Individuals with Attention-Deficit Hyperactivity Disorder in a Multimedia Learning Environment

Werona Król-Gierat

Pedagogical University of Cracow

werona@krol-gierat.pl

Abstract

The paper is aimed at investigating the functioning of individuals with Attention-Deficit Hyperactivity Disorder (ADHD) in a multimedia learning environment. The first part defines the disorder, focusing on brain processes of ADHD individuals. The second part discusses key theories connected with multimedia learning. Finally, the last part is an attempt to observe how ADHD learners learn from words and pictures.

Key words: Attention-Deficit Hyperactivity Disorder (ADHD),Cognitive Load Theory (CLT), Multimedia Learning, Special Educational Needs (SPE), brain research

1 Introduction

Our understanding of the Attention-Deficit Hyperactivity Disorders (ADHD) has changed for some decades. Much is known thanks to brain research, though operational and cognitive processes occurring in individuals suffering from disorder are still to be thoroughly studied. ADHD becomes evident in early age and thus poses a challenge for teacher working with such pupils. The following paper aims at investigating the functioning of individuals with Attention-Deficit Hyperactivity Disorder (ADHD) in a multimedia learning environment, since this medium is inevitable in modern education.

2 Attention-Deficit Hyperactivity Disorder

2.1 What is ADHD?

In her article, Sadat Sajadi (2012: 1), presents the development of ADHD teminology. Since 1940s, different interpretations have been introduced with respect of ADHD: Postencephalitic Behavior Disorder (PBD), Brain Damage Syndrome (BDS), Minimal Brain Dysfunction (MBD), Hyperkinetic Reaction of Childhood (HRC), Attention Deficit Disorder (ADD) and finally Attention-Deficit Hyperactivity Disorder (ADHD).

Today, Attention-Deficit Hyperactivity Disorder (ADHD) is understood as a syndrome that interferes with an individual's different spheres. Sousa (2007: 49) distinguishes three of them, namely:

- ability to focus (inattention),
- regulate activity level (hyperactivity),
- inhibit behaviour (impulsivity).

In the *Diagnostic and Statistical Manual of Mental Disorders IV* (DSM T-R; American Psychiatric Association, 2000) symptoms of ADHD are group according to inattention, hyperactivity and impulsivity (see Table 1. below).

Table 1. ***Symptoms of ADHD*** **(adapted from DSM T-R; American Psychiatric Association, 2000)**

INATTENTION	- often fails to give close attention to details or makes careless mistakes in schoolwork, work or other activities; - often has difficulty sustaining attention in tasks or play activities; - often does not seem to listen when spoken directly; - often does not follow through on instructions and fail to finish schoolwork, chores, or duties in the workplace (not due to oppositional behaviour or failure to understand instructions) - often has difficulty organising tasks and activities; - often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework); - often loses things necessary for tasks or activities (e.g. toys, school assignments, pencils, books, or tools); - is often easily distracted by extraneous stimuli; - is often forgetful in daily activities
HYPERACTIVITY	- often fidgets with hand or feet or squirm in seat; - often leaves seat in classroom or in other situations in which remaining seated is expected; - often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness); - often has difficulty playing or engaging in leisure activities quietly; - is often "on the go" or often acts as if "driven by motor"; - often talks excessively
IMPULSIVITY	- often blurts out answers before questions have been completed' - often has difficulty awaiting turn; - often interrupts or intrudes on others (e.g. butts into conversations or games)

As parents, teachers, clinicians and other specialists may observe, many children at some point manifest symptoms of the above enumerated hyperactivity, impulsivity and inattention. The difference is that there are children in whom six or more of such primary indicators persist for at least six months in at least two different environments (e.g. at school and at home), becoming the rule rather than exception. Hannell (2006: 93-98) notes that pupils with ADHD are often physically restless, finding it hard to remain still in every context. They can be impatient, excitable, easily distractible and poorly organized. All these characteristics may affect their daily lives and lead to learning and socialisation difficulties. For example, ADHD frequently co-occurs with Specific Learning Difficulties (SpLDs) such as dyslexia and dyscalculia, 8-39% and 12-30%, respectively, depending on the system of diagnosis (Frick *et al.*, 1991 in Kormos and Smith, 2012: 51).

People do not grow out of this disorder. Contrary to common belief, the severity of difficulties connected with ADHD may only decline with age. The exact causes of ADHD are unknown, but scientific evidence shows that this is a neurological condition which appears to lie in brain structure and functioning. There is also a strong genetic link for many individuals with ADHD. Research evidence shows that there is a 57% chance that a parent with ADHD will have a child with the same disorder (Biederman *et. al.*, 1995 in Kormos and Smith, 2012: 51) and that the co-occurrence of AHDA is 81% among monozygotic twins (Kormos and Smith, 2012: 51).

2.2 Brain research in ADHD

Virtually every human activity requires the brain's functioning. Analogically, most learning entails the brain's attention. Brain reaserch systematically solves old riddles and reveals new complexities, which is of great value for educators. Thanks to neuroscientists, teachers can turn the latest developments into classroom practice.

Gazzaniga, Ivry and Mangun (2002 in Sousa, 2007: 48) explain that attention is often driven by emotions. This activity occurs firstly in the limbic area of the brain and requires the coordinated effort of three natural networks presented in Figure 1. below:

1) altering,
2) orienting,
3) executive control.

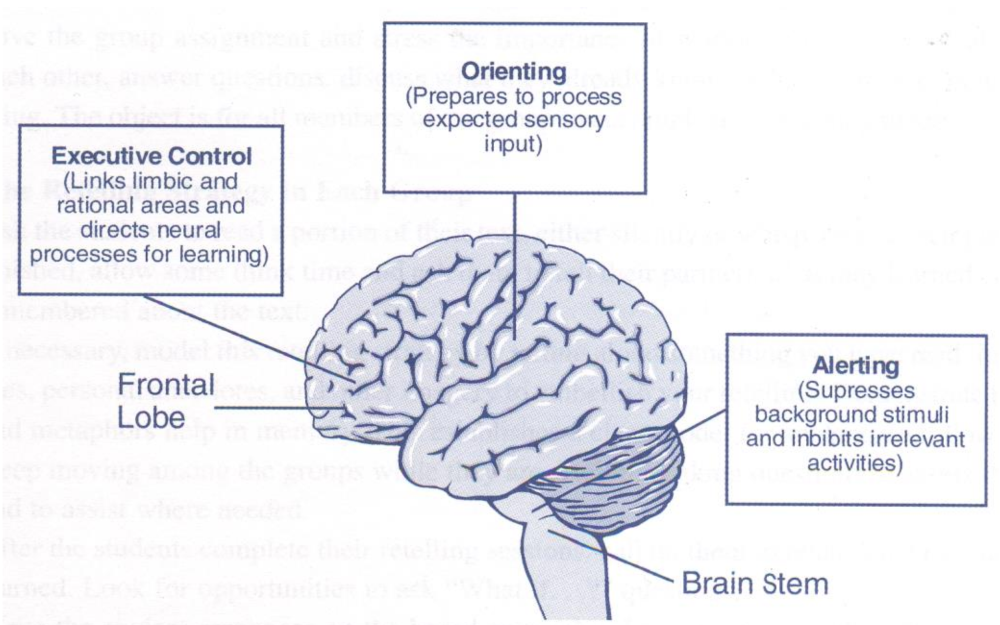

Figure 1. Attention for learning required the coordination of three neural networks (Sousa 2007: 48)

Alerting occurs first in the brain stem. Its role is to supress background stimuli and inhibit irrelevant activities. Orienting prepares to process expected sensory input in the central cortex and limbic areas. Executive control links limbic with rational areas of the cerebrum, directing neural processes for learning. Executive control decides how to respond to the specific input. Note that problems can arise anywhere within these systems.

Let me explain the process on an example. Say you are in a café chatting blithely with a friend. Suddenly you hear a strange noise coming from the back rooms of the café. The altering system detects the sounds, interrupts your talk and inhibits the processing of your friend's words. In the meantime, the orienting system determines the direction of the noise, turns your heard to locate the source and immediately processes the sound information. The decision what to do next is up to the executive control. If a waitress comes out from the kitchen with a tray full of broken chipping glasses, your frontal lobe tells you to continue your conversation. Yet, if an armed bandit shows himself, the executive, limbic and other brain areas work together as if to give you a signal to escape.

Magnetic Resonance Imagining (MRI) indicates that the frontal and temporal lobes on both sides of ADHD brains, as compared with non-ADHD subjects, are significantly reduced in size. The lined area in Figure 2. shows the parts of the two lobes which control behaviour and contain components of the attention systems (Sowell *et al.*, 2003 in Sousa, 2007: 52).

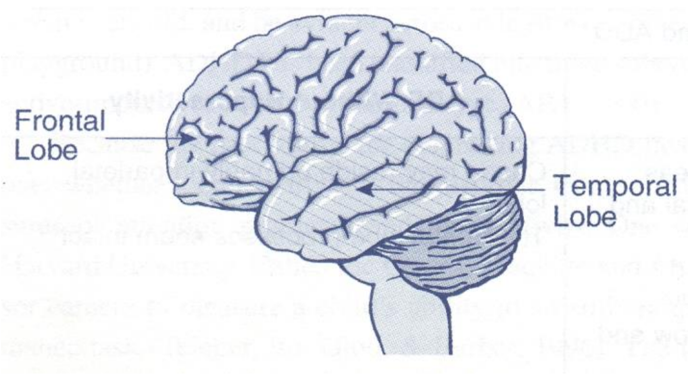

Figure 2. Parts of the frontal and temporal lobes on both sides of the brain that are smaller in children with ADHD (Sousa 2007: 52**)**

Moreover, neuroimaging shows that the caudate nucleus and the globus palladius, two structures in the limbic area, as well as the vermis, a structure in the cerebellum, are also smaller in ADHD adults than in non-ADHD persons (see Figure 2.). The first two are thought to be involved in the dopamine network, which is a neurotransmitter helping to control attention and coordinate movement. The vermis appear to contribute to smooth motor coordination. Imbalance in this structure may lead to hyperactive and impulsive behaviours (Sousa 2007: 52).

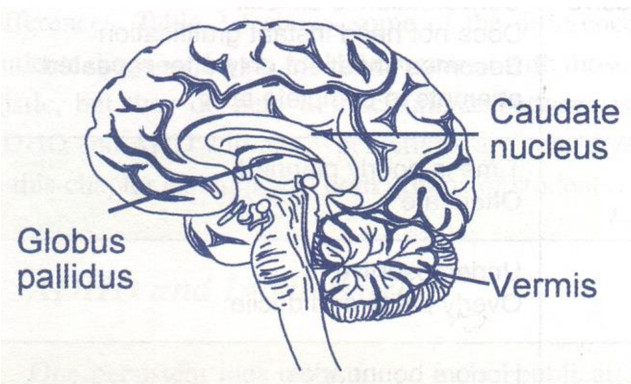

Figure 3. The globus pallidus, the caudate nucleus and the vermis are smaller in adults with ADHD (Sousa 2007: 52)

MRI scans also reveal that ADHD brains have significantly smaller total volumes than the ones of the control group without this disorder (Castellanos *et al.*, 2002 in Sousa, 2007: 52). Besides, several MRI studies have shown that ADHD brains function differently when performing the same tasks as non-ADHD ones. Different brain areas are activated (Bush *et al.*, 1999 in Sousa, 2007: 52).

3 ADHD in a Multimedia Learning Environment

3.1 Multimedia Learning

Mayer and Moreno (2003: 43) define multimedia learning as learning from words and pictures. Words can be printed (e.g. captions) or spoken (e.g. narration), whereas pictures can be static (flash cards) or dynamic (e.g. video cartoon). The researchers highlight that meaningful learning requires that the learner engages in substantial cognitive processes. At the same time, they claim that the learner's capacity for cognitive processing is limited. Instructional designers have come to recognise the need for multimedia instruction that is sensitive to cognitive load (Clark, 1999; Sweller, 1999; van Merrienboer, 1997 in Mayer and Moreno, 2003: 43). Cognitive (over)load (described in section 3.2) is when the learner's intended cognitive processing exceed his/her available cognitive capacity (Mayer and Moreno, 2003: 43)

Cognitive Theory of Multimedia Learning encompasses several principles of learning with multimedia. According to one of them - the Modality Principle – "the learner possesses a visual information processing system and a verbal information processing, such that auditory narration goes into the verbal system whereas animation into the visual system" (Mayer and Moreno, 1998). One might expect that these competing sources of information would tend to overwhelm or overload the learner. However, psychological research has shown that verbal information is in fact better remembered when accompanied by a visual image. Mayer's research (Mayer, 2003 in Wang and Shen, 2007) on the theory indicates that individuals have a limited capacity to attend to and process incoming information through a single sense modality, e.g. auditory. This means that only a certain amount of information can be heard, understood, and processed by a learner at a given time. However, if a second channel, e.g. visual, simultaneously conveys additional information, the capacity for processing can be expanded to some degree.

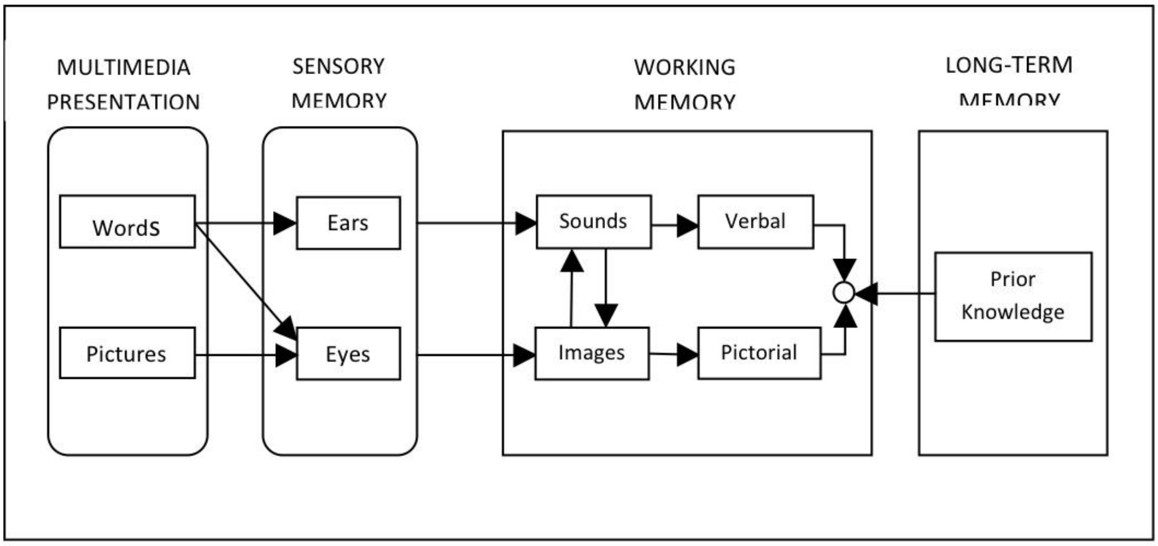

Figure 5. Visual Representation of the Cognitive Theory of Multimedia Learning (Mayer and Richard, 2001)

Drawing conclusions from the Modality Principle, video, for instance, appears to be a perfect instructional medium, providing a dual-mode presentation by the use of both visual and aural input. In simpler words, because there are two channels for taking in the new material, the work is divided between the learner's eyes and ears.

In video, for example, spoken words and corresponding pictures are presented simultaneously. A concept presented as an image finds its verbal label, and vice versa. In this way, properly arranged and implemented video facilitates learning (Wang and Shen, 2007).

Another theory which is worth-mentioning is the Dual Coding Theory (DCT), according to which human cognition involves an intricate interplay between two distinct subsystems, namely the verbal and the nonverbal (imaginal). The verbal system deals directly with language, while the imaginal one is specialized in nonlinguistic objects and events. The systems are composed, respectively, of internal representational units, called logogens, denoting the mental representations of language information, and imagens, denoting the mental representations of visual information. These units are activated when a person recognizes, manipulates, or just thinks about words or concepts (Paivio, 2006).

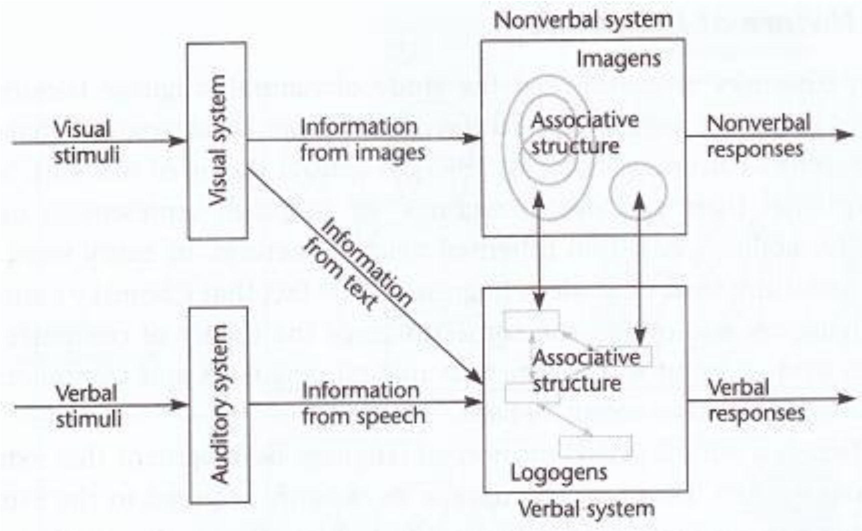

Figure 5. The architecture of Paivio's Dual-Coding Theory (Ware, 2000)

These systems are independent, yet representation in one can activate those in the other. Visual traces are better remembered than verbal components. However, items are remembered best when encoded dually. As a result, in the case of foreign language acquisition, "the more words and expressions are learned in direct association with appropriate nonverbal referents, the richer and more meaningful are the referential interconnections, thus resulting in better language recall and appropriate use" (Wang and Shen, 2007: 9). Summing up, the fundamental principle of DCT is that recall and recognition are enhanced by presenting information in both visual and verbal form (Kearsley, 2001 in Binhack, 2002).

To conclude, three assumptions about how the human brain works in multimedia learning can me made:

1) dual channel – human possesses separate information processing channels for verbal and visual material;
2) limited capacity - there is only a limited amount of processing capacity available in the verbal and visual channels;
3) active processing - learning requires substantial cognitive processing in the verbal and visual channels (Mayer and Moreno, 2003: 44).

3.2 Cognitive Load Theory

Chandler and Sweller's (1991 and 1999, in Mayer and Moreno, 2003: 44) central assumption is that each channel in the human information-processing system has limited capacity. Only a certain amout of cognitive processing can take place in the verbal and the visual channels. As already stated is section 3.1, learning in the multimedia context requires substantial cognitive demands, of which Mayer and Moreno (2003: 45) distinguish:

1) essential processing - aimed at making sense of the presented material including selecting, organizing, and integrating words and selecting, organizing, and integrating images;
2) incidental processing - aimed at nonessential aspects of the presented material;
3) representational holding - aimed at holding verbal or visual representations in working memory.

Cognitive overload occurs when the total intended processing exceeds the learner's cognitive capacity (Mayer and Moreno 2003: 45). Sweller's (1988, 1989, 1994) Cognitive Load Theory suggests that some instructional techniques may assume a processing capacity greater than a person's limits and thus are likely to be defective. From Sweller's papers we learn that humans' working memory and long term memories are limited. Since learning requires processing information from the working to the long term memory, it may prove ineffective if the resources of the working memory are overloaded. "Learning occurs when the learner perceives and selects relevant information, organizes it into a coherent mental representation, and builds referential connections between individual pieces of information and integrates it with prior knowledge" (Brünken, Steinbacher, Plass and Leutner, 2002: 110; after Mayer, 1997; Schnotz and Bannert, 1999; Schnotz, Böckheler and Grzondziel, 1999; Wittrock, 1990). These processes take place in the working memory. If the new information is to be remembered, it has to pass to the long term memory.

3.3 ADHD Learners and Multimedia

Contrary to common belief, some learners may have increased difficulty with multimedia, especially when it is visually demending (Lewis and Brown, 2012a: 2). This fact is taken for granted when it comes to visually- or hearing-impaired individuals, but tends to be ignored or unnoticed in other special cases. Although several studies have established, for example, the impacts of computer technology on some Special Educational Needs such as Autism, Dyslexia, or Down Syndrome (Khan, 2010; Doyle and Sanchez, 2010; Tan and Cheung, 2008; Gross and Voegeli, 2007; Alty *et al*, 2006), ADHD has not been much studied.

ADHD learners have a decreased ability to process visuospatial information (Lewis and Brown, 2012a: 2; after Alderson, Rapport, Hudec, Sarver and Kolfler, 2010; Sowerby, Seal and Tripp, 2011). They may experience a disruption in information processing, which affects their ability to accomplish instructional objectives (Brown, 2009 in Lewis and Brown, 2012a:2). Brown and Lewis (2012b: 4645; after Alderson, Rapport, Hudec, Sarver and Kofler, 2010; Sowerby, Seal and Tripp, 2011) explain that the symptoms of impulsivity and hyperactivity seem to effect the phonological and the visuospatial subsystems within the working memory of individuals with ADHD. Because of their memory deficits, learners with Attention-Deficit Hyperactivity Disorder may process multimedia instruction differently.

The same symptoms, namely impulsivity and hyperactivity, contribute to ADHD learners' susceptibility to dictraction by extraneus stimuli. It becomes most evident when teachers observe their pupils' inability to stay concentrated for a longer period of time. This is because ADHD individuals are not able to narrow their attention to a specific spatial region or to locate targeted stimuli within high density displays (Shalev and Tsal, 2003 in Brown and Lewis, 2012b: 4645).

However, there is evidence that multimedia can sometimes be effective with ADHD learners. Quantitative electroencephalographical EEG studies confirm that ADHD children differ from typically developing children on the basis of theta wave activity (Robert, Adam and Stuart, 2003; Adam, Robert, Rory, Ching, *et al*, 2007; Megan, Adam, Robert, Rory and Mark, 2007). In their research, Lee and An (2011) evaluated qualitatively the therapeutic efficacy of a multimedia intervention programme applied to four ADHD children, aged 10-12, to improve their cognitive awareness. The programme consisted of 3 levels in which children carried out several tasks for focusing attention, sustaining attention and selective attention. It was made of 20-minutes long sessions and lasted 24 weeks. All 13 sessions were recorded by electroencephalographical (EEG) electrodes capped in the children's prefrontal lobes. Lee and Ann chose theta wave as an evaluation measure for therapeutic improvement. After finishing the program, the overall spectral density of theta wave was decreased as compared with before-procedure. According to literature, ADHD children have higher theta wave activity than children without the disorder. The results obtained by Lee and An confirmed that the proposed multimedia intervention program could be effective because the theta wave activity was lower after the intervention.

Just to give one more example, Lewis and Brown' s study (2012a) showed that subtitles appear to cause non-ADHD learners to experience a cognitive overload as they process animation and text which splits the attention, whereas quit the opposite was noted with the ADHD participants. The researchers conclude that perhaps the use of subtitles provided additional support to these learners resulting in a higher score. Contrary to Mayer and Moreno's findings (2002 in Lewis and Brown, 2012a), ADHD individuals performed better with redundant visual information. According to Chandler and Sweller's redundancy effect (in Lewis and Brown, 2012: 3), duplicate or redundant information provided during instruction may induce an unnecessary extraneous cognitive load upon the learner. As can be seen from the Lewis and Brown's study, the redundancy effect may not have the same impact on ADHD learners. There is conflicting evidence from theoretical literature and empirical research conducted.

4 Conclusion

Overall, cognitive load coming from multimedia, combined with external distractors and the school demand to retain different information at the same time may lead to learners with ADHD's slower responses and lower accuracy performance. On the other hand, some empirical studies show that, if properly conducted, individuals with ADHD's learning in a multimedia environment may prove to be effective. The only aspect we can be sure of, thanks to neuroscience, is that ADHD brains and their functioning is different from typically developing ones. This fact is not be undervalued, since it surely has a great influence on learning processes.

References

American Psychiatric Association. 2000. Diagnostic and Statistical Manual of Mental Disorders (4^{th} ed. revised). Washington, DC: Author.

Binhack, A. M. 2002. "Maximizing the Strengths of the Verbal and Visual Mediums in Information Graphics." In http://www.annebinhack.com/Info%20Graphics.pdf [28.12.2009].

Brünken R., Steinbacher S., Plass J. L., Leutner D. 2002. "Assessment of Cognitive Load in Multimedia Learning Using Dual-Task Methodology." Experimental Psychology 49(2)/2002: 109-119. Hogrefe & Huber Publishers.

Hannell G. 2007. Identifying Children with Special Needs. Checklists and Action Plans for Teachers. Thousand Oaks, CA: Corwin Press, A SAGE Publications Company.

Kormos J., Smith A. M. 2012. Teaching Languages to Students with Specific Learning Differences. Bristol, Buffalo, Toronto: Multilingual Matters.

Lewis D., Brown V. 2012a. "Multimedia and ADHD Learners: Are Subtitles Beneficial or Detrimental?" (paper presented at the annual meeting of the AECT International Convention, The Galt House, Louisville, 2012) In http://www.davidlewisphd.com/publications/2012-AECT-LewisBrown.pdf [13.12.2013].

Lewis D., Brown, V. 2012b "Individuals with ADHD and the Cognitive Processing of Multimedia." In Proceedings of Society for Information Technology & Teacher Education International Conference, by Paul Resta. Chesapeake, VA: AACE, 4645-4649.

Mayer R. E., Moreno R. 2003 "Nine Ways to Reduce Cognitive Load in Multimedia Learning." Educational Psychologist 38(1)/2003: 43-52. Lawrence Erlbaum Associates Inc.

Mayer R. E., Richard E. 2001. Multimedia Learning. New York: Cambridge University Press.

Mayer R. E., Moreno R. 1998. "A Cognitive Theory of Multimedia Learning: Implications for Design Principles." In http://www.unm.edu/~moreno/PDFS/chi.pdf [28.12.2009].

Megan J., Adam R., Robert J., Rory M., Mark S. 2007. "EEG abnormalities in adolescent males with AD/HD." Clinical Neurophysiology 118(2)/2007: 363-371.

Lee S. H., Ann J. 2011. "Quantitative EEG Evaluation of Multimedia Intervention Program for ADHD Children." (proceedings of the 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies) In http://delivery.acm.org/10.1145/2100000/2093714/a16-lee.pdf?ip=83.29.188.110&id=2093714&acc=PPV&key=C255C604BE916AEE830137BFA98E7C38&CFID=388594240&CFTOKEN=61093206&__acm__=1386941820_244a16f44b771c81b75a61e12bf11195 [13.12.2013].

Paivio A. 2006. "Dual Coding Theory and Education." (draft chapter for the conference on Pathways to Literacy Achievement for High Poverty Children, The University of Michigan School Education. Retrieved) In http://www.umich.edu/~rdytolrn/pathwaysconference/presentations/paivio.pdf [28.12.2009].

Robert J., Adam R., Stuart J. 2003. "A Review of Electrophysiology in Attention-Deficit/Hyperactivity Disorder: I. Qualitative and Quantitative Electroencephalography." Clinical Neurophysiology 114/2003: 171-83.

Adam R. C, Robert J. B., Rory M., Mark S., Stuart J.J., Ching I. H., et al. 2007. "Coherence in children with attention-deficit/hyperactivity disorder and excess beta activity in their EEG." Clinical Neurophysiology 118/2007: 1472-1479.

Sadat Sajadi S. 2012. "Development of a Pedagogy Framework in Social Network-based Learning: Support for Special Educational Needs." The International Conference on E-learning in the Workplace 2012. New York.

Sousa D. A. 2007. How the Special Brain Learns. Thousand Oaks, CA: Corwin Press, A SAGE Publications Company.

Sweller J. 1994. "Cognitive Load Theory, Learning Difficulty, and Instructional Design." Learning and Instruction 4/1994: 295-312, Elsevier Science Ltd.

Sweller J. 1988. "Cognitive Load During Problem Solving: Effects on Learning." *Cognitive Science* 12/1988: 257-285.

Sweller, J. 1989. “Cognitive Technology: Some Procedures for Facilitating Learning and Problem Solving in Mathematics and Science.” Journal of Educational Psychology 1989/81: 457-466.

Wang,Y., Shen C. 2007. “Tentative model of integrating authentic captioned video to facilitate ESL learning.” Sino-US English Teaching 4(9)/2007.

Ware C. 2000. Information visualization: Perception for design. San Diego, CA: Academic Press.