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Eye-Tracking in the Diagnosis, Therapy and Education of Children with Multiple Disability: An Outline of Issues

Eye-tracking w diagnozie, terapii i edukacji dzieci z niepełnosprawnością sprzężoną. Zarys problematyki

KEYWORDS

child with multiple disabilities, non-speaking child, augmentative and alternative communication, eye-tracking, psycho-pedagogical diagnosis

ABSTRACT

The aim of the article is to present the possibility of using eye-tracking in the education of non-speaking children with multiple disabilities. The author uses the analysis of the existing data from the perspective of her own therapeutic experience in the use of eye-tracking in work with preschool children with multiple disabilities. In the text, she first presents the principle of eye-tracking, and then she shows its use in marketing, cartography, IT, as well as learning techniques. She indicates eye-tracking as a potential tool for communication with non-speaking children and for their education. In the following part, she presents Polish devices that use eye-tracking technology in diagnostic, therapeutic and educational activities. The research shows that eye-tracking can change the lives of children for whom the only communication channel is sight, because it offers them new forms of spending free time, learning and communicating with the environment. In addition, eye-tracking technology can and must be used to re-diagnose children with multiple disabilities in whom psychological and pedagogical counselling centres – using traditional testing techniques – have recognised profound intellectual disability.

SŁOWA KLUCZOWE

dziecko ze sprzężoną niepełnosprawnością, dziecko niemówiące, alternatywne i wspomagające metody komunikacji, eye-tracking, diagnoza psychologiczno-pedagogiczna

ABSTRAKT

Celem artykułu jest przedstawienie możliwości wykorzystania eye-trackingu w szeroko pojmowanej edukacji dziecka niemówiącego ze sprzężoną niepełnosprawnością. Autorka posłużyła się analizą danych zastanych dokonaną z perspektywy własnego doświadczenia terapeutycznego w stosowaniu eye-trackingu w pracy z dziećmi w wieku przedszkolnym z niepełnosprawnością sprzężoną. W tekście przedstawiła najpierw zasadę działania eye-trackingu, a następnie ukazała jego wykorzystanie w badaniach z zakresu marketingu, kartografii, informatyki, jak również technik uczenia się. Następnie wskazała na eye-tracking jako potencjalne narzędzie do komunikacji z dziećmi niemówiącymi oraz do ich edukacji. W dalszej części zaprezentowała polskie urządzenia wykorzystujące technologię eye-trackingu w działaniach diagnostycznych, terapeutycznych i edukacyjnych. Z badań wynika, iż eye-tracking może odmienić życie dzieci, dla których jedynym kanałem komunikacyjnym jest wzrok, ponieważ oferuje im nowe formy spędzania wolnego czasu, uczenia się i komunikowania z otoczeniem. Ponadto technologię eye-trackingową można i trzeba wykorzystać do ponownej diagnozy dzieci ze sprzężoną niepełnosprawnością, u których poradnie psychologiczno-pedagogiczne posługujące się tradycyjnymi metodami rozpoznały głęboki stopień niepełnosprawności intelektualnej.

Introduction

A preschool child with multiple disabilities (physical and intellectual disabilities) experiences specific developmental problems. If it is a child affected by cerebral palsy, a genetic defect, neurodegenerative diseases, or if he/she suffered a cranio-cerebral injury, he/she is often unable to communicate with the environment by speaking, due to damaged central and/or peripheral nervous system. In such a situation, neither them nor their parents can satisfy the basic need to build relationships and effectively communicate with others.

Unfortunately, specialists often deny a cognitive competence of children with a disability, deprive them of the right to decide about themselves, and condemn them to incapacitation, which usually results from the lack of reliable pedagogical and psychological diagnosis of their condition. Meanwhile, a situation in which a child cannot experience that his/her behaviour influences their living environment – that they are efficient, leads to a disruption in their personality development: a disorder of the sense of identity and self-esteem (Smyczek et al. 2006: 15-18).

In this situation, the question arises whether a child for whom vision is the only communication channel can be given education adequate to his needs and possibilities.

Are there any technologies: methods and techniques, tools and software, that would support the development of a non-speaking child who has complex communication needs, but who can only point and choose with his/her eyes? This way of supporting a child has a history of several decades and is referred to as augmentative and alternative communication (AAC) (von Tetzchner, Martinsen 2002: 46-48; Vessoyan et al. 2018: 230).

The purpose of this article is to outline the perspective of diagnosis, therapy and education of a non-speaking child with multiple disabilities when we use the latest eye-tracking technology that is able to change a child's life in terms of spending free time, learning and communicating with the environment. In my research, I used the analysis of the existing data ordered from the perspective of my own therapeutic work, in which I use eye-tracking technology in the education of preschool children with multiple disabilities.

The way eye-tracking works

The word "oculography" (eye-tracking, French: *l'oculométrie*, German: *Okulographie*) comes from the Latin word *oculus,* which means "eye." It is most commonly assumed that oculography is a system for measuring, recording and analysing data on the position and movement of eyeballs (Kunka, Kostek 2009: 105). It is a technology that allows you to track points on the computer screen that you are watching at a given moment, thanks to visual interaction with the computer using a specially designed camera. The camera detects the position of the eyeballs (the location of the corneal reflection), which are illuminated by infrared light. Therefore, the eye-tracking process takes place in two stages and consists of: recording eye movement and presenting data and results using software (Chrobot 2014). The effect of applying eye-tracking technology are heatmaps, which determine the concentration of visual attention on individual elements, scan paths and gaze plots showing the order and time of viewing particular elements or areas of interest.

Oculography has been known and used in scientific research for over a hundred years (Stolińska, Andrzejewska 2017: 260). At the beginning, the mechanical contact between the measuring apparatus and the cornea was used. Attempts were made to use special mirrors to observe the movement of the eye (optokinetography) or to use a special stylus attached mechanically to the eyeball (often using anaesthetic opiates during the attachment of the stylus). Pioneering attempts in measuring were imprecise, invasive and painful because a direct mechanical connection of the metal wire to the cornea of the eye was necessary (Carr 2013: 167).

A team of Krakow researchers dealing with eye-tracking in pedagogical research underlines the importance of 1879, when Professor Louis É. Javal from the Sorbonne University in Paris observed that, while reading, eyes do not move smoothly over words, but make small leaps – so-called saccadic movements (Javal 1879; Błasiak et al. 2015: 176). Since then, it is obvious that the eye performs two types of movement: fixation and saccades, and it is this property of eyeball functioning that is used in eye-tracking studies (Duchowski 2007). Fixations (eyesight focus) and saccades (eyesight transfer from one element to the next) allow us to illustrate how the recipient reads, i.e. perceives and views a given image (Piotrowska 2014: 177-178).

Eye-tracking applications

The possibilities of using eye-tracking have been described mainly in such areas of science as marketing – advertising effectiveness, website usability (Mruk, Sznajder 2008, Kaczmarek 2012; Stolecka-Makowska, Wolny 2014), cartography – map usability features (Opych 2011), IT – ergonomics of computer program interfaces (Weinschenk 2011). Many experiments have confirmed that marketing research conducted with the help of cognitive neuroscience techniques using eye-tracking allows us to effectively prepare marketing strategy and communication, but also manipulate the consumer (Kaczmarek 2012). Researchers note that the big advantage of research using an eye-tracker is obtaining quantitative data based on physiological indicators that are not subject to user control or manipulation by the environment. These results are reliable because they are not based on consumer opinions (which are susceptible to environmental influences), but on their behavioural responses. The collected research material makes it possible, among others, to improve the ergonomics of websites (based on the information on what consumers look at first, what attracts their attention the most, and what is invisible) (Stolecka-Makowska, Wolny 2014: 203).

In the recent years, eye-tracking has also been used in the research on learning techniques. The way children with dyslexia read is measured (Mawduk et al. 2015: 21-24); multimedia presentations supporting early school education are being studied (Nowakowska-Buryła, Joński 2012); didactic experiments on tasks in physics (Błasiak et al. 2013) or didactics of natural subjects (Błasiak et al. 2015) are conducted; and the relationship between the dynamics of visual attention and cognitive involvement is assessed when reading a hypertext (Krejtz et al. 2015).

The undeniable advantage of this research is the enrichment of the set of research tools with a new measurement technique that provides physiological data making it possible to better understand the students' cognitive capabilities: the processes of selecting and remembering information, directing attention, reacting to new situations, problems and tasks (Stolińska, Andrzejewska 2017: 273). Then, the analysis of human perception provides information not only about where the eyesight is directed, but it also provides the basis for the research on how to solve problems, reason or focus attention.

Should we, however, limit ourselves to pedagogical experiments? It should first be noted that there is no consensus among authors as to whether eye-tracking is a research method (Błasiak et al. 2013: 486; Piotrowska 2014: 177; Wass 2016: 24) or a research technique (Czerski, Wawer 2009: Opych 2011: 155; Stolińska, Andrzejewska 2017: 259; Léger et al. 2018: 34). In any case, it is used by most researchers for empirical quantitative research, to make objective measurements using eye-trackers.

Eye tracking is also beginning to be used in special education. In 2018, Canadian researchers used eye-tracking technology to assess the cognitive function of children with Rett syndrome. They asked the question whether using eye-tracking technology with the support of therapists (AAC) can help four participants with Rett syndrome to achieve individualized communication goals, i.e. to improve their psychosocial functioning (Vessoyan et al. 2018: 230-241). The study provided preliminary evidence that eye-tracking can be a valuable and satisfying technology to support people with disabilities in communication – in this case with Rett syndrome (Vessoyan et al. 2018: 230-241).

From my perspective as a researcher and a therapist, I believe that the perception of eye-tracking only as a research technique (providing empirical data) is insufficient. I share the opinion of these researchers (Kunka 2009: 75; Wilkinson, Mitchell 2014: 106) who treat eye-tracking not only as a technology for collecting objective data (experiments, diagnosis), but also as an instrument to support therapy and communication with a child with serious physical and cognitive impairment and language – a child who is not able to explain his/her thought processes in a traditional way through cognitive or linguistic tasks. The lack or loss of speech and severe motor apraxia significantly affect functional communication in a group of children with multiple disabilities. In many cases, only the use of eye-tracking technology makes it possible to achieve individualized communication and educational goals (Vessoyan et al. 2018: 230). Eye-tracking technology allows us to make contact with a non-speaking child and carry out therapy and education tailored to his/her needs. Thanks to eye-tracking, it is possible to diagnose a child with multiple disabilities in a modern way and design appropriate educational programs, therapeutic aids, or use the eye-tracker as a communication tool.

Eye-tracking as a communication tool

A non-speaking child is often in a situation in which he/she cannot say “what they want, when they want, and how they want something to be done.” In this case, the task of teachers and specialists is to develop an individual communication system for them. Janice Light, who has been dealing with AAC for several decades, suggested significant changes in defining communication competences in 2014. While 30 years ago in AAC face-to-face interactions were emphasized, nowadays expectations for communication with a non-speaking child have changed due to, for example, a virtual keyboard. Light emphasizes that these changes have increased communication requirements that need to be met with AAC strategies based on modern technologies (Light, McNaughton 2014: 1-18).

Therefore, a child communicating with the help of vision needs technology (tools and software) to express his/her needs and desires, develop social relations and exchange information with others. For a child who, for various reasons, cannot use his hands to operate a computer, i.e. for a child with cerebral palsy, muscle wasting, spinal cord injury, amyotrophic lateral sclerosis, or neurodegenerative diseases, eye control is the fastest, easiest and most ergonomic way to use a computer, and thus – a means of communication.

Polish devices: CyberOko and C-Eye®

In our country, eye-tracking has found a new application that is important from the educational perspective – namely, as a technology supporting the diagnosis and therapy of a child with multiple disabilities. The beginning of such use of oculography was the creation of the CyberOko [CyberEye] device for assessing the state of consciousness (distinguishing the state of awareness from the state of wakefulness) of patients in a condition commonly known as “coma” (Apallic syndrome/Unresponsive wakefulness syndrome) (Kunka et al. 2012). The inventor of the device was professor Andrzej Czyżewski from the Gdańsk University of Technology. The device received the prize of the Polish Prime Minister in 2015. The special equipment helped not only to diagnose the patient, but also to make contact with him/her (Kochanowicz 2016: 75).

The latest device created in Poland under the licence of the CyberOko Method is C-Eye®, implemented as a certified medical device available in two versions: C-Eye® for individual use and C-Eye® PRO for use in medical centres, hospitals, schools (www.assistech.eu). The originality of C-Eye® and C-Eye® PRO devices is based on the use of sight to control the computer (an infrared camera tracks the eyesight), thanks to which the examined child can communicate with the environment, as well as perform special tasks based on multimedia content. With the help of sight, the child interacts with the content displayed on the screen, such as graphics, photos, inscriptions. In this way, individual centres of the child's central nervous system, in particular those responsible for their sight and hearing, as well as language and cognitive functions, are examined.

The C-Eye® Methodological Guide is included with the device. Its authors: Agnieszka Kwiatkowska and Bartosz Kunka inform that C-Eye® and C-Eye® PRO is a system used to objectify the diagnosis of the patient's state of health with various injuries of the central nervous system as well as an instrument for its neurorehabilitation. C-Eye® allows alternative audio-visual communication with the user through eye-tracking technology. The software uses three modules. The first is the patient condition assessment module. It is used to: first, study the senses (eyesight – the range of vision and hearing – the comfort level); second, to study language functions: understanding words (single words, simple sentences, complex sentences); reading words and understanding them; reading sentences and understanding them; writing skills; identifying sounds with a picture; third, to study cognitive functions: visual-spatial (the study of object recognition, the study of size perception, the study of colour perception, the study of perception of the structure of objects – letters, objects); memory test (semantic memory test, visual material memory test); the study of thinking (the study of cause and effect thinking, the classification of objects); testing communication skills (situational linguistic skills, pragmatic language skills, testing the expression of needs), fourth, the assessment of emotional states. The second module – neurorehabilitation – consists of five groups of tasks: exercises of language functions, visual-spatial functions, memory, thinking and imagination. The goal of the last module, called "Communication and entertainment," is to provide the patient with functional tools for communication and entertainment (Kwiatkowska, Kunka 2016; Kochanowicz 2016: 76-77).

C-Eye® is, therefore, a device used to diagnose the condition of patients (but also children with multiple disabilities), for which the only communication channel is vision, to stimulate their central nervous system and to carry out alternative communication with them (Kunka et al. 2016: 89-94). Importantly, eye-tracking technology makes it possible for researchers to assess the cognitive and linguistic capabilities of a child reviewing various visual materials without the need for a complicated verbal description or waiting for a physical response of the child.

In the case of a non-speaking child, the ability to perceive, recognize and interpret visual stimuli can be tested, but also stimulated, thanks to eye-tracking tasks based on multimedia content to measure the level of visual perception. Interactive exercises are based on: perceiving the figure and background (the ability to distinguish objects, focus attention on a selected object, isolate it from the environment); perceiving constancy (perception of specific features of an object, such as its shape, colour, size, regardless of the changing conditions of its perception); perception of the position of the object in space (perception of the relationship between the object and the observer); perception of spatial relations (the ability to perceive the location of two or more objects relative to each other) (Warchał 2011: 72; Kwiatkowska, Kunka 2016: 41-42).

Foreign manufacturers supplying eye-tracking equipment are also present on the Polish market. Many available eye-trackers can be used to treat and support communication. One of the smallest devices that allows one to operate the computer with eyesight is PCEye Mini, which smoothly converts eyeball movement to the cursor movement on the computer screen. It only requires a single calibration lasting several tens of seconds. PCEye Mini tracks eye movement enabling computer operation regardless of the person's glasses, contact lenses, lighting or uncontrolled head movements. PCEye Mini can be attached to any computer with a magnet, and connected with it via a USB input. Other portable eye-trackers available in Poland are: Irisbond Duo, PCEye Plus, myGaze Power, PcEye Explore with Windows Control, IntelliGaze, EyeTech TM5 (www.harpo.com.pl).

Some companies, such as Tobii Technology, SMI and SR Research, also produce software for collecting and analysing oculographic data. Therapy software specially designed for learning how to control eyesight can be divided into Polish and foreign one. The primary English-language software is Look to learn: Scenes and Sounds or KINKA Eye Tracker Games. However, in the set of Attention and Looking, Exploring and Playing and Choosing and Learning programs you can find exercises that allow you to acquire specific skills, from learning cause and effect actions, up to communication. The Polish innovative program is Eyefeel®, designed for therapy through play and entertainment, as well as for communication.

Conclusion

The purpose of the article was only to outline the issue of using eye-tracking in the diagnosis, therapy and education of a child with multiple disabilities. It would be necessary to reconstruct the historical contexts of eye-tracking development and look at it with an Argus' eye (in a very careful manner), so as not to be misled by some modern researchers claiming that eye-tracking is only a measuring technique used in empirical quantitative research. Therefore, it is necessary to formulate pedagogical questions in relation to eye-tracking as a technology supporting the development of a preschool child. In empirical research, it is worth paying attention to such aspects as: free viewing of materials by the child (screen exploration); shaping the child's sense of agency (activation of objects on the screen on a cause-effect basis, aiming and improving precision), performing tasks (moving objects with eyesight, the ability to make choices, solving various educational exercises), establishing dialogue, shaping independence and autonomy (independent computer control). For a child with quadriplegia, it would be important to study eye-tracking as the only direct activity of that child: from deliberate looking to expressing their own opinions.

Based on my therapeutic experience, I can say that eye-tracking changes the lives of individual preschool children with multiple disabilities in terms of spending their free time, learning and communicating with the environment. With this technology, we can discover the unexpected intellectual capabilities of a non-speaking child. Eye-tracking allows us to assess the pattern of eye movement, visual attention, field of viewing, preferences and the ability to point and choose with eyes. It enables the child to use the computer (eyesight replaces the computer mouse). Exercises attract the child's eye (e.g. a child chooses a picture and colors it on the screen with his/her eyesight); they support communication (from choosing individual graphic characters on the screen to running a blog or writing a book with the help of sight, as Joanna Mikołajczuk does (https://www.facebook.com/zycie.Ceye.pisane/?_rdc=2&_rdr).

On the other hand, for educational policy and educational practice, eye-tracking will be a serious challenge if it turns out that it can (and should) verify the diagnoses made by psychological and pedagogical counselling centres which assign a high degree of intellectual disability to children with multiple disabilities.

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Netography

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