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http://dx.doi.org/10.23925/2176-2724.2018v30i1p72-79

Electromyographic signals as analytical and hardware tool for alternative communication

Sinais eletromiográficos como ferramenta de avaliação e *hardware* para comunicação alternativa

Signos electromiográficos como herramienta de avaluación y *hardware* para la comunicación alternativa

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Abstract

The present study shows electromyography interface as positive control for Alternative and Augmentative Communication (AAC). The aim of this work was to relatio electromyography signal as entrance dipositive for positive control to choose switchs on AAC. Tthis had support on clinical-qualitative and descritive methods,   three subjects were selected for this research, two with cerebral palsy and one with Spinal Muscular Atrophy. After the selection of the subjects, were made evalutions with Alternative Augmentive Communication Neurofunctional for Choosing Switchs Protocol (AACNS). In this context, the neurofunctional evalution using the AACNS guided the selection of switchs regions; after the switchs were made, electromyography test in instrumentalization day was realized. The results found using EMG confirm the group muscle group chose by AACNS indicate the correct switchs. EMG tests facilitate and confirm the switchs chooses with support of positive control.

Keywords: Communication Aids for Disabled; Electromyography; Speech, Language and Hearing Sciences

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Authors' contributions:
ECM and VLOR: data collection and analysis, construction of study findings and manuscript writing. RCNG: Project management, study design.

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Received: 09/09/2017
Accepted: 27/02/2018

Resumo

O presente trabalho apresenta a interface do Eletromiógrafo como alternativa de controle positivo para escolha de recursos de Comunicação Alternativa e Ampliada (CAA). O objetivo deste trabalho foi relacionar sinais eletromiográficos como dispositivos de entrada para controle positivo para escolha de acionadores para CAA. Foi respaldado no método clínico-qualitativo e descritivo, foram selecionados três sujeitos para participar da pesquisa, dois sujeitos com diagnóstico de paralisia cerebral e um com diagnóstico de Amiotrofia Espinhal Progressiva tipo um. Apos a seleção dos sujeitos, foram realizadas avaliações utilizando o protocolo de Avaliação Neurofuncional para Comunicação Alternativa e Ampliada (ACADM). De modo que a avaliação neurofuncional utilizando o ACADM norteou a escolha do tipo e região do acionador. Após a confecção do acionador, foi realizado no dia da testagem coleta dos sinais eletromiográficos. Os achados encontrados no Eletromiógrafo confirmam o potencial do grupo muscular escolhido pelo protocolo ACADM, e indica a escolha do acionador correto. Os testes com o EMG facilitaram e confirmaram as escolhas dos acionadores com o apoio do controle positivo.

Palavras-chave: Auxiliares de Comunicação para Pessoas com Deficiência;, Eletromiografia; Fonoaudiologia

Resumen

El presente trabajo presenta la interfaz con el Electromiógrafo como una alternativa de control positivo para elegir recursos Aumentativos y Alternativos de Comunicación (CAA). El objetivo de este trabajo fue relacionar las señales electromiográficas como dispositivos de entrada para el control positivo para la elección de disparadores para CAA. Se apoyo en el método clínico-cualitativo y descriptivo. Se seleccionaron tres sujetos para participar del estudio, dos con diagnóstico de parálisis cerebral y uno con diagnóstico de Amiotrofia Espinal Progresiva tipo uno. Después de la selección de los sujetos, se realizaron evaluaciones utilizando el protocolo de Evaluación Neurofuncional para Comunicación Alternativa y Aumentada (ACADM). Por lo tanto, la evaluación neurofuncional utilizando el ACADAM guió la elección del tipo y región del disparador. Después de la confección del disparador, en el día de la recolección se realizo prueba de señales electromiográficas. Los hallazgos encontrados en el electromiógrafo confirman el potencial del grupo muscular elegido por el protocolo ACDAM y indican la elección del disparador correcto. Las pruebas con el EMG facilitaron y confirmaron las elecciones de los disparadores con el apoyo del control positivo.

Palabras claves: Auxiliares de Comunicación para Personas con Discapacidad; Electromiografia; Fonaudiología

Introduction

The present work presents the interface of the Electromyograph as an alternative of a positive control for the choice of Alternative and Augumentative Communication (AAC) resources. The tool developed was designed to serve as an evaluation tool and as a possibility for therapeutic adaptation. The subject-computer interface was mediated through the recording of an electromyographic signal (EMG) in real time and in functional use.

The nervous system controls muscle activity – contraction and relaxation. The EMG is used as a diagnostic tool in neuromuscular diseases. Regarding the existence of the population that needs high-tech adaptations to communicate, they can use the EMG as an access hardware to the computer, since it is already used to control hand, cognitive response and human-machine interaction[1].

The consequences of motor impairment through central nervous system problems are common in the clinic, especially in Alternative Communication. Thus, the EMG can act as a hardware that could be used in many clinical cases, since it is possible to take advantage of the muscular group of volitive predominance of the patient[2,3]. The EMG captures the possibility of moving information from a part of the body and generates a biosignal that activates a brain computer interface (BCI) computer system. The applications for communication system can be: control of equipment, replacing the computer mouse; conjugated use with accelerometer, for automatic speech recognition by analyzing the signs of the following muscles: mentalis, mouth angle depressor, masseter, digastric, major zygomatic, angle lifter of the mouth, platysma, and the eye's orbicularis[2].

Hidden Markov Models use muscle maps for activation of phonemes. These maps verify statistical probabilities of state transition and do the recognition of patterns by algorithms. Electrooculography was also a used method, as a click to activate the computer[5-7]. At least, in the last twenty years, technological advances of equipment for Alternative Communication have been growing numerically. Access to AAC and electrical biosignals equipment can help control the computer in the presence of severe motor disorder [5,8,9].

The advantage of using the EMG relies on its features like instant response in the muscles and in the viability of possible motor control. It can be used in diagonal movements, in order to perform vertical and horizontal movements. In addition, it is able to process the information with the TMS320C31 processor in real time[10]. The EMG is able to analyze muscle function by screening the electrical signal produced by the muscle during a movement. The action potential generated during muscle contraction is captured by the electrodes on the surface of the skin, in the region of the desired muscle group[11]. Some tests have shown that this assistive communication system has great potential for the assistance of users who are not able to communicate, due to severe motor dysfunctions and speech loss [12,13].

The need for adaptive resources implies the need to know about the motor frame and low and high-cost tools that provide adaptation[14]. It is clear that the EMG is a medium-cost technological resource that is easy to adapt, even in subjects with severe motor impairment. There is a shortage, however, in the literature, relating the EMG to pathologies, neuromuscular condition and adaptations, as well as the importance of the moment of evaluation and positive control of the musculature of interest to interface adaptation. As it is recurrent in the AAC area, patients spend a lot on adaptations that are not functional or efficient for their neuromuscular condition.

Regarding people with motor disabilities – who present speech development disorders due to neurological problems, with preserved cognitive abilities –, the expressive motor aspects of language are the most impaired, with a need to adapt communication resources[1]. When we work with AAC, it is recurrent the need to choose a trigger. Therefore, using the electromyographic signal registration facilitates the evaluation process for the choice of the trigger that will be used for each subject specifically.

The literature review – in order to investigate the efficacy of electromyographic biofeedback for the Speech, Language and Hearing Sciences rehabilitation work of the orofacial musculature – noted, in the inclusion criteria, the presence of a study with neurological patients. Finally, the study reveals that the use of the electromyographic signal at the time of the rehabilitation exercise gives the patient a positive visual response regarding the efficacy of its movement[4].

Changes in public health policies in Brazil and in the world show that the mortality rate of people with disabilities has declined and, increasingly, there is a need for inclusion and to create resources to adapt daily activities and communication[3]. There is a need for technological advances that collaborate with inclusion to think in the short and long term adaptations.

The EMG is a technological resource of medium cost and easy adaptation, even in subjects with severe motor impairment. This work sought to understand how EMG use can contribute to the evaluation and therapeutic use of the trigger, that is, real-time human-computer interface and functional use. For the evaluation, the Neurofunctional Evaluation for Alternative and Augumentative Communication (ACADM) protocol was used, defining the muscle group. Right after, the EMG was used to confirm the group and better positioning the interface constructed to the patient.

Therefore, the objective of this work was to relate electromyographic signals with input devices for positive control, in order to choose triggers for Alternative Communication.

Methods

This work was approved in the clinical-qualitative and descriptive method and was developed in the Research Group Estudos da Linguagem e Comunicação of the Universidade Federal de Sergipe. The project was approved by the Ethics in Research Committee of the the Universidade Federal de Sergipe, under the CAAE number 15822613.7.0000.5546.

Three subjects were selected to participate in the study. Two with a diagnosis of cerebral palsy and one with a diagnosis of type one Progressive Spinal Amyotrophy. The subjects of the research were selected from some inclusion criteria: having the need for Alternative Communication adaptation resources and having no cognitive changes. Table 1 presents the presentation of each subject, regarding their age, gender, diagnosis and linguistic situation[2].

Table 1. Subjects Presentation

Subject	Age	Sex	Diagnosis	Language Situation
1	15 years old	M	Severe Spastic Cerebral Palsy	Comprehends simple questions and figurative language; communicates by blinking the eye
2	9 years old	M	Moderate Atetoid Cerebral Palsy	Comprehends simple questions; communicates by indication and speaking a little
3	5 years old	F	Progressive Spinal Amyotrophy Type 1	Comprehends simple questions; communicates by blinking the eye

After the selection of the subjects, evaluations were performed using the protocol of Neurofunctional Evaluation for Alternative and Augumentative Communication (ACADM). The ACADM is divided into joint, voluntary and involuntary movements, physiological and pathological reflexes. Within these variables, strength, resistance, mobility, stability, control, rigidity and spasms are analyzed[6]. Table 2 shows all the steps taken to achieve the objectives of this research.

Table 2. Research Phases

Phase	Content
1	Subjects selection
2	Application of the Neurofunctional Assessment for Alternative and Augmentative Communication (ACADM) protocol
3	Trigger Instrumentalization and Evaluation with Electromyograph

The neurofunctional evaluation using the ACADM guided the choice of the type and region of the trigger. After the preparation of the trigger, the collection of electromyographic signals was performed on the testing day. The neurofunctional evaluations, guided by the protocol, were performed in the therapeutic setting. The protocol used to perform the acquisition of the EMG signal is described in Table 3.

Table 3. Protocol for the acquisition of the Electromyographic signal

Subjects	Basal Period	Contração Máxima	Período de Ativação
Without Contraction	Maximum Contraction	Activation period	Ciclos:10 segundos de contração e 5 segundos pausa
1	15 seconds	3 seconds	Cycles: 10 seconds of contraction and 5 seconds of pause
2	15 seconds	3 seconds	Cycles: 10 seconds of contraction and 5 seconds of pause
3	5 seconds	3 seconds	Cycles: 5 seconds of contraction and 5 seconds of pause

It is possible to observe that in subject 3, due to the diagnosis of a muscular dystrophy, it was necessary to reduce the basal time and the contraction in the period of activation. The Miograph software was used, which allowed the capture and analysis of the Elmromiographic signals of the variables: strenght, angles, acceleration and pressure. The device used was the Miotool 200/400, which makes acquisitions of signals of Surface Electromyography through suitable sensors, has 4 channels and a reference sensor input. The two-pole low-pass active filter with 1 kHz cut-off frequency was used to eliminate unwanted high frequencies.

Results

Considering the crucial importance and dependence of the improvement of evaluation and adaptation methods for the implementation of Alternative and Augmentative Communication, the present study brings out the possibility of the use of the Electromiography as a method of medium cost and easy interface-computer adaptation at the AAC clinic in the evaluation.

As explained in Methods, the ACADM protocol was first applied. After applying the ACADM, it was found out that Subject 1 needed a trigger in the eyes; Subject 2 needed a trigger in the right leg movement; while Subject 3 needed a trigger in the right wrist. Table 4 relates the trigger to the muscle group.

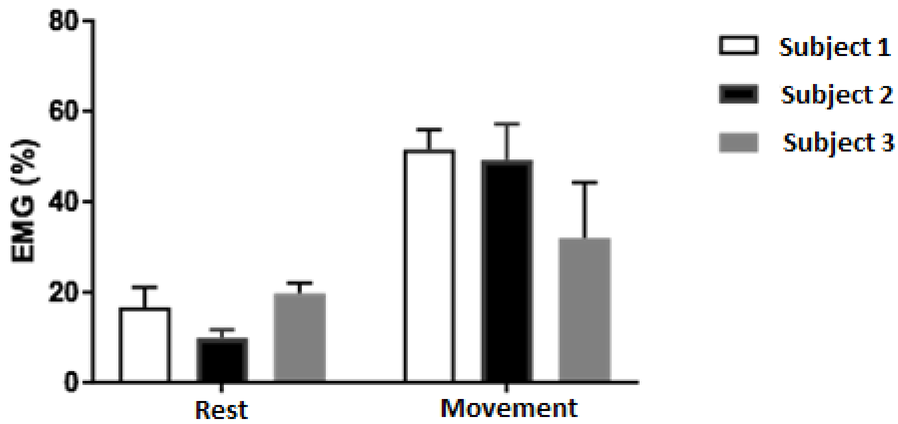
The construction of the trigger along with the partnership of the Department of Computer Science of the Federal University of Sergipe, made possible the instrumentalization of the subjects regarding the trigger. As described in Table 4, Subject 1, using infrared sensor glasses, blinked eyes to activate computer use. Subject 2, using a pressure trigger activated with right foot movement, presented consistent responses and instrumentalization. Subject 3, using an accelerometer on the right wrist, presented a slower but sufficient response for the software, perceiving the subject's intention to trigger the device.

Table 4. Relationship of the trigger and the muscle group tested in the Electromyography

Subject	Trigger	Muscle group evaluated in the EMG
1	Infrared sensor glasses	Orbicularis eye muscle
2	Pressure trigger activated with right foot movement	Right Femoral Biceps
3	Accelerometer on the right wrist	Common finger extender

The findings of the Electromyograph confirm the potential of the chosen muscle group and how much the ACADM protocol indicates the choice of the correct trigger. It also confirms the trigger positioning in regions where the electrical signal prevails.

Graph 1. Evaluation of the effectiveness of the choice of triggers through EMG, data presented as a percentage of MVC (maximum voluntary isometric contraction).



Graph 1 shows that subjects 1 and 2 present a greater difference in percentage of microvolts between the moments of rest when compared to the moment of activation. Subject 3 does not present a significant difference between the moment of rest when compared to the moment of activation. It should be noted that Subjects 1 and 2 presented the diagnosis of cerebral palsy while Subject 3 presented spinal amyotrophy type 1. Therefore, it is possible to use the EMG as a therapeutic interface for patients who have motor alterations originating from the central nervous system, not muscular-skeletal.

The possibility and necessity to use the electromyographic evaluation to confirm the effectiveness of the muscular group for adaptation and construction of the driver is, therefore, verified. However, the EMG, based on the findings of this study, is not applicable as a long-term trigger for neuromuscular diseases with pathophysiology of muscle metabolism and changes in the neuromuscular junction. The delta between rest and activation is not enough to use it as a long-term trigger in this type of pathophysiology, unlike that observed in cerebral palsy.

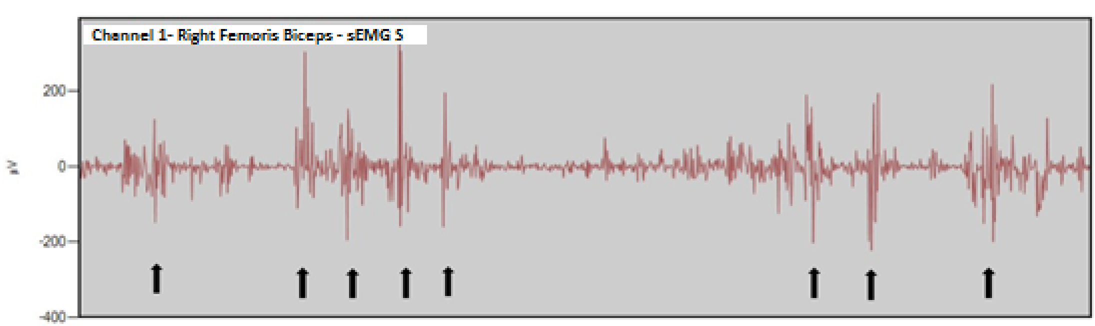


Figure 1. Demonstration of the electromyographic signal of subject 2 EMG

Figure 1 shows how the activation moments, indicated by the arrows, show the satisfactory delta in a test performed on subject 2, on the right femoral bicep of the pressure trigger activated by the right foot movement. The difference in voltage between rest and contraction is an important factor for the software to understand what is noise, response and rest, thus effectively using the alternative communication system.

Tests with EMG facilitated and confirmed the choices of the triggers with the support of the positive control in the evaluation through the electromyographic bioelectrical signals. Regarding the tests performed, we verified that the electromyographic signal confirms the accuracy and efficacy of control of the subject's musculature, even with the presence of involuntary movements of the different musculatures. The results show that even without full control of muscle movement, the response signals at the time of activity are precise and coherent.

Our patients presented EMG signals similar to those found in the literature. That corroborates with our study, regarding the consistency of the presented data. The clinical distinction was essential for the clinical decision, noting that the musculoskeletal pathophysiology of the motor disorder was essential for the choice of the communication adaptation feature.

Discussion

The process of evaluation of the subjects explained above has put into question the affirmation of the need to improve evaluation and classification tools for the choice of triggers, as well as to provide efficacy and agility when choosing the long-term trigger. Especially in the cases regarding subjects with severe motor impairment, the selection of AAC tools was better guided by the evaluation using the ACADM protocol along with the positive EMG control.

The use of ACADM, then the use of the instrumentation with the EMG, allowed a better positioning of the chosen trigger, besides the confirmation of the muscular group of interest to adapt the trigger. The EMG capture system can already be done at the Federal University of Sergipe, along with the partnership of the Department of Computer Science.

Contraction and functional motor functions in cerebral palsy are consistent, even with changes in strength and coordination, as well as associated with pathological reflexes. In cerebral palsy, the muscle group chosen by the ACADM that the patient presents control and consistency in movement does not become disorganized and does not lose functionality[16], therefore, being able to use agonist and antagonist[17].

Subject 3 presents Progressive Spinal Amyotrophy (PSA), which is a progressive genetic disease of autosomal inheritance of the motor neuron survival gene 1 (MNS), located in the telomeric region of the 5q13 chromosome. It means that it affects the body of the motor neuron in the anterior horn of the spinal cord[18,19]. The AEP presents denervation, with fibrillation at rest in cases of denervation, in the anterior horn of the spinal cord. There, motor unit potentials of increased duration and amplitude are found and the contraction speed is reduced[20].

Subject 3 presents diffuse and symmetrical hypotonia and progressive muscular weakness. These findings in the literature's EMG corroborate with the findings of our study, reaffirming the need for the use of a trigger, in the moment to choose the best trigger position and realizing that the use of EMG as a long-term trigger for the patient is not feasible with muscular dystrophy, only during instrumentalization.

Conclusion

The work showed, unprecedentedly, the use of EMG in the instrumentation of triggers in AAC, with the proposal of therapeutic use, relating two types of neurological disorders: cerebral palsy and Progressive Spinal Amyotrophy. We saw that, with cerebral palsy, it can be used as a resource in the instrumentalization of the trigger and as a therapeutic feature. Unlike PSA, EMG is essential only at the moment of instrumentalization, because the symmetrical diffuse progressive muscular weakness did not allow having enough delta to define it as a therapeutic resource.

Realizing the need for continued research, the next step will be the clinical evaluation covering more motor disorders that require adaptations in communication. The project continues in progress at Federal University of Sergipe with the partnership work of the research group of Estudos da Linguagem e Comunicação of the Department of Speech, Language and Hearing Sciences and the Department of Computer Science. The goal of this project was to try to finalize the creation of a hardware that can be triggered through the action potential of a muscle, with low cost and accessible to society. In addition to the creation of signal algorithm processing that encodes muscle contraction, it promotes the recognition of information through the AAC-EMG system.

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