Attention Process and Learning: What is the Relationship?
A Psycho-Cognitive Educational Approach

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Abstract

Attention plays a crucial role in learning by enabling individuals to focus cognitive resources on relevant stimuli while filtering out distractions. This selective focus enhances cognitive efficiency, allowing for deeper processing and better retention of information. Effective attention management is essential for efficient learning, as it helps learners concentrate on important material, thereby improving comprehension and memory. Educational strategies that engage and stimulate attention, such as interactive and problem-solving approaches, can significantly enhance learning outcomes. Theoretical models, like Broadbent's filter theory, illustrate how attention operates within cognitive systems, emphasizing its critical role in managing information flow during learning tasks. Overall, attention is fundamental to the learning process, directly influencing how information is processed, stored, and recalled, making it a central focus in both educational practices and cognitive research.

Keywords: Attention; Learning; Relationship

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Introduction

Attention is considered a cognitive psychological system alongside other cognitive systems such as perception and memory. It is linked to the mental processes involved in cognitive input. For instance, activating the process of understanding during reading is difficult without stimulating attentional capacity. This highlights the importance of the attentional system in meaning production and comprehension. Therefore, cognitive efficiency is directly related to attentional capacity, where higher attention to stimuli results in achieving the desired cognitive outcomes.

Based on the above discussion, we can consider that the pedagogy of attention falls within active and effective pedagogies, which rely on interaction, activation, and problem-solving instead of solely delivering content by the teacher. It places the learner at the center of learning and acquisition, while the teacher's role is limited to providing the appropriate pedagogical context to activate attention in the learner.

Generally, in this paper, we aim to comprehensively address attention from all its aspects to understand how it operates and can be stimulated, with the hope of achieving maximum attentional efficiency and motivating the learner towards learning and acquisition. This will be done by elucidating its conceptual meanings, types, and relationship with other cognitive competencies, as well as examining the main theories that explain it and clarifying the nature of the relationship between attention and learning. However, before delving into these aspects, it is essential to explore how interest in the process of attention began, by addressing the following question: Is attention, like many other themes, a product of philosophical thought, or did its emergence result from purely psychological scientific inquiry?

1. Attention Between Philosophical Reflection and Scientific Psychological Thought

In ancient times, many philosophers and sages of the Greek and Roman eras recognized the importance of attention in relation to other mental processes. Evidence of this is found in the early conceptualizations of attention's value and its significance within the cognitive system, alongside perception and memory (Derryberry, 2010). For instance, Aristotle, in his discussions on the soul and intellect, emphasized the importance of the senses as the windows of the mind to the external world, and he highlighted the importance of attention as the mind's focus on thought. Similarly, Spencer viewed the human mind as capable of being imprinted with multiple and diverse experiences based on direct sensory interaction with the environment, where sensory attention plays a crucial role in shaping these experiences.

From the above, it is evident that although ancient philosophers showed interest in the topics of sensation and attention within the cognitive formation process, their explanations were not subjected to objective scientific methodology, as most were based on subjective opinions and inductive reasoning rooted in reflection. This continued until the publication of British psychologist Donald Broadbent's book *Perception and Communication* in 1958, which marked a modern study of attention as a purely psychological subject (Vergara et al., 2019). Broadbent considered attention as the product of a limited-capacity information-processing system. In this view, the human being, in interaction with the environment, is exposed to a large number of stimuli that exceed their limited perceptual capabilities, necessitating selective attention to some stimuli while tuning out others.

This model, therefore, focuses on the flow of information between the stimulus and response dichotomy, where information from stimuli enters the model through sensations and passes through what can be termed a short-term storage stage, responsible for holding information temporarily until it is called to the next stage. However, before this process is carried out, it passes through a "filter," whose primary function is to select and filter the information flowing to the next stage of processing.

The question then arises: did the model presented by Donald Broadbent in 1958 provide a form of cognitive satisfaction to the research community, or did it serve as the first stepping stone towards transitioning from the philosophical interpretation of attention to a purely scientific one?

In continuation of the previous discussion and response to the earlier question, it is clear that the initial interests in the subject of attention by thinkers and philosophers were characterized by reflections predominantly based on inductive reasoning and subjectivity, as seen in the interpretations of both Aristotle and Spencer. This continued until the advent of Donald Broadbent, who succeeded in establishing a cognitive psychological approach to addressing cognitive processes in general and attention in particular, paving the way for subsequent psychologists to complete the remaining aspects. So, what are the most prominent definitions that have addressed attention?

2. Definitions of attention

In this section, we will present, discuss, and analyze the most prominent definitions of the attention process, particularly those belonging to the fields of educational and cognitive psychology, as these are the frameworks guiding this work. The definitions can be explored as follows:

William James provided the first psychological definition of attention in 1890 in his book The Principles of Psychology. He described it as a clear, active, and sequential mental mobilization of topics among other possible topics or sequences, with its essence being focalization and concentration of consciousness. This involves excluding some topics to effectively and efficiently process others. Thus, attention is the vibrant acquisition of one thing among several others or chains of thoughts that may be available simultaneously (James, 1842).

Parasuraman, on the other hand, views attention as a set of brain processes that internally interact to perform motor, cognitive, or perceptual tasks. It is linked to the nature of the subject being attended to, with language serving as an attentional field that makes attention a cognitive phenomenon connecting language with perception and understanding. The attentional energy arises from language, stimulating the cognitive energy to provide perceptions of things, thereby constructing meaning (Parasuraman & Manzey, 2010).

Robert Sternberg defines attention as the ability to handle limited amounts of information selected from a vast amount of information provided by the senses or memory. He notes that when we focus our mental energies on a task, our subsequent behavior becomes fully under our conscious awareness and control, as we consciously decide which stimuli to focus on and which to ignore (Gladwin et al., 2012).

Steven J. Luck and James M. Gold agree that attention usually refers to a cognitive process among various processes of selection, concentration, and awareness. It is a cognitive competency that operates in interaction with other cognitive processes, most notably perception, memory, response, and choice (Luck & Gold, 2008).

Meanwhile, Michael Marder views attention as an irreducible and indivisible cognitive competency. In this context, it is seen as the focus of mental effort on a specific situation, the reception of one stimulus, and the exclusion of another (Marder, 2013).

In reflecting on the forms and content of the above definitions of attention, it is essential to note three key conclusions:

1. After a careful reading of the definitions, it is evident that they intersect and share many ideas, particularly the perspectives of William James, Robert Sternberg, Steven J. Luck, and James M. Gold, regarding the emphasis on explaining attentional competency from the angle of concentration and selection.

2. Most of the definitions consider the attention process as a competency that operates consciously, with the intention of selecting one stimulus over another or over other stimuli.

3. After presenting and analyzing all the definitions, the researchers conclude that attention is the focus of an individual's awareness of a stimulus that holds significance compared to other variables that confront them at the same time.

3. Theories of attention

3.1. Donald Broadbent's Filter Theory (1958)

Broadbent developed the first comprehensive theory of attention in 1958, known as the Single Channel Theory. This theory initially emerged in connection with experimental research conducted in an applied context. The primary motivation for these experiments was to analyze the practical situation of flight controllers in control towers, where they communicate simultaneously with several airplanes. Subsequently, Broadbent presented auditory questions to participants, who were required to respond based on information provided visually (Neumann, 1996).

The theory is based on the fundamental idea that information processing is limited by channel capacity. Broadbent explained that the messages transmitted through a particular nerve could differ either according to the type of nerve fiber stimulated or according to the number of nerve impulses produced (Roda & Thomas, 2006). According to Broadbent's model, these messages are processed through several parallel sensory channels. Incoming information is processed after gaining attention and passing through a selective filter into a limited-capacity channel.

In an early experiment to support this theory, Broadbent used the dichotic listening method, where participants were presented with three digits in one ear and three different digits in the other ear simultaneously. In one experimental condition, participants were asked to recall the digits presented in each ear, and in another condition, they were asked to recall the digits in the order they were presented. Broadbent predicted a recall accuracy level of 95%, based on the amount of information to be recalled, but the actual recall accuracy was lower, around 65%.

In summary, the implications of this theory suggest that the senses receive a set of information for processing, and a selective filter intervenes to decide which of this information can enter a limited-capacity channel for further processing (previous reference). Since the filter directs attention to a specific stimulus, Broadbent concluded that it is very difficult to combine two complex attention tasks into one task. Thus, the filter plays a crucial role in selecting specific information according to the given task (Rayner, 1977).

As a general comment on the contents of Broadbent's filter theory, it is true that the original idea of his theory of attention emerged in the 1950s, and its impact was not limited to just one generation of researchers; it was also crucial for developing the concept of limited capacity in information processing. Other theories were formulated that built upon Broadbent's scientific basis, which was modified and refined.

However, despite its influence, Broadbent's theory faced criticisms, notably for its lack of detail in explaining how the nervous system functions in directing attention (Driver, 2001). Additionally, it ignored cultural and social factors that could significantly impact how attention is directed. Furthermore,

the problem arises when some messages are subject to semantic analysis even without being consciously attended to. Since there is selection, what prevents unattended elements from being processed? Anne Treisman provides an answer to this question in her Attenuation Theory as follows:

3.2. Anne Treisman's attenuation theory

In relation to the previous model, Treisman proposed a modification to Broadbent's filter theory by altering the proposed attentional filter in the earlier model. She considered the filter to be flexible. In other words, while it allows the passage of attended stimuli, it also permits the passage of other unattended stimuli, but with less intensity (Sorko & Irsa, 2016). This means the filter needs to be attenuated to allow other unattended stimuli to pass through so that they are not entirely excluded.

In this model, the filter acts as an intermediary that does not disrupt the processing of other stimuli, even though it focuses on them. Some elements may not be processed, while others are processed effectively. Therefore, the process is not just about selection, but about attenuation and gradual processing of information (McAvinue et al., 2012).

Based on this, we can further understand Treisman's concept by noting that the data she provided about attention differs somewhat from filtering. This is because the cerebral executive cells must make a decision to analyze the properties of the received signal before conducting this analysis. This involves an initial screening of the information (Spence & Frings, 2020). According to Treisman, this screening initially relies on the physical characteristics of the signal, followed by a more complex filtering to judge the signal in terms of meaning and significance.

Consequently, it becomes clear that the attenuation theory is a flexible one. This is evident in the varying capacity of attention depending on the task's requirements. The processing of two different stimuli occurs in varying and parallel manners. We can conclude that this concept is based on the idea that attentional selection occurs after the initial analysis of features to distinguish between attended and unattended stimuli. The attended stimulus follows the perceptual process, whereas the unattended one does not enter this process.

Anne Treisman's contributions were crucial in transitioning from pre-selective attention to post-selective attention. However, despite this, the attenuation theory still has several shortcomings. One of the main criticisms is that Treisman did not explain how this model operates in semantic analysis, which is a critical phase for selecting the appropriate input. Additionally, like Broadbent's filter theory, Treisman's model overlooks several factors that could influence attention, such as sociocultural factors.

3.3. Daniel Kahneman's theory of effort in attention

In 1973, Daniel Kahneman published his famous book titled "*Attention and Effort*", which was the culmination of years of dedicated study on various aspects of attention, including divided attention, task interference, and the role of perception and its relationship with the process of attention (Khalil, 2022).

Daniel Kahneman argues that there is a possibility of dividing attentional effort between multiple activities. Additionally, attention shifts in a sequential and selective manner from moment to moment. However, it is important to note that most of Kahneman's psychological conclusions were reached based on what he calls "imposed attention" on individuals. In this context, the researcher asks the participants to direct their attention to elements chosen by the researcher, rather than those the participants themselves are interested in (Bruya & Tang, 2018).

Building on this, Kahneman makes a crucial distinction regarding effort, differentiating between its objective and mental dimensions. Effort as a cognitive process is objective (goal-directed), while the feeling of effort is mental. For this reason, Kahneman, in his book "Attention and Effort," describes his theory as a theory of perceptual activation, considering that perceptual processes require the expenditure of energy. In other words, Kahneman's theory posits that attention is a limited resource directed toward different tasks (Compton, 2003). Thus, the depletion of this resource ultimately leads to the depletion of mental effort. Kahneman considers attention to be an effort through the increase in metabolic activity in the brain.

Commenting on the contents of Daniel Kahneman's effort theory in attention, it is true that it attempts to encompass attention efficiency in relation to effort. Although Kahneman's ideas were the result of numerous experiments, they lack the epistemological foundations on which scientific theory is based. This is evident in the overly experimental approach he took to the subject, where participants were asked to direct their attention to separate elements chosen by him instead of other elements connected to the participants' interests. This approach contradicts how attention is directed in environmentally relevant contexts. Moreover, the concept of effort is ambiguous and insufficiently defined, as Kahneman describes the same characteristics of effort with the term "energy" in the same book, making effort difficult to understand and measure. Additionally, Kahneman's coupling of effort with attention is inaccurate and lacks distinction in the nature of each process individually.

3.4. Feature analysis theory

According to both Buskist and Gerbing, every stimulus in the environment consists of a set of basic components or elements that can be accessed. What is matched with memory models are actually the primary elements that make up the stimulus. When all the elements of the stimulus are identified, they are assembled, matched, and compared with the original stimulus present in the environment (Peng et al., 2021). To clarify the idea further, the following figure illustrates the possibility of breaking down the parts of the stimulus to allow for perception and comparison with memory:

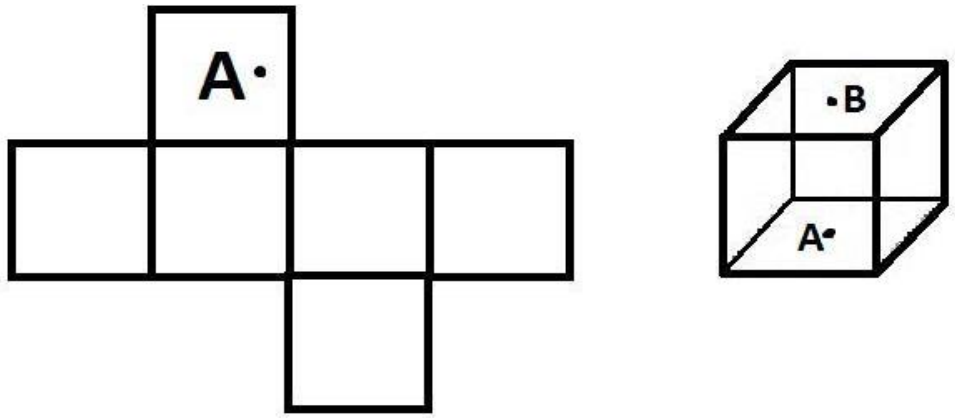

Figure. 1 Breaking down the stimulus into parts

Based on the figure displayed above, and according to the conceptualization of both Buskist and Gerbing, there are several steps to analyze the attended stimulus into basic components. The first step is to identify the stimulus received from the environment (Hove & Press, 2000). This is followed by the necessity to analyze the stimulus into its basic elements, as shown in the figure above. Next, the search for similar elements to those of the attended stimulus in memory begins. This process leads to what is called the evaluation of the search process, where the individual eventually reaches a state of matching or non-matching with the existing knowledge in memory.

It is evident from the above that this conceptualization provides an opportunity to compare the components of the stimulus in the environment rather than comparing the entire stimulus. Additionally, this theory does not require the stimulus to be in the exact orientation when matching, as what is being matched are the elements of the stimulus. Consequently, the mind can rotate and manipulate the elements until they align with the path of the attended environmental stimulus (Pozzulo et al., 2007).

Based on the above, and after presenting the contents of Buskist and Gerbing's element analysis theory, it becomes clear that this conceptualization fundamentally relies on analyzing the elements of the stimulus that capture an individual's attention in the environment. One might wonder: Can we analyze all stimuli that capture our attention and break them down into parts and elements? The answer is definitely no. This is primarily due to the nature of the stimulus that engages the attention process. For example, we might be able to break down and analyze parts of an image or geometric shape, but it becomes quite difficult when it comes to language. For instance, we cannot break down sound into parts and elements. Thus, we conclude that the epistemological basis of this theory allows it to be applied to visual stimuli, but it becomes less effective or even difficult with other types of stimuli that capture our attention.

4. Attention and learning in education

Education in the school environment primarily relies on a set of educational activities that require focused attention. For instance, when preparing for an exam, the learner must dedicate their attention to the required content. They must also focus on certain aspects while neglecting others during learning and acquisition, whether inside or outside the classroom. From this, the educational importance of attention within the school environment becomes evident, placing attention in a leading position within cognitive studies related to education, whether in terms of teaching and learning strategies or even regarding the difficulties faced by some learners, which hinder the success of the educational process (such as ADHD). Therefore, the teaching process cannot proceed without the attentive engagement of the learner (Poissant et al., 1993).

Supporting what has been mentioned, it can be acknowledged that successful and effective learning primarily relies on the success of a set of attention-related mechanisms, including attention shifting as *"The ability to deliberately shift attentional focus to specific channels, thus avoiding involuntary focusing on certain channels"* and attention focusing *"The ability to maintain attentional focus on specific channels and resist involuntary shifting to irrelevant or distracting channels"* (Ólafsson et al., 2011). All these mechanisms are indispensable in all types of learning, primarily because they enable the learner to quickly establish connections between knowledge and concepts (Kruschke, 2003).

Generally, attention leads the learner (in a normal situation) to organize their thoughts and improve the effectiveness of their performance. Moreover, attention impacts the functioning of other cognitive processes, most notably memory. This is particularly evident in its influence on the mechanism of recall, as attention stimulates memory to work and function, thereby significantly contributing to enhancing the learner's ability to learn and acquire knowledge. Additionally, it is considered an essential requirement to achieve the educational objectives of a variety of subjects and components, especially learning reading and mathematics. Speaking of the latter, we might ask: What is the relationship between learning mathematics and attentional motivation? And is the activation of the attentional process in learning mathematics a fundamental support for the teacher to implement the objectives of the educational curriculum?

4.1. Attention and learning; Example of learning mathematics by Gamification

At present, technological advancements have significantly influenced daily life, including the field of education and learning. This has led to the development of new technological tools for learning within the educational environment, aiming to renew pedagogical tools and methods and enhance the teacher's educational toolkit, allowing them to diversify, innovate, and motivate.

In line with the above, it can be confirmed that learning mathematics through the strategy of gamification enables the learner to transition from beginner understanding to deep comprehension. The reason behind this is that traditional learning methods, such as print and chalkboard, remain limited in

addressing the numerous and diverse challenges and needs of learners. These methods are non-interactive and rely on a unidimensional representation (e.g., visual modes like pictures or texts), without providing appropriate support for individuals who learn more effectively through other dimensions (e.g., sound or video). In contrast, learning through digital games and gamification strategies includes educational materials with diverse representations (text, images, video, animations, sound) and varying levels of difficulty in educational tasks to capture learners' interests and stimulate their abilities (Shin et al., 2011).

Further supporting this, it appears that the relationship between attention and learning mathematics through the strategy of gamification suggests that digital games contribute to enhancing attentional efficiency during mathematics learning. This is particularly evident in response speed and time. Moreover, learners are naturally drawn to learning through gamification applications because they stimulate the cognitive system and increase motivation, excitement, and curiosity for exploration. Additionally, they simulate real-life situations and promote critical thinking and problem-solving, which helps the learner interact and focus their attention to solve the problem (Mahmoudi et al., 2015).

Conclusion

In conclusion, after discussing the most prominent definitions that approached the concept of attention, as well as the theories explaining the process of attention, it has become evident that the latter holds a significant position in the processes of learning and acquisition, alongside memory and perception. Regarding the nature of the relationship between attention and learning in the field of education and learning, it has been shown that it is a complementary relationship. The process of learning and acquisition necessarily requires the presence of attentional competence in both aspects whether it be the focus of attention, which serves as *"The ability to maintain attentional focus on specific channels and resist involuntary shifting to irrelevant or distracting channels"* and even in terms of shifting attention, which has been defined as *"The ability to deliberately shift attentional focus to specific channels, thus avoiding involuntary focusing on certain channels"* Thus, attentional competence enables the learner to particularly engage in selection, meaning choosing the useful stimulus and ignoring the non-useful one.

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