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The effectiveness of virtual reality in improving attention

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Abstract

The purpose of this research is to investigate whether or not virtual reality (VR) makes a difference in terms of attention. Experimental findings show that following the training process, children's attention was considerably better overall. Success in many daily tasks is based on the ability to focus one's attention, although voluntary attention is not sustained for very long. According to a number of research, computer-based attention training exercises can help adults and kids pay better attention. When users engage with various media content, their level of immersion can change, leading to varying degrees of presence, particularly in a virtual reality (VR) setting. The findings indicated that user attributes including degree of immersion, and emotional valence influenced their level of presence (Kim et al., 2021). The utilization of virtual reality has been demonstrated to be a very beneficial method for enhancing the attentional capabilities of individuals.

Keywords: Virtual Reality; Attention; Immersion; Focus; Presence

1. Introduction

The term "attention" describes a person's capacity to focus and stick with a specific task. Children's attention has always been a top priority for educators and parents (Lodge and Harrison, 2019). Three main ways that attention typically impacts children's learning are (1) motivation prior to learning, (2) degree of involvement during learning, and (3) effectiveness following learning. Children's reading and math abilities are impacted by attention deficiencies, according to Grills-Taquechel et al. and Ahissar et al., preschoolers' capacity for sustained attention may serve as a predictor of their future academic success. Numerous studies have demonstrated that children's academic performance is significantly impacted by attention (Ahissar and Hochstein, 1993; Jiang and Chun, 2001; Trabasso and Bower, 1975). As previously mentioned, learning and attention are tightly intertwined, and attention is a major component influencing learning performance. Children will be more attentive and focused on their academics if attention is appropriately formed and used.

People used to believe that "attention" meant focusing on a specific task. Over time, a number of specialists have come to the conclusion that attention is a set of behaviors to complete one or more tasks rather than a single thing. The precise concept of attention has not yet been agreed upon. The primary theoretical foundation for this research is the clinical model of attention put forward by Sohlberg and Mateer. Five criteria are used by this model to categorize attention:

- The capacity to concentrate on a task and react immediately to particular visual or aural cues is known as **focused attention**. This is the most fundamental kind of attentiveness.

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- The capacity of a person to continue responding and acting in a consistent manner throughout a task is known as **sustained attention**.
- When confronted with a stimulus or distracting things, **selective attention** refers to the capacity of an individual to choose a certain object and proceed with the activity without being influenced by the distracting ones.
- The capacity to shift the focus of attention and switch between tasks is known as **alternating attention**. For instance, during class, students must alternate between paying attention to lectures and taking notes.
- The capacity to allocate suitable attention to several tasks at once is known as **divided attention**. When doing several things that must be done simultaneously, divided attention is utilized.

Finalizing this setion, we want to emphasize the value of all digital technologies in the field of education. ICTs enable universal education, provide new techniques for effective teacher training, enhance memory retention, promote cooperation, increase transparency, develop learner-centered strategies, develop new teaching techniques, and quicken learning. Additionally, through virtualization, mobilization, artificial intelligence, and new learning environments-worlds, give new instruments for knowledge representation and support educational activities and methodologies. More specifically, ICTs are very effective and productive in attention training, facilitating and improving the assessment, intervention, and educational procedures via mobile devices that bring educational activities everywhere [47] and through a variety of ICT applications that are the main supporters of education [48-51]. While games turn education into a multimodal, incredibly amiable, and enjoyable interaction, the use of AI, STEM, and ROBOTICS raises educational procedures into new levers of adaptation, creativity, and performance [52-54]. Additionally, the adoption, enhancement, and blending of ICTs with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation [55-61] brings the mental abilities to the center of the educational procedures and policies, and as a result, accelerates and improves the educational practices and outcomes, particularly in people with attention disorders like ADHD, treating domain and its practices like assessment and intervention.

2. Virtual Reality categories based on devices used

A computer interface and immersive tools create a virtual three-dimensional environment known as virtual reality (VR). Apart from offering a novel visual and aural experience, the user can engage with other users within the virtual environment (Mitsea et al., 2022b). Immersion gives people the impression that they are in a genuine environment full of possibilities for exploration and imagination. For example, Burdea and Coiffet, suggested that the three I's of virtual reality are imagination, immersion, and interactivity. Imagination means that there are countless possibilities in the virtual world, where virtual characters and objects can be created even if they do not exist in the real world. Interaction means that users can interact with the objects and avatars in the virtual environment and receive responses in real-time, and immersion means that the 3D virtual world gives users the feel of being in the real world (Papoutsi et al., 2021; Drigas et al., 2005).

VR technology, which combines sound effects and visual synthesis to create a virtual environment, is widely employed in a variety of sectors including education, tourism, medical training, and gaming. In order to feel more involved and immersed, users can also engage with the virtual world using tools like data gloves, position trackers, and head-mounted displays (HMDs). There are four categories of virtual reality based on the various devices that are used:

- The simplest and least expensive form of virtual reality is **desktop VR**, also referred to as non-immersive VR. All you need is a standard computer, the VR software, a mouse, and a keyboard to interact with the computer. Despite its potential to improve interaction, a data glove is more immersive than a joystick (Lee et al., 2010).
- **Simulator VR**, sometimes referred to as vehicle-based VR, is the first virtual reality system created specifically for simulation. With simulator VR, the user can practice flying or driving in a particular hardware environment. A pilot training system is one example of a real-life scenario that may be simulated with simulator VR's operating interface and scenery equipment (Grabowski and Jankowski, 2015).
- In **Immersion VR**, Real-time feedback stimuli can be given to the user by specialized input and output devices, such as cellphones, HMDs, and stereo sound equipment. Isolation from the outer world and complete immersion are made possible by the sensation and interaction (Wang et al., 2016).
- In **Projection VR**: A three-dimensional scene is created by projecting images onto a screen using a projector equipped with stereo sound effects. Similar to viewing a 3D film in a theater, users can experience virtual reality with 3D glasses (Muhanna, 2016). Additionally, VR can be categorized into the following three classes based on the development of object and virtual scene models:
- Geometrically based, another name for VR is **geometric virtual reality.** The virtual scene's objects can be made using 3D modeling tools, such as Maya, AutoCAD, Cinema 4D, and 3D Studio Max. The orientation of 3D objects

with varying viewing angles can be controlled by designers, and they can also add programs to these objects to set various attributes (Tarng et al., 2018; Ou et al., 2021).
- Two techniques are used to develop **image-based virtual reality** (VR) employing photosynthesis technology: The first method involves using a camera as the axis and rotating it at a predetermined angle in order to capture photographs of the surroundings. In order to create the virtual scene quickly, the photos are then combined using image processing software. This approach is frequently used to create virtual art galleries or museums. The second technique involves encircling the object with one or more cameras and shooting it from a predetermined distance around the circle. This approach works well for showcasing an object, and viewers can view it from many perspectives (Wu et al., 2021).
- In **hybrid virtual reality** (VR), which combines object-based and image-based VR, a panoramic environment is created as the virtual backdrop after several photos of an actual area are taken. To create the required interaction, the application can adjust the features of the 3D virtual objects that are added to the scene (Teo et al., 2020).

3. Reasons for applying virtual reality to enhance focus

In light of VR's significant features and the benefits of integrating it with education, this study intends to explore VR technology in attention training for the following reasons:

- **Immersion training**: Users can concentrate on attention training more readily since virtual reality (VR) can offer 3D imagery to improve immersion and block out outside distractions.
- **Creating an enjoyable learning environment**: Using virtual reality (VR) in the classroom can improve focus and decrease the rejection of learning materials. With VR, students may engage with and learn from a virtual classroom environment. Additionally, by making studying enjoyable, this innovative method might lessen the issue of inattention brought on by dull classes.
- **Multimedia fusion**: To provide a wider range of stimuli effects, virtual reality (VR) systems integrate learning content with 3D models, stereo audio, and animation.
- **Direct engagement**: Elementary school kids may simply operate virtual reality (VR) systems and focus on attention training since they offer the most direct interaction for users without the need for complex training instructions and explanations.
- **Integration of physical application**: Training shouldn't be conducted solely through spoken instruction because youngsters with attention impairments are prone to distraction. The VR system is regarded as an appropriate instrument for attention training since it offers a variety of sensory stimulation and an immersive experience.
- **Learning process recording**: The VR system has the ability to record the user's training, which not only makes analysis easier later on but also enables training difficulty to be adjusted based on user age.

Virtual reality not only enhances education in schools but also performs exceptionally well in a variety of teaching and learning tasks (Bravou et al., 2021). According to a study by Carbonell-Carrera and Saorin, pupils' spatial orientation abilities could be enhanced by a virtual learning environment made with Google Street View and VR glasses. It is clear from the literature study that virtual reality has had a big impact on education and has been used extensively (Drigas, A., Mitsea, E. and Skianis, 2022; Mitsea, E., Drigas, A. and Skianis, C. et al., 2022a). Many studies have demonstrated that using virtual reality (VR) technology into instruction can improve learning effectiveness in addition to increasing students' enthusiasm to study and extending their attention span.

4. Findings from the Survey

Many academics have digitally integrated game components with attention training as game-based learning technology advances (Lumsden et al., 2016). Action video games have been shown to significantly improve perceptual ability and focus, which has a good effect on learning effectiveness, according to studies by Green and Bavelier (2012). In order to address issues related to attention deficit hyperactivity disorder (ADHD), Lim et al., employed brain waves in conjunction with speed-based digital games. Four typical characteristics of digital attention training were proposed by Green, Li and Bavelier: (1) Unpredictability: the capacity to focus on training while paying attention to unforeseen events, (2) cooperation between perception, cognitive, and motor: players must use perception, cognitive, and motor in the training of movement types, (3) extraordinary speed: the ability to switch objects quickly during training and (4) emphasis on peripheral processing: the capacity to focus on the center of the screen while handling tasks around it.

Two VR attention-training games were created by Tarng, Pan, and Ou using Unity3D and the clinical model put forth by Sohlberg and Mateer. The virtual reality games are "Matching Shape or Color" and "Electrical Maze." Focused attention, selective attention, and alternative attention are intended for the latter, whereas sustained attention, divided attention, and selective attention are intended for the former.

It is assumed that virtual reality is immersive and interactive in terms of “focused attention”, enabling participants to concentrate on reacting to the visual and aural inputs during the training process without being distracted by external stimuli. Furthermore, the VR games force players to react to the stimuli quickly, which helps them develop focused attention and quick reflexes. VR games helped also participants improve “sustained attention” by enabling them to concentrate on the training material for extended periods of time. For instance, in order to select the right objects in the "Electrical Maze" game, players had to pay close attention and not touch the border (Tarng et al., 2018).

Additionally, the incorporating distractions into the VR games helped participants' “selective attention”. For instance, the "Matching Shape or Color" game helped players practice selective attention by allowing them to concentrate on the job of choosing the right objects when they were distracted. In terms of “alternating attention”, the VR games enabled players to alternately assign various attentional capacities. By successfully alternating the color and shape of items, players in the "Matching Shape or Color" game were able to improve their alternate attention skills. The "ElectricalMaze" game helped participants develop split attention since it taught them to manage two tasks simultaneously (clicking the target object and avoiding collision with the border). To finish the mission, players had to divide their attention between the two activities improving “divided attention” (Tarng et al., 2018; Grills- Taquechel et al., 2013).

To confirm the potential of virtual reality for improving attention in a cognitive training program, Cho et al., created a few cognitive training tasks utilizing VR technology. They verified that cognitive training may increase the attention span of kids and teenagers with behavioral issues and discovered that immersive virtual reality combined with cognitive training is an effective way to improve attention. Mei et al., suggested a method for training joint attention that makes use of a VR game and a Customizable Virtual Human (CVH). Their research provided information on how the user engaged with the CVH and how joint attention was impacted by these interactions. The findings demonstrated that the CVH reduced participants' attention to the VR game's pointless sections. The goal of a virtual reality attention training system, which is based on the definitions and theories covered above, is to enhance the conventional Attention Process Training (APT) approach, increase elementary school children' attention spans, and give them a more engaging and productive training environment (Tarng et al., 2018; Drigas, A., Mitsea, E. and Skianis, 2022).

The 10-minute VR mindfulness meditation that Asati and Miyachi contributed was particularly useful for restoring or enhancing sustained attention. It can be used by anyone to rejuvenate and restore sustained attention at their peak during a hectic day. A game score (Vaishali and Ramesh, 2018), Muse headband data, and ECG sensor data were used to assess their training. Following the training, participants' mind wandering (no one entered the active state) was considerably decreased, and their evaluation-game score rose.

With the use of a virtual reality headset, the mindfulness intervention makes mindfulness training more accessible to teenagers and shows positive effects on participants' working memory and attention. The findings indicated that the experimental and control groups significantly differed from one another in terms of working memory and divided attention (visual and auditory), while there were no differences between men and women. This suggests that the 21-day mindfulness intervention with virtual reality significantly improved the participants' performance. When used for learning, virtual reality can have positive effects on cognitive and attentional capacities by creating a stronger immersion experience and presence (Budhwani et al., 2021; Parsons et al., 2017; Blume et al., 2017). It is also a tool that enhances interventions of all kinds, particularly mindfulness (Yuan, 2021; Hillhouse et al., 2021; Miller et al., 2021). This study supports and advances our knowledge of the direct impacts of mindfulness intervention with virtual reality by confirming that adolescents' motivation is demonstrated by their adherence to process monitoring (Asati and Miyachi, 2019).

Users' propensity for immersion is a source of presence effects, and their degree of immersion is one of the most important measures for assessing presence (Witmer and Singer, 1998). As stated by Rotter and Rotter, attention after the VR tale stimulus shown a low standard deviation among users with a high degree of immersion in the media with positive valence and female users with a high level of immersion in nonverbal media. Having a high level of absorption in nonverbal media, as stated by Rotter & Rotter. It indicates that there is a high presence effect that reacts to the stimulus and heightens attention. The majority of participants were concentrating on the important objects throughout the story's conclusion. Higher attention groups have somewhat higher memory levels, according to the study. Additionally, both the female group and the group with a high level of media exposure demonstrated a high overall rate of right answers. When asked a subject that calls for more focus, the male group's percentage of right answers was comparatively higher than the other groups'. The presence effects were more pronounced in the high immersion with positive valence group, which is more inclined to engage with media content and concentrate on virtual reality (Asati and Miyachi, 2019; Lodge and Harrison, 2019).

According to De Leo et al., users' sensation of presence can be enhanced by prior exposure to and knowledge of VR content. De Leo et al. claim that high presence effects are caused by a greater propensity for immersion, which is a crucial element of creating presence. According to De Leo et al.'s findings, individuals in the low immersion group may feel more present if they are exposed to more VR content, which probably includes the presence effects we looked at. Every user characteristics category has a distinct propensity for immersion, according to the study. Examples of this include the location of a group user's gaze or the degree to which a user concentrates on the scene's key objects as the tension in the narrative increases. Scene planning and arrangement are finished beforehand in linear media creation and editing (Mitsea et al., 2023b; Kim et al., 2021).

5. Conclusion

Following the training, the experimental groups made notable progress, according to the data. The statistical analysis's findings showed that VR training significantly increased participants' attention spans. It is assumed that participants were able to concentrate on their training without being distracted by outside factors because to the immersive quality of virtual reality, which improved their performance.

Because VR training enabled participants to concentrate on a particular task for an extended period of time, the experimental group outperformed the control group in the majority of attention training tasks, particularly sustained attention. Cho et al., obtained this because VR training can help children and adolescents with behavioral issues pay attention for longer periods of time. This is a key component of school learning is sustained attention. Children who are able to focus on their studies without being sidetracked by external factors are more likely to perform better academically. The experimental findings demonstrate that the VR training method is more successful than the computerized APT and that attention may be enhanced with appropriate training. In order to improve their pupils' learning effectiveness, teachers can conduct attention training by letting them play virtual reality games.

The development of VR systems is also impacted by creating VR experiences that are tailored to the unique characteristics of various user groups. One may, for instance, design an adaptive plot that shifts its course according to the traits of the user and how they react to the material. Machine learning using pre-trained models for various user groups is a good method for this. However, before fully customized virtual reality immersion can be achieved, more investigation and testing are required. To develop techniques for "training" users' immersion skills and creating VR experiences that can automatically adjust to each user's current immersion level (e.g., different levels of realism, different interaction modalities, social presence, and so forth), it is crucial, for example, to look into the underlying reasons why users in the low immersion groups are less inclined to immersion. Last but not least, new techniques for encouraging immersion that take into consideration the user's context, user characteristics, and desired presence effects can be designed as VR devices become more cognizant of the user's context (e.g., environment geometry, eye tracking, facial expressions, physiological data).

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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