CSC: Capstone Finale

1. AI / Machine Learning / Deep Neural Networks / Big Data / Bias / Scientific Method
(1-2 pages, double-spaced)

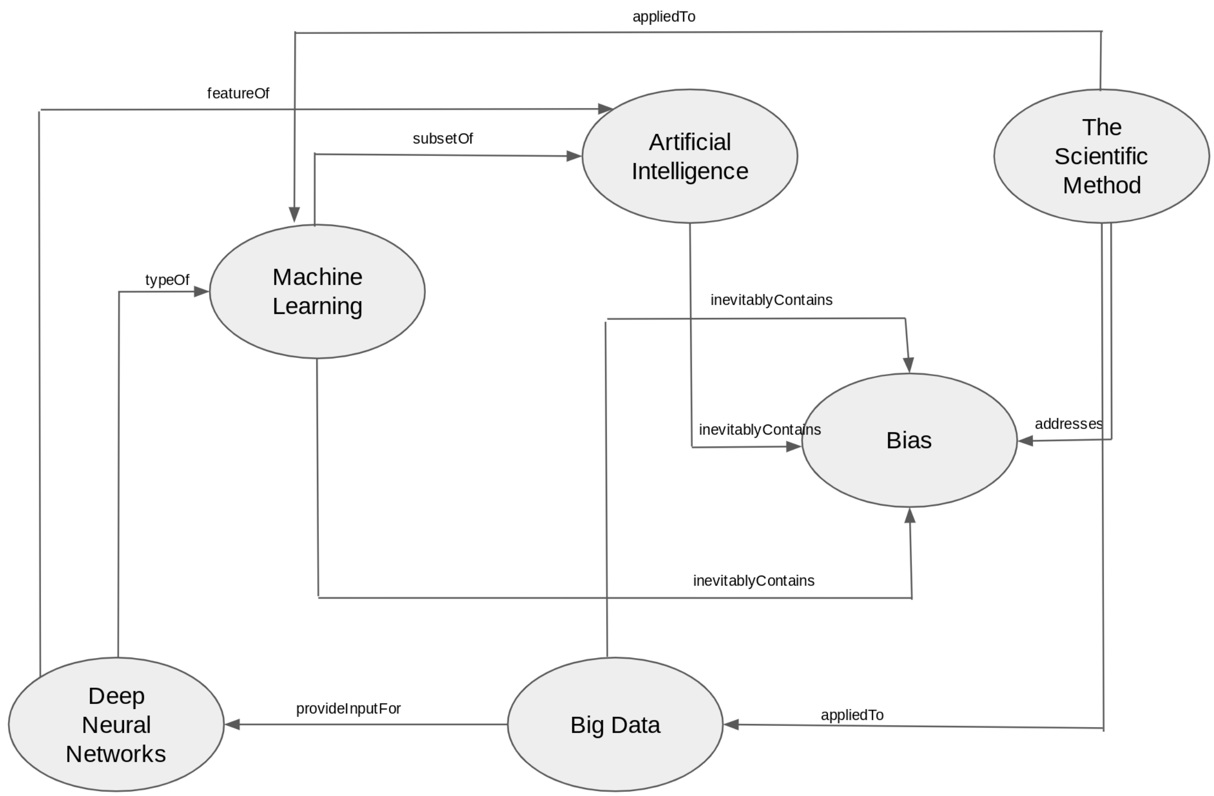
Artificial Intelligence: A Complex, Ever-Evolving Area of Research

Artificial intelligence (AI) is defined by Politecnico di Milano as “the branch of computer science that studies the development of hardware and software systems with typical human capabilities and which is able to independently pursue a defined purpose by making decisions that, until then, were usually entrusted to humans” (P.M.F. ltd., 2021). Developers seek to construct a machine, system, or program that can accurately interpret data from its external environment, learn from the acquisition of this data, and apply learned information in novel instances where specific goals and tasks must be executed and adjustments must be made as necessary (Tai, 2020). The overall purpose of AI concerns the application of the advancements made in this area of research and implementation as a means of assisting human beings in a variety of settings, particularly in aiding their problem-solving abilities (Tai, 2020) and improving the overall quality of human life with the elimination of tedious, difficult, or otherwise unfavorable tasks (Yeung, 2020). One highly influential area of research in AI encompasses the effort to implement cognitive functions that appropriately encapsulate human natural intelligence (Tai, 2020). While weak/narrow AI defines an ability of a machine to accomplish specific or narrow tasks, such as facial recognition,Internet searches using Siri, suggestions concerning products to buy, movies, or music according to personal preferences, or a car with a self-driving mode, strong/artificial general intelligence (AGI) constitutes the long-term goal of many developers and is defined as a machine’s intelligence encompassing an ability to learn and understand all tasks that an intelligent human being can accomplish, virtually functioning like a human mind itself and carrying out perceptions, beliefs, and other cognitive mechanisms (P.M.F. ltd., 2021; Tai, 2020).

One specific area of AI concerns machine learning, which aims to program a machine or computer to execute tasks using deep learning in order to predict and analyze data (Tai, 2020). Accordingly, machine learning constitutes the training of a machine’s software so that it can correct errors and acquire and store information with the intention of effectively performing a particular activity (P.M.F. ltd., 2021). For instance, this would include the programming of a mechanical hand with a control algorithm that assists in its ability to utilize great precision in cutting performance (P.M.F. ltd., 2021). Advancements being made in the area of machine learning have largely been influenced by its utilization of deep neural networks (DNN), which are key in the development of more advanced artificial intelligence algorithms. A key feature of DNNs include its multilayered organization, which creates an element of depth in learning. More recent progressions made in DNN research include programmed learning processes that are modeled after the structure and function of neuronal networking in the brain (P.M.F. ltd., 2021). As such, deep learning in DNNs requires specially designed artificial neural networking with exceptionally robust performance abilities in computation and stamina so that they can effectively store information in multiple layers for subsequent computation and analysis (P.M.F. ltd., 2021). Some examples of DNNs include those used in pattern recognition, speech and image recognition, and in Natural Language Processing (P.M.F. ltd., 2021).

As defined by Gartner, big data "requires a new processing mode in order to have stronger decision-making, insight, and process optimization capabilities to adapt to massive, high growth rate and diversification of information assets" (Yeung, 2020). Thus, big data defines larger, more complex data sets that are often found in more novel sources of data, and can be used in the construction of DNNs. Since these data sets are so extensive in nature, more traditional data processing systems can no longer effectively handle them (Oracle, 2021). Further, the five characteristics of big data (5V) involve massive data scale (volume), fast data flow (velocity), diverse data types (variety), quality and trustworthiness in data (veracity), and low-value density (value) (Yeung, 2020). All in all, modern technological advancements have lowered data costs associated with data storage and computation considerably, which have improved accessibility and allowed for the construction of more accurate and precise decisions in working with more sizable and elaborate data sets (Oracle, 2021).

Bias is inevitable in any sort of human-led activity, and this includes the programming and development of AI, machine learning, DNNs, and any interactions with big data. Since machine learning algorithms are dependent upon the quality, objectivity, and size of the training data used during the machine's learning process, the presence of an inherent bias in the input data could very likely influence the algorithm's output decisions (Chandrakant, 2021). Such biases can be intentional or unintentional, and could include the incorporation of prejudicial or racial bias, sampling bias, algorithm bias, and confirmation bias in AI and machine learning developments, among others (Chandrakant, 2021; Tai, 2020). The scientific method is defined as "a systematic framework for experimentation that allows researchers to make objective statements about phenomena and gain knowledge of the fundamental workings of a system under investigation" (Forde & Paganini, 2019). The fundamental principles of the scientific method can thus be applied to help combat the risk for biases in the development of AI and machine learning algorithms that utilize big data.



Works Cited

Chandrakant, K. (2021). *Biases in Machine Learning*. Baeldung. https://www.baeldung.com/cs/machine-learning-biases

Forde, J. Z. & Paganini, M. (2019). The scientific method in the science of machine learning. *arXiv*, *abs/1904.10922*, 1–9.

Tai, M. C.-T. (2020). The impact of artificial intelligence on human society and bioethics. *Tzu Chi Medical Journal*, *32*(4), 339–343. https://doi.org/10.4103/tcmj.tcmj_71_20

Oracle. (2021). *What is big data?* Oracle. https://www.oracle.com/big-data/what-is-big-data/

P.M.F. ltd. (2021). *Deep neural network: How far can artificial intelligence go?* PMF Research. https://www.pmf-research.eu/en/deep-neural-network-how-far-can-artificial-intelligence-go/

Yeung, J. (2020). *Exploring big data and artificial intelligence: What is big data and what artificial intelligence can do?* Towards Data Science. https://towardsdatascience.com/what-is-big-data-and-what-artificial-intelligence-can-do-d3f1d14b84ce

2. Working Narratives

(Three paragraph essay)

A Brief Reflection on Statistical and Computational Cognitive Modeling Experience

Throughout my undergraduate studies at SUNY Oswego, I have had the opportunity to engage in a variety of statistical methods as applied to research and the interpretation of statistical findings in various contexts, implementation in software such as SPSS, Minitab, MATLAB, R, and SAS, examination of results, and the drawing of conclusions from statistical analyses, as well as in computational cognitive modeling through Prolog. My experiences in PSY280 (Analysis of Psychological Data), PSY290 (Research Methods), and PSY471 (Advanced Statistics in Psychological Science), in addition to my research experiences and my decision to declare a minor in Applied Statistics will be briefly explored as they relate to my engagement with statistics. Then, a particular experience in COG/CSC366 (Computational Models of Cognitive Processes) will be examined as it relates to my engagement with computational cognitive modeling.

When I took PSY280 during my freshman year, I discovered the value of statistics in quantifying more abstract phenomena, and decided to pursue a minor in Applied Statistics. Having the opportunity to take additional statistics courses through the Mathematics Department has allowed me to gain experience with statistical software that I otherwise would not have been exposed to, and has provided me with other opportunities to develop analytical skills as they relate to statistical analysis. I worked as a Teaching Assistant for this statistics course in the spring of my sophomore year, where I held office hours and review sessions, graded selections of homework, exam, and lab assignments, resolved student issues concerning data entry and statistical test generation during lab periods, wrote select exam questions, and constructed a lab assignment independently. This experience allowed me to apply my knowledge of statistics in a pedagogic manner and run statistical tests in SPSS to a multitude of research scenarios in the laboratory setting, assisting students as necessary. Further, my first in-depth exposure to statistics in research methodology occurred in PSY290, where I had the opportunity to develop a semester-long research experiment on the relationship between sensation-seeking tendencies, stress response, and personality characteristics of introversion and extraversion. From this experience, I discovered how much I enjoyed the research process, and I volunteered for a few days over that summer in the Developmental Studies Lab with Dr. Leigh Bacher on her child cognition study. In this setting, we investigated visual attention, blinking patterns, and pupil fixation patterns through a series of working memory tasks, and I assisted in data collection and the experimental procedure with child participants. I later worked as a Research Assistant in her lab during the fall 2020 and spring 2021 semesters, where I explored research papers that utilized statistical methods in the investigation of pupil fixation and blinking patterns and their relationship to memory and other aspects of cognition and contributed to the construction of the manuscript accordingly. I also gained experience utilizing E-Prime experimental software, observing the eye tracking device's functionality, conducting pupil fixation analysis with Pupil Labs software, and coding, inputting, and analyzing data in SPSS. I also had the opportunity to learn more about statistics, specifically pertaining to psychological research, with my decision to take PSY471 as one of my upper division electives. In this course, I learned more about the strengths and weaknesses of null-hypothesis significance testing and the available alternative approaches to testing significance in statistics, some of which include the reporting of effect size, confidence limits, and Bayesian estimation approaches, which can more accurately and completely describe research findings. I also learned of the importance of conducting meta-analysis and regularly replicating both significant and nonsignificant study findings to raise their certainty.

In COG/CSC366, which I am currently in this semester, we have learned how to model cognitive phenomena through Prolog. Specifically, Prolog is a logic programming language that allows us to model human cognitive processes through logical relations. In this course, I was able to develop a semester-long project that explores some sort of cognitive process through computational modeling in Prolog, specifically one that relates to belief revision. My group chose to model the process of diagnosing and treating patients with schizophrenia and related mental disorders, with a focus on belief revision as it relates to the doctor or therapist providing treatment as additional information concerning the patient is learned, in addition to the common difficulties that patients diagnosed with schizophrenia face in revising their delusional beliefs. For instance, from the clinician's perspective, beliefs must be revised quite frequently, whether it be learning of underlying health conditions during the diagnostic and treatment process that prevent them from carrying out their top choice in treatment, a patient's adverse reactions to a specific treatment, or a recent discovery in the field of medicine or therapy that constitutes the modification of the clinician's current treatment method with a patient. On the side of the patient diagnosed with schizophrenia, the clinician must be aware of the patient's difficulties in recognizing false beliefs or delusions, their overconfidence in these delusions, and their frequent and rapid dismissal of opinions, arguments, and evidence in disagreement with their own views. As such, these complex, dynamic challenges that clinicians face in the diagnosis and treatment of schizophrenia were modeled in Prolog, where the program itself and its outputs functioned as the advice of the proverbial doctor, while the inputs were those of the individual seeking a diagnosis and treatment. Due to the complexity of the diagnostic process, later on in our project's development, we decided to include other disorders in which symptomatology could manifest in a similar manner to that frequently seen in patients with schizophrenia in our program. Such disorders that could showcase overlapping symptoms included major depressive disorder, bipolar disorder, post-traumatic stress disorder, schizoaffective disorder, and schizotypal personality disorder. Throughout the project's development, we learned that the determination of a patient's etiology is even more complex than we initially thought. While our program did accomplish the foundations of what we had hoped it would accomplish, there are still many aspects of human cognition that we had not initially considered adding to our program. For instance, symptom severity could have been accounted for with a weighting system, treatment progress could have been stored in a manner that would allow the program to reference patient history and use these "learned elements" concerning the most frequently occurring symptoms for given disorders as a means of diagnosing a patient more quickly and more accurately.

3. Wason's Selection Task

(1-2 pages, double-spaced)

The Importance of Context and Deontic Conditionals in Logical Reasoning as a Part of the Wason Selection Task

In 1966, Peter Wason developed the Wason Selection Task, an experiment designed to assess how well human beings comprehend and reason about conditional, if-then reasoning, specifically when presented with facts that go against an established hypothesis (Bermúdez, 2010; UPenn, n.d.). Influenced by Karl Popper, who theorized that scientific principles arose from hypothetico-deductive reasoning (the pursuit of contradictory evidence to a widely-supported hypothesis), Wason decided to test if these reasoning principles were regularly exercised in human learning (UPenn, n.d.). This test consisted of four "facts," each of which are shown on cards, where each card contains one piece of information on either side. Those completing the task were tested according to their ability to recognize the relationship between the information displayed on either side of the cards, where only one side was shown to them at a time (UPenn, n.d.). Accordingly, participants were instructed to determine the cards that should be flipped over in order to test the hypothesis that one side of the card contained a letter, while its other side contained a number. Given the rule, "If a card has D on one side, then it must have 7 on the other side," and presented with the situation of D, F, 7, and 5 all being face up, the participant should flip D and 5, or P and not-Q, as the falsifying instances (UPenn, n.d.). Overall, according to numerous trials held over the previous 25 years, when these relations are unfamiliar, less than one quarter of those tested routinely arrive at the best answer, and this finding remains consistent across a variety of individual backgrounds. This indicates that human beings are generally not very good at performing this task, and they likely do not engage in scientific reasoning on a daily level (UPenn, n.d.).

Interestingly, other modifications of this task show a reversed success rate; how participants perform on the selection task seems to be heavily influenced by the means by which the task is administered (Bermúdez, 2010). For instance, if the task is presented to the participant in a manner that applies its elements to a "real-world" problem, a deviation from the abstract nature of the original task, such as in the case of verifying the conditional that the drinking age must be over 19 (consistent with Florida law when this conditional variation was developed), then the participants' abilities to effectively solve the problem greatly increased (Bermúdez, 2010). Researchers Richard Griggs and Jerome Cox more appropriately contextualized the task to participants, asking participants to "evaluate the conditional: If a person is drinking beer, then that person must be over 19 years of age," in which cards were shown that exhibited the names of drinks and ages on opposite sides of the cards (Bermúdez, 2010, p. 104). More specifically, prior to being prompted to make a decision, participants were instructed to view themselves as police officers tasked with the responsibility of determining if any illegal alcohol consumption was taking place at the bar (Bermúdez, 2010). In this instance, the correct solution to this problem is reached when the participant selects the BEER card and the 16 card as the two to be flipped over. Participants performed overwhelmingly better in this case than they did with the original task (Bermúdez, 2010). Another unique finding as it relates to this variation concerns a return to the worsened task performance levels comparable to that of the original task when the imagined scenario with the police officer role is omitted (Bermúdez, 2010). Accordingly, task performance seems to improve more drastically when the prompt is formulated in such a way that asks participants to check a condition that references rules, permissions, agreements, privileges, prohibitions, and/or other social and relational occurrences, attributing our heightened reasoning abilities to domain-specific tasks with deontic conditions (Bermúdez, 2010; Cosmides & Tooby, 1992; UPenn, n.d.).

Leda Cosmides and John Tooby have attributed this strangely specific strength to a highly specified cheater detection module that has developed over time from the evolutionary process in order to help us to manage specific problems that are presented to us, including danger evasion and the search for a mate (Bermúdez, 2010; UPenn, n.d.). Building off of this idea of a social contract relation, Leda Cosmides conducted a series of experiments that reframed the Wason selection task execution to four different conditions: one that presented an unfamiliar situation as a social contract, another with an unfamiliar situation with no social context, one utilizing an abstract rule like the original task, and the last task being a familiar situation presented in a detailed manner (UPenn, n.d.). In the social contract attribute, in which participants tried to identify a cheater or rule breaker, performance results improved drastically, likely due to this sensitivity to social cheating and a desire for social exchange as a result of evolutionary influence (Cosmides & Tooby, 1992; UPenn, n.d.). Further, familiarity improved results, too, but not as much as the social contract conditions. As anticipated, in unfamiliar situations without social contracts and in abstract situations, results were quite comparable to the original experiment, as under a quarter of participants obtained the correct answer (UPenn, n.d.). All in all, the Wason selection task and its variants imply that logical reasoning ability in human beings seems to be situational in nature. Results from the original Wason selection task and its variants indicate that in abstract, formal instances, unfamiliar instances without context, and possibly in familiar instances without social contracts, humans do not seem to successfully engage in logical reasoning. Especially in situations where a social contract is employed, and the social contract can be broken, logical reasoning does seem to occur.

Works Cited

Bermúdez, J. (2010). *Cognitive science: An introduction to the science of the mind*. Cambridge University Press.

Cosmides, L. & Tooby, J. (1992). Cognitive adaptations for social exchange. In *The adapted mind: Evolutionary psychology -- and the generation of culture* (pp. 163–228). New York: Oxford University Press. https://www.cep.ucsb.edu/papers/Cogadapt.pdf

UPenn (n.d.). Leda Cosmides and the Wason Selection Task. https://www.ling.upenn.edu/courses/hum100/evolutionary_psychology.html

4. Technical Writing

(approximately 1 page)

The Basics of the For vs. the While Loop in Java: What They Are, How They Differ, and How They are Used

Overall, loops in programming languages allow for the implementation of a set of instructions or functions that can be carried out continuously while some condition evaluates to true (GeeksforGeeks, 2021). In Java, loops can be executed in three different ways (while, for, and do while), although this section will only cover for and while loops. Concerning basic functionality, these loops are quite similar, but they differ in their syntax and condition checking time (GeeksforGeeks, 2021). Further, while for and while can achieve different things in programming, it is possible for every for loop to be reconstructed using while and every while to be reconstructed using for (Nookala, 2016).

A **while loop**, which functions as a repeating if statement, is a control flow statement that permits code to be implemented repeatedly according to a given Boolean condition, and it is more general in nature than the for loop (GeeksforGeeks, 2021). While loops are recommended when a fixed number of iterations is not specified (www.javatpoint.com, 2021). To start, while loops first check the condition (also known as the entry control loop), and if this condition evaluates to true, then the body statements that are written inside the body of the loop are implemented. These statements often include an update value for the variable that is being handled for the upcoming iteration. On the other hand, if this condition evaluates to false, then the loop terminates, ending the iterations of the while loop, and the initial statement immediately following the loop is executed (GeeksforGeeks, 2021). Overall, while loops work quite well in counter controlled situations, which specify the amount of values that will be used in the program. Counter controlled loops involve a header, which is a metadata item that indicates how many data items are to be processed (Graci & Schlegel, 2019).

The **syntax** for the **while loop** is as follows:

```
initialization
while ( test ) {
    sequence-of-statements
    change
}
```

(Graci & Schlegel, 2019)

Example:

```
int i = 0;
while ( i < primes.length ) {
    System.out.println( primes.[i] ) ;
    i = i + 1;
}
```

A **for loop** provides a more concise way of writing the loop structure in Java, and they are recommended when a fixed number of iterations is specified (www.javatpoint.com, 2021). The for statement differs from the while loop by condensing the initialization, condition, and increment/decrement pieces of the syntactic structure in one line, which creates a shorter looping structure that is easier to debug (GeeksforGeeks, 2021). First, the initialization condition initializes the variable being used, marking the starting point in a for loop. Here, a variable that has already been declared can be used, or a variable can be declared. The testing condition is then used in order to test the loop's exit condition, requiring that a boolean value is returned (also known as an entry control loop, since the condition is checked before the loop statements are executed). During the statement execution step, once the condition evaluates to true, implementation of the statements in the loop body can occur. The increment/decrement is used as a means of updating the variable for the upcoming iteration. Finally, when the condition evaluates to false, the loop terminates, ending the iterations of the for loop (GeeksforGeeks, 2021). For loops are particularly useful when a fairly sizable portion of iterations in loop execution must be performed in Java (Nookala, 2016). Overall, for loops work quite well in data controlled situations, which specify the pieces of the data that show that the program has finished. Data controlled loops involve a trailer, which is a metadata item that indicates the end of a stream of data items has been reached. Accordingly, there must be a range restriction on the data in order for the trailer situation to be applicable (Graci & Schlegel, 2019).

The **syntax** for the **for loop** is as follows:

```
for ( initialization; test; change ) {
    sequence-of-statements
}
```

(Graci & Schlegel, 2019)

Example:

```
for ( int i = 0; i < primes.length; i = i + 1 ) {
    System.out.println( primes[i] ) ;
}
```

Works Cited

GeeksforGeeks. (2021). *Loops in Java*. GeeksforGeeks. https://www.geeksforgeeks.org/loops-in-java/

Graci, C. & Schlegel, D. R. (2019). *A First Course in Computer Programming: Laboratory Manual*. https://danielschlegel.org/wp/wp-content/uploads/2019/08/CS1_Labs.pdf

Nookala, S. (2016). *For vs while loop in Java*. Meritcampus. https://java.meritcampus.com/core-java-topics/for-vs-while-loop-in-java

www.javatpoint.com. (2021). *Loops in java: Java for loop*. JavaTpoint. https://www.javatpoint.com/java-for-loop

5. Contemporary Cognitive Science Debate

(1 page)

The Hard Problem of Consciousness and the Esoteric Features of Qualia

Consciousness and its numerous subjective qualities are no easy matter to grasp, and they present a number of challenges when investigators attempt to classify and reason about it in a reasonable, practical, and consistent manner. The hard problem of consciousness is defined as the point of disagreement underlying the reasoning behind why certain physical states are considered conscious, as opposed to nonconscious (Weisberg, n.d.). More specifically, this issue characterizes and attempts to clarify the reasoning behind individual accounts of internalized conscious experiences and their associated mental states that surface in response (Weisberg, n.d.). Josh Weisberg supports the enactment of an explanatory model that serves to explain the functional, dynamical, and structural properties of this strange occurrence, meant to more clearly investigate what something does, how its purpose and development is altered in response to temporal influence, and the mechanisms by which it is constructed (Weisberg, n.d.). Even with this methodological approach, which arguably produces fairly straightforward results, it still begs the question of why certain behaviors and subjective experiences are considered *conscious* (Weisberg, n.d.). These subjective conscious experiences that are so challenging to quantify and empirically investigate are referred to as *qualia*, and they include an individual's perception of taste, smell, sound, and color (Sturm, 2012).

Thomas Sturm (2012) provides an informative example concerning the qualitative nature of subjective perceptions and feelings: "If I look at the color of a pair of socks inside a gloomy shop, it may appear differently to me compared with how it appears outside in bright daylight [...] one might also think of the distinctive kind of anxiety or depressive feeling a psychiatric patient suffers from when faced with a situation that healthy people perhaps find merely a bit worrying" (p. 56). These feelings, perceptions, and experiences encompass considerable variability across individuals, and they can be attributed to distinct mental states. While consciousness and its obscure, subjective qualities are fairly difficult to comprehend, some investigators are interested in mapping its cognitive manifestations to the brain in an attempt to better understand its diverse features. Accordingly, this vantage point can be viewed as an intersection of philosophy and neuroscience. These investigations are driven by the fundamental question: "Are qualia reducible to material states of the brain?" (Sturm, 2012, p. 56). Proponents of physicalism claim that this is possible. Historically, many have claimed otherwise, with an overwhelming portion of skeptics falling within the disciplines of philosophy and cognitive science (Sturm, 2012). Skeptics have argued that this reducibility to the brain is not possible with the utilization of only the techniques and practices regularly applied in the empirical sciences (Loorits, 2014). One argument in disagreement with the physiological grounding of consciousness concerns that of an experienced neuroscientist who has been made aware of the existing laws that constitute the brain's structure and function. While this scientist has acquired expertise in the field, color perception deficits were present from birth. Those in disagreement with the physicalist perspective claim that the neuroscientist's acquired knowledge would then be lacking some key features of color sensation and perception, even with extensive experience, and, if color sensation and perception were somehow made possible, new knowledge and insights would ensue (Sturm, 2012). Further, if researchers were able to uncover every existent law that explains every neural process, it does not seem likely that the phenomenological elements of subjective sensations, such as smells and tastes, could be fully explained and understood by the known laws and initial conditions of these extensively studied mechanisms, thereby outlining an apparent "explanatory gap" (Sturm, 2012).

More recently, neuroscientific endeavors in exploring the mapping of consciousness and its associated qualitative features onto the physiology of the brain have been promising. For instance, experimenters have been investigating the internal structures that constitute these qualitative phenomena, and have had some success in determining their corresponding neural patterns (Loorits, 2014). For instance, researcher Hans Flohr has engaged in anesthesia studies in an attempt to better understand the physical underpinnings of consciousness, and postulates through experimental investigation that N-methyl-D-aspartate (NMDA) synaptic activity is a necessary and sufficient precondition to the occurrence of consciousness and conscious thought (Sturm, 2012). All in all, while the possibility of attributing phenomenological elements of qualia to specific neural patterns may be attainable in the future as technological advancements persist in science and medicine, this potential for discovery is still ambiguous at present (Sturm, 2012).

Works Cited

Loorits, K. (2014). Structural qualia: a solution to the hard problem of consciousness. *Frontiers in Psychology*, *5*(237), 1–9. https://doi.org/10.3389/fpsyg.2014.00237

Sturm, T. (2012). Consciousness regained? Philosophical arguments for and against reductive physicalism. *Dialogues in Clinical Neuroscience*, *14*(1), 55–63. https://doi.org/10.31887/DCNS.2012.14.1/tsturm

Weisberg, J. (n.d.). *The hard problem of consciousness*. Internet encyclopedia of philosophy. https://iep.utm.edu/hard-con/