Utilizing Current Technologies to Foster Augmented On-line Learning

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Abstract: Science involving the human brain, psychology, and cognition has progressed sufficiently that the technology exists to develop a mutually beneficial exchange of information between a human and an AI. Dubbed "AI Symbiosis," this process enables positive feedback between humans and adaptive computer algorithms in which both human and AI would "learn" how to perform tasks more efficiently than either could alone. Several new technologies and inventions allow a vast array of augmented input and/or output between humans and AI, including mental activity wirelessly operating computers, manipulation of targeted neurons with or without implants, non-invasive, surface-level implants the size of a coin transmitting real-time neural activity of senses, real-time video feed of human mental images, and estimation of thoughts and emotions. A research project is planned to study students' divided attention when they are learning content in on-line environments. The research will target eye-tracking, click timing, and task performance data to determine the levels of impact divided attention has on student learning. We believe that this line of research will also inform best practices in on-line instructional settings.

Keywords: Augmented Cognition Educational Applications, Artificial Intelligence, Consumer-grade sensors

1 Introduction

Understanding of the human brain has grown exponentially over the last millennia. Long gone are the days of ancient Egyptians who during mummification discarded the brain as if mucus, rather than preserving it as they did with organs considered more important such as the intestines [5]. Only within the last century have psychology and cognitive science emerged, which have already become involved in some of the most competitive research in modern times. Leaps and bounds in progress have been made in developing scientific methods to treat, manipulate, and emulate human behavior. Academia at large has recognized the brain's complexity and plethora of functions to include perception interpretation, the regulation of body functions, and information processing capabilities. Since the invention of electronic computers, the human brain has increasingly been considered as an organic carbon-based computer as opposed to today's silicon-based electronic systems. This comparison has inspired a remarkable amount of research seeking to develop a passible digital equivalent of human consciousness. Despite being unknown decades from either developing true artificial intelligence (AI) or potentially uploading a human brain's contents to an electronic equivalent, a new stage of human evolution has already been reached dubbed "AI Symbiosis" [6] signifying the development of mutually beneficial relationships between humans and AI.

Such capabilities once only dreamed of are now upon us after numerous recent advancements in a variety of academic fields such as psychology, cognitive science, and nanobiotechnology. Altogether, these discoveries and inventions have realized computer-assisted augmentations which can provide a feedback loop between AI and human intelligence (HI). Now that computers capable of hosting AI have reached such miniscule sizes, humans can be outfitted with inobtrusive augments complete with an onboard AI and input/output functionality, also known as intelligent agents (IA). These IA enable a give and take of assistance to its wearer in near-real time, as well data monitoring and interpretive processes allowing them to undergo mutual adaptations and advancements towards higher efficiency and expanded capabilities—not only toward the task at hand, but towards each other as well. Initially the augmented subjects will perform simple tasks while the AI would use the gathered data to develop an algorithm attempting to mimic the actions of the subject, complete the specified tasks, and develop a model sufficient to recognize variations of initial conditions such that it can adapt to modified parameters without human intervention (i.e. manually altering the code). Overall, a primary goal of AI Symbiosis is to develop and provide augments for human use to provide them with enhanced abilities beyond that which a human, AI, or robot could do on their own. In time HI/AI interfaces will inevitably become commonplace, incorporating a vast array of technologies and functions such that our civilization will undergo a fundamental shift more impactful than any other in the history of mankind.

2 Research Foundation

2.1 Background

Research into AI incorporates a diverse community of scientists and philosophers who analyze the human brain with the intent to develop understanding of our own species' cognition, which is then utilized to further AI capabilities by reverse engineering our own cognitive processes. A common theory among these researchers is that a human brain can be emulated using electronics. There are several factors which support this perspective. Computers are inherently modular, not unlike the brain, with different sections specialized for certain tasks [3]. Both AI and HI use electrical signals to perform operations within milliseconds. In another significant similarity, humans have distinctly separate short-term memory and long-term memory functions [3] similar to computers—random-access memory (RAM) and non-volatile memory (e.g. HDDs and SSDs). Although the central processing unit (CPU) of a computer is a single component, unlike the neural network of the brain, both can process data at a rate too fast for humans to consciously keep up with. These comparisons inspire possibilities for IAs to supplement humans with expanded abilities. For example: many inputs and stimuli go unnoticed to humans (as we can only focus on so much at the same time) yet incorporating IAs could store such data for later examination *and* represent information in a far more resilient and trustworthy form than human memories alone, which have a wide range of reliability. As such, there is a foundation of similarities upon which scientists can bridge the gap between HI and AI.

2.2 Potential applications of augmented intelligence

Beyond simply allowing humans and AI to interact and adapt to each other, our bodies can be controlled by either humans or AI. Electrical manipulation of neurons using hardwired implants were discovered decades ago, and advancements in its usage are ongoing [3]. Another form of cerebral manipulation called optogenetics involves modifying the DNA of neurons causing them to activate when a specific wavelength of light is applied. This process enables stimulating specific neurons in the brain with only a colored flashlight, which has the advantage over electrical manipulation that it does not require a hardwired cerebral interface [3]. These methods could be supplemented by an AI-influenced exoskeleton with input from the brain, remote guidance systems, electronic monitoring equipment, and even an AI program capable of autonomous movement such as a robot developed by Google researchers [4]. Such a rig could react to stimuli 50x faster than a human could (5 msec vs 250 msec), allowing an appropriate response to be taken about a quarter second sooner than a single focused individual or even more if no human consciousness was initially aware of the event. Astronauts, construction workers, spelunkers, soldiers, and mountain climbers could all benefit from this technology, both in efficacy and hazard mitigation.

Additional opportunities exist allowing interaction and learning between brain and AI with the digitization of sensory inputs. Gertrude, Elon Musk's cyborg pig, has an implant that transmits sensory input from its snout and displays a visual representation of what she smells on a display monitor allowing real-time analysis [9]. This reveals the potential to examine and understand brain activity in the context of its input, as well as combine the extraordinary senses of certain animals with human analysis to improve sensory detection and tracking methods. For example, an implant used on a police dog could display all detected scents on a monitor, quickly identify odors of specific illicit substances, and verify the K9 unit has not lost the scent trail. Sensory impressions can also be interpreted from human brains without a need for implants- visual and conceptual images held by humans can be recorded from scans of their cerebral activity. Researchers have been able to create videos representative of mental pictures held by volunteers via the utilization of an MRI to monitor their medial prefrontal cortex. By comparing the signals to the frames of the movie observed at the corresponding moment, researchers were able to derive an algorithm to convert brain signals to video. This experiment was successful to the extent that they could correctly identify which individual of a group the volunteer was thinking about by analyzing the brain scans [2]. Another example of HI-AI interactivity is the development of technology allowing a person to mentally operate computers. Implants of various types have achieved this outcome, most notably the development of a microscopic device at the end of an ultrathin wire which can be inserted for navigation to the brain's motor cortex, where it wirelessly transmits the subject's intentions to move as input to a computer. Several volunteers paralyzed with Lou Gehrig's disease (amyotrophic lateral sclerosis) were able to send texts and browse the internet freely without using a muscle in their body [7]. This afforded them with new levels of enjoyment and interactivity.

2.3 AI Symbiosis

Although several computer-enhanced abilities for humans have been discussed, we have not yet examined furthering development of AI itself. Symbiosis is built upon mutual benefits, so it is important consider the benefits to AI from the perspective of current technologies. Consider the recent findings of Neuralink, a business venture with the goal of developing brain-machine interface (BMI) technology achieved in the mid-2000s to make them accessible to consumers. Non-invasive implants the size of a coin have been fitted to animals (such as Gertrude) that can gather signals related to movement, smell, vision, and hearing without probing beyond the brain's surface. An AI gathering these types of data paired with separate sensory inputs such as cameras and microphones would be able to comprehend such signals given sufficient analysis. The next logical step would be to use this information to emulate those modules, which would be a significant contribution towards an electronic simulation of a human's cerebral activity. Elon Musk said that the *ultimate goal* would be to perfect AI symbiosis [9], with the AI and human learning from each other in such a way that would be far more efficient and powerful than all prior applications.

Even if AI can learn and adapt from the plethora of data accessible via human interaction, how can we know for sure when an AI can sufficiently act like a human? The Chinese Room experiment [9] illustrates asynchronous communication providing enough ambiguity that it is difficult to be certain of whether the other entity is sentient. Taking that into account, the Turing test has been modified to include visual signals and other methods of gauging interpretations and responses, which begin to test for intentionality. Interpreting symbols according to a constant set of rules is one thing but understanding complex objects, or concepts beyond a list of characteristics, is another entirely. The concept of intentionality involves the subject understanding an object beyond its symbolization and characteristics and is a popular topic among those debating the possibility of AI reaching consciousness [9]. Theoretically, giving computers an array of sensory inputs, social behaviors, and physical interaction programming could lead to intentionality the way humans may have developed it by using perception, prior knowledge, and the ability to think critically. In the future, AI avatars may be able to engage in physical interactions such as exercise, work, and even human conversations on our behalf - in our own bodies, as we cognitively experience virtual reality. It currently appears to be imaginary, but as AI Symbiosis evolves and nanobiotechnology becomes more capable and specialized the potential will seem more tangible with each passing year.

It seems undeniable that AI development is inextricably linked with HI as advances in one field of study advances the other as well, like the mutual learning inherent to AI symbiosis. There are a multitude of ways that computers can control or assist humans and vice versa, and beyond certain constrictions such as quantum processing and digitization of cognition there is much potential for progress. Evidence exists that the minimum requirements of obtaining AI Symbiosis are exceeded on a fundamental level as demonstrated by Musk's Neuralink experiments [9]. Both HI and AI can sense, process, interpret, transmit, and receive data - thus enabling the mutual learning process. The future of human enhancement is approaching; quantum processing and mind digitization could catalyze development with AI Symbiosis as a foundational component. The technological capabilities of AI, IAs, and BMIs that exist today illustrate the beginnings of this approach. Humans can fully operate personal computers remotely using an implant and their mind, which among other possibilities can give quadriplegics an opportunity to be active in different ways in modern society. Noninvasive brain scans can display a visual representation of a subject's mental images, an invaluable tool with disabled patients. Implants can gather sensory input from an animal and transmit it to a computer for storage and further analysis. AI interfaces can shave tenths of seconds off the average human reaction time, similar to the near-instantaneous responses displayed by Tesla cars utilizing video cameras in conjunction with predictive algorithms to avoid accidents [1]. With the many advancements of science in recent years, the potential to utilize these technological breakthroughs continuously increases.

3 Proposed Research

3.1 Divided Attention

Divided attention is a common phenomenon associated with multitasking, where a person performs multiple tasks in rapid succession [9]. Performing tasks in this manner creates the illusion of multitasking and results in reduced task performance or an increased time on task when getting accustomed to the new assignment. Van der Stigchel described in detail the impact of divided attention on work and learning environments. In many working environments, employers often ask that subordinates immediately respond to their email, text messages, and phone calls. This tends to result in superficial levels of depth in productivity, where major breakthroughs and critical thinking tasks may be delayed or not completed at all. Therefore, the attempted parallel process dynamic prevalent in offices and schools alike known as multitasking actually causes lower levels of productivity than if each of the tasks were performed individually in series.

In education, the deepest levels of learning and profoundest insights typically take place with high levels of focus on content [9]. Students can still learn while multitasking but later will not be able to use the information as effectively as those who focused solely on the material. For many multitasking during the learning process may result in short-lived benefits but will inevitably result in long-term disadvantages. Not only will these multitaskers have greater difficulty recalling pertinent information, but their aptitude for critical thinking skills with the subject-matter will be significantly diminished.

Divided attention and multitasking in students is a growing concern in learning environments due to the myriad distractions that exist. These adverse behaviors can be mitigated to an extent in the physical classroom environment, where students are less likely to pay attention to non-educational tasks such as checking social media, watching videos, or playing games. However, due to the COVID-19 pandemic leading to the growth of on-line learning and learning from home, these counterproductive habits have risen to the forefront of obstacles to modern-day education. Researchers teaching synchronous classes online have experienced an increase in their students multitasking, to an extent which would be impossible in a physical classroom. Many teachers have discussed their concerns with students watching television, playing games, and browsing social networking feeds while attending class. In some cases, the researchers and teachers observed students manipulating their game controllers, using a television remote, and scrolling on their phones during class sessions. Students mute themselves to hide evidence of their divided attention while their video continues to stream, and it is impossible to tell how many students are multitasking who are scrupulous enough to hide their distracting devices.

While ongoing pandemic precautions have resulted in many schools pivoting to online education indefinitely, we believe that online educational opportunities will continue to experience widespread use even after the pandemic is over and schools again open their doors. Therefore, it is vital to educational professionals to study divided attention such that augmented cognition could be developed to create applications for AI Symbiosis resulting in students reaching higher levels of comprehension and retention in a variety of learning environments.

3.2 Methodology

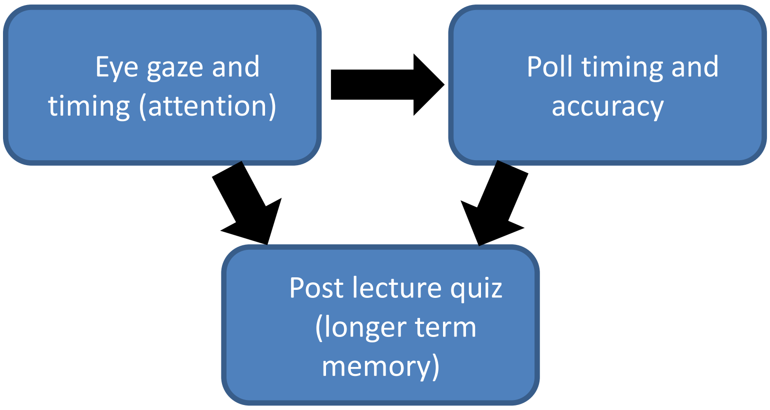
The researchers plan to conduct a study targeting divided attention when learning content in on-line environments. The research will target eye-tracking, click timing, and task performance data to determine the levels of impact divided attention has on student learning. We believe that this line of research will also inform best practices in on-line instructional settings.

The researchers partner with a large-enrollment course in computer science that typically enrolls between 200 and 300 students per semester. The course focused on computer science principles, application usage, and technology and its impact in society. Due to the general content of the course, the students come from a variety of backgrounds including over 30 different majors. The class includes a 75-minute synchronous lecture each week and two 75-minute synchronous lab sessions per week. The lectures are conducted via Zoom and include multiple interactive elements including *polls,* where students can respond to multiple choice questions posed by the instructor. Students are also asked to respond to questions in the chat for open-ended type questions. After the lecture, a multiple-choice quiz is posted to the course management system for students to complete within a few days. These elements make the lecture portion of the course a strong area to study augmented cognition using consumer-level devices. The proposed methods are pending institutional review board approval.

Since most students use a laptop with a built-in web camera, we plan to collect eye-tracking data during the synchronous lecture sessions. The eye-tracking data and timing will be aligned with slide and audio content to acquire evidence of the students' focus on content throughout the session. Since the poll questions used in the lectures focus on recalling or applying information learned, we will collect the data submitted to the polls and timing related data. This data will indicate the amount of time taken to respond to each question and the correct or incorrect nature of the response. Lastly, we will collect the students' end of lecture quiz in the course management system to determine if they could apply knowledge after learning the material.

These data align with the divided attention framework, where the researchers plan to use a repeated measures design for each student to determine if how their focus shifts during a lecture and if it impacts their poll response correctness and timing. Based on Van der Stigchel's work [8], we also plan to use the post lecture CMS quiz as a dependent variable to determine the amount of impact divided attention has on longer term performance in learning (Figure 1).

Figure. 1. Research design



We believe that the findings of the proposed study will serve as a foundational component of AI symbiosis research. It will provide insights into the impact of divided attention on learning. These insights could be used in the feedback loop for AI symbiosis research.

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