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Enhance Learning Performance Through Enriching Video Content Based on Ego State Therapy

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ABSTRACT

One of the most important aspects of learning is attention. This is even more pronounced in online education due to the instructor's need for sufficient control over the learner's environment. This study aims to identify the pattern of changes in the cognitive state of learners, from unconsciousness to consciousness. By observing the brain's response while learners watch micro videos, we sought to understand the impact of these ego states on learners' performance in E-Learning environments. Our findings suggest that learners' ego states significantly impact their learning performance. The first phase aimed to precisely detect the transition point from the unconscious to the conscious state. In the second phase, we tried to differentiate between these two states by comparing their learning performance. Finally, the obtained results led us to believe that learning outcomes are subject to a significant increase when the brain state changes. These findings emphasize the importance of early engagement strategies in online learning, as improving the initial phase of content delivery significantly increases overall learning outcomes. By understanding the transition between different ego states, educational content authors would create more effective learning materials that maintain continuous learner engagement.

Keywords— Engagement, E-Learning, Ego State, Video Learning Object, Learners' performance

1. Introduction

This research sheds light on an important dimension that influences learning outcomes. Identifying the point at which the brain transitions from an unconscious to a conscious state while engaging with video learning objects (LOs) provides valuable insights into how learners absorb information. This knowledge can help educators and instructional designers create more impactful and engaging learning experiences, ultimately improving student educational outcomes.

The findings of this research have practical implications for e-learning environments. By recognizing the significance of the transition from an unconscious to a conscious state, e-learning platforms can design interventions and strategies to optimize learner engagement and performance. This research can guide the development of instructional techniques, personalized learning approaches, and timely interventions that address learners' attention and maximize the effectiveness of online learning experiences.

This research offers valuable insights into the relationship between ego states, consciousness, and learning performance, contributing to our understanding of effective learning processes. By bridging the fields of learning psychology and brain science, this study can inform education practices, improve e-learning environments, and unlock new opportunities to enhance students' learning experiences.

In previous works [1], studies that use neurophysiological measurements are categorized to capture learners' psychological constructs amid the learning process without providing any feedback or adaptations. This includes studies that collect and log data, such as EEG, facial expressions, or skin conductance, to identify attention levels, emotions, engagement, and many more metrics in educational settings. Most such studies aim to observe the impacts of different teaching methods or materials

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on psychological constructs. Certain studies go beyond observation and employ neurophysiological data to evaluate and recommend more effective teaching methodologies. A common theme in said studies is the appliance of brain or physiological signals solely to differentiate learner states under various conditions without providing feedback or modifying the learning system or content. Overall, monitoring studies represent early research efforts that may pave the way for more advanced tools that estimate performance, deliver notifications, or adapt to the user.

In both virtual and traditional classroom settings, one common problem that educators often encounter is learners' lack of attention. This issue arises due to various factors, such as distractions from electronic devices, a passive learning environment, or a lack of engagement with the course material. In virtual classrooms, learners may face additional challenges like technological issues or isolation that further contribute to inattentiveness. Addressing this problem requires implementing effective strategies that enhance learner engagement and interaction, such as incorporating interactive activities, utilizing multimedia resources, and encouraging active participation. Furthermore, fostering a supportive and collaborative learning environment can help combat learners' attention issues by promoting motivation and accountability among the students. Ultimately, addressing the issue of learners' inattentiveness in both virtual and traditional classrooms is crucial for ensuring effective learning outcomes and maximizing the educational experience.

A critical inquiry that arises while exploring learners' attention issues is the exact time at which learners experience a diminished attention rate while watching video learning objects.

To tackle the challenge mentioned above, it is crucial to adopt a two-dimensional approach that combines Learning Psychology and Brain Science. By combining these two, we can find when a learning interruption happens.

In other words, the teachers can create more effective video learning objects by finding a specific time point that significantly differentiates the learner's ego state and if the learner's performance is lower in the unconscious than in the conscious state.

This study differs from prior work by focusing on the dynamic transition between unconscious and conscious states, providing a more nuanced understanding of how learners' attention evolves during the learning process. Our model seeks to bridge the gap between brain science and learning psychology, offering practical applications for enhancing e-learning environments through real-time attention monitoring and content adaptation.

This paper is structured as follows: Section 2 provides an overview of previous studies and definitions. Section 3 describes the methodology behind finding the switching point and the experiment design. Section 4 presents the analysis and results of the study, while Section 5 outlines the conclusions and potential areas for future research.

2. Literature Review

2.1. Attention rate and its calculation

Attention is readily defined, but its calculation is a more complex matter. In traditional, offline education environments, instructors may judge the attention rate of students by observing their visual expressions. However, this method is problematic for two primary reasons: the difficulty of continuously analyzing the facial expressions in a classroom and teachers' subjectivity when engaging in this task. In addition, as of recent years, online education has become prevalent, especially at the height of the COVID-19 pandemic outbreak, which has added to the difficulty of visual assessment of engagement rate by instructors. Therefore, one must analyze the brain's activity for a practical calculation of the attention rate. A viable method to gauge brain activity is by EEG signals. These five relevant EEG signals vary in their frequency range [2]: Alpha, Beta, Theta, Delta, and Gamma.

Incorporating Mayer et al.'s [3] study on the effectiveness of instructional video offers valuable insights into the design of video-based learning objects. The study highlights five principles that improve learning outcomes: dynamic drawing, gaze guidance, generative activity, perspective, and subtitle principles. These findings suggest that learners benefit from videos where instructors actively draw, guide attention through eye movements, and encourage engagement through generative tasks such as note-taking. By integrating these evidence-based principles, educational video content can be made more interactive and effective, particularly in enhancing learner engagement and cognitive processing.

2.2. Academic performance and learning

A higher attention rate has a positive correlation with improved academic performance. Studies have shown the positive effect of increased attention rates on students. In a study by Robert Reid and Karen R. Harris, continuous SMA (Self-Monitoring of Attention) was utilized to keep students' attention rates from falling while participating in a spelling course. The results and post-study interviews with students show that this procedure positively impacted the spelling ability of said students [4].

Attention administration plays a critical function in accomplishing success in various fields, from athletic to academic pursuits. The ability to consistently monitor and adapt to changing states of attention, sustain optimal levels of focus, and swiftly recover from lapses in attention are all highly advantageous in tasks that necessitate the identification and execution of appropriate actions. Attention is categorized by three aspects: distribution, intensiveness, and selectivity. In this study, the main focus is on the intensiveness aspect, as the state of awareness, in contrast to its contents, is at play [5].

Attention and learning are closely interconnected, as they are both fundamental aspects of human cognition. The acquisition of knowledge and the subsequent behavioral responses of individuals heavily rely on the ability to direct and focus attention on the relevant features of stimuli and events present in the surrounding environment. Therefore, learners must devote a certain portion of cognitive resources to information acquisition to promote efficient and effective learning. This prerequisite for successful learning is equally applicable in electronic learning, where learners must also exhibit a certain degree of attentional engagement to optimize their educational experiences. Hence, attention plays a pivotal role in the process of learning, in disregard of the learning modality implemented [6].

Pinazo, Garc´ıa-Prieto, and Garc´ıa-Castellar conducted a study in 2020 focusing on the concept of mindfulness and examining the effects of classroom and home mindfulness. Tutorial sessions for subjects were held during school time and spanned many weeks. As for home training, some intervention subjects were instructed to listen to meditative audio tapes. They found that these mindfulness programs managed to reduce violent and impulsive behavior among students, which is a crucial factor regarding the maximization of academic performance [7].

Extensive research and analysis have examined the impact of attention on children. Several investigations have examined the influence of attention on children's growth. One example is the examination of the consequences faced by children who enter formal education without the necessary attention skills. These children struggle with tasks such as remembering instructions and demonstrating self-control, leading to difficulties throughout their elementary and high school years.

The persistence of attention spans in children is closely linked to their executive function. This concept encompasses a broader construct known as self-regulation, including cognitive and emotional regulation. Self-regulation pertains to the capacity to govern and oversee various facets of attention, cognitive flexibility, working memory, inhibitory control, and emotional regulation.

The significance of self-regulation cannot be exaggerated. It plays a crucial role in helping children effectively manage and direct their actions across various cognitive, emotional, and social domains. By fostering strong self-regulation abilities, children are better prepared to navigate the intricacies of their daily lives and thrive in various dimensions of their development [8].

Components of self-regulated attention include the ability to persevere with difficulty concentrating, handle conflicting information, and function ably in school, especially on academic tasks and academic performance, all of which lead to better academic performance. The inferred relationship between interest and aspects of mathematics in elementary and middle school was solid compared to reading, which may indicate the importance of interest when engaging in STEM topics. Following a simultaneous review, these studies indicate that children with high levels of attention and persistence perform more effectively in school by virtue of possessing the ability to dismiss distractions, concentrate on pertinent information, monitor their progress, and complete assignments [8].

Another study on the effects on attention rate, published in 2017, was conducted among children diagnosed with IDD (Intellectual and Developmental Disabilities). The study discovered that the children who participated in the attention training program experienced more significant improvements in their numeracy abilities during the 3-month follow-up compared to those who participated in an active control program. These findings indicate that maintaining a persistent attention span may hold a significant correlation with achieving success in mathematics throughout one's educational journey [9].

Given the significant association between attention and academic success, it is expected that individuals diagnosed with Attention-Deficit Hyperactivity Disorder (ADHD) may experience lower academic performance. This notion is substantiated by a study conducted by Szu-Ying Wu and Susan Shur-Fen Gau in 2012. The researchers explored the functionality of students within educational settings, comparing those with persistent ADHD, those with non-persistent ADHD, and those without ADHD. They identified the clinical factors associated with school functionality in these three distinct groups. The findings indicated that both ADHD groups exhibited more significant impairment across all areas of school functionality compared to individuals without ADHD. Furthermore, a gradient relationship was identified, with the most notable impairment evident in the persistent ADHD group, followed by the non-persistent ADHD group, and ultimately the nonADHD group [10].

Another paper, published in 2010, aspired to find the association between attention problems and academic achievement. After examining various studies on this matter, they concluded that attentional impairments have a negative correlation with academic performance. This observed effect was consistent among different genders and social backgrounds. The subjects were children between 4 and 17 years old [11].

The role of visual attention in learning has been increasingly examined, particularly in multimedia and online learning environments. Wang, Antonenko, and Dawson [12] explored the impact of visual attention to an instructor in online video learning environments through an eye-tracking study. Their findings suggest that the presence of an instructor on-screen can significantly affect how learners allocate their visual attention, which, in turn, influences learning outcomes. For complex topics, the presence of an instructor was shown to reduce cognitive load and improve learning transfer by directing learners' attention to relevant information. Additionally, visual attention allocated to the instructor positively predicted learner satisfaction and engagement, highlighting that attention plays a crucial role not only in cognitive performance but also in enhancing learners' overall experience. However, there is a potential trade-off, as the instructor's presence might cause a split-attention effect, requiring learners to divide their focus between the instructor and the learning content, potentially leading to cognitive overload in more complex scenarios.

Similarly, Hasenbein et al. [13] investigated how immersive virtual reality (IVR) classrooms affect students' visual attention and learning experiences. Their study demonstrated that attention distribution is highly dependent on social configurations within the virtual classroom, such as seating position, avatar realism, and peer behavior. Students seated in the back of the IVR classroom tended to focus more on virtual classmates than on the instructional content, which negatively impacted their performance. Conversely, students whose attention was directed primarily toward the instructional content demonstrated better post-lesson performance. This underscores the importance of guiding visual attention in learning environments, as students' ability to focus on relevant instructional elements is directly tied to their learning outcomes. The findings from both studies emphasize the pivotal role attention plays in learning, reinforcing the need for instructional designs that minimize distractions and optimize learners' focus on key educational content.

This effect is not limited to humans; apes, for instance, are also positively impacted in a similar manner. A study on rhesus monkeys focused on neuron activity in visual area V4, and it found that greater attention resulted in an increased V4 firing rate and improved signal-to-noise ratio of individual V4 neurons [14].

2.3. A neurobiological account of Freudian ideas

Despite heavy criticism, Freud's theories continue to remain significant in their contributions to education and psychology as we know them today. Many contemporary psychologists do not give credence to Freud's ideas; his theories, however, hold lasting importance. In educational contexts, Freud's theories have been instrumental in understanding the conscious and unconscious mind of learners, and understanding them is an essential part of this research, as the transition from the unconscious to the conscious state is being analyzed. By studying the distinct modes of the brain and utilizing them to maximize learning efficiency, educators can help learners to learn the topics as efficiently as possible to instill the required knowledge to become productive members of society.

To understand the ego as Freud envisioned, it is described as possessing the ability to protect oneself and manage actions dealing with both external and internal aspects, learning to improve its response process as time passes. He described that externally, the ego perceives stimuli, stores memories of experiences, and avoids situations involving extreme stimuli by escaping, also known as flight. The ego adjusts to moderate circumstances and brings about positive changes in the outside world through action. Internally, when interacting with the id, the ego handles the desires of instincts by deciding whether to fulfill them by delaying gratification for a certain time or by suppressing them entirely. The ego strives to keep an equilibrium by regulating, adjusting, transforming, restraining, and managing the id's impulses to prevent arousal while supporting logical thinking and decision-making processes [15].

To best understand Freudian ideas concerning brain functions and the dual nature of ego states, one must study Federn's two-energy model.

Based on the findings of research conducted by Carhart-

Harris and Friston [16], Freud's concept of ego functions may relate to the brain's default mode network (DMN). The development and functioning of the DMN mirrors Freud's descriptions of ego emergence and repression - the DMN develops connectivity through childhood in parallel with ego functions, contains endogenous limbic excitation akin to repression, and supports self-referential processing like the ego supports the sense of self. Furthermore, the reciprocal relationship between DMN activity and subordinate networks resembles Freud's give-and-take relationship between ego-libido and object-libido. Thus, the suppressive effect of the DMN on limbic areas and anti-correlated networks may represent a neurobiological substrate for ego functions and the secondary process described by Freud.

The paper also reviews evidence that loss of hierarchical control, such as DMN control over limbic areas, occurs in non-ordinary states like psychosis and the psychedelic drug state. This initiates an unconstrained primary process akin to Freud's descriptions - phenomena like vivid recollection, perceptual distortions, and disturbance of self-boundaries. Common neurophysiological markers also emerge across these ego-dissolving states, including abnormal hippocampal theta synchronization. The present study asserts that modern neuroimaging techniques can detect shared substrates for primary process cognition. Exploring the neurobiological underpinnings of ego integrity versus dissolution may offer novel insights into disorders characterized by self-disturbance, such as schizophrenia.

2.4. Ego State Therapy

After being familiarized with the ego according to Freud and understanding how it functions, it will be explained that the aim is to assert a higher degree of control over the ego state at a given time. In the case of this research, bringing the ego state from unconscious to conscious during the process of learning is desired. To achieve this goal, EST (Ego State Therapy) will be utilized.

The concept of Ego State Therapy integrates concepts from psychoanalysis, hypnosis, and Janet's notion of dissociation to address trauma issues and dissociative disorders. EST proposes that individuals possess mental states influenced by internalizing behaviors and messages from others. These ego states may manifest as aspects of an individual's personality during distressing situations. The concept emphasizes the relationship between consciousness, unconsciousness, and these ego states, which can be either self-oriented or oriented towards objects [17].

The use of EST in this research will not coincide with its traditional uses such as psychotraumatherapy. Instead, it will be utilized towards identifying the current ego state of the learner, and using this knowledge to predict the depth of learning for them at that point of time. In future works, this ego state could then be controlled, and with it, the consciousness degree, which would ensure the most efficient and lossless learning process using video learning objects as the method of teaching.

3. Methodology

In pursuance of understanding the relation between attention rates and academic performance in e-learning environments, this experiment was partitioned into two sections: one regarding the brain activity and attention rate calculation, and the second aiming to quantize the academic performance of a student and determining the exact time of a switch in the conscious state of the brain.

With regard to calculating attention rate, participants were provided with EEG hats, which would then analyze the signals of one's brain while participants observed the LOs. Afterward, toward logging one's academic performance per time, participants would partake in an online platform and answer questionnaires following the completion of the display of the LOs.

In this study, several hyperparameters were considered to ensure the robustness and reliability of the research findings. The duration of each micro video, ranging from a few seconds to a couple of minutes, was a critical parameter taken into account during the design phase, as it directly influences participants' attention and engagement levels. Additionally, the hypothetical hyperparameter of EEG sampling rate and electrode placement was carefully selected to optimize the quality and resolution of brain activity measurements, thus enhancing the accuracy of cognitive state assessment. Thresholds for defining significant changes in attention rate and academic performance were established based on pre-defined criteria and statistical tests, ensuring objective and consistent evaluation of learning outcomes. Furthermore, the standardization of testing protocols and instructions was prioritized to minimize confounding variables and ensure the reproducibility of results across experimental conditions. Looking forward, replication studies with diverse participant samples and learning contexts are suggested as they could provide further insights into the findings' generalizability, enhancing the research outcomes' robustness and applicability.

The participating fields were diverse in background and age. They ranged from high-school sophomores to senior bachelor of engineering students. The age of the participants varied from sixteen to twenty-four years old, with the majority being twenty or twenty-one years of age. Participants' gender was diverse, with 60% of them being male and 40% female. The students were studying either mathematics and physics in high school or were elected from those enrolled in an engineering major at the University; therefore, all participants were familiar with the STEM field to their degree. However, we tried to maximize the efficiency of the assessments by choosing topics that, while not overly complicated for the participant field, were not included in the syllabi for this stage of education. This way, it would be ensured that the assessment is true for the learning process while watching the LOs, and no prior information on the topics could influence the results.

Participants were not given the details of the experiment methods beforehand to remove the possibility of a biased outcome. They would instead receive necessary instructions amid the experiment's progress.

Ten participants initially partook in the first session of the experiment; after the early results were analyzed and the expected results were obtained, that number was increased to thirty to counterbalance the p-value of the test.

The experiment's second session examined participants' academic performance via an online test. Once again, a two-sample t-test was conducted on the results, separated between the first two questions (Which translated to the first twenty seconds of the LOs) and the other seven questions.

Contextual Considerations

In the initial session of the experiment, participants were situated in a laboratory environment due to the necessity of using EEG equipment to monitor brain activity. Despite the inherent differences of a lab setting, considerable efforts were made to control environmental variables meticulously. The aim was to create conditions that closely mimicked the participants' everyday surroundings, thereby reducing potential discrepancies that could arise from an artificial testing environment. By maintaining such controlled conditions, the study aimed to uphold ecological validity, ensuring that the findings would be more generalizable to real-world scenarios.

In contrast, the second phase of the experiment was administered online, enabling participants to complete the study remotely from their own homes. This deliberate shift to an online platform was motivated by a desire to foster a learning environment that mirrored the natural, everyday contexts in which participants typically engage with educational materials. By affording participants the flexibility to participate from their familiar home environments, the study aimed to capture a more authentic representation of their cognitive engagement and performance.

3.2. Session One: EEG Analysis

In order to gauge a student's attention rate when watching educational videos, analyzing EEG signals is the most informative method available. Subjects were presented with ten Learning Objects in the test session. The topics of these videos were mainly in the STEM fields, majorly physics and chemistry. The videos were between 120 and 150 seconds in length. This length of time ensured our ability to draw meaningful conclusions regarding the early seconds of the LOs while we could still focus on the process of learning while watching short instructional videos. This is an increasingly important method of learning in today's educational world; for example, flight attendants present the safety precautions and information in a quick interval, and failure to focus on any part of these instructions could lead to increased fatal rates in the event of an accident occurring. Therefore, conducting the experiment with videos that are 140 seconds long on average will present more information on these types of LOs and instructions [18].

3.3. Session Two: Performance Examination

The second stage of the examination was conducted autonomously. The objective was to monitor scholarly achievement at various time points of observing LOs. It did not employ electroencephalogram (EEG) signals to assess the attention level, instead we opted to employ multiple-choice questions as the method of evaluation.

The examination was administered online. Upon accessing the website, the students were shown a video. The duration of the video was 268 seconds. The subject matter of this video was nuclear fusion, which is not an exceedingly advanced physical topic. Nevertheless, it is still not covered in the curricula of high school or undergraduate engineering students. This was done deliberately toward reducing the possibility of subjects having prior knowledge on this topic. The video was collected from YouTube and re-recorded in Persian. This was done in order to remove the language barrier; as the LO's instructional content was the main focus of assessment, not its presentation.

Following the video, a 30-second pause was implemented before the participants were given the multiple-choice questions. The participants were not previously informed about the structure of the experiment and thus had no prior anticipation of receiving these questions. Nine questions were presented, each with a maximum time limit of twenty seconds. For each question, three potential choices were provided, and the participants would indicate their answer by pressing the matching key on their keyboard.

These questions were distributed throughout the length of the LO; with the first two questions being related to the first twenty seconds of the video, and the remaining seven concerned the rest of the LO's length. The answers given to the questions and the time before entering the answers were recorded and sent to the examiners.

The website link was provided to a class of engineering students. The number of participants stood at 80, which ensured a high power for the experiment.

Table 1 includes information on the video learning objects, EEG data collection, participant demographics, and statistical methods. The parameters were carefully chosen to optimize the accuracy of attention measurement and learning performance assessment.

4. Results

In this section, the results of the two sessions of the experiment are presented. In the first session, the attention rate of subjects is measured at each point of time. As per the sources in section II, when the ego state switches to a conscious mode, their attention on the LO presented will be subject to a rise. Therefore, if a rise in attention levels is observed at this point in time, it is caused by a change in the ego state.

Our hypothesis revolves around investigating whether there exists a statistically significant difference in the mean attention levels over the first 20 seconds of watching video learning objects compared to the attention levels along the remaining duration. We propose the null hypothesis (H_0) that there is no difference in mean attention between the initial 20 seconds and the subsequent period. The alternative hypothesis (H_1) posits that there is a significant difference in mean attention levels during these two-time segments. The significance level is set at 0.05, commonly accepted in scientific research, which means we will reject the null hypothesis if the p-value from the t-test remains under this threshold.

To test our hypothesis, we employed a two-sample t-test, a statistical method used to compare the means of two independent groups. The t-test assesses whether the observed difference between group means possesses statistical significance or, alternatively, if it could have occurred by chance. In our case, it helps us determine if the observed difference in mean attention during the first 20 seconds and the remaining time is likely a real effect or merely a random fluctuation. Based on the calculated p-value, if it is less than 0.05, we reject the null hypothesis, indicating that the difference in mean attention is statistically significant. This inference is crucial for understanding the impact of time on attention during video learning and can inform instructional design strategies.

Table 1. Hyperparameters of Experiment

Hyperparameter	***Description***
Video Length	120-150 seconds for each video learning object (LO)
EEG Sampling Rate	256 Hz
EEG Electrode Placement	Standard 10-20 system
Number of Participants	30 participants (aged 16-24, 60% male, 40% female)
LO Topics	STEM topics (physics and chemistry)
Questionnaire Timing	Questions delivered immediately after watching each video (20-second time limit per question)
Number of Videos	10 videos per participant
Data Analysis Method	Two-sample t-test used for statistical analysis
Significance Threshold	p-value of 0.05 for determining statistical significance

4.1. Session One

Firstly, the results of this session were calculated for every subject per video. These calculations were done using the pre-existing formulas and used the values for Alpha, Beta, Theta, Delta, and Gamma signals per second. The attention rate per second was plotted for each subject-video pair, and then the mean attention per second for each subject was calculated and plotted (Figure 1).

After each subject's mean attention graph was created, they were combined to calculate the mean attention among all subjects to give a better idea regarding the attention rate at all times (Figure 2). The SEM is also displayed to give a better demonstration of the deviation in the recorded data.

In order to more accurately calculate the SEM for these data, an alternative calculation method was also utilized; this time, it started with videos. The mean attention rate for all subjects was calculated per video, and then the mean of that data was plotted (Figure 3). Following these calculations, it was observed that the SEM range was much narrower in comparison to the initial route of calculation utilized (Figure 2). This translates to the fact that the videos possess a more homogenous and similar output among the subjects who watch them, and in contrast, the results for each subject vary more between videos.

For the purpose of analyzing the results, first, a two-sample t-test was performed on the p-value per time graph. A splitter progressed incrementally along the time axis, beginning from the start of the data collection period. At each increment, the mean attention rates on either side of the splitter were calculated and compared. In each step, the splitter divided the mean attention into two segments, and a statistical test was performed on these segments for each position of the splitter. The results of these tests were then plotted, with the horizontal axis representing time. The point in time where the two mean attention values were closest was identified as the inflection point. This inflection point occurred at the desired value well within the first minute of the experiment (Figure 4).

Upon analyzing the p-values of the subjects, it was evident that the p-value remained consistently below the maximum threshold during the first 40 seconds of the videos (Figure 5). Based on the attention rate of subjects within this time frame, it can be concluded that the attention rate is lower in the first 20 seconds compared to the subsequent period. The subsequent decline in attention rate observed after the 60-second mark cannot be considered reliable for drawing conclusions due to the p-value exceeding the reliable boundaries during that time.

In conclusion, the analysis indicates that in the first 20 seconds of viewing the videos, the mean attention rate of students is lower, as highlighted by the red background color (Figure 4). An increase in attention rate is observed around the 20-second mark, indicated by a teal background color, which remains relatively consistent while the p-value stays within acceptable limits. This supports the original hypothesis that the brain reaches a higher stage of consciousness after 20 seconds have elapsed. Therefore, the following conclusion can be drawn: an unconscious state corresponds with a reduced attention rate, and when the brain transitions to a conscious state, the attention rate increases accordingly.

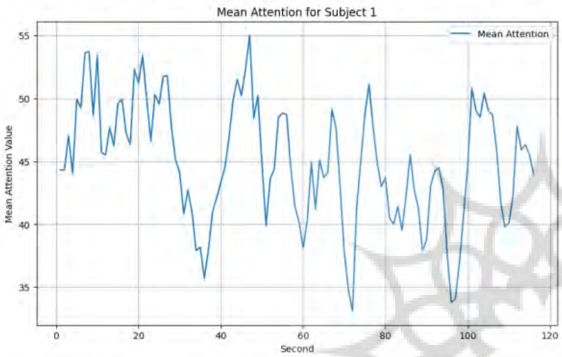

Figure. 1. Mean Attention for Subject 1 among all videos

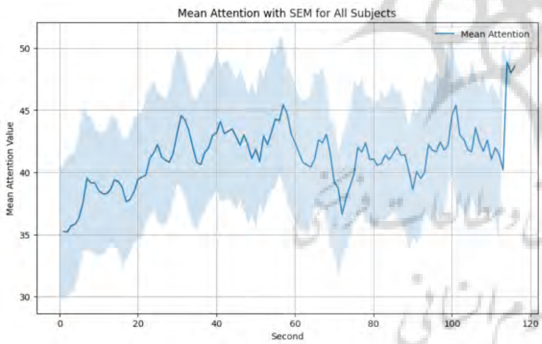

Figure. 2. Mean attention for all subjects among all videos

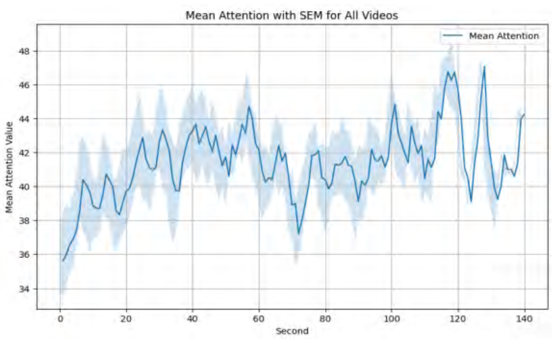

Figure. 3. Mean attention for all videos among all subjects

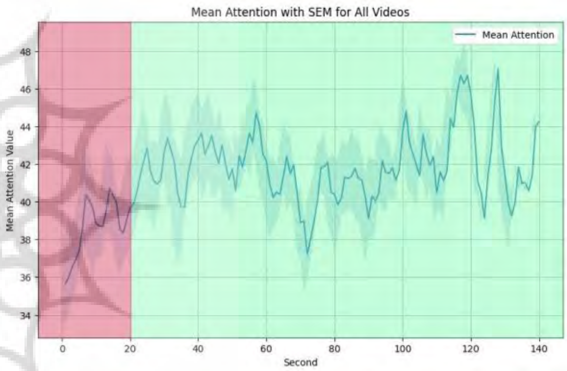

Figure. 4. Attention rate of students, divided into two sections: unconscious/preconscious mode on the left and conscious mode on the right.

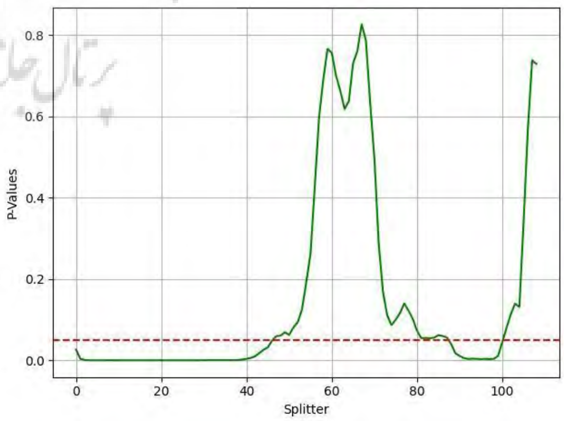

Figure. 5. The P-value of the test

4.2. Session Two

In the experiment's second session, students' cognitive performance while watching video-based LOs was measured. With a sufficient number of participants, the statistical power of the test was adequate, ensuring the reliability and validity of the findings. This robust sample size allowed for a thorough analysis of the data collected.

Data Collection and Initial Observations

The primary data collected included the participants' answers to the questions embedded within the LOs and the time taken to answer each question. This allowed for a detailed examination of both the accuracy and the response time, providing insights into the cognitive engagement of the students throughout the session.

Upon initial analysis, it became evident that participants' academic performance, measured by the accuracy of their answers, was significantly lower during the first two questions, which corresponded to the first twenty seconds of the LOs. Specifically, the average scores for these initial questions were markedly lower compared to subsequent questions, indicating a distinct pattern in cognitive performance (Figure 6)

Interpretation of Findings

These findings suggest a notable trend: similar to the attention rate metrics, academic performance is considerably diminished at the beginning of the LOs. This pattern can be interpreted as an indicator of a lower state of cognitive engagement or consciousness at the onset of the videos. The data imply that the brain requires approximately twenty seconds to transition from an unconscious or passive state to an active, conscious mode of engagement with the educational content.

Further analysis revealed that this transition is not merely a function of time but also correlates with a cognitive shift. The improved performance after the twenty-second mark suggests that students become more attentive and cognitively engaged, which enhances their ability to process and respond to the educational material effectively.

Discussion and Implications

These results have significant implications for the design of educational content and instructional strategies. Understanding that students' cognitive performance is initially low highlights the need for strategies to capture and maintain attention from the very beginning of a lesson. Educators and instructional designers might consider incorporating engaging hooks or interactive elements at the start of LOs to accelerate the transition to a conscious, attentive state.

Moreover, this pattern underscores the importance of pacing and structuring educational content in a manner that aligns with natural cognitive rhythms. By recognizing and accommodating the initial lag in cognitive engagement, educators can optimize learning outcomes and enhance overall educational effectiveness.

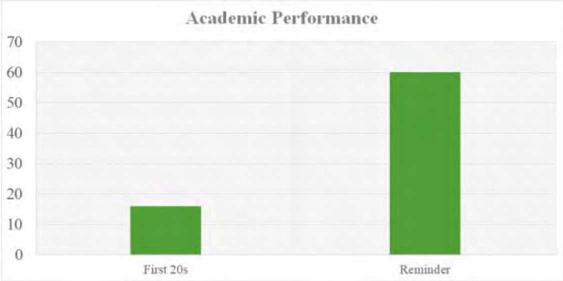

Figure. 6. The mean test results for the second session were scored out of 100. The graph clearly shows initially low scores during the first twenty seconds of the video. This initial low performance starkly contrasts with the improved scores observed in the remaining duration of the LOs.

In conclusion, the experiment's findings contribute to a growing body of evidence on cognitive engagement and performance in educational settings. By highlighting the initial dip in academic performance and the subsequent recovery, this study provides valuable insights for improving the design and delivery of educational content.

While previous research, such as [3], has provided several principles to enhance the effectiveness of instructional videos, this study presents a significant deviation. Specifically, our findings indicate that the first 20 seconds of an instructional video may not be the optimal time for conveying crucial information, as learners typically transition from an unconscious to a conscious state during this period. Therefore, unlike Mayer's suggestion to immediately engage learners, we propose that critical content should be delayed until after the initial 20 seconds to ensure better cognitive engagement and information retention. Both [12] and [13] emphasize the critical role of attention in learning, aligning with our findings while offering distinct perspectives. Wang et al. explored how instructor presence in online videos directs visual attention, improving learning outcomes and reducing cognitive load for complex topics, though at the potential cost of split attention between the instructor and content. In contrast, our study focuses on the neurocognitive aspect of attention, identifying the transition from unconscious to conscious engagement as a key factor in enhancing learning performance. The previous research underscores the importance of managing distractions to optimize learning, our research adds a novel dimension by analyzing attention shifts through neurophysiological transitions, offering a deeper understanding of how and when learners achieve optimal cognitive engagement. Together, these studies reinforce the need for instructional designs that strategically guide attention to improve learning outcomes, with our findings providing further insights into the timing and mechanisms behind these cognitive shifts.

5. Conclusion

In this research, we determined the ego state's transition point from unconscious to conscious. This transition would result in changes to the attention rate and academic performance of learners.

The results indicated a rise in participants' attention rate, as well as their academic performance (Figure 7). In the first twenty seconds of the LOs, the attention rate of subjects was insufficient for effective learning, leading to subpar academic performance (measured by the number of correct answers). Afterward, with time, both metrics were subject to a sharp rise.

The aforementioned increase in these two metrics would lead us to believe that the ego state changes from an unconscious to a conscious mode at the same transition point.

In future research, we aim to expand our study by exploring the application of this model across diverse learning domains, such as humanities and arts, to assess whether similar patterns of attention shifts occur. Additionally, conducting experiments with broader demographic groups will help validate the generalizability of our findings. To generalize the results of this research, it would be beneficial to branch out in choosing LOs, as in this phase, the learning objects were taken from STEM subjects. Also, environmental manipulation is suggested to change the EGO state transition point. Environmental factors such as lighting, noise levels, and seating arrangements can all impact learners' ability to transition to a conscious state. It must be mentioned that it won't be a straightforward solution to leave this 20-sec without any educational content because, in the long term, learners would find out they can skip this ineffective solution. Therefore, any solution should consider such a dilemma. We also envision integrating real-time adaptive learning systems that dynamically adjust content based on learners' cognitive states, potentially revolutionizing personalized e-learning environments.

Some parts of this research were completed in a home environment to obtain valid and robust results. To maintain control over the testing environment, the authors provided oral instructions outlining the ideal environment for this test.

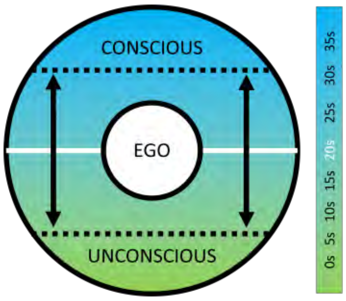

Figure. 7. EGO State Changepoint time – This study shows that it takes about 20 seconds to change the EGO state. According to the results of the subjects' performance, the score of questions in conscious mode is higher than in unconscious/preconscious mode.

Supposing this transition point to be known, researchers could conduct a study to develop a method to increase attention span and academic performance, providing a scaffolding that would speed up the change in the ego state of learners.

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Conflict of interest

The authors declare that no conflicts of interest exist.

Author Contribution

Taghiyareh, F.: Supervised the research.

Mahmoudi, M.: Designed the experiment, conducted the analysis, and interpreted the results.

Hidaji, A.: Contributed to writing the paper and assisted in the implementation of the experiment.

References

[1] A. Darvishi, H. Khosravi, S. Sadiq, and B. Weber, "Neurophysiological Measurements in Higher Education: A Systematic Literature Review," International Journal of Artificial Intelligence in Education 2021 32:2, vol. 32, no. 2, pp. 413–453, Jun. 2021, doi: 10.1007/S40593-021-00256-0.

[2] N. H. Liu, C. Y. Chiang, and H. C. Chu, "Recognizing the degree of human attention using EEG signals from mobile sensors," Sensors (Switzerland), vol. 13, no. 8, 2013, doi: 10.3390/s130810273.

[3] R. E. Mayer, L. Fiorella, and A. Stull, "Five ways to increase the effectiveness of instructional video," Educational Technology Research and Development, vol. 68, no. 3, 2020, doi: 10.1007/s11423-020-09749-6.

[4] A. Wischgoll, "Combined Training of One Cognitive and One Metacognitive Strategy Improves Academic Writing Skills," Front Psychol, vol. 7, 2016, doi: 10.3389/fpsyg.2016.00187.

[5] A. P. Silva and A. F. Frère, “Virtual environment to quantify the influence of colour stimuli on the performance of tasks requiring attention,” Biomed Eng Online, vol. 10, 2011, doi: 10.1186/1475-925X-10-74.

[6] M. Händel, S. Bedenlier, B. Kopp, M. Gläser-Zikuda, R. Kammerl, and A. Ziegler, “The webcam and student engagement in synchronous online learning: visually or verbally?,” Educ Inf Technol (Dordr), vol. 27, no. 7, 2022, doi: 10.1007/s10639-022-11050-3.

[7] D. Pinazo, L. T. García-Prieto, and R. García-Castellar, “Implementation of a program based on mindfulness for the reduction of aggressiveness in the classroom,” Revista de Psicodidactica, vol. 25, no. 1, 2020, doi: 10.1016/j.psicod.2019.08.004.

[8] M. M. McClelland, A. C. Acock, A. Piccinin, S. A. Rhea, and M. C. Stallings, “Relations between preschool attention span-persistence and age 25 educational outcomes,” Early Child Res Q, vol. 28, no. 2, 2013, doi: 10.1016/j.ecresq.2012.07.008.

[9] H. Kirk, K. Gray, K. Ellis, J. Taffe, and K. Cornish, “Impact of attention training on academic achievement, executive functioning, and behavior: A randomized controlled trial,” Am J Intellect Dev Disabil, vol. 122, no. 2, 2017, doi: 10.1352/1944-7558-122.2.97.

[10] A. Glasofer and C. Dingley, “Diagnostic and Medication Treatment Disparities in African American Children with ADHD: a Literature Review,” 2022. doi: 10.1007/s40615-021-01142-0.

[11] T. J. C. Polderman, D. I. Boomsma, M. Bartels, F. C. Verhulst, and A. C. Huizink, “A systematic review of prospective studies on attention problems and academic achievement: Review,” 2010. doi: 10.1111/j.1600-0447.2010.01568.x.

[12] J. Wang, P. Antonenko, and K. Dawson, “Does visual attention to the instructor in online video affect learning and learner perceptions? An eye-tracking analysis,” Comput Educ, vol. 146, 2020, doi: 10.1016/j.compedu.2019.103779.

[13] L. Hasenbein et al., “Learning with simulated virtual classmates: Effects of social-related configurations on students’ visual attention and learning experiences in an immersive virtual reality classroom,” Comput Human Behav, vol. 133, 2022, doi: 10.1016/j.chb.2022.107282.

[14] M. R. Cohen and J. H. R. Maunsell, “Attention improves performance primarily by reducing interneuronal correlations,” Nat Neurosci, vol. 12, no. 12, 2009, doi: 10.1038/nn.2439.

[15] F. De Masi, “The Ego and the Id: Concepts and developments,” International Journal of Psychoanalysis, vol. 104, no. 6, 2023, doi: 10.1080/00207578.2023.2277024.

[16] R. L. Carhart-Harris and K. J. Friston, “The default-mode, ego-functions and free-energy: a neurobiological account of Freudian ideas,” Brain, vol. 133, no. 4, p. 1265, 2010, doi: 10.1093/BRAIN/AWQ010.

[17] S. Leutner and O. Piedfort-Marin, “The concept of ego state: From historical background to future perspectives,” European Journal of Trauma and Dissociation, vol. 5, no. 4, 2021, doi: 10.1016/j.ejtd.2020.100184.

[18] M. Mahmoudi, A. Hidaji, and F. Taghiyareh, “Awake Ego: Finding When Brain’s State Changes from Unconscious to Conscious in Watching Video Learning Objects,” 2024 10th International Conference on Web Research, ICWR 2024, pp. 70–75, 2024, doi: 10.1109/ICWR61162.2024.10533363.

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