Impact of Using an Eye-Gaze Technology by a Young Adult with Severe Cerebral Palsy Without Speech

Yu-Hsin Hsieh[1(✉)], Mats Granlund[2], Ai-Wen Hwang[3], and Helena Hemmingsson[1]

[1] Department of Special Education, Stockholm University, Stockholm, Sweden
yu-hsin.hsieh@specped.su.se
[2] CHILD, School of Health and Welfare, Jönköping University, Jönköping, Sweden
[3] Graduate Institute of Early Intervention, College of Medicine, Chang-Gung University, Tao-Yuan City, Taiwan

Abstract. This case study explores an eye-gaze technology intervention for a young adult with severe physical and speech difficulties and visual impairments. Data were collected over a six-month intervention period encompassing measures on pupil's occupational performance of computer activities and psychosocial impact, and interviews with the user, the parents, and the teacher on the technology acceptability. The results showed that the six-month intervention enhanced the pupil's performance in three computer activities and led to a positive psychosocial impact. The parent and teacher described the intervention as appropriate to increase the pupil's self-expression and interaction with others, and there was no adverse event during the study period. The pupil demonstrated motivation to use the eye-gaze technology after the intervention continuously. In conclusion, this study shows that a young adult with severe motor impairments and visual problems can benefit from using eye-gaze technology to increase participation in leisure activities, communication, and social interactions.

Keywords: Communication · Computer activity · Gaze-controlled computer · Participation · Severe motor · Speech impairment

1 Introduction

Individuals with severe motor and speech impairments experience participation restrictions in communication, interpersonal interactions, education, and recreation [1]. They were reported to engage in fewer activities and tend to have a lower diversity of activities in community participation than same-age peers [2, 3]. Computer assistive technology provides access for individuals with severe disabilities to participate in communication and learning, which is emphasized as a fundamental right by the Convention on the Rights of Persons with Disabilities [4]. Eye-gaze technology is a feasible method to access a computer via eye movements, applying an infrared camera to calculate the direction of eye gaze, which enables individuals to perform computer activities in play, communication, or learning [5, 6]. Compared to other access methods such as a switch, eye-gaze

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technology could be less demanding and a reliable method concerning the restricted abilities of persons with severe motor impairments to control a computer through hands, head, or other body parts [5]. Studies have demonstrated the effectiveness of applying eye-gaze technology for adults with amyotrophic lateral sclerosis [6]. A few longitudinal studies in children and youths showed increased participation in computer activities and communicative interactions [7, 8]. However, there was insufficient research on whether the eye-gaze technology could benefit young adults with severe motor and speech difficulties and visual impairments and to what extent the individual can use the technology and perform activities in everyday situations.

This article reports on a case study with a young adult with severe cerebral palsy and visual and cognitive impairments who was a novel user of eye-gaze technology that started to learn for six months. This study referred to the International Classification of Functioning, Disability and Health (ICF) [9], focusing on the enablement of participation and the environmental factor, applying eye-gaze technology and services to support an individual's functioning and participation in leisure, communication, and interactions. The aim was to explore the impacts of a six-month intervention for this non-verbal young adult with severe disabilities on the performance of computer activities, psychosocial impacts, and the acceptability of using the technology in everyday contexts.

2 Methods

This case study is part of an eye-gaze technology intervention research in Taiwan. It involves a young adult with severe cerebral palsy who was followed with repeated outcome measurements before, during, and after a six-month intervention. Ethical approval was obtained for the study (201812EM004, Dnr 2019-04902).

2.1 Participant Profile

The young adult, 22 years old, male, has a diagnosis of spastic cerebral palsy with severe gross motor, fine motor, and communication function restrictions based on the Gross Motor Function Classification System [10], the Manual Ability Classification System [11], and the Communication Function Classification System [12]. He has visual impairment of strabismus, nystagmus, and myopia and unspecified cognitive impairments according to medical records. He had low-eye control skills gazing for target selection on a screen (accuracy $<10\%$) based on Compass Aim Test [13] initially. He showed understanding of simple instructions in a routine conversation and mostly used non-verbal communication through vocalization, facial expressions, or looking to express his needs or interact with familiar people. He had tried other computer interfaces (such as a switch) but showed limited functional use. An occupational therapist evaluated him as a candidate for and in need of eye-gaze technology. He attended an adult day center during weekdays, which provides daily life skills training, leisure activity, and community participation program.

2.2 Eye-Gaze Technology Intervention

The six-month eye-gaze technology intervention was introduced in the center, including eye-gaze devices and services. After three months, his parents were motivated to use it at home as well.

The participant was provided with an add-on eye-gaze device, Tobii PCEye Mini (Tobii Dynavox Ltd.), for a laptop computer. The software included play/leisure program and individualized content with dynamic pages in communication, learning, and leisure activities (e.g., music, photos) tailored to the participant's interests and needs. In total, there were about 125 symbols/pictures in the application. High contrast colors, specific arrangements of cell display, and a shorter time for gaze activation were applied regarding the visual problems.

Service delivery used a collaborative approach, involving the special educator in the center, his parents, one occupational therapist, and the researcher. There was one planning meeting for joint goal setting and planning intervention and one follow-up meeting to review progress and modify strategies. Twelve times individual support to the teacher and parents were provided by the therapist and the researcher jointly to promote the technology uptake in everyday contexts.

2.3 Procedure and Measurements

Data were collected at baseline (26 days, using the computer as usual), at the three-month intervention (T2), and after the six-month intervention (T3).

The performance in computer activities was assessed by the Canadian Occupational Performance Measure (COPM) [14] using a proxy report. The parent and teacher were interviewed to rate the level of the participant's performance and their satisfaction with his performance for each activity using the performance and satisfaction scales, from 1 (low) to 10 (high). The functional independence was measured by the Chinese version of the Psychosocial Impact of Assistive Devices Scale (PIADS) [15] on the impact of eye-gaze technology versus low-tech devices from the perspective of the teacher, with a rating scale from -3 (maximum negative impact) to $+3$ (maximum positive impact). It includes three subscales, competency, adaptability, and self-esteem. After the intervention, the parent and teacher received interviews on their perceived acceptability of supporting the participant's use of eye-gaze technology. The young adult was interviewed on his favorite activities when using the technology.

2.4 Data Analysis

Descriptive analysis reported the changes in the average score on the two scales of COPM at T2 and T3 from baseline and each subscale score of PIADS at baseline and T3. Clinically important differences of the COPM were defined as a score change of two points or more [14]. The minimal clinically important difference of each subscale of PIADS was defined as 0.50 score change [16]. Interview data were transcribed and analyzed using content analysis [17].

3 Results

3.1 Improved Performance in Computer Activities

Three activities were determined at the beginning of the intervention, including (1) engaging in computer game activities for at least 10–15 min each time, (2) commenting on activity through communication pages in group sessions, and (3) choosing pop music to interact with classmates/teachers during leisure time. The teacher's and the parent's ratings on the pupil's performance showed clinical significance for two activities at T2 (score change = 3–4) and all activities at T3 (score change = 6–7). After the six-month intervention for all activities, their satisfaction ratings with the pupil's performance reached clinical significance (score change on the satisfaction scale = 4–5).

3.2 Improved Psychosocial Impact

As displayed in Fig. 1, the results showed that the participant increased in functional independence after introducing the eye-gaze technology. The score changes in the three subscales (Competence, Adaptability, and Self-esteem) were 1.25 to 1.67. The findings indicated an overall positive psychosocial impact of eye-gaze technology and achieved a minimal clinically important difference in the three domains.

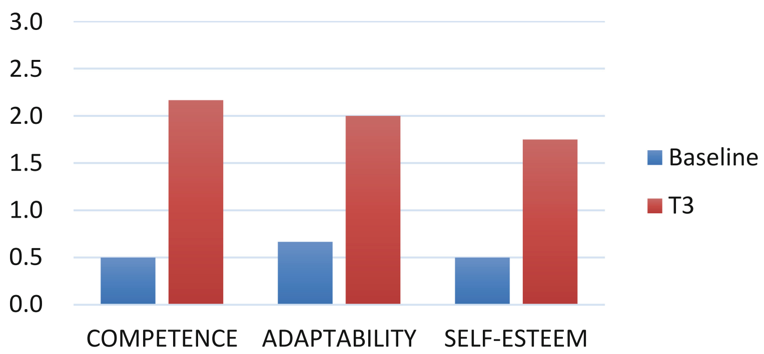

Fig. 1. Subscale scores of PIADS at baseline (using low-tech pictures) and T3 (eye-gaze technology).

3.3 User and His Teacher's and Parents' Acceptability

The participant used eye-gaze technology to respond that he felt interested in using the technology to perform computer activities. His favorite activities were choosing music to share with peers and painting. He also expressed that he wanted to continue to learn eye-gaze technology.

The parents and teacher described that eye-gaze technology is appropriate for increasing young adults' participation and control in computer activities. It offers opportunities to communicate what he wants and self-determination, unlike in the past, showing passive and waiting for the caregivers' total assistance. His teacher and parents described that using the technology enhances others to understand his thoughts as the communication pages on a screen and voice out functions of the software enhanced the clarity of his communication messages, reducing the time for guessing. The stakeholders reported no adverse events during the intervention phase, although the pupil appeared tiresome easily at the beginning of the intervention. His eye stamina developed from practicing gaze control on computer games. He expanded the visual search field on a screen, from focusing only on the lower part of the screen to searching the whole area. Both the parents and teacher observed his faster speed and longer gaze time when selecting an object on a screen. The teacher mentioned that he enjoyed using EGAT to interact with peers and got a sense of accomplishment from mutual interactions. The teacher reported that the pupil showed more confidence and engagement from relying on others to be "translators" to demonstrating his agency during group activities. Overall, the teachers and parents reported the eye-gaze device as sensitive to detecting the user's eyes, and the activity content meets the pupil's needs and preferences.

4 Discussion

This study shows positive findings that a young adult with severe and multiple disabilities and visual impairments learned to use eye-gaze technology to conduct meaningful activities in everyday circumstances. He showed improved performance in playing games, making comments, and utilizing the technology in interactions with peers. The effects were also found in the changes of the three psychosocial domains, indicating eye-gaze technology helps the pupil develop functional independence and self-confidence. The findings were supported by the parents' and teacher's descriptive comments. They perceived a positive influence on the pupil's self-expression, agency, and social interactions with others. Notably, the pupil expressed motivation to use eye-gaze technology continuously. The findings combining quantitative and qualitative outcomes support the usability of eye-gaze technology for the young adult to increase participation in leisure, communication, and interactions, and the key stakeholders showed satisfaction with the pupil's changes in performance.

This study entails that providing eye-gaze technology as environmental alternations could partially compensate for severe motor impairments and facilitate participating in everyday activities through a computer for pupils with severe motor and speech difficulties [9]. For clinical implications, it is essential to provide opportunities to trial eye-gaze technology for pupils with severe motor and speech impairments with limited functional use of other aided methods for communication. Novice users with visual problems might easily demonstrate tiredness at the initial learning stage; hence, offering short breaks with use, appropriate head positioning, and motivating activities with careful display arrangement would be crucial to ease the demand for eye control. It is important to bear in mind that pupils require time and practice to develop gaze control skills and communication competencies and also rely on the opportunities the key stakeholders provided to use the technology for varied communication purposes and to discover potential activities they could perform and benefit from [5, 18]. Therefore, continuous team support to parents and teachers is essential in adapting strategies and content to fit the pupil's skill development and varied needs across time [7].

This study as a case report has limitations for generalizability, and the results need to be interpreted with caution. Concerning the heterogeneity in this small group, future studies could apply a single-case research design [19] to provide more robust evidence and consider including objective measures for participation in computer activities such as the measurement of computer engagement on specific activities at baseline, during, and after the intervention. This study involved the key stakeholders in the application of eye-gaze technology and incorporated the user's interests into the design of activities; however, the user did not participate in the development of the intervention. Future research is worth considering different methods to collect credible views of pupils [20] to enhance a user-centered approach. Eye-gaze technology has the potential to be a practical method to gather the user's perspectives on the intervention process, given that the user could access a computer to express their thoughts with context-fitting content. A longitudinal follow-up study is also critical to evaluate the long-term effects of using eye-gaze technology across situations.

In conclusion, the results indicate that eye-gaze technology can be introduced to young adults with severe disabilities and visual impairments to enhance self-expression and social interactions.

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