



24th COBEM - 2017



24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017-2102 COMMUNICATION DEVICE FOR DEAFBLINDS: TESTING WITH USERS FOR SOFTWARE AND HARDWARE ENHANCEMENTS

Taciana Ramos Luz

Universidade Federal de Minas Gerais. Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte - MG, 31270-901
tacianaluz@gmail.com

Rudolf Huebner

Universidade Federal de Minas Gerais. Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte - MG, 31270-901
rudolf@demec.ufmg.br

Abstract. *The purpose of this study is to present the partial results of the tests of a communication device for deafblind people. People with deafblindness usually communicate through tactile stimuli and, most often, the intermediation of an interpreter. However, in a digital world, in which interpersonal contact is replaced by interfaces such as computers, smartphones and tablets, it is necessary to develop a technology that meets the demand of mobile communication for the deafblind to ensure these people a greater autonomy. This device allows the emission of signals by means of 10 digital buttons and the signals reception is made by the modulation of vibratory stimuli. The mechanical and electronic design involved the choice of the most suitable materials for the emission and reception of the signals. The choice of sensors, actuators and buttons takes into account the prevention of overload and fatigue of the user's hands after prolonged use, through biomechanical and ergonomic studies. The software design involved the development of an app in which the programming of the linguistic study was inserted by the mathematical combination and optimized association of the characters. The results of this study show the aspects that should be considered for the development of an improved second prototype which new studies will be carried out with a larger sample of participants that will contribute to the development of a final product in an affordable cost that will be effectively used by the deafblinds.*

Keywords: *deafblindness, bioengineering, communication, accessibility, ergonomics*

1. INTRODUCTION

The Communication Device for Deafblinds aims to promote the inclusion in the world of information and the autonomy in discussions' contexts increasingly mediated by technology. The device consists in the manual operation of ten buttons and in the reception of vibratory signals. The characters – letters, numbers, punctuation marks, accents and other symbols – are outputted by different combinations of fingers.

With the development of this device, the current limits of communication, which demand vision and hearing, even if residual, will be exceeded. Many products on the market make use of letters enlargement or volume boosting of speech synthesizers, which requires a certain degree of vision and hearing. With this device in particular, a person with profound hearing and visual impairments can use this technology. It is a product without similar on the market.

Other equipment involves printing embossed content. However, for online surveys and discussions, there must be simultaneity and agility in data exchange, as there is a high volume of information during conversations and Internet browsing. With the Communication Device for Deafblinds, the costly printing of numerous embossed contents will be avoided.

The communication can be done between two devices or between the equipment and an Android device - such as tablets and smartphones - that contains the app developed by the team. Thus, the user can communicate with other deafblind people who have the equipment or with non-deafblind people who have the app in their tablets and smartphones.

The Communication Device for Deafblinds promotes greater insertion of deafblind people in family, social, academic and work environments.

2. MATERIALS AND METHODS

This is an experimental pilot study conducted with two deafblind individuals with the objective of testing the communication device in terms of hardware and software operation, design and ergonomics and assessment of the comprehension of the letters and numbers combinations developed according to the frequency of use in the Portuguese language (Cader-Nascimento and Faulstich, 2016; Cristófaró-Silva, 2007). In "Fig. 1", an individual has the fingers positioned on the device.

The choice of sensors, actuators and buttons (Carvalho, 2014) was made considering the prevention of muscle fatigue after prolonged use of the hands, based on ergonomic criteria (Falzon, 2006) and biomechanical criteria (Hammil et.al., 2016; Marchetti et.al., 2007; Fonseca, 2011).



Figure 1. Prototype of Communication Device for Deafblinds

The tests were carried out at the Bioengineering Laboratory of the Mechanical Engineering Department of the Federal University of Minas Gerais (LabBio-UFMG) from March 13, 2017 to April 24, 2017 and the duration of each test was two hours. The users performed test protocol activities, developed to assess the learning of movement combinations and, consequently, the functioning of the device, regarding the emission and reception of the signals.

In signals emission exercises, the users typed pre-established combinations of letters, numbers and special characters by pressing different combinations of buttons, and these characters were sent to a tablet with the app developed by the team. In signals receiving exercises, the test protocol supervisor entered the exercises' contents in the app and the users had to identify the combinations by sensing the vibratory signals.

During the tests, the functioning of the software and the hardware, and the assimilation of the combinations developed for the letters, numbers and characters were analyzed. These combinations specially made for the device were called language.

3. RESULTS

During the tests, three dimensions of the device were assessed: hardware and software, design and ergonomics, and language comprehension. The problems were identified and solved during the test period so that the users could be reassessed. An analysis was done to verify whether the solutions proposed were effective or not. The problems and solutions for each dimension are discussed in the following topics.

3.1 Hardware and software

Hardware and software problems refer to the device's electronic structure and to software programming issues. Usually, such problems are difficult to be identified and solved. On the inside of the device, there is limited space to fit electronic components in, and any structural modification may lead to disconnections and cause malfunction. Regarding the keys, their development is always a challenge. Certain users prefer softer keys and others prefer keys that clearly identify whether it has been activated or not. Reconciling these factors and developing a key that works properly demand continuous improvement. In Table 1, these issues are explained and the proposed solutions, after several attempts, have proven to be effective.

Table 1. Problems and solutions regarding hardware and software

Problems identified	Solution proposals
Keys leaving their positions or sinking.	Replacement of the buffers of the buttons.
Vibrations of a key propagating to others.	Insulation and coating of the triggering components of each button.
Repetition of the last characters typed. When typing the combinations with greater speed, some characters are outputted repeatedly and the subsequent characters do not appear on screen.	Timing adjustments on data outputting via software.
Certain characters not appearing on screen.	Identification and solution of the problem via software.

The chaining of sentences in software programming can often generate overlapping of the program reading. For this reason, some information that had been sent was cancelled due to the subsequent programming. Identifying in which part there was the overlapping, thereby avoiding the damage of the program reading in its totality, was the focus of the discussion among the entire team of programmers in the laboratory so that the problem could be solved.

3.2 Design and ergonomics

Interface design and ergonomic issues are important to verify the degree of usability of the product. If the user feels fatigued after a short period of use or cannot handle it intuitively and independently, it is clear that the prototype or product has faults in aspects of design and ergonomics. The prototype had inadequate color and positioning of the buttons, according to Table 2.

Table 2. Problems and solutions regarding design and ergonomics

Problems identified	Solution proposals
The buttons are not visible to those who have low vision.	Buttons with more contrasting colors.
Inadequate positioning of the buttons. The position of the wrists is uncomfortable, in internal rotation	A study on the size and placement of the wrists and fingers was realized in order to find the optimal average position.
Difficulty in finding the buttons to place each finger on the ten keys.	Insertion of an embossed marker to indicate the start and the end of the buttons sequence and to direct the placement of the fingers.

One issue that was neglected by the development team and corrected after contact with users was the fact that many deafblind people have low vision, and not total blindness. The team started from the assumption of total blindness and deafness and did not think more carefully about the colors and a marker that allows the autonomous identification of the keys, very important issues for those who have low vision.

Another aspect raised and that demanded the attention of the physiotherapists who are part of the team was the positioning of the hands on the keyboard. One should always keep the fist in neutral (without lateral deviations of the hands) and consider the interindividual differences in hand size. To collect anatomical variations, a sample of 20 people was requested. The volunteers were the members of the laboratory themselves. They had their wrists and fingertips painted black and then, their hands were placed on a paper. Measurements of the distance were made from the wrists to the fingertips and an average was established.

3.3 Language comprehension

The finger combinations were established using sequential logic criteria to facilitate memorization and cognition. The users did not have difficulty in comprehending the combinations and were able to enter them in the keyboard. However, there was difficulty in understanding the combinations via vibratory signals. To solve this problem, according to Table 3, adjustments were made in the output speed of the signals and, with that, there was better understanding.

Table 3. Problems and solutions regarding language comprehension

Problems identified	Solution proposals
<p>Difficulty in identifying the vibratory signals. It was requested that the test supervisor slowly typed each character combination to facilitate the comprehension.</p>	<p>Development of a potentiometer to regulate the speed of the signals emission. As the user becomes proficient in identifying the signals, the speed of the vibrations emission can be increased. On the other hand, if the user has difficulties in the process, the emission speed can be reduced.</p>
<p>The users were confused with the combinations of adjacent letters and numbers.</p>	<p>This problem was identified less frequently with more training time. Therefore, the strategy was to prioritize the language training at points where the users had greater difficulty.</p>

The data in Table 3 also indicate that learning the codes used for communication requires a learning time that varies from individual to individual. The process is similar to learning a foreign language, i.e., it is necessary to work on the weak points, to respect the time each user demands to memorize the information and to identify their "level of proficiency" to determine the exact time to teach new combinations.

4. DISCUSSION

The concepts of product development (Rozenfeld, 2006) and ergonomics were fundamental to, as in the title of Guérin et.al. (2001), "Understand the Work to Transform It". Through the analysis of the usage activity of the device by the deafblind, it was possible to have dimension of the factors that determine the success or failure of a product, i.e., if this product will be used or discarded by the user. As a judge, the one who should be on the front line of the judgment and give the judgment is always the user during all stages of development.

The factors that will guide the improvement of the prototype for the development of the final product were identified. The next step will be tests with an expected sample of 16 deafblind people. From the experiences of the users during the tests, continuous improvements will be made on the experimental interfaces to the development of a final product with affordable cost and maintenance that is effectively used by the deafblind.

5. CONCLUSION

Engineering solutions should be tied to user validation at all stages of product development. Often, engineers and developing teams devise solutions that at first seem ideal, but users refute them or suggest details that go unnoticed during the project. For this reason, the user should be consulted since the first version of the prototype. On the Communication Device for Deafblinds project, the suggestions of the two users were of extreme importance for the modeling of the second version of the keyboard. New studies will be needed with a larger sample of users.

6. ACKNOWLEDGEMENTS

The development of this research has financial resources from the FINEP (Public Financier of Studies and Projects), based on the Bartholomeu's project (Bartholomeu, 2012) and has a favorable opinion from the Research Ethics Committee. It has partnership and support from AHIMSA - Educational Association for Multiple Disability for equipment testing among people with dysfunction.

7. REFERENCES

- Bartholomeu, A. Communication Gloves for Deafblind. FUNDEP-DEMEC-UFMG. Edital 01/2011. Belo Horizonte, 2012.
- Carvalho, MDR. Development of piezoresistive sensor matrices for advanced applications. Thesis of Doctorate in Mechatronics Engineering. Minho's university, 2014.
- Cader-Nascimento, F.; Faultsch, E. Linguistic expression and written production of deafblind people. MOARA. ISSN: 0104-0944, 1(45), 2016, 108-127.
- Cristófaros-Silva, T. Phonetics and Phonology of Portuguese. 9th edition, 2007. Ed. São Paulo: Contexto.
- Falzon, P. Ergonomia. São Paulo: Editora Edgard Blücher (edição aumentada do livro), 2006.
- Fonseca, F. Fundamentos de Biomecânica. Publindústria, 2011.

- Guérin, F.; Laville, A.; Daniellou, F.; Duraffourg, J. & Kerguelen, A. Compreender o trabalho para transformá-lo: A prática da Ergonomia. São Paulo: Edgard Blücher: Fundação Vanzolini, 2001.
- Hamill, J.; Knutzen, KM.; Derrick, TR. Bases Biomecânicas do Movimento Humano – 4th edition. Manole, 2016.
- Marchetti, P; Calheiros, R.; Charro, M. Biomecânica Aplicada - Uma Abordagem para o Treinamento de Força. Phorte, 2007.
- Rozenfeld, H; et.al. Gestão de Desenvolvimento de Produtos: uma referência para a melhoria do processo. Editora Saraiva, 2006.

8. RESPONSIBILITY NOTICE

The author(s) is (are) the only responsible for the printed material included in this paper..