

**EFFECTS OF THE EYE TRACKER TRAINING PROGRAM FOR STUDENTS
WITH NEUROMUSCULAR DISEASE**

***EFEITOS DO PROGRAMA DE TREINAMENTO DE RASTREADOR OCULAR PARA
ALUNO COM DOENÇA NEUROMUSCULAR***

***EFFECTOS DEL PROGRAMA DE ENTRENAMIENTO DEL SEGUIMIENTO OCULAR
POR ESTUDIANTES CON ENFERMEDAD NEUROMUSCULAR***

Juliana Roberta FANTI¹
Ligia Maria Presumido BRACCIALLI²

ABSTRACT: That Article presents part of an research of master's degree that was elaborated, applicated and analyzed an training program of use of eye tracking as dispositive access to computer to students with neuromuscular diseases, checking the effects about the motor performance. The research characterizes as experimental with outline as subject unique as type A-B-A. The resource variety where accurate, reaction time, moviment time and error, measured by the softwares Discrete Aiming Task 2.0, Tracking Task 2.0 and Single Switch Performance Test 1.0. The results demonstrate positive changes on motor performance, except on error frequency, that raised proportionally to the percentage of moving time, showing an positive relation between the variants, on the demanding of the task. It oncludes that the training program raised up the motor performance of the student that used eye tracking, giving independency to the source on school ambient.

KEYWORDS: Special education. Supportive tecnlogy. Neuromuscular diseases. Eye tracking. Motor learning.

RESUMO: *Este artigo apresenta parte de uma pesquisa de mestrado que elaborou, aplicou e analisou um programa de treinamento de uso de rastreador ocular como dispositivo de acesso ao computador para alunos com doenças neuromusculares, verificando o efeito do programa sobre o desempenho motor. A pesquisa caracterizou-se como experimental com delineamento de sujeito único do tipo A-B-A. As variáveis pesquisadas foram acurácia, tempo de reação, tempo de movimento e erro, mensuradas pelos softwares Discrete Aiming Task 2.0, Tracking Task 2.0 e Single Switch Performance Test 1.0. Os resultados demonstram mudança positiva no desempenho motor da participante, exceto na frequência de erros, que aumentou proporcionalmente à porcentagem de tempo de movimento, indicando uma relação positiva entre as variáveis, relacionada à demanda da tarefa. Conclui-se que o programa de treinamento melhorou o desempenho motor da aluna no uso do rastreador ocular, proporcionando o uso independente do recurso no ambiente escolar.*

¹ São Paulo State University (UNESP), Marília – SP – Brazil. Master's in Education. ORCID: <https://orcid.org/0000-0003-4698-0449>. E-mail: julianafanti@yahoo.com.br

² São Paulo State University (UNESP), Marília – SP – Brazil. Retired Professor at the Department of Special Education. PhD in Physical Education (UNICAMP). ORCID: <https://orcid.org/0000-0002-2540-3725>. E-mail: ligia.braccialli@unesp.br

PALAVRAS-CHAVE: *Educação especial. Tecnologia assistiva. Doenças neuromusculares. Rastreador ocular. Aprendizagem motora.*

RESUMEN: *Este artículo presenta parte de una investigación de maestría que elaboró, aplicó y analizó un programa de capacitación sobre el uso de un seguidor ocular como dispositivo de acceso a computadoras para estudiantes con enfermedades neuromusculares, verificando el efecto del programa en el desempeño motor. La investigación se caracterizó como experimental con un diseño de un solo sujeto de tipo A-B-A. Las variables investigadas fueron precisión, tiempo de reacción, tiempo de movimiento y error, medidos por el software Discrete Aiming Task 2.0, Tracking Task 2.0 y Single Switch Performance Test 1.0. Los resultados evidencian un cambio positivo en el desempeño motor del participante, excepto de la frecuencia de errores, que aumenta proporcionalmente al porcentaje de tiempo de movimiento, lo que indica una relación positiva entre las variables, relacionadas con la demanda de la tarea. Se concluye que el programa de capacitación mejoró el desempeño motor del alumno en el uso del eye tracker, brindando el uso independiente del recurso en el entorno escolar.*

PALABRAS CLAVE: *Educación especial. Tecnología de asistencia. Enfermedades neuromusculares. Rastreador de ojos. Aprendizaje motor.*

Introduction

This article presents an excerpt of a dissertation from a strictu sensu post-graduation program of a public state university located in the city of Marília, in the state of São Paulo, and partially funded by the National Council for Scientific and Technological Development - CNPq. The present research developed an eye-tracking assistive technology training program for computer access in students with neuromuscular diseases and analyzed its effect on the student's motor performance after the application of the program by the researcher, in a single-subject A-B-A design study. This research design was selected due to the number of participants who met the inclusion requirements for this study.

The text of this article discusses the application of the training program and its effects on the measurement of motor performance of students with neuromuscular disease, considering the variables accuracy, reaction time, movement time, and error.

The process of including children with physical disabilities resulting from progressive neuromuscular disease is quite challenging, because these students need modifications and adaptations of resources and pedagogical strategies in order to have their participation, autonomy, and independence in the school context, while maintaining their quality of life.

The adaptations for these students must focus on the use of their residual functions and offer the least energy expenditure and motor effort possible during the activities.

Among the assistive technology resources, the computer stands out as a piece of equipment that can promote the stimulation of residual motor functions, independence and inclusion of children with severe physical disability.

The computer offers several possibilities for reading, searching, communicating, and writing pedagogical content, when these functions are significantly impaired by motor structure impairments.

However, the peripheral equipment that allow access to the computer, such as mouse and keyboard, are not always efficient for people with neuromuscular diseases, significantly reducing the opportunities of participation of this population to technologies (RAYA *et al.*, 2010).

Many are the offers of software and computer access devices, such as virtual keyboard, scanning system, voice command activation or head movements, however the continuous progression of motor impairment in students with neuromuscular disease may prevent the use of the computer and more common access devices, being necessary an assistive technology resource that is more sensitive to movement and requires less motor functions for its activation.

The eye tracker is considered a suitable device for various communicative and environmental control purposes for people with severe physical disabilities, including neuromuscular diseases (MAJARANTA; DONEGAN, 2012).

However, limitations are also found in the use of these devices, such as visual exhaustion, ergonomics and environmental conditions, system calibration and configuration, high cost, and training (SPATARO *et al.*, 2014; KÄTHNER; KÜBLER; HALDER, 2015; GARRY *et al.*, 2016; CHANG *et al.*, 2017).

For people with neuromuscular diseases, these limitations increase the rate of disuse of the tracking device. According to Federici and Borsci (2014), to remedy these limitations, an "assistive solution" should be presented, which involves not only the provision of the device, but also training and monitoring carried out by a specialized professional for the use of the resource.

The reality in different countries has shown that the acquisition and use of assistive technology resources, whether low or high cost, must be accompanied by training programs with the user and with the educational professionals. The lack of a training program has been a reason for abandoning the resource, many times without ever having used it.

For training to be effective in the use of the eye tracker, a program should be proposed that favors a change in the individual's ocular motor performance, considering that this access device demands specific oculomotor functions from human beings, which are different from the habitual use of the eyes.

Based on this information, we questioned: can a training program for the use of an eye-tracking device improve the oculomotor performance in computer access for students with progressive neuromuscular disease?

The study aimed to compare the oculomotor performance of students with neuromuscular disease before and after the application of an individualized training program.

Method

The research was conducted by a single-subject, A-B-A study, characterized by collection with a single participant being his own control. Its findings were obtained by the effect of an intervention under controlled conditions, and the behavior measured repeatedly until stability or minimal variations. The dependent variable is the measured behavior, on which the researcher applies his intervention and measures its effects. The baseline (A) describes the responses of the non-intervention period, reflecting the natural performance of the measured behavior, while the B-line, called the intervention, measures the performance responses during the intervention. In this experimental research model (A-B-A), the baseline is replicated after the intervention to prove that changes in performance are maintained even after the intervention ends (GAST, 2010).

Research Ethics

At first, the Municipal Secretary of Education and the Regional Board of Education of a medium-sized city in the interior of the state of São Paulo were contacted for clarification about the research and later authorization to carry it out.

After the authorization, the above-mentioned institutions were asked to survey the students enrolled in regular public schools in the city and region, registered in the Companhia de Processamento de Dados do Estado de São Paulo (PRODESP) with neuromuscular diseases, aged between seven and seventeen. The sectors responsible for Special Education in the two institutions collaborated with the research by providing the names of the schools and

specialized care rooms that had students with physical disabilities enrolled. So far there was no information about the diagnoses of the students with physical disabilities.

Then, the researcher went personally to each school indicated, for the identification of possible participants for the research. To identify the students diagnosed with neuromuscular disease, the researcher had access to the school records of each student with physical disability.

The students with neuromuscular disease confirmed by medical report were listed by the researcher and, subsequently, permission was requested from the school principal for data collection in the school environment, days, time, and place for collection were established, and then, the families of selected students were contacted for presentation of the research and delivery of the Informed Consent Form, if they agreed to participate in the study.

Initially, seven participants with the necessary criteria for inclusion in the study were identified, but one had moved to another city, belonging to another jurisdiction, two other participants' family members did not authorize their participation in the research, and one had died on the date of the beginning of the collection, thus only three participants started the research. After one week of data collection, two participants could not continue in the research, because the school transportation was suspended due to maintenance and they had no way to go to school, and only one participant finished the research.

The project was approved by the Research Ethics Committee with CAAE number: 81841417.1.0000.5406. Following the ethical criteria, the Informed Consent Form and the Term of Consent were read and signed by the guardian and participant, respectively, before the beginning of data collection.

Participant

A 9-year-old female child, diagnosed with Muscular Dystrophy, unspecified type, student of the 4th year of regular education in a state school, participated in the research.

To describe the motor limitations and potentialities of the child, she was evaluated using the Motor Function Measure in Neuromuscular Diseases - MFM scale, and the information obtained was organized and presented by Figure 1. The child presented severe motor impairment in the upper and lower limbs, decreased range of motion in the shoulders, and postural compensation to perform the desired movements. Other relevant information for the participant's description is that she used a wheelchair with an abdominal band for positioning and used adapted school transportation. The school desk, on the other hand, did

not present any adaptation. In the activities of recording educational content, she was slow to copy, and the adaptation proposed by the school for this task were the prints of some school activities. In the after-school period, the student attended the physical disability resource room, at the school, twice a week.

Figure 1 – Motor skill score as % of participant

Dimensions	Score %
Dimension 1 (D1)	0
Dimension 2 (D2)	58,3
Dimension 3 (D3)	76,1
Total score	38,5

Fonte: Elaborado pelos autores

D1= standing and transfers; D2 = axial and proximal motricity; D3 = distal motricity

Data collection

To position the student during data collection we used a common rectangular school desk with the following dimensions: height 76cm, length 60cm and width 45cm; a common wheelchair with total width of 64.5cm, total height 88cm.

Following the ergonomic norms, besides the table, a reclining support for notebook was used, with inclination variable from 0 to 90°.

For data collection an HP TouchSmart PC notebook was used, with a 12.1-inch monitor, Windows Vista operating system, and the TobiiPCEye Go eye-tracking device (TobiiDynavox), which was attached to the notebook display allowing the user to control on-screen activities with eye movements, without the use of a common mouse or keyboard (TOBII DYNVOX, 2015).

Figure 2 contextualizes in a temporal way the five weeks of data collection and the activities developed during this period, including the training of the pedagogical support professional, who was responsible for applying the tests, so that there was no bias in the research, and also motor assessment of the student and measurement of data through specific software, and the baseline and intervention.

Figure 2 – Timeline of data collection with participant A

	Training - pedagogical support professional (evaluator)	Motor evaluation - MFM	Baseline - A ¹	Intervention - B	Baseline - A ²
Week 1					
Week 2					
Week 3					
Week 4					
Week 5					

Source: Prepared by the authors

Initially the researcher performed the motor evaluation of the study participant. Also in the first week, a training session was held with the educational support professional on the following content: eye-tracking computer access device (TobiiPCEye Go) and use of the motor performance measurement software. This professional, during data collection, performed the daily calibration of the eye-tracking device and applied the tests using the measurement software, DiscreteAimingTask 2.0 (DAT) (OKAZAKI, 2008), Tracking Task 2.0 (TT) (OKAZAKI, 2008) and Single Switch Performance Test 1.0 (SSPT), which measured the student's motor performance. The evaluations were performed by this professional so that there would be no bias in the research, since the researcher developed the intervention program.

The four subsequent weeks included data collection on oculomotor performance in the use of the assistive technology eye-tracking device, totaling twenty sessions, five school days a week.

The first five school days of data collection were characterized by measuring natural oculomotor performance from baseline A¹. The next ten school days, second and third week, characterized the intervention phase (B), in which the eye tracker training program was applied.

The fourth and last week, during the five school days, included the final phase of data collection, baseline A², which measured the student's natural oculomotor performance in the use of the eye-tracking device after the intervention period, i.e., without the application of the training program.

During all twenty days of data collection a field diary was developed in descriptive format, with notes on the student's behavior when using the assistive technology device.

Every day, during the period of data collection, the researcher organized the materials, furniture and equipment, and only then the student was directed by the educational support professional to the room for collection. Then, the support professional positioned the participant and performed the calibration and configuration of the device using the software Gaze Interaction, which comes with the equipment itself, TobbiPCEye Go.

The activation method was configured individually for the participant in the two possible ways, stay and blink, being in the stay with feedback clock type, in red color and dwell time of 640 milliseconds. The dot size was 68 px, with 80% opacity; and in the blinking with minimum activation duration of 162 milliseconds and maximum activation duration of 644 milliseconds, feedback pulsing dot type, in red color, with size of 68 px and 80% opacity.

The software used in this research to measure the participant's oculomotor performance during baseline data collection A¹ and A² and intervention phase B were developed by researcher Prof. Dr. Victor Hugo Alves Okazaki, in 2008, and are available for free download on the website (<https://okazaki.webs.com/softwaredownloads.htm#297051518>), being the DiscreteAimingTask used to measure accuracy, theTrackingTask to measure reaction time, and the Single Switch Performance Test used to measure movement time and errors, all measured through the use of the eye-tracking access device.

As for the training program used in the intervention phase B of the study, it was designed by the researcher based on the theoretical framework proposed by Hagedorn (2007), the developmental occupation level, which uses a reductionist perspective for small performance episodes, i.e., the use of tasks graded from simple to more complex levels to train specific aspects of the functions.

The duration of the intervention sessions, line B, was one hour, in which the first fifteen minutes were spent on oculomotor stimulation exercises, and the remaining forty-five minutes were used to perform the tasks in the training program designed by the researcher.

Data analysis

The motor performance measures analyzed were accuracy, reaction time, movement time, and errors.

For measurement, the accuracy variable was fragmented into two measures, the total movement time, which is the time spent to select the target in the task, and the time per movement, which is the average time spent to trigger the task target.

To measure reaction time, this variable was divided into three measures, average trigger time, which is the average time spent to trigger the task target, fastest trigger time, which is the least time spent to trigger the task target, and slowest trigger time, which is the most time spent to trigger the task target.

The movement time and errors were considered a single variable, as they are inversely proportional, and are broken down into percentage of time in the circle, which is the percentage of time the cursor stayed inside the circle during the task time, and frequency of errors, which are the errors made in tracking the target during the task.

The data collected with the DiscreteAimingTask, Tracking Task, and Single Switch Performance Test motor performance measurement software, after being measured, were automatically exported to Microsoft Excel by the software itself, and represented by line graphs; subsequently, they were forwarded to three judges for visual analysis, and then their answers submitted for agreement analysis.

To make the graphs, all data referring to task execution time were transcribed in deciseconds and the vertical axis was adjusted in all graphs, and a trend line was added to each graph for better visualization of the changes in the variables researched in this study.

The visual analysis was performed by three independent judges with training and specialization in special education and motor development, and the graphs were sent via electronic address along with a visual analysis protocol based on Vieira (2007).

The visual analysis protocol had five questions directed to the trend characteristics presented per graph in each phase of the research, baseline and intervention, as well as the perceived change in oculomotor behavior resulting from motor learning.

The agreement between the judges was evaluated using the Fagundes (1999) agreement index, with values between 66% and 90% being considered, where an index higher than 90% represents very high reliability, an index between 80% and 89% represents high reliability, an index between 66% and 79% represents acceptable reliability, and an index lower than 66% represents low reliability (BAUER; GASKELL, 2004).

Results

The results were represented in graphs, showing the relation of the variables: (1) accuracy, (2) reaction time, and (3) movement/error time.

As previously described, accuracy is the precision with which the task was executed, and the total response time and the time per movement are measured.

The reaction time (RT), on the other hand, measures the amount of time in deciseconds that the user took to start the task, that is, the time between the beginning of the task stimulus and the beginning of the user's action, the stimulus being represented by a light signal, sound or written word, in this case a visual and sound stimulus. For this variable the average triggering time, the fastest triggering time, and the slowest triggering time were measured.

As for the measure of errors, this scores the performance of the action as to accuracy, considering the number of errors committed in the performance of the action required by the task.

On the other hand, the movement time considers the speed required by the action of the task, defined by the variation of the object's position as a function of time.

Accuracy

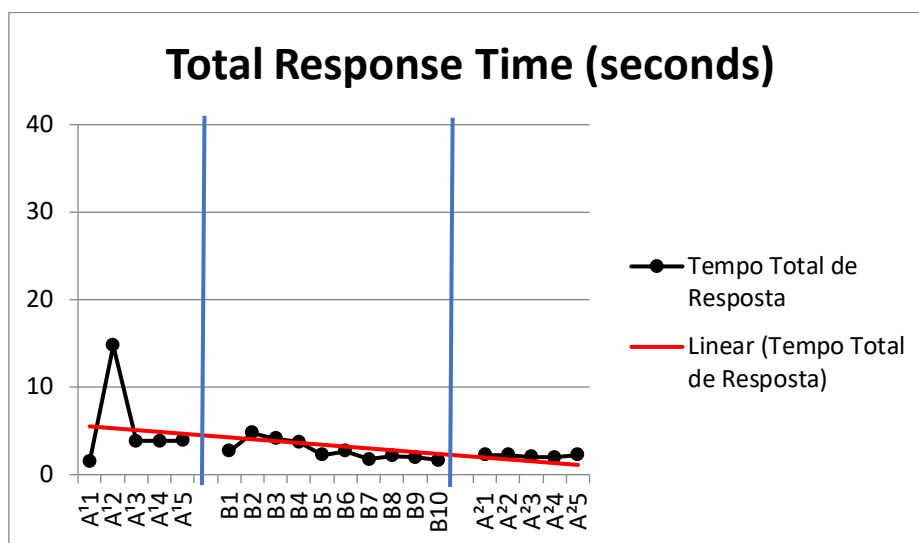
As for accuracy, two variables were measured, total response time and time per movement.

Figure 3 graphs the time per movement variable.

The data presented by figure 3 indicated a stable trend line in the total response time of the initial phase, which was decreasing in phase B and stabilized in the final phase, reducing its time by 16.6 deciseconds from baseline A¹ to baseline A².

The visual analysis of the graph showed a 100% agreement index for the decreasing trend change and motor performance. As for the agreement concerning learning, the index was 66%, representing an acceptable reliability..

Figure 3 – Time per Motion Graph (deciseconds)



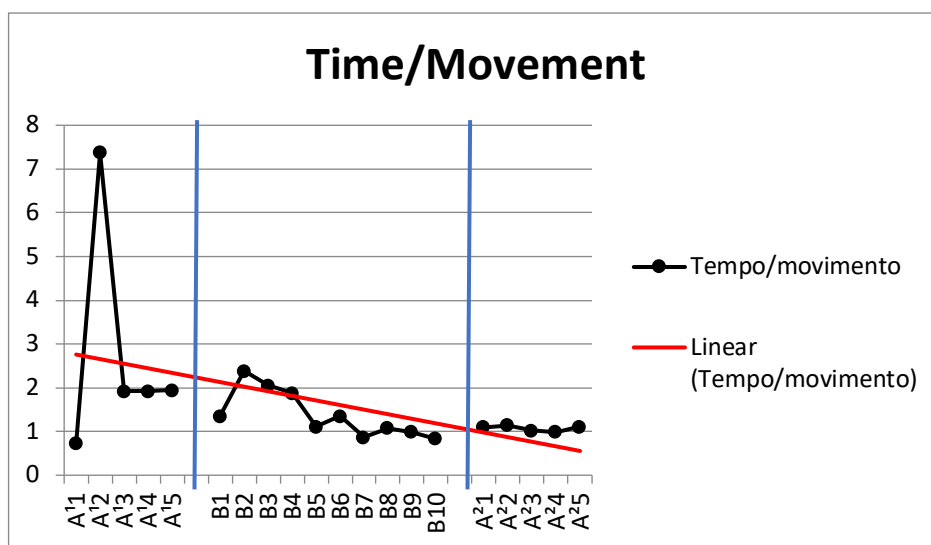
Tempo total de resposta = Total Response Time; Linear = Straight
 Source: Prepared by the authors

Another variable related to accuracy was represented in figure 4, in which the graph presents the measurements of time per movement.

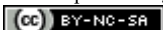
The data presented by figure 4 indicated a decreasing trend in the division of total time by each executed movement, reducing its time by 8.3 deciseconds.

The visual analysis of the graph showed a 100% agreement rate for both the decreasing trend change and motor performance. As for the agreement concerning learning, the index was 66%, representing an acceptable reliability..

Figure 4 – Time per Motion Graph (deciseconds)



Tempo/movimento = Time/movement; Linear = Straight
 Source: Prepared by the authors



Reaction time

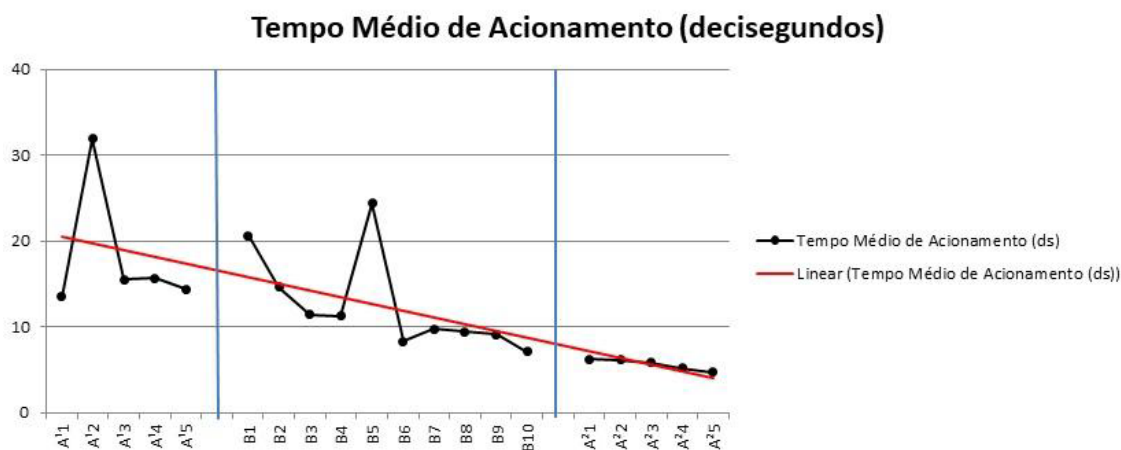
The reaction time variable was broken down into average trigger time, fastest trigger time and slowest trigger time.

Figure 5 graphs the average trigger time variable.

The data presented by figure 5 indicated a decreasing trend line from baseline A¹ to baseline A², reducing its time significantly by 9.68 deciseconds.

The visual analysis of the graph showed a 100% agreement index for decreasing trend change and motor performance. In the agreement concerning learning, the index was 66%, representing an acceptable reliability..

Figure 5 – Average triggering time (deciseconds)



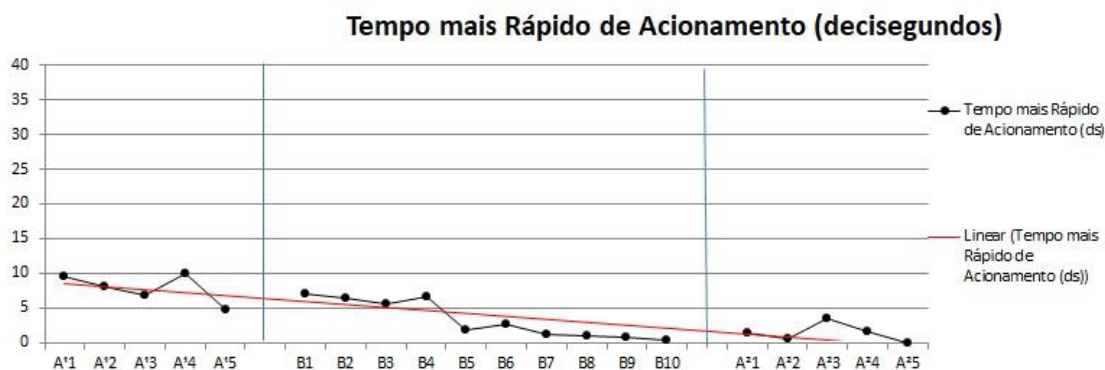
Tempo médio de acionamento = Average triggering time; Linear = Straight
Source: Prepared by the authors

The second measurement of the reaction time variable was represented in figure 6, in which the graph presents the fastest triggering time measurements.

The data presented by figure 6 indicated a downward trend in the intervention phase, reducing its time by 4.88 deciseconds, with the longest triggering time being 4.89 deciseconds and the shortest fastest triggering time being 0.01 deciseconds.

The visual analysis of the graph showed a 100% agreement rate for both the decreasing trend change and motor performance. As for the agreement concerning learning, the index was 66%, representing an acceptable reliability.

Figure 6 – Fastest triggering time (decisseconds)



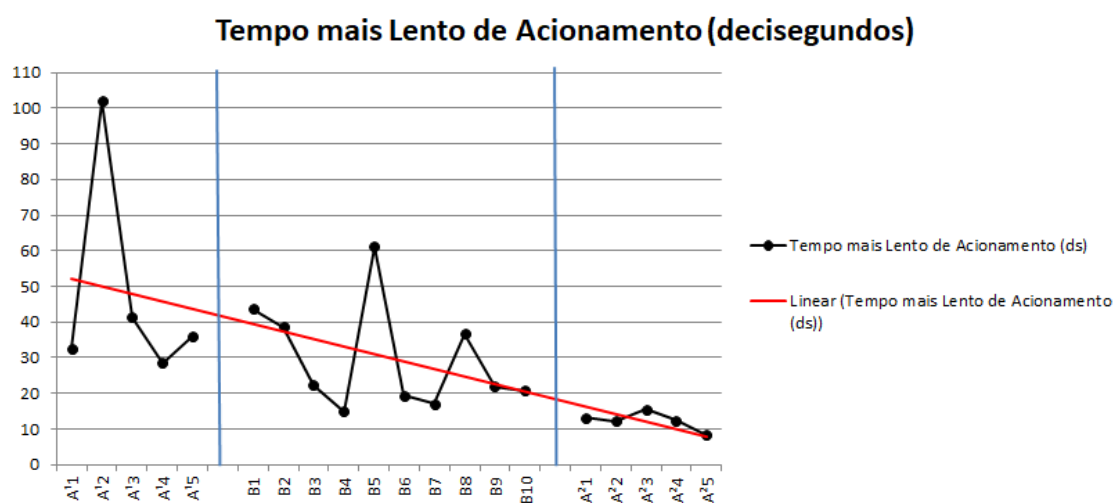
Tempo mais Rápido de Acionamento (decisegundos) = Fastest triggering time (decisseconds)
 Source: Prepared by the authors

The last measurement of the reaction time variable was represented in figure 7, in which the graph presents the slowest triggering time measurements.

The data presented by figure 7 indicated a decreasing trend in the intervention phase, showing a relevant reduction of 27.82 deciseconds, where the slowest triggering time was 36.12 deciseconds and the slowest triggering time was 0.01 deciseconds.

The visual analysis of the graph showed a 100% agreement rate for both the decreasing trend change and motor performance. In the agreement concerning learning, the index was 50%, but only two examiners answered this question.

Figure 7 – Slowest triggering time (decisseconds)



Tempo mais Lento de Acionamento = Slowest triggering time (decisseconds); Linear = Straight
 Source: Prepared by the authors

Movement and error time

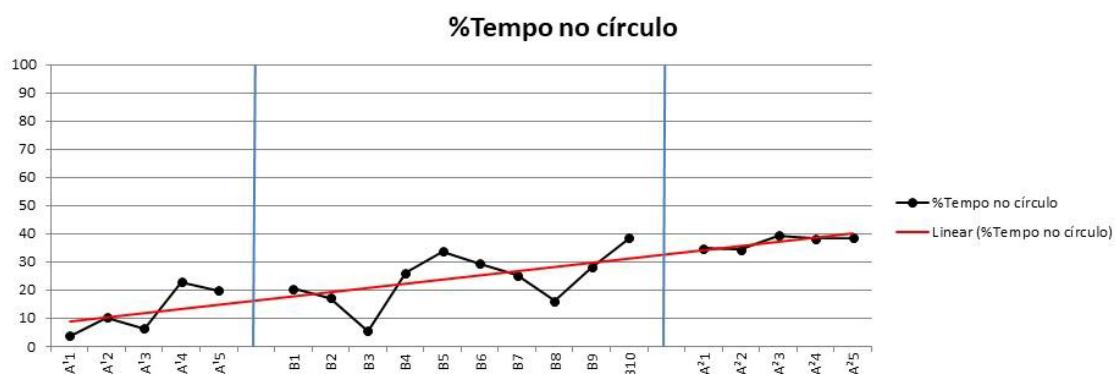
The variables movement time and error were represented by the measures percentage of time on the circle, frequency of errors, and percentage of time per frequency of errors.

Figure 8 graphically represents the variable of percent time on circle.

The data presented by figure 8 indicated an increasing trend line from baseline A¹ to baseline A², increasing their time inside the circle by 18.7 deciseconds, with the shortest time inside the circle being 19.7% and the longest time inside the circle being 38.4%.

Visual analysis of the graph showed a 100% agreement index for increasing trend change, motor performance, and motor learning.

Figure 8 – Percentage of time in the circle



Tempo no círculo = Time in the circle; Linear = Straight

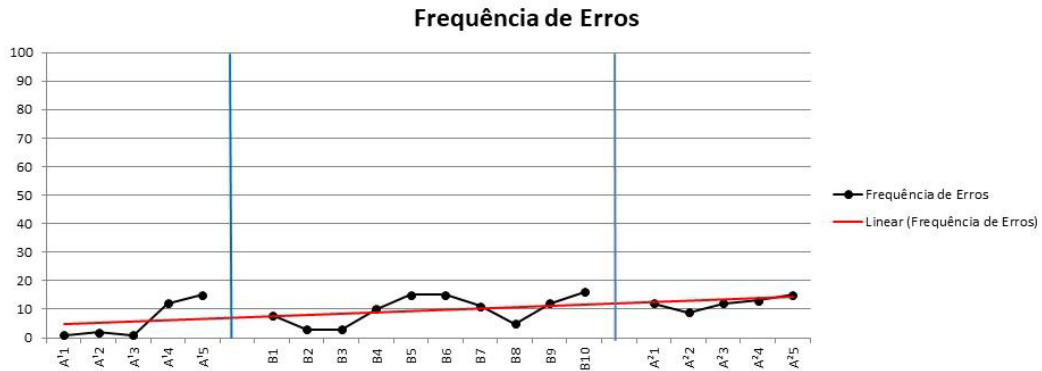
Source: Prepared by the authors

Another measure of the movement time/error variable was represented in figure 9, in which the graph presents the measures of error frequency, which should be inversely proportional to circle time.

The data presented by figure 9 indicated an increasing trend.

The visual analysis of the graph showed a 100% agreement rate for both the decreasing trend change and motor performance. In the agreement concerning learning, the index was 66%, representing an acceptable reliability.

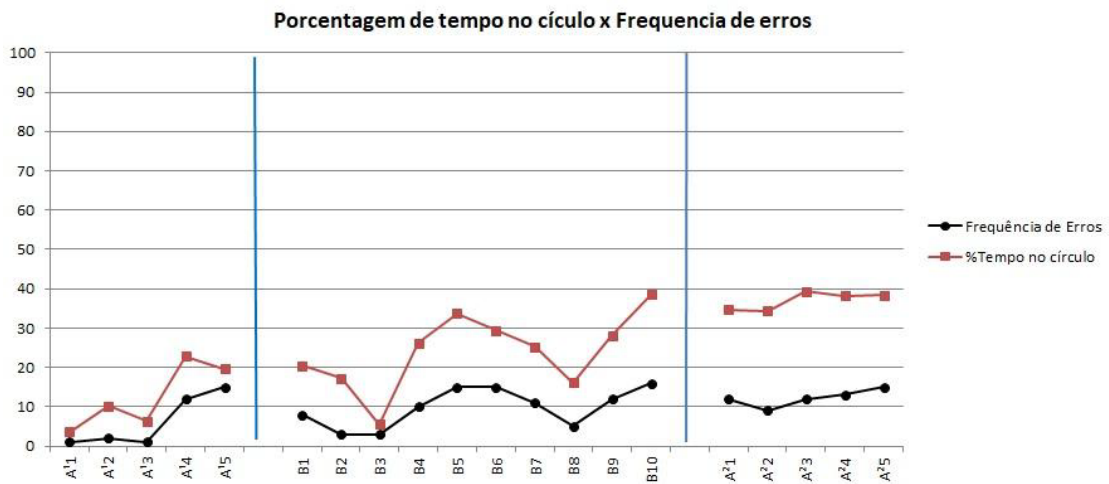
Figure 9 – Error Frequency



Frequência de erros = Error Frequency; Linear = Straight
 Source: Prepared by the authors

As described above, there is a relationship between the percentage of people in the circle and the number of errors, and the results may suggest that the variables presented a directly proportional relationship.

Figure 10 – Percentage of Time x Error Frequency



Porcentagem de tempo no círculo x Frequência de erros = Percentage of Time x Error Frequency;
 Linear = Straight
 Source: Prepared by the authors

Final remarks

The present study is a part of a master's thesis that discusses the development and applicability of a training program for the use of an eye-tracking device by a student with neuromuscular disease. Measurable variables of oculomotor performance were analyzed to

verify whether the program developed can generate motor learning by improving the student's motor performance.

The results showed a positive evolution in the participant's oculomotor performance for accuracy, movement time, and target tracking after the intervention with the training program developed, which suggests the effectiveness of the program for dexterity and functionality in the use of the eye-tracking computer access device.

Considering the common classroom activities, the demand for recording content and activities, and the agility required in performing tasks in this context, the computer may be an indispensable resource for students with severe physical disabilities. However, this resource alone is not enough for the student with physical disabilities to perform the motor actions required mainly for recording and research, requiring the use of computer access devices other than the usual ones. In the case of students with neuromuscular diseases, the impairment of movements and joint range in the upper limbs, in addition to constant muscle fatigue, reduce the effective assistive technology resources to access the computer, and the eye-tracking access device is the most indicated to be used with this population, but high rates of disuse are observed due to lack of training, as the equipment requires oculomotor functions that are not conventional for human eyes.

Thus, a training program directed to specific oculomotor functions, as shown in this study, enhances the functional use of the device, making it effective as a school adaptation to access the curriculum.

Other relevant information pointed out by the study is the extended training on installation and settings of the resource for the support professionals for the student with disabilities, and the student will need this support to position the resources and equipment, as well as to turn on, calibrate and turn off.

The training of the student and the school staff, as support teacher, caregiver, common classroom teacher are of the same importance, considering that the assistive technology resources have specific characteristics and personalized use for each student, which reinforces the partnership between health and education professionals and assistive technology services.

It is expected that this study will stimulate new researches with this computer access device, both in students with neuromuscular diseases and in other populations of students with physical disabilities.

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