TLT 462: Book Synthesis

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TLT 462: AI, Machine Learning, and Robotics

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When asked to select two books pertaining to Artificial Intelligence (AI) and Machine Learning (ML) for a book synthesis project, I imagined the subject matter would include computers and robots, but was surprised to end up studying reading and grammar. I was initially uncertain about how these subjects related to AI and ML, but I was naturally drawn to the books I selected for a variety of reasons. Professionally, my role is to teach struggling readers to become successful readers, and personally, I have always enjoyed reading for leisure; for these reasons, Stanislas Dehaene's, *Reading in the Brain: The New Science of How We Read*, was an obvious choice. My second choice, Stephen Pinker's, *Words and Rules: The Ingredients of Language*, studies language - how it develops in children, grammar, and what that teaches us about the human mind, through the specific phenomenon of regular and irregular verbs. This appealed to me as someone who has learned a second language as an adult and taught non-native speakers English as a second language. When teaching English as a second language, I was surprised to find how little I knew and understood about my own language (which was frequently brought to my attention by my persistent students' questions about when, why and how to use specific rules). I knew the books would be helpful for me in my career, and insightful for me based on my background and interests, but the big question remained - what do the topics of reading and grammar have to do with Artificial Intelligence and Machine Learning?

The first assignment for this course introduced the topics of AI and ML. The introduction included the idea that, in order to understand these topics and concepts, it's necessary to first prepare oneself in the following ways: gain conceptual understanding, understand AI/ML application "to relevant real-world cases or examples", and hands-on exploration of AI and ML tools. (Garrigan) By exploring both Dehaene's and Pinker's ideas, I was able to apply the

conceptual understanding I learned through class assignments to enhance my understanding of the subject, as well as see the application of AI and ML in real world examples. Finally, in seeing how the seemingly unrelated topics of reading and grammar do pertain to AI and ML, I am now able to see the broad impact and applications of these technologies.

I began with Dehaene's book and was able to make connections between what I have learned in class and the content within the first few pages. Dehaene breaks down the process of reading with great detail and complexity, beginning by comparing a reader to a robot. He equates the eyes to cameras that use the input of pixels on a page (letters) to identify the output (words), through the process of complex operations in the brain, he compares to algorithms. (Dehaene, 2010, p. 12) As I learned more about how machines acquire knowledge, I was able to make comparisons between how the brain works and how machines learn, using ideas from the book. Like machine learning examples that show us that it is possible for machines to become more accurate through training with large data sets, learners are able to become better in the areas of visual acuity after hours spent "training" to recognize letters, patterns, and strings of letters. (Dehaene, 2010, p. 211) Also, Dehaene discusses the idea of neuronal recycling and the usage of cortical space. He brings up the idea that devoting space in our brain to the skills required for reading, may possibly impair other skills, for example face perception abilities (Dehaene, 2010, p. 215) This is an example of the advantage machines have over the human brain - unlimited "space" for a variety of functions, and a way in which the human brain, while capable of amazing things, is unable to compete with machines. However, in contrast, what may be perceived as a limitation could also be seen as a strength with regard to the plasticity of the brain. In people that have brain damage in areas responsible for decoding words and making

meaning (the Letterbox region), it was shown that the brain is able to compensate through activation of other brain areas not originally known to be as useful for reading. (Dehaene, 2010, p. 169) In contrast, if there is an error where something goes awry in a machine learning system (something comparable to a "lesion" on the processor, for example an error in coding, data etc.), from what I have learned thus far, it seems that a machine lacks the ability to compensate through something similar to plasticity or neuronal recycling. Machines do not have this type of hierarchy of areas that can all perform similar skills and can be activated due to a failure in another area. Maybe the human brain does have the upper hand after all… for now, at least.

While Dehaene allowed me to compare the complexities and limitations of the human brain to those of machines, Pinker, conversely, helped me understand how machine learning and algorithms are most helpful through, not in spite of, collaboration with humans. Throughout *Words and Rules*, Pinker analyzed a variety of hypotheses to make sense of regular and irregular verbs, and looks at the potential for an artificial neural network, known as a pattern associator, to show how the mind represents them. As Pinker attempted to strengthen his words and rules theory, he utilized the findings of other experts' use of a pattern associator as a tool to do so, by pointing out its failings. In thinking about what makes a machine "intelligent", we can look at the contrast of computer pattern associator models to Pinker's methods of developing his words and rules theory to explain regular and irregular verb patterns. The machine's inability to perform multiple jobs with "contradictory demands", continues to show that the human brain is superior to machines. (Pinker, 1999, p. 146). I was able to see how the failings of the machine, helped Pinker gain insights about the human mind; for example, the understanding that the kinds of words matter - not just the words. Had Pinker completely disregarded the machines work as

ineffective, he may not have been able to come to the conclusions he did or articulate his theory in a way that is so convincing. This is an example of how machines and humans work best when they work together. Crunching numbers and data that are far beyond a human's capabilities is a strength of machines; however, the capabilities are enhanced when made sense of or utilized by humans who have the ability to perform different types of operations simultaneously and understand nuance that machines are incapable of.

Both Dehaene and Pinker helped me understand how the use of artificial intelligence through understanding of the brain's inner workings can prove to be effective in advancing the capabilities of machine learning, though limitations will likely always exist. Dahaene's explanation of the brain's various parts and processes as they pertain to reading, show that the brain responds to culture to perform specific tasks it was not originally intended for. An implication for this with regard to machine learning is that understanding machine capabilities as *they* relate to culture may allow us to develop tools to help us become more effective in a variety of areas - from communication, to collaboration and innovation. Pinker helped me to see that while machine learning may appear to "think" like a human, sometimes its important to look deeper and question what is really happening. It's important to consider not only what the machine can do, but what the machine cannot do. By looking at a machine's limitations, we can explore ideas such as what cannot be taught - or what exists as a result of nature over nurture, and what is instinctual for humans.

I found the two books to have many overlapping themes and ideas. Dehaene describes a dual-route model where infrequently used words move along a phonological route (via sound), and frequently used words are recalled from a "mental lexicon" in brain areas related to meaning,

which can be subdivided by categories (Dehaene, 2010, p. 109). Similarly, Pinker looks at frequency of word use when explaining how the brain deals with words that are common or uncommon, in addition to regular and irregular. He found that more frequently used verbs tend to be irregular which may be why they are more likely to be stored in memory. Also, regular verbs follow rules, which also matches Dehaene's explanation, based on various psychological models, of infrequently used words being decodable - for example, *stem* + "ed" = past tense. Both Pinker and Dehaene use the analogy of words as trees, being built of of various components that follow patterns to dissect them, and look at the concept of the brain compartmentalizing by categories. The two authors study brain activity; however, Pinker takes an approach of looking at human behavior and responses to stimuli to prove his hypotheses about the brain, whereas Dehaene looks at the brain's activity to understand human behaviors in reading. Additionally, Pinker's work revolves around language which is instinctual, whereas reading is not.

I really enjoyed both books, but I will say that Stephen Pinker's style was a little more palatable and I look forward to reading more of his work. I loved learning about how children's ability to instinctively communicate, and quickly learn to do so effectively could help us understand the workings of not only the brain, but also what is innate or relies on genetics. Stanislas Dehaene's style of writing was much more difficult to get into, and while I understand the importance of the details, it was a lot to work through them. That being said, I do feel as though this should be required reading for educators. Teacher preparedness at the undergraduate level seems to really be lacking in scientific basis for how we teach and how students learn, which is negligent at best. I found the later chapters on learning to read, the dyslexic brain and reading and symmetry to provide practical information for educators that I will utilize. I found

the final chapter, “Toward a Culture of Neurons”, particularly intriguing. It’s powerful to see the potential of studying the brain to understand culture, particularly learning about the relationships between how the brain works and how things like religion and art have developed as a result. In conclusion, the experience of reading both books, has inspired me to continue to learn more beyond the content of the class to understand more about cognitive science, psychology, education and their relationships to artificial intelligence and machine learning as they continue to rapidly evolve.

References

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