emotional gaps and enrich the text with a wider breadth of expression. Other than emojis, three major ideographic systems prevalently appear in modern digital communication: emoticons, memes, and Graphic Interchange Formats (GIFs). While they are in different forms, they all serve as visual representations of both abstract and concrete ideas. Vyv Evans, a professor at the School of Linguistics and English Language, remarks, "emoji is the fastest growing

form of language in history based on its incredible adoption rate and speed of evolution," of which he implies that out of the four ideograms, emojis arouse the strongest emotions between the interlocutors (Doble, 2015).

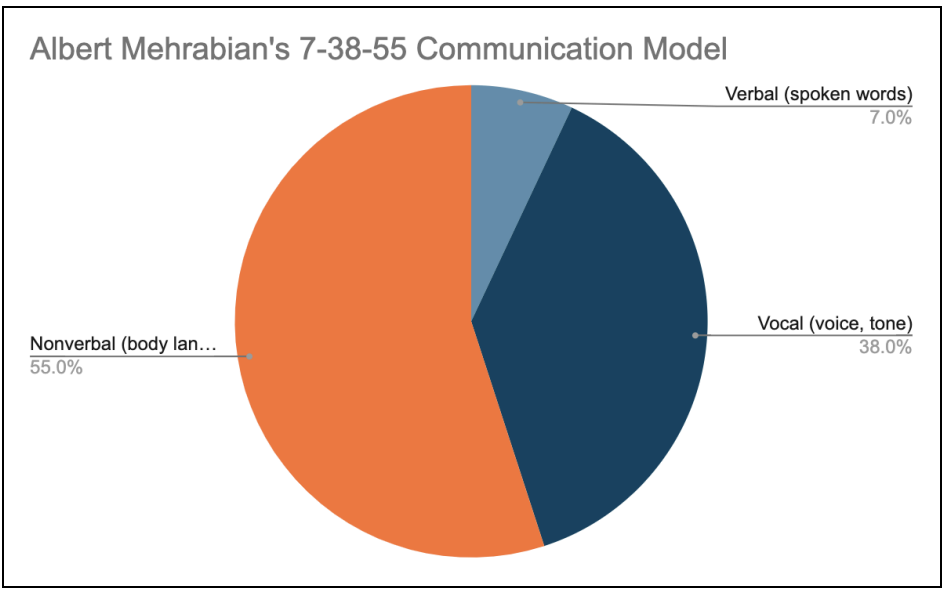

Figure 1: *The 7-38-55 rule proposed by Albert Mehrabian*

Universality of Emojis

Some people have claimed that emojis are more universally accepted than languages. In a 2019 TEDx Talk, Alisa Freedman, a professor of Japanese Literature, Cultural Studies, and Gender, stated:

> "Often in texting we use abbreviations, like in the United States we often use LOL … but LOL's not often understood outside the United States. … Emojis were preprogrammed into phones to make sure that we use the right emotional message when we text — to make texting more fun" (Freedman, 2019).

Her remark suggests that emojis may be more universal than languages; since emotions and facial expressions are omnipresent, everyone can associate the same feelings with the same emojis. Likewise, a professor of

Semiotics and Linguistic Anthropology Marcel Danesi states, "... the emoji code might well be the universal language that can help solve problems of comprehension that international communication have always involved in the past" (Danesi, 2016). With regard to Freedman's claim, it is reasonable to deduce that emojis allow individuals to transcend language barriers.

Interpretation of Emojis

Emojis and ideograms including emoticons, memes, and GIFs are open for countless ways of interpretation largely due to three fundamental reasons: user generation gap, design nuance, and cultural differences.

1. *Generation gap between users.* A 2020 study on the gender and age influences on emoji usage showed that while older populations tend to interpret emojis literally, younger adults desire a more abstract and softer definition. Therefore, a single emoji could take on multiple meanings due to users' disparate intentions and interpretations (Herring & Dainas, 2020).
2. *Nuance in emoji design.* The visuals of emojis differ between platforms, and those mixups could lead to miscommunication. This is evident in an example outlined in a University of Minnesota study, in which two people, Bill and Abby, are texting each other but through different phone platforms — one using a Google Nexus, and the other using an iPhone. Bill texts Abby, "Just went on that date 😁" which Abby sees as "Just went on that date 😬." Abby perceives a negative feeling through the emoji and thus replies, "Yikes! Sorry it went badly. Can't wait to hear stories!" but Bill doesn't understand, because the emoji he sent was clearly a positive indication in his mind. Even when the sender and receiver see the same emoji, they can interpret the context very differently due to the differing visuals (Miller et al, 2018).
3. *Cultural differences.* The complexity behind cultural differences can be exemplified by the "Person with Folded Hands" Emoji (🙏). While some might see this ideogram as a sign expressing gratitude, religious people might take it as a praying sign, and others may even

perceive it as a high-five gesture (Kelly, 2019).

Linguistic and Visual Factors

The varied interpretation of emojis is produced because signs and symbols have several perceptual forms. Roland Barthes, a French semiotician, proposed a Semiotic Theory that states that a sign is comprised of two components: the signifier, which is any material representation of a sign; and the signified, which is an idea or concept expressed by the signifier (see Barthes, 1977; Saussure, 1960). The two terminologies are in a complementary relationship, meaning that their definition cannot be separated in any way. Media Studies 101 written by Media Texthack Team claimed that each signifier has a signified, and that only together do they form a sign (Mediatexthack, 2014). Furthermore, a British visual semiotician, Daniel Chandler wrote the following in his book, Semiotics: The Basics:

> "There is no one-to-one link between signifier and signified; signs have multiple rather than single meanings. Within a single language, one signifier may refer to many signifieds (e.g. puns) and one signified may be referred to by many signifiers (e.g. synonyms)" (Chandler, n.d.).

Referring back to the Semiotic Theory, Barthes also identifies two 'levels of meanings' that an individual undergoes as they analyze the signified concepts: denotative and connotative, or in other words, verbal and nonverbal (Isfandiyary, 2017). The statements by the three authors lead to the supposition that the scope of the interpretation of signs arises due to the arbitrary relationship between the signified and the signifier.

Barthes's Semiotic Theory can be applied to emojis as well and is demonstrated in the 2018 study by Miller et al. on the variance of interpretation. The research team selected the 22 most popular

anthropomorphic emoji on 5 platform renderings (Apple, Google, Microsoft, Samsung, and LG) and asked the participants to explain the sentiments and semantic meanings associated with the emoji.

- *Sentiments.* The participants assessed the emojis on a scale from -5 (strong negative feeling) to 5 (strong positive feeling). The researchers found that there is a noticeable degree of misinterpretation of emojis both within and across-platform communication. The construal in the latter is especially substantial.
- *Semantics.* The researchers gathered free-text responses from the participants in relation to the perceived meanings of the 22 emojis. The research team first aggregated the participant's text responses using a platform called Scikit-Learn Python library, then converted the text to word vectors ($0 \leqq n \leqq 1$). The more the value is closer to 1, the greater variety of words the participants used in their responses. Again, the results demonstrated a variance in the interpretation of the meanings behind emojis used in within and across-platform communication (Miller et al, 2018).

Semantic Evolution of Digital Ideograms

All digital ideograms, especially emojis, go through a significant evolution in their meanings over a long period of time. A professor at the University of Edinburgh Alexander Robertson, along with a team of researchers, looked through emoji-embedded tweets posted on Twitter from 2012 to 2018 with the conjecture that "if an emoji always appears in the same context, [it is possible to say that] its meaning doesn't change much" (Robertson et al, 2021). The researchers categorized a total of 348 emojis into 5 Clusters (A, B, C, D, and E). The characteristics of the observed Semantic Change (SC) scores are described as the following:

- Cluster A: Gradual
- Cluster B: Extreme but temporal
- Cluster C: Gentle and temporal
- Cluster D: Minimal

- Cluster E: Continuous and non-static

An in-depth analysis of selected emojis in 3 Clusters allowed for a more elaborate conclusion. The researchers looked specifically into five emojis: 🐸 from Cluster B, 💀, 🏀, and 🎃 from Cluster A, and 🍁 from Cluster D. Their results revealed that SC can be associated with "different kinds of seasonality, … world events, or a shift from literal to figurative usage." Considering that emoji semantics are susceptible to trends and fads, it can be concluded that the meanings and functions of emoji are greatly influenced by external factors related to the difference in people's understanding of emoji usage. Moreover, the research suggests an inevitability of a progressive shift in the meanings behind those ideograms.

METHODS

To investigate how people from various age groups interpret emojis, semi-structured interviews and 1 small-scale replication study were conducted in an international high school in Japan. A convenience sampling method was used. Although the sample size was small, it did not negatively affect the quality of the results, as the main goal was to gather specific examples of how people used and viewed emojis. Furthermore, the sample allowed for various perspectives across age ranges and cultures (Bryman, 2012).

Phase 1

Semi-structured interviews were conducted with 13 teachers and 3 office staff. Interviews were conducted both in Japanese and English, and subsequently transcribed in English. Questions focused on thoughts about the relationship between emojis, language, and digital communication. The responses were thematically analyzed and compared with information found in peer-reviewed journals and the results of a survey.

A qualitative survey was collected from 37 individuals. In this survey, respondents were provided with 6 chosen emojis based on research, and

asked to describe the hypothetical context in which they could use the emoji. The survey accepted free-form text responses, and participants gave multiple answers.

Phase 2

Research conducted by the University of Minnesota (see *section 2.3)* was modified and replicated under analogous conditions. The methodology was adapted to carry out a small-scale replication of the study. A survey was sent out to all teachers and students at the same international high school, of which 33 (n=33) responded. The survey was divided into 3 sections: 1) participant's background information, 2) semantics, and 3) sentiments of emojis.

Out of the 33 participants, both males and females, as well as young and mature age groups were represented. In addition, participants responded that they never use emojis (6.1%), occasionally use (24.2%), sometimes use (33.3%), use most of the time (30.3%), or always use (6.1%) (see Fig. 2).

The survey then asked respondents to analyze the semantics and sentiments of six iOS 9 version emojis. These emojis were chosen based on the results of the original study — the emojis that exhibited the most and least degree of misconstrual (3 each) in terms of the two categories: semantics and sentiments. Regarding the section on semantics, the participants were asked to answer the following 2 questions with respect to each emoji:

Describe this emoji in 1 or 2 words
Fill in the blank: I would use this emoji [to/for/when] ___.

To quantify the open-text responses, results were evaluated by grouping similar answers and noting any patterns.

Regarding the section for sentiments, the participants were asked to judge the sentiment expressed by the given emoji on a scale from "strongly negative (1)" to "strongly positive (10)." The pairwise differences of the

semantic scores were evaluated; the values ranged from 0 to 10, indicating a perfect agreement to perfect disagreement respectively (See Appendix A).

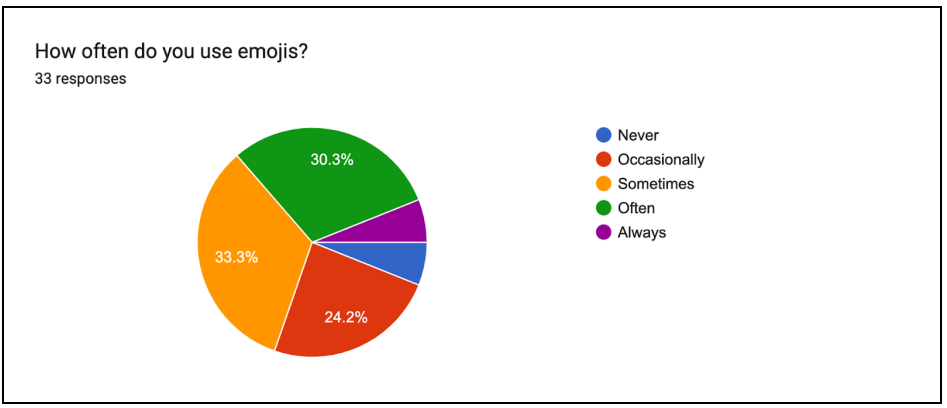

Figure 2. *Participant's emoji usage*

FINDINGS AND ANALYSIS

Phase 1

Whether digital ideograms — emojis in particular — aid or complicate online communication depends on how people view the use of emojis. Thus, interviews with 16 teachers and staff at an international school in Japan was conducted to solicit their views on the evolution of emojis. In particular, their responses to 2 out of the 4 questions provided evidence that strengthened the reasonings behind why emojis benefit or restrict digital communication.

Q1. Do you think emojis are a form of language? Out of the 16 participants, 13 responded that emojis are a form of language. While the reasons behind their opinions varied, the most common was that emojis can express and communicate emotions and body languages that can't be replicated with written text. The remaining 3 respondents stated that emojis are not a form of language because they are absent from a rigid system and structure. However, they also remarked that emojis are an augmentation of their accompanying text.

Q2. As professionals in your subject area, how do you think emojis affect the way we communicate online? While several participants mentioned the positive

influences emojis have had on digital communication, others gave opinions regarding the negative effects of emojis. One teacher, in particular, asserted that emojis might be deteriorating human language. Unlike written words which have their definition recorded in the dictionary, emojis don't have any conventional meaning and are dependent on each individual's interpretation. He stated, "when you have text talk, nobody really remembers what it means and what it meant originally … [This] damages what we all agree something means and it takes away the convention and … makes talk meaningless after a while." Such ambiguity of emojis oftentimes produces unnecessary subtexts, subsequently creating room for misinterpretation and obscuring the text message.

In addition, the questionnaire sent to the students and teachers, which surveyed their interpretation of 6 face emojis (see S*ection 3.1)* reinforced the idea that those digital icons are ambiguous in nature (see Tables 1 to 6). Although the sample size was small, their responses indicate that emojis can imply several meanings simultaneously.

Smiling Face with halo Emoji

RESPONSES	TALLIES
Happy / peaceful / heavenly	12
Dying	7
Innocence and peaceful mind	5
Sarcasm	5
Don't know, use, or care	3
Thankfulness / gratitude	3
Other responses	5

Table 1. *Aggregated Responses for Smiling Face With Halo Emoji (😇)*

Pleading emoji

RESPONSES	TALLIES
Sad / worried	12
Begging / pleading / wanting something	12
On the verge of crying	6
Faking innocence	6
Don't know, use, or care	5
Cute	3
Cringy	1

Table 2. *Aggregated Responses for Pleading Emoji (🥺)*

Laughing while crying emoji

RESPONSES	TALLIES
Funny / dying from laughter	34
Funny and sad	2
Ironically funny	1

Table 3. *Aggregated Responses for Laughing While Crying Emoji (😂)*

Hot Face Emoji

🥵

RESPONSES	TALLIES
When I'm feeling hot or when its a hot day	11
Ill; sick; exhausted; tired	9
When I really like the way someone or something looks	7
Don't know, use, or care	4
Spicy hot	3
Represents panic	2
Sweating	1

Table 4. *Aggregated Responses for Hot Face Emoji (🥵)*

Upside down face emoji

🙃

RESPONSES	TALLIES
Other responses	7
Being ironic; sarcastic	6
Don't know, use, or care	5
Blank mind; bored	5
Unhappy; things not going the way I want it to go	5
Misunderstandings	4
Happy	3
"Haha"	2

Table 5. *Aggregated Responses for Upside Down Face Emoji (🙃)*

Salute Face Emoji

🫡

RESPONSES	TALLIES
To express agreement; yes sir; when I'm told to do something	19
Greeting; salute; respect	10
Random moments; idk; don't use it	7
Other responses	3

Table 6. *Aggregated Responses for Salute Face Emoji (🫡)*

Phase 2

Phase 2 was adapted from Miller et al, 2018, revealing a significant congruence with the original study. The survey involved two sections: semantics and sentiments.

- *Semantics.* Table 7 shows a comparison between six iOS 9 version emojis that exhibited the most and least (3 each) within-platform semantic misconstrual scores, in both the original 2018 study and the replication carried out in this research (2023) (see *Section 2.3* for further information on the original study). Categories were determined by grouping the responses that contained similar words. Subsequently, the emojis were ranked based on the number of categories they are associated with; more categories indicate greater response variation. Although there is a small variance in the order of the emojis, it is worth noting that there is not a drastic difference between the data of the original and replicated study.

	Most/Least Within-Platform Semantic Misconstrual (Apple, iOS 9)	
	Original study	Replicated study
Top 3	0.97	20+15 = 35 categories
	0.96	11+15 = 26 categories
	0.95	8+11 = 19 categories
Bottom 3	0.73	6+12 = 18 categories
	0.63	8+8 = 16 categories
	0.52	4+7 = 11 categories

Table 7: *Comparison of the Results of the Original and Replicated Study (Semantics)*

- *Sentiments.* Table 8 represents the misconstrual in the sentimental judgments of the respondents. In the survey, the participants were instructed to judge the feeling expressed by 6 emojis on a scale from "strongly negative (1)" to "strongly positive (10)." To understand the degree to which individual participants disagree on the sentiment of each rendering, we generated and averaged the pairwise differences of those sentiment scores; values closer to 10 indicate greater response variation.

	Most/Least Within-Platform Sentiment Misconstrual (Apple, iOS 9)	
	Original study	Replicated study
Top 3	3.64	3.15
	3.50	2.86
	2.72	2.19
Bottom 3	1.25	2.13
	0.65	1.81
	0.45	1.46

Table 8: *Comparison of the Results of the Original and Replicated Study (Sentiment)*

DISCUSSION

Emojis are now widely used due to their ability to adapt and be flexible to a myriad of situations, but a significant hindrance in their functionality lies in the fact that people interpret them differently. The results of this study can be discussed using Barthes's Semiotic Theory, with the intention of generating new connections and understanding.

The comparative analysis between the interview and survey conducted in the international school suggested that emojis are, indeed, capable of enriching emotional expression, which leads to an increase in engagement in online conversation. The interviewees gave a mostly unanimous answer when they were asked whether or not emojis are a part of language, and they all mentioned that emojis can convey some kind of message. Likewise, Brad Tousnard, the founder of SpinupWP, said, "written messages can come across as cold and abrupt. To counteract this we encourage the use of emojis to let people express their personality and humor" (Anas, 2021). He is implying that emojis can be an accessory of language, which can serve as a replacement for facial expressions, gestures, and non-verbal cues.

The University of Minnesota study and its replicated version described in *Sections 2.3* and *4.2* has a direct correlation to Barthes's Semiotic Theory. The results allowed for a conclusion that all emojis are subject to differing interpretations, even if in the context of *within* and *across-platform* communication. Considering the semiotic theory from *Section 2.3*, it can be concluded that both the "signifier" and"signified" of the emojis were altered due to the myriad visual representations of the emoji renderings and individual interpretations.

Limitations

The replication study attempted to delineate the relevancy of the original study and understand the extent to which emoji renderings are interpreted differently by each individual. This reinforced the data gathered through the initial comparative analysis. Nonetheless, the sample size of the study was small, and the capability of obtaining an accurate interpretation was therefore limited. In addition, the method of analysis used by the original study was altered slightly in the replicated study, which may have generated an inevitable imprecision in the holistic analysis.

Future Study

Future research could focus on working with a larger sample size for the replication study and interview. This would lead to the establishment of a firm conclusion about the advantages and drawbacks of emoji usage. Another approach that could be taken to make this inquiry more accurate is by conducting a full-size replication study instead of a scaled-down version.

CONCLUSION

The findings of this inquiry reveal how people of all ages, especially young generations, perceive emojis in text-based communication. A rigorous evaluation of the advantages and drawbacks of this ideogram and a critical analysis of interviews and surveys explicate the fact that emojis are often lost in translation due to multifarious factors such as the user's age, gender, and culture. Both means of assessment also hint at the likelihood that emojis will continue to thrive in the future.

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What can we learn from revolutions?

Sakura N, Emily, Austin

Supervisor: Nathan Hensley

ABSTRACT

This inquiry focuses on political revolutions and changes as a concept focusing on how different historical events could be compared, the causes of revolutions, and their outcomes. Studying research papers on JSTOR written by various scholars and experts on political science and revolutions, and conducting an interview with a history professor, has brought about new ideas on how revolutions could be categorized. Statistical models that display the economic effects of revolutions, case studies of major revolutions, and the study of the categorization of the outcomes of revolutions have been studied to generate an understanding of the importance of revolutions.

LEARNING READINESS

Introduction

Revolutions are a cycle of radical change and transformation that has occurred repeatedly throughout human history. They have led to social destruction and reforms, impacting the world in both negative and positive ways. New ideas that have developed throughout history have led to vast changes in the societal construct (Haferkamp & Smelser, 1991). Thus, it is critical to examine the changes that revolutions bring to humanity, to fortify an understanding of what could possibly happen in the future following the issues of our current society.

Learning Context and Problem

The context of this inquiry is focused on revolutions, and how they could be studied to recognize their influence and significance on modern society.

Revolutions can be interpreted in multiple ways, and is therefore an ambiguous phenomenon that is nearly impossible to exactly define.

However, in considering revolutions synonymous to political change, past historical events are evidence of the radical changes that have been brought to society. Historians and other experts on revolutions have developed various theories and conducted studies that explore the causes and outcomes of revolutions. Jack A. Goldstone – an American sociologist – for example, has studied and analyzed theories of revolutions from general to structural theories in his paper, *The Comparative and Historical Study of Revolutions* (Goldstone, 1982). Through further examining the investigations made by scholars on revolutions and recognizing their importance in our contemporary world, we can gain a broader understanding of how different historical events could be interpreted.

Aims and Objectives

The aim of this inquiry is to compare historical and modern revolutions whilst studying the theories formed by various scholars to further understand the cause and effect of the phenomenon. In developing a further understanding of the changes that revolutions bring to society, we can identify the importance of studying and analyzing historical events.

ENGAGING WITH SKILLS, IDEAS, & INFORMATION

Big Question: What can we learn from revolutions?

Throughout the course of history, revolutions have led to massive shifts within society. As the world undergoes constant changes, it is of great importance to study revolutions to understand what provokes people to want change corresponding to the issues of society. In studying and comparing the causes and effects of major historical events, the importance of revolutions can be investigated.

Engaging with Ideas & Information:

Change:

The definition of the term "revolution" has changed over time due to the occurrences of different historical events. A bestselling author of multiple history books, Peter Furtado stated, "Through the past 250 years, the concept of revolution has morphed sufficiently for an exact definition to be impossible." (Furtado, 2020) in *Revolutions: How They Changed History and What They Mean Today*. This reveals the comprehensiveness of revolutions and the various ways in which they could be interceptores. As an example, Furtado mentions Karl Marx's definition of revolutions, which pointed towards achieving an ideal or total transformation of society. He compared this to the Iranian revolution in 1979, which was the first upheaval that differed from Marxist ideologies as they were more focused on the liberation from an oppressive regime. This shows that the different forms of revolutions have led to the changes to its definition and interpretation.

Causation:

Many factors contribute to the cause of revolutions, as they are large organized movements that require the immense effort of the people. According to National Geographic, revolutions are most often ignited by four main components – the power of dissident elites, mass frustration, shared motivation, and state crisis (National Geographic, 2022). This shows that instability and the change in beliefs and values held by society are fundamental factors in the emergence of a revolution. However, the theories developed by various philosophers and experts have revealed several other notable factors that could be the precursor of these events. As an example, in relation to revolutions beginning from an unstable government, Aristotle has claimed in *Politics* that "revolutions against tyrannical regimes are natural and virtually inevitable" (Goldstein, 2001). The many causes of revolutions could be studied through the different theories and findings of scholars.

Form:
Revolutions are an equivocal concept that takes on many forms. The term holds a different definition today than in the past, due to the changes in its characteristics. Jack A. Goldstone – a political theorist and historian known to have defined revolutions in the broadest way – has described revolutions as "an effort to transform the political institutions and the justifications for political authority in a society, accompanied by formal or informal mass mobilization and non institutionalized actions that undermine existing authorities." (Goldstone, 2001). Goldstone's interpretation brings about the stark connection between revolutions and political change. However, social and cultural revolutions such as the Sexual Revolution of the 1960s to 80s – a feminist movement about female sexual empowerment (PBS, 2023) – shows that some radical changes of society are unrelated to the reform of governmental structures. Even so, this is not within the scope of our inquiry, and therefore, our main focus will be on political changes.

Perspective:
The perspective of revolutions vary according to the country and their political stances. Different government and economic states will promote the ideal of overthrowing their current government or changing the economic structure. This is shown throughout history such as in the Cuban and French revolution, which both displays the idea of change. In the Russian revolution, Vladimir Lenin and the Bolsheviks viewed the Tsar as a weak and unsuitable system for Russia, replacing the Russian Tsar with communist states to ensure a better society for everyone. Karl Marx's ideal of capitalism created the economic gaps between classes, thus causing a revolution. A communist state will not cause that because wealth is equally distributed (Booth & Sewell, 2017).

Responsibility:
Revolutions are caused by the enlightenment ideals, economic problems, and weak leaders who caused the country to go into deficits. Without a weak leader that financially ruins a country that is causing the lower and

middle class in poverty, it is less likely for them to start a revolution. Only under such pressure will cause the people to rebel against the current government (National Geographic Society, 2022). The state of the country is one factor prompting people to revolt against the government and such organized revolt happens under groups of leaders. Revolutions without a leader or group won't be organized, thus will be easily knocked down by the government, but all revolutions are led by a leader or group that have one united goal, which is to overthrow the current government and replace it with a better one. Revolutions such as the American revolution are led under the leadership of George Washignton, Samuel Adams, Patrick Henry, Benjamin Franklin, Thomas Jefferson, and etc (Lloyd Sealy Library, 2023). Without such leadership and organization, the American revolution will be less successful.

DIGGING DEEPER & CONSOLIDATING LEARNING

How can we compare revolutions?

Revolutions happen under the pressure of an economic crisis and the people's dissatisfaction towards the government. In *The Comparative and Historical Study of Revolutions,* Jack A. Goldstone examines the basic problems that cause revolutions, the solutions to revolutions, and the latest studies from the 21th century (Goldstone, 1982). There are multiple views when it comes to the causes for revolutions which therefore, does not display a correlation of any form. Some view that the causes of revolutions are often associated with misery and oppression, as dissatisfaction grows to uprising which does not apply to all the cases of revolutions. However, all revolutions share some similarities: riots, coups, and civil wars. According to the views from Smelser and Johson, examining the society as a whole, which is the economy, the political system, and the education, if those factors are growing at around the same rate, the society will be balanced. However, when those factors are not balanced, radical ideals will arise and challenge the government.

Why do revolutions happen?

Revolution is a term that has been used throughout history to describe significant and often violent changes in the political, economic, or social order of a society. Scholars have highlighted the various perspectives on revolution, ranging from material and economic conditions to cultural transformation. Tocqueville and Davies emphasized the material conditions that contribute to a revolution, such as long-term economic development followed by an aggrieved population seeking a significant change in the structure of society, often accompanied by nonviolent protests or civil resistance. However, other scholars argue that revolution stems from institutional imbalances in society brought about by modernization and commercialization. These imbalances weaken the state and create increased incentives for rational, cost-calculating individuals to participate in revolutionary activity. Castells stresses that for a revolution to occur, there must be objective conditions and subjective insight into those conditions. Marxist theories also prioritize the material basis of revolution, emphasizing the role of class struggle and economic inequality. Despite the diverse perspectives on revolution, it is widely agreed upon that significant changes in society require collective political action from an aggrieved population. Moreover, it is important to note that revolutions not only change the political and economic systems of a society but also have significant effects on cultural norms and values.

What changes occur after a revolution?

Revolutions bring about vast changes to many different factors within a society. In a study by Ekkart Zimmerman – a German sociologist and political scientist – titled, *On the Outcomes of Revolutions: Some Preliminary Considerations*, he has assessed revolutions within four sectors: politics, economics, social-cultural, and state power. Zimmerman stated that "there are strong causal effects from politics to the economy, the social-cultural realm and state power" (Zimmerman, 1990). This can be seen specifically in the American revolution, which according to The American Yawp by the

Stanford University Press, is an event that has led to wide changes in both politics and economy (Locke & Wright, 2019). More importance was placed on the representation of the government due to the growth in political participation that came from the right to vote. Additionally, "the Revolution ended the mercantilist economy, opening new opportunities in trade and manufacturing." proving that out of the four sectors, the outcomes of the American revolution aligns with the political and economic sectors made by Zimmerman.

Methods

The team has conducted an interview with Mr. Devon Williams – a history teacher with a political science degree – to gain a deeper understanding of the causes and effects of revolutions. In asking questions that also required the teacher's opinions based on their knowledge, we have been able to figure out a way to categorize revolutions and to consider possible future events.

Generating New Understandings

Throughout investigating revolutions by reading various research papers and conducting an interview, the significance of revolutions within society has emerged. *Some Economic Effects of Revolution: Models, Measurement, and the Cuban Evidence* by an American political scientist – Michael S. Lewis-Beck – has displayed statistical models that show the economic effects of revolutions (Lewis-Beck, 1979). The first economic model shows the general outcomes of revolutions based on three different ideologies: the Conservative, Marxist, and Thermodorian theory. The Conservative theory indicates that the revolution will create long term destruction and will take a long time for society to return back to normal. The Marxist theory argues that the revolution will revolutionize the economy and production, allowing the economy to return back to normal, benefiting the society in the long term.

To understand the cause of revolutions, case studies were made to investigate what provoked the changes to be made within society during

different periods of time. Focusing on the causes and outcomes of the four major revolutions: The American revolution, French revolution, Russian revolution, and Cuban revolution, we will proceed to create a spectrum that organizes the different revolutions into 3 categories based on their outcomes.

In our interview with Mr. Williams, he mentioned that the "two easiest ways (to categorize revolutions) are socioeconomic on one hand, militaristic on the other". With this interview, the team received more articles, resources and ideas on how to perform their final artifacts. Articles have been a key contribution to the team research and understanding of revolution.

Findings & Summary

The findings of this inquiry reveal the importance of studying about political revolutions. Most scholars held the shared idea that a revolution required the shared contribution and agreement of the desire for change. This leads to the understanding that revolutions reflect the social situations and the people's reactions towards the society that they live in.

APPLYING NEW KNOWLEDGE

Conclusion

This inquiry has generated an understanding of how different historical revolutions could be interpreted. Due to the complexity and magnitude of political revolutions as a concept, comparing various historical events have led to conflicting results. Despite seeing that there were no clear correlations to the causes behind different revolutions, some theories have shown that the outcomes of the phenomena could be connected and categorized. Therefore, learning about revolutions brings insight into the many perspectives that are brought about through the comparison of their cause and the change they bring about to society.

Future Study

The findings of this inquiry reveal the diverse ways in which past

revolutions could be classified according to the roots and results of the event. In creating a visual diagram – such as a graph – to categorize different historical revolutions, we can gain a further understanding of how revolutions could be compared.

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How is society responding to the emergence of different iPS-related biotechnological techniques?

Aoi Nagashima, Ema Matsuura, Yumiko Baba

Supervisor: Nathan Hensley

Abstract

This paper examines the ethics and controversies associated with the use of Induced Pluripotent Stem Cell (iPSC)-related biotechnological techniques. Through a provocational activity in an international school in Japan, students shared their thoughts on the morality of such techniques. An attempt to create new ways of using iPSC was also made, and those inventions were evaluated considering their practicality. The findings show that society develops the ethics of iPSCs usage primarily based on the procedures that it entails. The results allow for a deeper discussion on the other factors that influence their ethicality as well.

List of Abbreviations

iPSCs	Induced Pluripotent Stem Cells
ISSCR	International Society for Stem Cell Research
TSCs	Totipotent Stem Cells
PSCs	Pluripotent Stem Cells
ESCs	Embryonic Stem Cells
MSCs	Multipotent Stem Cells
ASCs	Adult Stem Cells
AVVs	Adeno-associated Viral Vectors
hESC	Human Embryonic Stem Cells

TFs	Transcription Factors
OSKM	OCT4, SOX2, KLF4, MYC
SCNT	Somatic-Cell Nuclear Transfer
PD	Parkinson's Disease

Learning Readiness

The novel discovery of stem cells is deemed a phenomenal breakthrough in the biotechnological sphere, and the application of those cells in the medical industry has been investigated by numerous researchers over the past several decades. iPSCs (see Section Form for the definition of iPSCs) are one of such promising scientific developments that was discovered by Professor Shinya Yamanaka in 2006 (Omole & Fakoya, 2018); however, the ways they are employed in the therapeutic field today entails a slew of convoluted ethical issues. Thus, it is pivotal to critically analyze their potential as well as the challenges that inevitably follow the practice.

Learning Context and Problem

The context of this inquiry is iPSCs, and how they are clinically applied in molecular studies and viewed by the science faction. iPSCs are applicable in countless biomedical fields, such as regenerative medicine and cell therapy. However, since they are a newly-established method, they are subject to improper usage and exploitation. In response to the rapid medical advancements, the International Society for Stem Cell Research (ISSCR) recently released an updated set of guidelines pertaining to stem cell research, which addresses the risks of new scientific techniques i.e. chimeric embryos, and prohibits certain activities i.e. the use of stem cell-derived gametes (ISSCR, 2021). While these regulations may help maintain the responsibility and integrity within the scientific community and moderate the pace of progress, the certainty that they will not be transgressed is not guaranteed. Through a closer investigation of the utilitarian aspects of iPSCs, it is possible to gain a considerable understanding of the ethical problems that come along with such developments in medical research, as

well as recognize the potentiality of stem cells for the current generations and posterity.

Aims and Objectives

The aim of this research is to examine how iPSCs are applied in the modern medical sphere. The discovery of stem cells was discussed from the beginning of the 20th century — immediately after its discovery. By generating a better understanding of how iPSCs are currently used and why they involve ethical problems, we can identify the issues that can be resolved in order to ameliorate the adverse effects.

Engaging with Skills, Ideas, & Information

Big Question: How is society responding to the emergence of different iPSC-related biotechnological techniques?

Modern society has been seeing a boom in the use of biotechnology — a technological application of biological systems that enhances human health and life (Food and Agriculture Organization of the United Nations, 2023). The development of such revolutionary techniques, especially gene therapy and cloning — those related to iPSCs — contribute to the inventions of pharmaceutical drugs and regenerative medicine, which are endorsed by the majority. However, these pioneering inventions are always accompanied with potential drawbacks that tend to be related to ethics and controversies. The ways different sectors of communities view the advancement of biotechnological approaches considering that some have superficial knowledge about them represent an important area of study.

Stem cells and their potency

Stem cells are defined as cells that can replicate themselves multiple times (self-renew) themselves and undergo differentiation, which is when cells acquire specialized functions (Mayo Clinic, 2022). They cannot perform specialized functions yet; however, they can be categorized into 3 groups based on their potency — totipotent, pluripotent, and multipotent —

which is their ability to differentiate into certain cell types (ThermoFisher, 2019):

1. Totipotent: Totipotent stem cells (TSCs) are only present in the earliest stages of embryonic life, and they disappear after generating the fundamental materials for an embryo to develop. They can divide into any types of cells and can potentially create an entire organism only through the process of dividing.
2. Pluripotent: Pluripotent stem cells (PSCs) can divide into any types of cells, but they cannot create an entire organism. Embryonic stem cells (ESCs) (See section Types of Stem Cells) are a type of PSCs.
3. Multipotent: Multipotent stem cells (MSCs) can differentiate into any cells within a particular lineage. For example, blood stem cells have the potential to develop into all blood-related specialized cells i.e. red blood cells.

Types of stem cells

Stem cells are divided into two main forms: 1) ESCs and 2) adult stem cells (ASCs) (University of Rochester Medical Center):

1. ESCs: ESCs are pluripotent but are present only during the embryonic development. They are the inner mass of the blastocyst, a cluster of zygote cells (See Fig. 1), and they will go through differentiation to create the human body. These cells can be extracted and grown in special laboratory settings where they can still retain the properties of ESCs; however, this process destroys the nascent life.
2. ASCs: ASCs are multipotent and are present in the adult body. They don't self-renew as easily as ESCs do, and they are also referred to as tissue-specific stem cells as they develop into cells that would carry specific tissue or organ functions. ASCs are difficult to find, isolate, and grow in a laboratory condition.

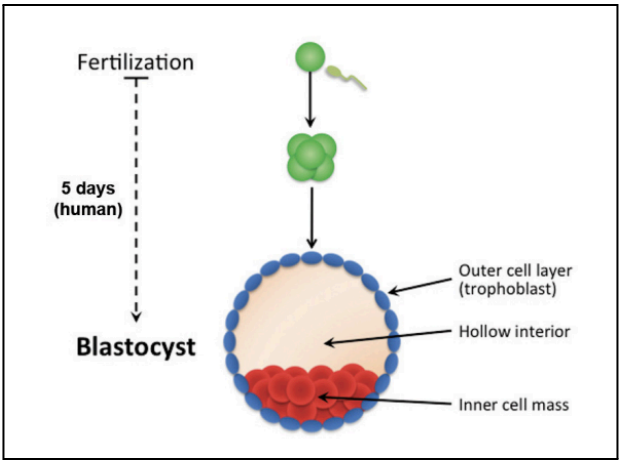

Figure 1 (Embryonic stem cells, n.d.)

Let's unpack two types of the countless biological techniques:

CLONING

Clones are organisms that have exact genotypic and phenotypic copies of the original, and it can be either natural or artificial (University of Utah). In natural conditions, certain plants and organisms undergo asexual reproduction and create an exact copy or clone of their own, while human identical twins are also considered natural clones as their genetic and physical characteristics are the same. On the other hand, 3 types of artificial cloning exists, which are 1) gene cloning, 2) reproductive cloning, and 3) therapeutic cloning (MedlinePlus). Each of these are defined as the following:

1. Gene cloning: Produce copies of genes or DNA segments. This can be used in gene therapy to treat genetic diseases.
2. Reproductive cloning: Produce copies of whole animals.
3. Therapeutic cloning: Produce clones of ESCs to create tissues that can replace damaged body parts. Unlike reproductive cloning, it is a way to remedy diseases. ESCs are gradually replaced by iPSCs as the latter involves less controversies.

While animal cloning has been proven successful with the first-ever case being Dolly the sheep (See section Dolly the sheep), human cloning has never been conducted and is still a practice long discussed due to their ethics and difficulties. Cloning is still in the evaluation stage, but it has the potential to be used in medical research.

GENE THERAPY

Gene therapy is a research-in-progress medical treatment aimed to remedy or prevent diseases at a genetic level. This is done either through insertion, removal, or modification of the genetic material in a human cell. Though it is a technique that carries huge potential, the medical team still cannot guarantee its safety and efficiency. Currently, 3 gene therapy methods have been developed: 1) ex vivo therapy, 2) in vivo therapy, and 3) in situ therapy (Papanikolaou & Bosio, 2021). They are:

1. Ex vivo therapy: Involves extracting the target cells from the body, genetically modifying them in artificial environments with the use of vectors (See section Vectors), and transplanting them back.
2. In vivo therapy: Involves inserting the vectors into the body fluids to deliver instruction directly into cells
3. In situ therapy: Involves directly inserting the vectors to the target cells to treat their defects.

Vectors

Vectors are a vehicle — a carrier that transports substances — to deliver a particular gene directly into a cell. Viral vectors are the most common as they most efficiently invade cells; those viruses are encapsidated by a shell called Capsid which helps transport the genes into the target cell. Viral vectors can be separated into 4 types: 1) Adeno-associated Viral Vectors (AVVs), 2) Adenoviral Vectors, 3) Retroviruses, and 4) Lentiviruses, though the latter two can be grouped into one (American Society of Gene & Cell Therapy, 2021). The types mentioned above are:

1. AVVs: AVVs are commonly used to target non-dividing cells such as liver, eyes, skeleton muscles, or nerve cells. They only have a

limited capacity to carry DNA packages to cells.
2. Adenoviral Vectors: While they have the same function as AVVs, adenoviral vectors are 8 times bigger and have a larger DNA-carrying capacity.
3. Retroviruses: Retroviruses are RNA viruses that can deliver large genetic packages of RNA to the target cell, which is then converted into DNA strands. Currently, this virus is regarded as the most reliable vector due to their functionality (Vargas et al., 2016). Lentiviruses are a subtype of retrovirus.

Dolly the sheep

The Roslin Institute conducted an experiment involving the process of inserting a cell taken from a Finn Dorset sheep into an egg cell of a Scottish blackface sheep with the aim of developing an efficient method to produce genetically modified livestock (The University of Edinburgh). The cloning was successful — the offspring, Dolly, had a white face, unlike its "mother" who has a black face (See Fig. 2). This experiment proved that specialized somatic cells could be used to create exact copies of an organism and led to the development of iPSCs.

Figure 2 (Dolly and her surrogate mother)

Engaging with Ideas & Information:

Change: Do biotechnological techniques disturb the concept of death?

Biotechnological techniques and their applicability in the medical industry are endless. Cloning deceased pets has already been proven possible, but can this practice be implemented on, let's say, a human child? Cloning deceased children remains to be one of the most controversial aspects of cloning technology as some claim that replacing a "lifeless" individual is equivalent to cheating death or resurrecting the dead (Lagay, 2001).

Moreover, the cloned child may be mistreated and face injustice. Since a cloned individual will share the same physical appearance as the original, parents who clone their child for the sole purpose of replacing a child they had lost would force the cloned child to act like the original. However, since personalities and behavioral traits will not be inherited, such pressures may hinder the child from developing their individuality (Murray, 2001). On one hand, cloning is an extraordinary development in the field of healthcare whereas on the other, restrictions and regulations considering ethicality and morality are needed to prevent the practice from going too far (Sperling, 2011).

Causation: What makes iPSCs useful and problematic in the medical industry?

iPSCs possess unique properties that make them exceptionally advantageous in the field of regenerative medicine and treatments. For one, they are a potential alternative solution to the human embryonic stem cell (hESC) research. hESC research poses ethical issues due to the process of having to extract cells from a blastocyst, which destroys a preimplantation stage embryo (Lo & Parham, 2009). iPSCs are significantly less controversial as they are derived from somatic cells which can be innocuously extracted from any individual. However, major hurdles still remain, and one of them is the genomic instability of iPSCs. Studies suggest that such risks of mutation caused by reprogramming lead to the loss of control over their self-renewal process, subsequently increasing their

potential for tumorigenicity (Liang et al., 2013; Harvard Stem Cell Institute).

Form: How are iPSCs formed?
iPSCs are ASCs that are reprogrammed artificially to behave like ESCs. Compared to ESCs which are present only during the embryonic development, iPSCs can be derived from people of all ages, and they would still have the same functionality. Different methods for making iPSCs have emerged over the past decades, but the classic approach is the insertion of the four transcription factors (TFs), which are proteins that regulate the gene expression and ultimately control certain cellular functions, also known as the "Yamanaka factor (Takahashi & Yamanaka, 2006)." This is done through retroviral or lentiviral transduction; retroviruses and lentiviruses are two of the four main types of viral vectors, and in this context, they are used to insert transcription factors to ASCs to make iPSCs; transduction is the process of genetic transfer from one bacterium to another through the use of viral vectors (See section Vectors) — tools that deliver genetic materials into cells. (American Society of Gene & Cell Therapy, 2021).

With the help of viral vectors, TFs are inserted to cells. Dr. Shinya Yamanaka has discovered the four "Yamanaka factors" that can reprogram ASCs into iPSCs: OCT4, SOX2, KLF4, and MYC (OSKM). Through in vitro studies, which are the studies performed in artificial environments, the ASC-derived colonies "resemble ESCs morphologically, molecularly, and phenotypically" (González et al., 2011). This process is inefficient and has a low success rate, however, thus scientists and researchers have been taking different improvement approaches.

Perspective: What are the differences between using biotechnological techniques to enhance humans' cellular functions and to rectify genetic defects?
Differences exist between using biotechnological techniques to improve and enhance human health. Cloning, one of the techniques that involve the

use of iPSCs, are divided mainly into 3 categories (See section Cloning): gene cloning, reproductive cloning, and therapeutic cloning — each type has different purposes and impacts on the human body. In particular, the latter two encompass similar processes, but one is used for reproductive purposes while the other is for medical treatment purposes. Both involve the use of a laboratory technique called somatic-cell nuclear transfer (SCNT) to fuse a somatic cell and an egg cell and create a functional embryo (Lakna, 2019). However, the similarity ends there. In reproductive cloning, the embryo is then implanted into a uterus and develops under real conditions. In therapeutic cloning, the embryo is grown in and developed under artificial, laboratory conditions (Denstedt & At
ala, 2009). This shows that the gap between the purpose of certain techniques could be manifested through their laboratory processes.

Responsibility: Who is responsible if a surgical procedure involving biological techniques went wrong?

In the healthcare industry, whether or not the surgeon is liable for a failed procedure is a controversial topic and frequently debated upon. In general, a surgeon has the responsibility and leadership during an operation. They are responsible for diagnosing the condition, performing the operation, and providing aftercare for the patient, post surgery (Shibley, 2019). The determination of whether or not they should be responsible is determined by examining other surgeons with similar skill levels in a similar situation and observing if they would perform similar action and mistakes (Callahan & Blaine, 2023). However, the determination of the ethicality of a procedure is also something that is very inconsistent. The degree of risk the procedure a surgeon is going to conduct is evaluated by the surgeon themselves, meaning that the assessment is solely based on their moral standards. Moreover, the surgeon is given the right to perform the procedure if its benefits are justified and the patients are willing to undergo the plan — this suggests that the discussion of ethics could be revoked as long as the people involved come to a consensus. (American Academy of Ophthalmology, 2020).

Digging Deeper & Consolidating Learning

Lines of Inquiry

Lines of Inquiry 1: How are iPSC-related biotechnological techniques impacted by their ethicality?

The achievements of scientific and technological progress have opened up new prospects in the development of techniques that involve the use of iPSCs (Al Abbar et al., 2020). On the one hand, the expansion of experimental research in those areas has given rise to new medical approaches such as genetic engineering, disease modeling, and organ transplantation. In particular, a great potential has been shown in the development of therapy in Parkinson's disease (PD), which is a progressive brain disorder that damages the nervous system and ultimately degenerates the motor system (WHO, 2022). In one experiment involving the use of in vivo animal models, replacing damaged neurons in rats and monkeys with healthy iPSC-derived cells led to a behavioral improvement (Takahashi, 2020). On the other hand, those studies have increased the severity of moral, ethical, and legal problems. Consequently, researchers currently face a reinforcement of rules, such as the demand to monitor the development of biotechnological techniques to avert catastrophic consequences, and the need to determine the criteria of death. (Langlois, 2017). In this way, society in the 21st century is faced with various bioethical problems that stem from scientific and technological progress.

In regards to such issues, it is necessary to focus on the prospects of iPSCs that arise in connection with the development of biotechnological techniques. As those techniques intervene in an organism's nature, a discussion of their socioeconomic and moral consequences are required. This discussion plays a crucial role as it impacts the pace of medical research and societal responses to the possibility and necessity of the approaches.

Lines of Inquiry 2: How can the iPSC-research open further possibilities for medical

treatments?

The possibilities of iPSC treatment and biotechnological techniques are endless, and such approaches can help treat a greater range of people. Currently, the main areas of use for this technology are disease modeling, regenerative medicine, and the development of new medical drugs.

Disease modeling

Researchers need to model diseases to find out their main cause and develop effective treatments. Most disease models involving the use of iPSCs are two-dimensional (2D). Although the complexity of the study is restricted, this model allows the scientists to illustrate key features of diseases i.e. PD, such as the proteins that account for their symptoms (Torrent et al, 2015). Moreover, modeling diseases at a three-dimensional (3D) level is also being explored, although it is still strictly in the research phase (Liu et al., 2018).

Organ transplant

With the use of iPSCs, the injured tissues of a patient can be regenerated and rectified through in vitro procedures (See section GENE THERAPY) and be inserted back into the patient. If this gene therapy method can be used in clinical circumstances, the need of organ transplantation may dwindle. Currently, society has been faced by the paucity of donor organs and expansion of the transplant donor pool — data has even shown that over 7,500 patients in the US die annually while waiting for a suitable organ (Vimal K. Singh et al., 2015).

Regenerative medicine and other new drugs

Research into iPSC-derived medicines have already shown significant progress. Researchers succeeded in producing a regenerative medicine for PD in a clinical trial that began in 2018 that involved the process of transplanting dopamine-producing neuronal cells deriving from iPSCs. In the experiment, trials for several other diseases i.e. Progressive Ossifying Fibrodysplasia (FOP) and Amyotrophic Lateral Sclerosis (ALS) were

conducted as well (CiRA, 2021).

Lines of Inquiry 3: How are different biotechnological techniques viewed by certain communities?

Every person in society has varying judgments on the iPSCs-related biotechnological techniques such as cloning and gene therapy. This was evident through the provocation conducted in an international school in Japan on April 27th and 28th of 2023. Grade 10 participants (n=35) along with 2 supervisors were presented with 3 hypothetical cases of cell research which were each linked to 2 open-ended questions, and a few participants were chosen at random to give their answers. Since the audience only had superficial knowledge of iPSCs and biological techniques, the questions involved widely-known and straightforward topics: cloning and gene engineering, as well as their ethicality. This activity suggested that the public opinion on the two matters largely depends on each individual's perception on the concept of "living beings."

One of the questions explored the value of human clones. Some participants stated that cloned individuals do not deserve to be treated like actual "humans" as they can be manipulated in heinous and sanctimonious ways, such as committing crimes and producing an "army of clones." This claim can be backed up with the moral argument that Christof Tannert, a bioethicist at the Max Delbrück Research Centre in Berlin, Germany, presents against human reproductive cloning. He states that cloning should not be tolerated as "it only fulfils the selfish interest of a creator" (Tannert, 2006); he is suggesting that clones are merely a tool for humans to gain authoritative power, and they will likely be relegated to lower statuses. In the context of the provocation and the responses of several participants, his claim implies that biotechnological techniques including cloning are a negative practice as they make humans egoistic.

On the other hand, other participants claimed that the value of human clones is tantamount to that of the original humans as clones could develop

personality traits and characteristics through the influence of external factors. Some researchers believe in genetic determinism, that is, how the genetic makeup of one individual is equivalent to their personal identity (Resnik & Vorhaus, 2006); however, mankind receives two types of heredity: biological and cultural (Ayala, 2015). While the biological aspects cannot be altered in any humans including cloned ones, culture is transmitted by instruction and learning, and it is unique to each individual. Accordingly, it is possible to conclude that biotechnological techniques such as cloning could make the distinction between original and manipulated humans nebulous due to the increased similarity, and thus society may be in two minds of whether to embrace the usage or not.

Methodology

To investigate how society is adopting the development of iPSC-related biotechnological techniques such as cloning and gene therapy, an original research proposal on the iPSC usage in the medical industries was created. Developing a comprehensive and holistic plan was infeasible due to the insufficient knowledge of iPSCs acquired throughout this inquiry process compared to the unfathomable amount of research other experts have conducted; however, it did not affect the quality of the proposal as the main goal was to demonstrate the vast usefulness of iPSCs.

Generating New Understandings

In relation to section LOI2, assiduous research and extensive experiments conducted by scientists have indicated that iPSCs have countless potential clinical applications. By investigating how society is adjusting to their emergence, plans of future iPSC usage that have not yet been touched on by the experts were devised. These proposals may overlap with a few features of the approaches currently examined on — thus to discern their potential, the pros and cons of those possible procedures were evaluated.

1) Therapeutic Cloning

Therapeutic cloning, as discussed in section CLONING, is a treatment that

involves replacing damaged body parts with healthy tissues. These tissues are derived by ESCs, which can be extracted only through the manipulation and destruction of the human blastocyst (see Section Types of stem cells).

Society is reluctant to embrace therapeutic cloning due to this sacrificial process, but their view may change if ESCs are fully replaced by iPSCs as the latter involves less ethical issues (Herranz, 2001). The diseases and conditions that can be cured through the cloning technique — ranging from spinal cord injuries to burns — will not be altered with the change of stem cell type. One issue is the cost: iPSC treatment is significantly more expensive than embryonic stem cell treatment (Nikkei, 2016; Cona, 2023).

However, suppose that the treatments would be conducted more frequently in the future — the price of the medication would decrease as its demand increases as described in the supply and demand curve (see Fig. 3), thus it could be deduced that the cost would not be a major issue in the time ahead.

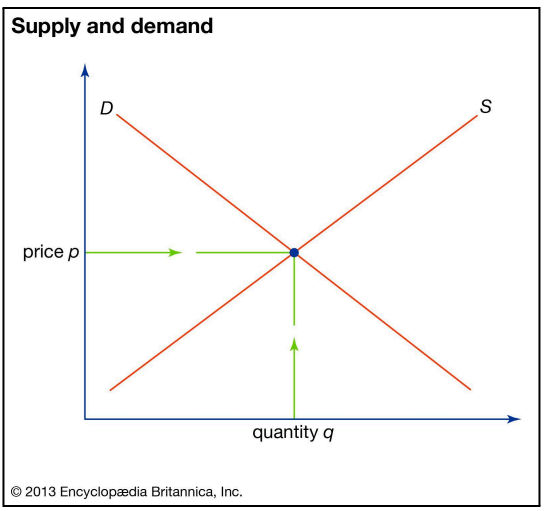

Figure 3: Supply & Demand (Britannica)

2) Animal Testing

Animal testing has been performed for a very long time as a part of drug

development. The main purpose isn't only to test if the drug has the desired effect against a particular disease but also to check if it does not have any adverse effects on the human body. For example, medical researchers use the blood of horseshoe crabs to develop vaccines against certain diseases detrimental to human health. However, the number of advocates on such experiments have dwindled due to the unethicality of the procedures they involve (Akhtar, 2015). The horseshoe crabs are captured from the wild and 30% of their blood is removed for medical usages — they are then released to the wild; however, it is believed that approximately 10-15% of them die later in their life stages (The Humane Society of the United States, Animal testing and experiments FAQ).

This is where the novel pluripotent cells come in — since iPSCs are capable of turning into any somatic cell, they can be grown into human organs and tissues through in vitro studies (UCLA). Testing the toxicity on iPSC-derived organs rather than the animals' would not only preclude innocent animals from getting harmed, but it could also yield more accurate data on the ways the drugs affect humans. However, this technology is still heavily in the research phase, and making human organs with iPSCs still is not possible.

3) Appearance Modification

Clinics specializing in cell technology use only a multipotent group of cells. According to the research results, they are less active and differentiate only into full-fledged cells of affected tissues and organs. It is mesenchymal stem cells that have shown the highest versatility and efficiency as a promising cellular raw material for growing organs (Taniguchi, 2016). Mesenchymal stem cell therapy involves three stages: the collection of biological material, such as adipose tissue or bone marrow, under anesthesia: the cultivation and production of approximately 200 million pure cells: and the administration of the resulting cell mass intravenously or through meso therapeutic injection into the damaged area of the body. These cells can be obtained from the patient's own biological material or

from the placental tissue of healthy newborns. Donor cell injections are typically given to underage patients, elderly individuals, those with chronic infectious or degenerative diseases, and those who have experienced prolonged intoxication. However, cell therapy is contraindicated during pregnancy, in individuals with oncological diseases, HIV infection, or conditions requiring constant antibiotic and hormone intake.

Weighing the pros and cons of the newly-devised ideas allowed for the conclusion that replacing ESCs with iPSCs in therapeutic cloning is the most feasible plan. Although the replacement will increase the cost of the procedure, the ethical dilemmas that cannot be resolved through expenses will be cleared up, and society would be open to accepting this biotechnological technique.

Findings & Summary

The findings of this inquiry and the process of devising new plans for iPSC usage reveal how society views the novel biotechnological techniques at the current stage and in the near future. The responses gathered through the provocation indicate that society's consciousness that humans are "living beings" involves greatly in the ethics of the techniques, while the process of devising new plans for iPSC usage suggests that ethical issues cannot be revoked in any of the methods.

Conclusion

The chief purpose of this inquiry has been to generate an understanding of the usage of iPSCs and biotechnological techniques that are derived from those cells in treatments. Through this examination, their potential and means of application in the near future become lucid, and it also allows for a speculation of how posterity would view this medical development. The creation of new iPSC-derived techniques and a qualitative provocation activity conducted in an international school show that the majority of society already accepts such approaches, but only on certain conditions i.e. the absence of ethical dilemmas. Both evaluative research also indicates that

biotechnological techniques would try to adapt to society's needs so that they would be used widely in the future.

Future Study

Future research could focus on comparing society's view on the use of iPSC-related techniques with that of experts and professionals. This could be accomplished by conducting an interview with people involved in the research field of stem cells, which is a matter that wasn't possible in this inquiry. Another approach that could be taken to deepen the analysis is by perusing research papers that discuss the use of iPSCs. By doing so, the inadequacy of the foundational knowledge of this topic can be tackled.

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How does ecology affect the evolution of the brain?

Minh Do, Mimi Okada, Lieke Poldervaart

Supervisor: Patrick Morrissey

Abstract

This inquiry examines the connection between the evolution of brain capacity and ecology. To begin with, evolution happens when there is natural selection, mutation, or genetic drift. Random error or change in the allele frequency could result in an extinction of a species. This process continued over until the current H.Sapiens first appeared. But at the same time species adapt to suit the environment. Tracing the history, the temperatures were cooling down and became more arid. Meanwhile, every species would also encounter extreme climates such as the Ice Age. In order to survive themselves in harsh conditions, they would come up with innovations and tools like hearth. Although it is hard to understand the intelligence level of each species because it does not remain as a shape, by looking at the tools they created, it enables us to estimate the intelligence level and analyze the connection between brain capacity and intelligence level. The discoveries of fossils further reveals the evolutionary changes humans went through.

Learning Readiness

Over millions of years, the anatomy and physiology of humans have evolved considerably to adapt to different environmental changes (Smithsonian Institution, 2022). As long as we successfully reproduce, humans will evolve further in the future. Therefore, it is important to understand how different environmental changes impact evolution in order to estimate what evolutionary changes can be expected in the future with the current environmental changes.

Learning Context and Problem

The context of this inquiry is the evolution of humans, specifically the evolution of the human brain. According to the Theory of Evolution, evolution happens because of natural selection. Natural selection is the process in which organisms change to adapt to their environment, to be more suitable to the living environment (National Geographic, 2022). Organisms that adapt and reproduce successfully are more likely to pass the trait down to the next generation. Many people assume that humans no longer evolve while we actually are. However, the process is much slower because of better healthcare and medicines (Yourgeonme, 2021). Our brains have changed abundantly over the last millennia. These changes date so far back that archeologists can only assume what evolutionary changes have occurred in the past based on fragments of the skull (Frontiers, 2011). Currently, there are a lot of environmental changes such as climate change. By understanding how ecology affects the evolution of the brain of different hominid species, we can better understand how these changes can influence the brain in the future and maybe give more definitive answers to questions about evolution in the past. In addition, by understanding how natural selection and gene mutation work, we can give finer predictions as to what and how the evolutionary process has occurred.

Aims and Objectives

The aim of this inquiry is to examine the past fossils of skulls of different stages of homo and specifically into environmental factors like temperature, and humidity level depending on the regions to understand how the human brain evolved. By digging a deeper understanding of the correlation between evolution and different elements, we could identify the key elements of the evolution of the human brain.

Engaging with Skills, Ideas, & Information

Big Question: How does ecology affect the evolution of the brain?

According to the Ecological Society of America, ecology is the study of the relationships between organisms and their environment. Ecologists study how organisms interact with the living and nonliving factors around them; what they need to survive in their environment. Ecology is divided into 3 branches, landscape ecology, population ecology, and behavioral ecology. In this inquiry, we will be focusing on behavioral ecology. Behavioral ecology focuses on how organisms evolve and adapt to environmental changes (National Geographic, 2022). The evolution of the brain refers to how the brain has evolved in size and complexity (Smithsonian Institution, 2022).

Engaging with Ideas & Information:

Change:
Over the course of evolution, the hominin species' brain has tripled in size and become much more complex (Smithsonian Institution, 2022). About 6 - 2 million years ago the hominin species' brain was similar to modern chimpanzees. One of the first early humans, Australopithecus afarensis had an average brain size of 450 ccs (1.3% of their body weight). Currently, homo sapiens have an average brain size of 1350 ccs (2.2% of their body weight). Anthropologists examine skull fossils to determine the brain size of past hominin species and tools that were created before to determine intellectual capabilities (Australian Museum, 2018). While having a bigger brain takes up more oxygen supply and requires more blood flow, the change in size has enabled humans to store more information; collect and process information quicker; solve problems, create ideas, etc …. (Smithsonian Institution, 2022).

Causation:
The concept of causation in evolution expresses itself through two concepts: genes and environment. There are seven types of hub genes that predict brain growth. The genes in these areas provide links between an individual's maximum brain size and processes such as DNA replication (Vuong, 2016). The second concept, environment, expresses itself through

different factors. These factors can include: temperature, climate, humidity, etc. (Potts, 2012) Either alone or fused together, these concepts can cause species to adapt to certain environments and thus evolve.

Form:
The brain is one of the most complex parts of the human body. It processes information, initiates movements and controls one's behavior. The brain has been divided into three sections, each in control of a different movement or action. The hindbrain is in control of coordinating movements. The midbrain controls reflex actions and lastly the forebrain, which is the largest and most highly developed part of the human brain, is the source of intellectual activities such as planning, holding memories and recognizing things. (NIH, 2022) The brain has undergone a great deal of changes already including the size of the brain in cc (cubic centimeters). This shows that evolution has played a role in the development of the brain throughout the last few millions of years and will likely keep doing so in the future. (Australian Museum, 2020).

Perspective:
The concept of perspective in evolution represents how scientists predict future evolution. As people look into the future, there are different perspectives on whether the brain capacity will increase, decrease, or stay the same. While it is hard to predict, by looking back to history, it enables us to predict. The main problem associated with brain capacity will be advanced technology and unnatural factors (Arthur Saniotis, 2011). As large brains could store more complex information, relying on those technologies could hypothetically decrease brain capacity.

Responsibility:
There are three factors that influenced the evolution of natural selection, mutation, and genetic drift. Natural selection refers to how selective pressures work in favor of different traits. The mutation is a random error caused inside the genes or the DNA of the body. And genetic drift is the

change in the allele frequencies caused by random changes in genes. Mutation can create multiple extreme traits but then natural selection often chooses the intermediate ones to stabilize. If the allele frequencies change over time then 1 species can go extinct which causes evolution (National Geographic, 2022).

Digging Deeper & Consolidating Learning

Lines of Inquiry 1: How does the ecology from approximately 6 million years ago affect the brain evolution of the hominin species?

The hominin species that were alive in the time period from 6 to 3 million years ago lived in a climate that slowly got warmer. Roughly 7 million years ago the temperature was an average of 3 to 4 degrees but rose to around 16 degrees in approximately 4 million years (Dapcevich, 2019). Temperature is a big factor that causes species to evolve over time. However, for hominins that were alive around this time, temperature was not the biggest factor that caused evolution. The main reason for evolution was how well hominins were able to adapt to their environment. They were bipedal, and thus needed to look for food on the ground too instead of only getting it from the trees. They started to use unmodified tools to break open nuts and some species used them to remove flesh from animals to eat (Dorey, 2021). This resulted in needing to process and store more information. Storing much information in a relatively small brain results in consuming large amounts of energy that could be better used for survival. Therefore, the reason for the expansion of the brain is to better store and process information without needing too much energy (The Smithsonian Institution, 2010).

Lines of Inquiry 2: How does the ecology from approximately 2 ~ 1 million years ago affect the brain evolution of the hominin species?

The hominin species that lived from 2 ~ 1 million years ago experienced drier and more arid environments. In this timeline, we focused on three different hominin species -- Homo habilis, Homo Ergaster, and Homo

erectus. H. habilis (H. Australopithecus) lived about 2.3 to 1.5 million years ago in Eastern and Southern Africa and is known to be one of the earliest members of the homo genus. This is because they had some similar physical features compared to modern humans (Smithsonian Institution, 2022). They are believed to be the first species to create stone stools. The first stone tools that were found in Ethiopia were said to date back to about 2.6 million years ago and scientists believe that it is linked to butchery and scavenging (Sapiens Organization, 2016). H.habilis has an average brain size of 610 ccs, 1.7% of its body weight, much larger than Australopithecine brains (Australian Museum, 2020); with cranial capacity ranging from 500 to 800 ccs, they are estimated to have an EQ of 3.1 - 3.5. Based on the skull case fossils found, scientists observed the increase in asymmetry in the two hemispheres of the brain. Their left cerebral hemisphere was larger compared to others. Moreover, they possessed Wernicke's area, which is the cortex that manages language comprehension.

The enlargement of the brain may have been the result of the decrease in gut volume and higher-quality diet, hence also the increase in cognitive capabilities (Milne Library, 2017). H. ergaster, which lived about 1.9 and 1.5 million years ago in Africa and Eurasia, is often referred to as African H. erectus instead. This species has an average brain size of 860 ccs, 1.6% of their body weight. Their cranial capacity ranges from 800 to 1200 ccs (Australian Museum, 2022). This species had developed sufficient intelligence to cope with unfamiliar environments. They created stone tools such as hand aes, cleavers, picks, choppers, and other bone tools. These tools were used for butchering animals, cutting, shaping wood, bone, and harvesting plants. They included meat in their diet, which increased the food supply options in seasonal arid environments, and helped with nourishing the bigger brain (Milne Library, 2017).

Lastly, H. erectus lived between about 1.8 and 110,000 years ago in Northern, Eastern, and Southern Africa, and East Asia (China and Indonesia). H. erectus has an average brain size of 1050 ccs, ranging from

750 to 1250 ccs -- 69% the size of the modern human brain (Palomar Education, 2013). Based on the skull case, their hearts were more elongated from front to back and less spherical, and their frontal and temporal lobes were narrower. This species continued to create more stone tools. The tools this time have more designs and are more complex compared to before (Australian Museum, 2020). During the period that Zhoukoudian was occupied, China underwent significant climate change. They had glacial periods with harsh winter temperatures, the cooling and drying that occurred brought an expansion of open habitats with grasslands and mixed steppes. While on the other hand, Java had a warmer climate (Australian Museum, 2020). However, when we look at the chart (figure 1) comparing cranial capacity between H.erectus in different places, there is not much difference. While the living conditions in places were different, indicating there is no correlation between colder climates with a more developed brain or warmer climates with a less developed brain (Palomar Education, 2013). This also goes the same with H. habilis and H. Ergaster. The creation of tools shows how these three species change in brain size indicating significant differences in the intellectual capabilities between them and earlier species. Furthermore, by including meat in their diet, they further nourish the brain and increase their food supply.

Important Homo erectus Sites

	Date of Fossil (years ago)	Cranial Capacity (in cm.^{3})
Africa:		
East Turkana	1,900,000-1,600,000	850-900
West Turkana	1,500,000	
Olduvai Gorge	1,300,000-700,000	1067
Bouri	1,000,000	
Swartkrans	1,800,000-1,500,000	
Ternifine	700,000-500,000	
Sale	400,000	900
Israel:		
Ubeidiya	1,600,000-1,400,000	
Europe:		
Dmanisi	1,750,000	600-650
Atapuerca	1,200,000	-
Java:		
Modjokerto	1,800,000	----
Sangiran	1,800,000-1,600,000	813-1059
Trinil	900,000 ?	----
Ngandong	546,000-143,000 ?	
China:		
Yuanmou	1,700,000 ?	
Lantian	800,000	780
Zhoukoudian	770,000-400,000	850-1250
Hexian	400,000	1025

Note: Several human fossils dating 800,000-400,000 years ago are controversial. They are classified as *Homo erectus* by some researchers and *Homo heidelbergensis* (a later human species) by others. They will be presented in the next tutorial of this series.
Note: It is likely that *Homo erectus* reached Java and other Indonesian islands during glacial periods when sea levels were low enough to create a land connection with the Southeast Asian mainland.

Figure 1: This chart shows the distribution of H.erectus; the age of their fossils; and cranial capacity.

Lines of Inquiry 3: How does the ecology from approximately 600,000 year ago affect the brain evolution of the hominin species?

The hominin species around 600,000 thousands years ago experienced fluctuation of extreme climate. 3 species, H. Heidelbergensis, H. Neanderthals, and H. Species overlap a lot but demonstrate adaptation to different environments. Around 600,000 ~ 300,000 years ago, the H.Heidelbergensis traveled back and forth between Africa and Europe as the 2 countries experienced warm and cool phases (Australian Museum, 2021). During this period of time, their brain size was 1250 cc which covered 1.9% of the body weights (180cm).

Moving to H.Neanderthal who lived from 300,000 ~ 28,000 years ago between Europe and Middle East experienced the most glacial condition,

Ice age (Australian Museum, 2021). The temperature drastically decreased around 110,000 years ago from 14 degrees celsius to -12 degrees celsius on average (Michigan News, 2020). Due to this, the environment became very arid, eradication of forest and woodland, drifting sand and wind erosion became common around North and central parts of Europe (Jonathan Adams, n.d). The Middle East did not experience such pronounced cooling, nevertheless they experienced an arid climate (Felis T., 2016). H. Neaderthals had the biggest brain capacity of 1500 cc which was to enable them to see at the low level of light intensity (Erin Podolak, 2011).

Lastly H.Sapiens who co-existed with H.Neanderthal around 300,000 years ago is experiencing the most favorable climate conditions. The average brain capacity also decreased to 1350 cc as the average global temperature also decreased. As a result, the key features of the brain and skull changed overtime in order to adapt to ecological changes (Australian Museum, 2020).

Methodology

In order to generate new understanding of climates during each period; specifically in the Ice age, numeracy was used to analyze the average temperature across the world. The image demonstrates the average temperature from the world map during that period of time which helps us get insightful information.

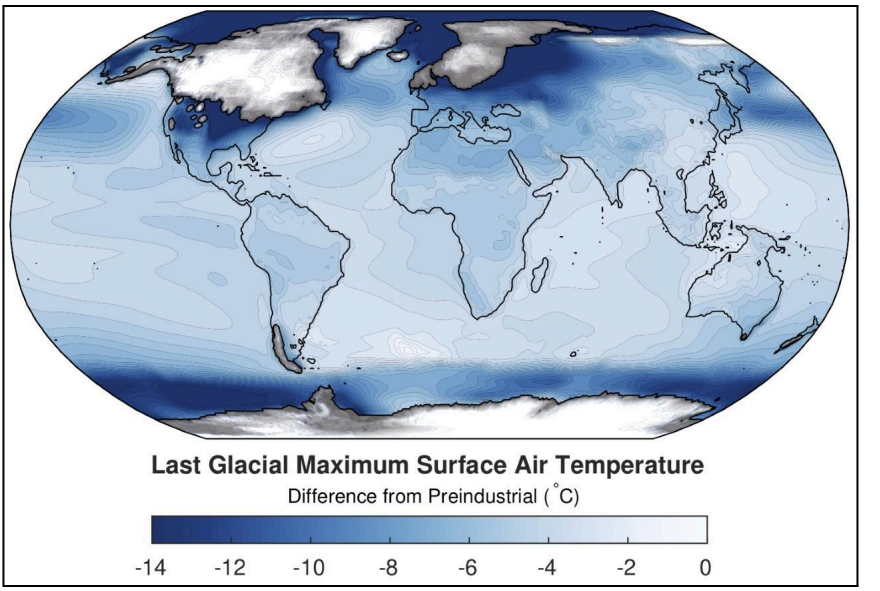

Figure 2: Surface Air Temperature

Generating New Understandings

Through the figure, we were able to figure out the average temperature of the world during the Ice age. The figure shows the maximum surface air temperature during the last glacial period through indication of colors in each country (figure 2). According to this figure, the average temperature was -12 degrees celsius during the Ice age with huge coverings of ice across the northern and southern hemispheres. This shows that during this period of time, animals and hominins were in a shortage of crops as the weather conditions were not favorable. Hunting could be a possible idea though in the meanwhile animals were also facing extinction. Additionally, another study suggested that the majority of the Hominins almost went extinct (Sam Walters, 2021). This allows the hominins to think carefully to survive which resulted in creating Mode 3 technologies such as the hearth (Australian Museum, 2021).

This data also supports the idea of migration between Europe to Africa or the Middle East. The figure shows how the temperature was higher around the equator and there is a high possibility of hominins escaping to either

Africa or the Middle East and stabilizing there. Since then H. Neanderthals evolved to H. Sapiens but after comparing the genetic information of modern H. Sapiens to the H. Neanderthals, it indicates that 1 ~ 4% of the European and Asian Neanderthal while 0% of the African Neanderthals. This shows that during or after the migration, African Neanderthals have possibly gone extinct due to the extreme climates. This data created a connection between different studies and allowed us to understand history through different perspectives.

Findings & Summary

The findings of this inquiry reveal how hominins constantly evolved to different species to confront different environmental challenges. As there are a lot of factors related to the evolution of humans, understanding one of the main factors, ecology allowed us to create connections between each species and develop a timeline of human evolution.

Conclusion

Big Question: How does ecology affect the evolution of the brain?

This inquiry has generated an understanding of how ecology affects the brain evolution of hominins throughout millions of years. As the Earth encountered many extreme climate changes throughout history, there are clear changes in brain capacity to intelligence level. Nonetheless, climate factors are not the only factors that affect evolution which makes it complicated. Despite that, the human brain has continued increasing its size until the current H.Sapiens brain decreased for the first time. The weather kept on cooling down and the climate became more arid for millions of years which could be the possible reason why the brain capacity increased progressively until the global temperature increased and brain size decreased by 200 cc. Furthermore, the inquiry showed that ecological factors play a key role in determining the past and future evolution of the brain capacity.

Future Study

This inquiry has allowed us to study a small part of human evolution. Thus to develop our understanding even further, it is important to understand all the factors related to evolution. This way we can find further connection between and help figure out the unknown part of the evolution.

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How can the evolution of AI art generators affect the illustration industry?

Wings Kao, Sakura Qian, Nanami Kinoshita

Supervisor: Benjamin Lancaster

Abstract

This research paper examines how the evolution of AI art-generating technology impacts the illustration industry through different aspects of society such as terms and policies, finance, and ethics. As industries continue to adopt AI nowadays, it is essential to investigate their effects in order to obtain a better understanding and insights on their forms and functions in the future.Through reading various articles, case reports, and papers, we studied that big changes in the restrictions in illustration community is needed, AI is taking away jobs from illustrators, and the eligibility of copyrights for AI art generating tool impacts the ethics of the illustration industry

Introduction

The improvement of technology has led to various emergence of artificial intelligence tools, including AI art generators, which use algorithms to generate free art for consumers. While many individuals are using AI art generators, it remains unclear whether it is really benefiting the illustration industry or not. Hence, in order to gain a better understanding of the impact of AI on the field of illustrations, it is crucial to look deep into the ethics and drawbacks of AI art generators.

Learning Context and Problem

The context of this inquiry is AI-generated art. We would explore this context by looking into the evolution of AI-generating skills, the impact on the illustration industry, and the means used. As AI art-generating tools is a complex phenomenon to approach as their eligibility on copyrights, ethics,

and policies is still not determined enough. Since AI art generators function by scanning thousands of existing works to analyze a specific aesthetic, supporting the art style of their final image, the ethics and artists'/illustrators' careers are affected drastically (Elgammal 2019). By closely analyzing the specific effects the evolvement of AI-generated art would have, we could gather the collected information to develop a new understanding of the aspects of society that could be improved in the next few decades.

Aims and Objectives

The objective of this inquiry is to explore the evolution of technologies, specifically in the field of AI, and their impact on the illustration industry. With the increasing emergence of AI art generators nowadays, we hope to determine whether these AI tools are truly benefiting the artist and users or not.

Engaging with Skills, Ideas, & Information

Big Question: How can the evolution of AI art generators affect the illustration industry?

The evolution of AI art generators is consistent with the development of technology and the change in common sense in the illustration industry. While AI art generators have been one of the convenient tools to create an illustration with only typing texts, the ethics and how illustrators perceive developing technology have been greatly impacted. For instance, a case was reported where AI-generated art won a prize at a state fair art competition (Salkowitz, 2022). This incident soon became a big problem through the illustration community as it antagonized the illustrators by how unethically these tools are used which had impacted the way illustrators perceive AI art generating tools. Numerous similar cases have been reported since AI-generating tools became accessible to anyone and illustrators are seemingly concerned about the replacement of AI in their jobs. Therefore, studying the current effects of adopting AI generators would

help us understand and generate possible strategies that could be used in the future.

Engaging with Ideas & Information

Change: How did AI art evolve? What has AI changed in the illustration industry?

Recently, the AI art generator has become better known and more developed in producing images with higher quality that are harder to tell it is made by AI. The history of AI painting can be traced back to the 1970s, the first AI painting was made by Harold Cohen, an American computer scientist. He developed an AI program called AARON, which creates art based on a set of rules he programmed into it (NightCafe, 2022). The early AI-generated art was pixelated and low-quality due to the limits of technology (H, 2023). However, with the rapid evolution of technology, there are many AI art generators nowadays that are able to produce high-quality drawings, such as DALL-E, Midjourney, and Bing Image Creator.

Causation: What is causing AI adoptions to negatively affect the illustration industry?
The causation in our inquiry applies to the cause of the adoption of AI art generators affecting the illustration industry negatively. In numerous media, a negative imprint on the adoption of AI has been spreading through unfair usage of AI generating technologies (Malathkar, 2022). While the tool itself the AI-generating

Form: What effects does AI have on the Illustration Industry based on the current means in which they are used?
With the increase of AI technologies, it becomes evident that those tools have brought both advantages and drawbacks to human lives. Before, the primary use of AI had been as a means to improve efficiency and productivity. However, since the emergence of AI art generators arose, it has had the unintended consequence of disadvantages, such as the devaluation of the labor force and the gradual displacement of humans

from their traditional roles. How AI art generators work is to use artists' production as a model to generate what consumers require, however, this move is usually without the artist's permission and credit, which is slowly becoming a threat to many artists. Various reports have indicated that there are already many job losses due to the impact of AI art generators, as companies increasingly turn to using this technology in order to reduce costs and time. This trend is now particularly prevalent in China, where a significant number of people have already been affected by the emergence of AI in various industries, leading to unemployment and upheaval in many professions (Pingwest, 2023).

Perspective: Can AI art generators positively affect the illustration industry?
AI art generators can also bring some positive effects that are beneficial to illustrators due to their characteristics. For example, AI-generated art can be created in a short period of time and with high quality, which could help illustrators to have a better idea of what the final product would be like if they let AI generate drawings based on their draft. Besides, the AI art generator is also known for its novelty since AI art is generated by keywords, and different combinations of keywords will create various pictures. Sometimes, typing in keywords that have totally no connection with each other could produce drawings that will never be completed by the illustrator, which can also be an inspiration for the illustrator (NYartlifeMarketing, 2023).

Responsibility: How would the copyright eligibility for AI-generated art impact the ethics of the illustration industry?
The concept of responsibility in our inquiry refers to the creation of AI-generated art as their existence impacts the illustration industry due to the system utilized when generating art, causing some ethical issues. As the means they take part in illustration creation could change the implementations towards developing technologies, it is important to focus on the possible impacts AI-generated art could cause on the illustration industry and the artists involved in them (Chiarella et al., 2022).

Digging Deeper & Consolidating Learning

Lines of Inquiry

Change: How did AI art evolve? What has AI changed in the illustration industry?
Throughout the involvement of technology and human ambitions towards more convenient tools, people have kept inventing and presenting new AI engines to the public. Recently, the AI art generators have become better known than before and much more developed in satisfying consumer's need and request by producing images with higher quality which are more difficult to tell whether it is produced by AI instead of by mankind.
The history of Ai art can be dated back to the 1960s, when the first Ai program that can generate paintings, named AARON, was developed by American computer scientist Harold Cohen. At that time, AARON was already capable of learning, adopting, and using a set of algorithms to generate compositions (computerhistory, 2016). With the evolution of technologies, more AI art generators have been coming up to the public's sight. During 2014, the Generative Adversarial Networks (GANs), developed by a researcher Ian Goodfellow, was already able to produce undistinguished images from real art using training data that users had inputted (technologyreview, 2018). Moreover, in 2022, a new type of generation was invented, which is called diffusion models. Unlike the GANs, diffusion models are more stable and easier to control as they use a continuous process to generate outputs (beautyandai, 2023).
In conclusion, the development of Ai art generators has been very rapid and nowadays, there are more and more AI generators that are able to produce high quality images which are more convenient for users, such as DALL-E, Midjourney, Bing Image Creator, etc.

Causation: What is causing AI adoptions to negatively affect the illustration industry?
While AI adoptions and workforces in the illustration industry have increased dramatically nowadays, the demands for human-made

illustrations and their request rates have fallen into a critical situation. This is due to the gap between the convenience and labor costs the AI compensates through the evolvement of image generation skills.
The biggest issue that is causing a negative implementation of AI adoptions is the possibility of human displacement from illustration creation due to financial convenience. Since AI generators have higher skills in human algorithm usage, it takes away opportunities for illustrators to earn their incomes (36Kr, 2023). Another issue is that the illustration-generating process has ethical concerns due to numerous existing works being scanned without permission. A case report was published in 2023, in which a lawsuit was launched by artists against one of the major AI-generating tools, Mid Journey and Stable Diffusion (The Verge, 2023). Since AI generators have the ability to create work by mimicking existing art styles from specific artists, they claim that these generating tools have infringed the rights of billions of artists without taking the original artists' concurrence.

Through looking into the possible negative effects AI generator adoptions could have, we can conclude that it is due to the fear the illustrators are feeling from the possibility of their jobs being taken away by AI replacement.

Form: What effects does AI have on the Illustration Industry based on the current means by which they are used?
With the increase of AI technologies, it becomes obvious that those tools have brought both advantages and drawbacks to human lives. Before, the primary use of AI had been as a means to improve efficiency and productivity; however, since the emergence of AI art generators arose, it has had the unintended consequence of disadvantages, such as the devaluation of the labor force and the gradual displacement of humans from their traditional roles.

How AI art generators work is to use artists' production as a model to

generate what consumers require, however, this move is usually without the artist's permission and credit, which is slowly becoming a threat to many artists. For instance, various reports have indicated that there are already many job losses due to the impact of AI art generators, as companies increasingly turn to using this technology in order to reduce costs and time. This trend is now particularly prevalent in China, where a significant number of people have already been affected by the emergence of AI in various industries, leading to unemployment and upheaval in many professions (Pingwest, 2023).

In conclusion, the rise of AI technologies has brought both advantages and drawbacks to human lives, as AI art generators, which generate art based on existing models without the artists' permission, have led to job losses, devaluation of the labor force, and displacement of humans from their traditional roles.

Perspective: Can AI art generators positively affect the illustration industry?
As technology improves rapidly at the moment, AI art generators are no longer limited to simple calculations as before. People have gained a further comprehension of AI art and some of them became interested in it and started using AI to generate images.

By accepting AI art generators and utilizing them in the right way, they can become helpful tools for individuals. The primary difference between AI-generated art and human-made art is how it is created, while one is crafted through algorithms, the other is made from human thought and creativity. In addition, AI art might be in need of emotional and personal touch that is more likely to find in art created by humans. (fromlight2art, 2023) Thus, if illustrators use the AI art generator as an assistant, they can improve their efficiency at the same time maintaining the emotional impact of their drawings for the audience.

Responsibility: How would copyright eligibility for AI-generated art impact the ethics of

the illustration industry?

Several impacts could be considered by the copyright eligibility for AI-generated art on the ethics of the illustration industry. The rights and the policies which the author possesses would have to be reconsidered depending on the extent to which the current policy could manage, as commercial use of plagiarized works has been expanding rapidly (JAJAAAN, 2022). Furthermore, due to numerous people taking part in generating artwork with AI, such as the innovator, the original artist, and the person who trained the generator, the qualification for the ownership and its credits of the generated work would be a complex issue. Secondly, the equitability in the illustration industry would also be impacted. This is because AI generators utilize an already existing piece as their base following their algorithmic system although they do not cost the client much, creating a critical contrast within its fairness in the business mechanism of the illustration industry. This would possibly increase the frustration of the active illustrators due to the unethical practices their clients tolerate, and plagiarized works leading to the illustrator's unemployment.

The final effect is the creativity aspect in the illustration industry. As explained above, as AI generators reference algorithms for their creation, minor art styles would also lose their chances to be in the spotlight which eventually could cause an art style generalization. Moreover, there are numerous cases observed in which artists are banned from certain communities since they were suspected of using AI generators for their work although they did not (Buzzfeed, 2023). Due to its traits and the algorithmic aesthetics they utilize, the creativity of existing artists is becoming restricted by the unreasonable treatments they receive in the illustration community.

To conclude, many ethics and common sense in the illustration industry could be affected by the eligibility for AI-generated art, and certain laws

and policies will need to be reconsidered.

Methods

In order to generate knowledge and gain a better understanding, we had read through and reviewed various professional articles and reports from diverse perspectives, which allows us to gain a comprehensive understanding of the functions of AI art generators and the impact they had on mankind's life. This process also enabled us to look into the ethics behind AI technologies and learn the effects they have brought out.

Generating New Understandings

Investigation into the means of AI art generators and their further effects on the illustration industry gave us new insight into how these tools could be improved in the future in order to be more ethical yet practical for the illustration industry. For example, we discovered that many policies on illustration creation would have to be reconsidered as numerous reports show that cases, where plagiarized works are used commercially, are increasing rapidly. These policies include the authorization of the work generated through AI as multiple people who have contributed to creating the art would be found causing a complex conflict within its ownership. Furthermore, our team investigated the main issue of what is causing AI adoptions to affect negatively, and we concluded that it is the mechanism of the AI art generator in which how they utilize an existing work as part of their algorithm system is one of the causes why negative imprints on AI adoptions are spreading around the illustration industry.

However, although numerous negative effects on the adoption of AI art-generating tools are reported, our research has also shown that they could have a positive effect as well depending on the role they play. For example, instead of utilizing them thoroughly in creating an illustration piece, we could use them as our assistance as they could support our creativity through the process of creating new artwork.

Through investigating this information, we were able to generate a new understanding and perspective on the possible future usage of AI art-generating technologies.

Findings & Summary

To generate new understandings, we looked into various articles and case reports to investigate the effects AI art-generating tools has given on the illustration industry, including topics such as policies in different illustration communities, the cause of AI art generators giving negative imprints in society, the positive aspects of AI generating tool adoption in the illustration industry, the ethics in the illustration industry and how they are affected by the adoption of the AI, and what means AI is used currently in the illustration industry. Furthermore, we have also experimented with the AI generator and have created our generating tool by creating a database of our original art. Through this experiment, we were able to evaluate the abilities of the AI art-generating tool by observing how AI utilizes the original work as part of its generated art.

Conclusion

Through this inquiry, we have found that AI illustration generation tools affect the illustration industry financially, morally, and guidelines.
The introduction of AI into illustration companies and private businesses is often perceived as a threat to illustrators, and as a result, people in various illustration communities are skeptical as to whether what they are seeing is original or AI. However, AI illustrations are based on analyzing algorithms from many works. Damage has been reported to illustrators who have been working with the same art style as those derived by the tool. In addition, AI illustration generation tools are based on thousands of existing works of art, which created many complex conflicts, including the issue of commercial use of these images and copyright infringement.

However, through our research, we have found that AI art-generating tools could bring a positive effect on the illustration industry as well depending

on the roles they play in creating the work, such as utilizing them as artist's assistants.

Therefore, the means and the roles the AI art generators play in the future would greatly affect how the illustration industry would be formed and function.

Future Study

The finding of this inquiry reveals the effects that Ai art generator tools have on the illustration industry both financially and morally. The further investigation into the area of Ai illustrations would be to analyze different views for the impact of Ai and investigate the solutions of the unemployment due to the rise of Ai art generators.

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How does addiction to social media impact the adolescent brain in cognitive functioning and brain development?

Jaeeun Jeong, Diane Hubert , Eliana Edwards-EL

Supervisor: Benjamin Lancaster

Abstract

At the beginning of this unit, we built a foundation of knowledge and set our goals for exploration. To confirm our base idea and gain inspiration, we send a survey to our classmates. Next, we clarified and explained any unfamiliar terms and concepts in order to gain a deeper understanding of our interests. Then, we researched and answer the fundamental question we had and collected all the necessary information to test a method for overcoming addiction. From this experience, we analyzed the data and drew conclusions, providing advice for others on a similar journey.

Introduction

Social media addiction is a big problem in modern society. Generations living in the information age are particularly exposed to the risk of this addiction. You can learn how to deal with serious social problems by investigating in detail what causes people's addiction, why they become addicted, and what the solution is.

Learning Context and Problem

The context of this inquiry is addiction to social media and how it affects human life: from mental health, physical health, to social life. Addiction to social media is a very common phenomenon for teenagers. We chose this topic because some of us are already addicted to social media and we would like to know how to overcome it or prevent it. The dopamine (neurotransmitter of pleasure that makes people addicted) needed to

survive, dopamine is the neurotransmitter that gives us the motivation to breathe, eat, and reproduce (primary needs). But the amount of dopamine received after these actions is very little compared to the amount of dopamine received after doing secondary needs: Social recognition, money, social media, drugs... This is why we are more likely to be addicted to these secondary needs than to primary needs. Teenagers are the most vulnerable to social media since their brains are still forming and upgrading.

Aims and Objectives

Our aim for this TDU is to study how the brain processes addiction and what are the common ways that it processes addiction. Since we are looking at addiction we want to look at the algorithms that use different social media apps. Whether it's to stay on the app or to make you buy it. Lastly, the main reasons why people can become addicted to something. Are there certain people that are more or less likely to become addicted to social media for example. These are the main things we are hoping to find information about.

Engaging with Skills, Ideas, & Information

Big Question: How does addiction to social media impact the adolescent brain in cognitive functioning and brain development?

Addiction is a serious problem affecting more and more teenagers. We would like to know the neurological mechanisms behind addiction, the point of view of the users, and how it affects a teenager's psychological and social well-being.

Engaging with Ideas & Information:

Change: How is algorithm and social media becoming better at making people addicted?

As the times progress, people are increasingly using online services. Social media is also one of the main communication methods in the information age, causing serious addiction problems. According to a survey conducted by the U.S. Department of Education, addiction among teenagers is on the rise. As such, the number of people addicted to social media continues to

increase. As algorithms develop, social media such as TikTok and Instagram identify users' needs and continue to provide videos or writings that they may like. This made it more prone to addiction by providing users with more enjoyable and satisfying information.

Form: What is addiction to social media like (brain)?
SNS addiction is a situation in which the urge to do social media cannot be controlled due to excessive immersion in online, which interferes with daily life. Psychological withdrawal symptoms such as depression, anxiety, and anxiety appear mainly, and it means that the productivity of professional and academic activities decreases as a result of spending a lot of time on SNS activities

Causation: Why are teenagers addicted to social media ?
One of the main reasons why teenagers are easily addicted to social media is peer's validation. (The Addictiveness of Social Media: How Teens Get Hooked | Jefferson Health, n.d.) Social media platforms use algorithms to provide them the content they like, giving them the peer"s validation they are craving (Riehm et al., 2019). This content gives them quick and powerful shot's of dopamine (Chemical that gives pleasure) making them want more and more. A study (Sherman et al., 2016)showed that teens' brains respond strongly to pictures with lots of likes and are less able to control their responses to risky pictures. In Conclusion, the algorithm (O'Brien, 2023) of social media platforms is using teenagers' need for validation to make them addicted by showing them target content following the data the algorithm collected on the user.

Perspective: How do people deal with addiction?
Health websites (Cherney, 2020) are sharing recommendations to overcome addiction: delete the social media app, turning the phone off at work or school, putting a time limit on the application, finding a new hobby, seeing friends and family more often,... Even with these recommendations, 210 million people worldwide are addicted to social media (Woodward, 2023).

This number keeps increasing through the years touching younger people each time.

Responsibility: Who is responsible for the teenager's addiction? Application or people
Social media app addiction is a growing concern in the digital community. Due to the design and development of social media. With social validation, immediate rewards, it's an escape for most people giving them lots of dopamine. Developers use persuasive techniques like the ability to infinitely scroll on the app, push notifications, and personalize content so that the user stays longer. Soon people begin to start seeking likes for approval that they are succeeding, comments, and sharing things such as posts and videos often show a certain status you have online. Finally because social media apps provide an escape for people and accessibility social media is very easy and creates these addictive behaviors. Having the responsibility falls on the app itself.

Digging Deeper & Consolidating Learning

Line of inquiry 1: What are the neurological mechanisms behind addiction, and how do they relate to changes in teenagers' brains?

Addiction (Drug Misuse and Addiction | National Institute on Drug Abuse, 2020) is defined as a chronic, relapsing disorder characterized by compulsive "drug" seeking and use despite adverse consequences. Dopamine (Healthdirect Australia, n.d.) is the chemical that gives pleasure and that our brain is seeking when consuming an addictive product. (Healthdirect Australia, n.d.-a) The amount of dopamine in a brain can affect the mental health of the individual making them addicted if too much and depressed if not enough. (The Disappearing Adolescent Brain, 2020) Teenagers are particularly susceptible to addiction as their brains are still developing (Watch the Mind, Explained | Netflix Official Site, n.d.). Social media is a huge source of dopamine stimulation for teenagers, as it offers novel and engaging content that is specifically designed to capture

their attention.(Newsela | Instructional Content Platform, n.d.) Over time, this can lead to a vicious cycle of addiction that can be difficult to break. (Volkow et al., 2001) While studies (The Brain in Recovery, 2019) are still sparse on this, most experts agree that it takes approximately three months (or 100 days) for dopamine levels to return to normal.

Line of inquiry 2: What are the factors of social media app addiction from a user perspective?

A 2019 survey found that 40 percent of U.S. online users aged 18 to 22 years reported feeling addicted to social media. Five percent of respondents from that age group admitted the statement "I am addicted to social media" (Lee Health, n.d.)

Ever since social media apps have been created, there has been an increase in peoples screen time all round the world and social media soon took over. So is it the fault of social media apps that make people now more addicted to their apps and their phones. Social media apps seek social validation and constantly want you to compare likes, comments, and shares to try and make it seem that this can improve self-esteem and status. Causing you to have excessive time spent on these platforms is because the apps are playing at people's desire for acceptance.

(Baruffati, 2023b)"Over 210 million people worldwide suffer from social media addiction, according to recent statistics. 2.95 billion people globally have access to social media only through smartphones. In 2021, people aged 40 to 44 years spent the most time on social media applications of all user demographics, amounting to almost 60 minutes per day. 47% of internet users across 17 countries admitted their time spent on social media has increased during the Covid-19 pandemic of their online time using social media. The average person spends 144 minutes a day using social media, which converts into 72 hours a month, and 5.7 years of your life are spent. just on social media." (Baruffati, 2023b) has reported that adults say

79 % of them check their phones or wake up at night to check their phones compared to 21% of adults who don't. Surveys have shown that people who are of the age of 40 and higher are less prone to be addicted to social media. People that were more affected by covid-19 have had a higher rate of addiction to social media caused by the pandemic. With the pandemic has ended they have seen that people have just gone to the normal hourly rate of using social media online while not going back to their everyday life before the pandemic.

Line of inquiry 3: What are the results and effects of social media addiction on individuals' psychological and social well-being?

Social media addiction causes many problems. On this basis, in a statistical survey on social media addiction, most adolescents are prone to addiction, and the JAMA Medical Association of the United States explained that social media addiction is 78% likely to cause mental health problems. In addition, Phil Reed's experiment to improve social media addiction revealed that daily life returned to normal as addicts were treated and that there was a severe disruption to daily life before that. This shows that there are so many problems that can arise from social media addiction that it is serious. Therefore, these problems must be solved by a specific system, method, or treatment. In addition to individual efforts, a system should be created to control social media use for more than a certain period of time. Baruffati (2023)

Methods

To generate New Understanding, we decided to run an experiment on ourselves. All our team members put a different time limit on the application they are the most addicted to. Every day during the week, we took notes of how we felt and if we were able to respect that time limit to collect data to then come up with advice to overcome addiction.

Generating New Understandings

Over the course of seven days, We documented our experiences and the effects of limiting our social media screen time of our favorite social media. Initially, Diane found it easy to avoid Instagram and other social media platforms. She replaced the application time by time spent with friends and practicing her guitar. However, she discovered that she replaced the application with another, spending excessive time on Webtoon. This showed that she spent the same amount of time as before on my phone, just on a different application.

Jena struggled to control her TikTok usage, realizing her strong addiction to the platform. Even with the time limit, she found herself breaking the limits repeatedly. However, Jena also noticed that doing other activities like homework, cleaning, and reading helped reduce her social media usage. Eliana successfully adhered to the time limits. She realized that Snapchat wasn't truly the problem but every social media application.She ended up putting time limits on all her social media apps based on her actual usage. She also recognized that the fear of missing out and the need to constantly check for updates caused distractions.

Overall, the experiment revealed several key takeaways. First, the participants realized the extent of their social media addiction and its impact on their daily lives. They observed how often they turned to their phones when bored or seeking entertainment. Second, engaging in alternative activities, such as hobbies, studying, and spending time with family and friends, helped reduce their social media usage. Finally, imposing time limits created a sense of control and allowed them to focus on more fulfilling and productive endeavors. By reflecting on our experiences, we recognized the need to balance social media usage and real-life interactions. We learned the importance of self-discipline. This experiment served as a reminder that while social media can be entertaining and informative, excessive usage can have negative effects on one's well-being and productivity.

Findings & Summary

Briefly summarize the results & findings from the action taken to generate knowledge. Explain your interpretation of the understanding gained from research, referring to concepts and ideas established in the Lines of Inquiry. In the "digging deeper" phase, we gained a better understanding of addiction, its effects, and the perspective of those struggling with it. Through our team's experiment, we were able to empathize with those trying to overcome addiction and offer advice to others on the same journey.

Conclusion

The big question: How does addiction to social media impact the adolescent brain in cognitive functioning and brain development?

Social media platforms use the vulnerabilities of teenagers such as their inclination towards novelty, risk-taking, and peer relationships to keep them engaged on the app for extended periods. These tendencies are the primary sources of dopamine for individuals in this age group. The app algorithms determine the target content for the user to provide them with more and more dopamine, leading to addiction. When teenagers watch the target content, their brains receive excessive dopamine, which can result in aggression, competition, and a lack of self-control. Moreover, excessive dopamine can lead to mental health problems such as ADHD, addiction, and binge eating. Conversely, insufficient dopamine can cause a lack of motivation and excitement, and can also contribute to mental disorders such as schizophrenia, depression, and psychosis. For the brain to fully heal, it will require more than 100 days. The use of social media can have a permanent impact on teenagers' developing brains, which continue to develop until the age of 25.

Future Study

According to the results derived from the study, it is necessary to identify

the current state of social media addiction and apply solutions in everyday life. Social media addiction is one of the most common addictions, and because most people don't think it's important, the problems of daily life caused by addiction are increasing. It is necessary to be alert and aware of what social media addiction is, why it occurs, and what scientific and social effects it has on the brain. In particular, efforts to resolve it continuously are important. In future studies, it would be beneficial to explore various methods for overcoming addiction in order to determine the most effective approach. As times changed, this problem became inevitable. Therefore, research will be conducted on how to control it more efficiently rather than trying to completely block it.

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