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HEURISTIC ASSESSMENT OF SOFTWARE USABILITY TO FACILITATE COMPUTER USE FOR PEOPLE WITH MOTOR DISABILITIES

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ABSTRACT

There are diseases that make it difficult to use computational tools efficiently. Of course, some entities and research centers develop software applications to facilitate the accessibility and usability of equipment for people suffering from diseases that significantly alter their motor skills. Tests are conducted to ensure the software product performs the functions for which it was designed. One of them is the usability evaluation of the software, which is often done empirically. This article proposes a method with a heuristic approach to evaluate the utility of software designed to facilitate computing access for people with motor disabilities. Often, as regards usability issues, a developer who does not know the specific needs of the people mistakenly approaches the software design guidelines. This research is particularly relevant because users with medical conditions assign weight to software features that usability experts consider important.

KEYWORDS: Heuristic, Usability, Specialized Software for People with Disabilities, Human-Computer Interaction, Motor Disabilities.

EVALUACIÓN HEURÍSTICA DE LA USABILIDAD DE SOFTWARE PARA FACILITAR EL USO DEL COMPUTADOR A PERSONAS EN SITUACIÓN DE DISCAPACIDAD MOTRIZ[1]

RESUMEN

Existen enfermedades que dificultan el uso de herramientas computacionales de manera eficiente. Por esto, algunas entidades y centros de investigación desarrollan aplicaciones de software para facilitar el acceso al uso de los

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computadores a las personas que padecen alguna enfermedad que altera de manera significativa su motricidad. Para garantizar que el producto de software cumpla las funciones para las que se diseñó se le realizaron algunas pruebas. Una de ellas fue la evaluación de usabilidad del software que, a menudo, se realiza de forma empírica. En este artículo se propone un método con enfoque heurístico para evaluar la usabilidad de software diseñado para facilitar el acceso a la computación a personas con discapacidad motriz. A menudo, en temas de usabilidad, un desarrollador que no conoce las necesidades específicas de las personas aborda erróneamente los lineamientos en el diseño del software. Esta investigación toma importancia debido a que los usuarios con patologías asignan pesos a características del software que los expertos en usabilidad consideran importantes.

PALABRAS CLAVE: Heurísticas, usabilidad, software especializado en personas con discapacidad, interacción persona-ordenador, discapacidad motriz.

AVALIAÇÃO HEURÍSTICA DA USABILIDADE DE SOFTWARE PARA FACILITAR O USO DO COMPUTADOR A PESSOAS EM SITUAÇÃO DE DISCAPACIDADE MOTRIZ

RESUMO

Existem doenças que dificultam o uso de ferramentas de cômputo de maneira eficiente. Por isto, algumas entidades e centros de investigação desenvolvem aplicativos de software para facilitar o acesso ao uso dos computadores às pessoas que padecem alguma doença que altera de maneira significativa sua motricidade. Para garantir que o produto de software cumpra as funções para as quais foi desenhado, se lhe realizam algumas provas. Uma delas é a avaliação de usabilidade do software que, com frequência, se realiza de forma empírica. Neste artigo propõe-se um método com enfoque heurístico para avaliar a usabilidade de software desenhado para facilitar o acesso à computação a pessoas com deficiência motriz. Com frequência, em temas de usabilidade, um desenvolvedor que não conhece as necessidades específicas das pessoas aborda erroneamente os lineamentos no desenho do software. Esta investigação toma importância já que os usuários com patologias atribuem pesos a características do software que os experientes em usabilidade consideram importantes.

PALAVRAS-CHAVE: Heurísticas, usabilidade, software especializado em pessoas com deficiência, interação pessoa-computador, deficiência motriz.

1. INTRODUCTION

The use of computers is growing as a part of everyday life, making different activities possible in a variety of areas such as work, education, and access to entertainment and information. However, users with motor disabilities find it difficult to make use of common software applications (Gajos, Wobbrock & Weld, 2008). While some experts argue that their needs and expectations regarding access to technology should be met by specialized support devices, these devices are thought to have three main defects: high cost, the complexity of their use and excessively high demand for maintenance. The above defects cause devices to be abandoned some time after their creation (Koester, 2003, Phillips & Zhao, 1993, Scherer, 2002). Often companies feel that designing unique devices for people with motor disabilities is economically unviable as it is a small population (Keates, Clarkson, & Robinson, 2000).

It is important to mention that devices are designed for the average user and, therefore, users with motor disabilities must adapt to their characteristics (Keates, Langdon, Clarkson, &

Robinson, 2002). Other experts argue that these hardware limitations should be solved with software applications that overcome the above mentioned cost barriers (Law, Sears, & Price, 2005). Among the alternatives are versatile applications that allow people in situations of disability to use other applications such as generic office software without the need for additional devices.

The International Organization for Standardization (ISO), in standard 9241-11, defines usability as the "extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (Jokela, Iivari, Matero, & Karukka, 2003). The previous attributes are important when assessing the quality of a software application (Ferré Grau, 2005). In connection with usability are the methods of cognitive walkthroughs, standards inspection, field observation, guided discussion groups, interviews, use recording, proactive field study, and questionnaires.

This article proposes a heuristic method that allows for an evaluation of the usability of software applications designed to provide access to technology for people with motor disabilities. This research contributes to the specialized literature in the development of a method to evaluate these types of applications according to the preferences of the end users. The method proposed in this paper differs from existing methods in that it takes user preferences into account, and, based on this, the heuristics are better categorized, due to the fact that the experts do not know the specific needs of the people. The possibility for the end user to assign weights to the heuristic characteristics, indicating which are the most important for them, and that it is not the expert who set the weights without knowing the requirements of the target population is what is innovative about the proposed method (besides being the only one designed for the purpose of evaluating these types of software applications).

The article has the following structure: Section 2 presents the background and theoretical reference framework; Section 3 proposes the development of the heuristic method of evaluating usability; Section 4 presents the results and discussion; finally, Section 5 presents the conclusions.

2. MATERIALS AND METHODS

Presented below are the problems in the areas of computer use, software design, and usability assessment methods in software applications for people with disabilities. The preceding serves as input for the development of the heuristics.

2.1. Problems in the area of computer use for people with disabilities

Diseases such as cerebral palsy, muscular dystrophy, Friedreich's ataxia and spinal disorders cause spasticity, spasms, poor coordination, restricted movements, and reduced muscle strength (Keates et al., 2000). People suffering from these diseases lack the necessary mobility or ability to operate the peripheral devices of a computer, such as the keyboard and mouse, for prolonged periods (Lazar, 2007). Also, performance errors in keyboard usage are often associated with physical issues. An example of a performance error is pressing the keys for too long, which generates repeated letters or inadvertently pressing keys adjacent to the desired ones (Trewin & Pain, 1999).

The low cost of keyboards and mice generates a dependency on them. However, many people with motor disabilities are not able to use them adequately. Nevertheless, these peripherals can be enhanced by software applications that adapt to the skills of users. This alternative contrasts with the more traditional approach of creating specialized hardware so that people with disabilities can access software that is not adapted to them (Wobbrock, Kane, Gajos, Harada, & Froehlich, 2011).

Some of the existing tools that allow people suffering from the above diseases to use computers are listed in **Table 1.**

TABLE 1. SOFTWARE/PERIPHERALS TO SUPPORT PEOPLE WITH MOTOR DIFFICULTIES. CREATED BY AUTHORS

Tools	Description	Autors
Plaphoons	Software to aid communication	Proyect Fressa
Magic keyboard	Word predictor	Proyect Fressa
Keys-U-See	Keyboard with bigger than standard keys	AbleNet's
Jelly Beamer	Peripheral that allows for precision mouse use	AbleNet's
Mouse keys	Change the handling of the mouse	Microsoft
On Screen Keyboard	On-screen keyboard	*Living made easy*

2.2. Designing software applications for people with disabilities

Designing software applications for people with motor disabilities requires the adoption of strongly user-centered design practices and rigorous usability testing. Usability engineering techniques allow a designer to build a more usable end product (Jakob Nielsen, Blatt, Bradford, & Brooks, 1994).

The best solution when designing software applications for this type of population is to make the interfaces adaptable to the specific needs of each user. However, due to the wide variety of impairments among these users, it has come to be considered impractical to develop interfaces for this population, and those that are developed are not scalable (Law et al., 2005).

2.3. Software Usability Evaluation Methods for People with Disabilities

Some previous studies aim to evaluate the accessibility of websites. Therefore, usability evaluation methods in software applications for people with disabilities are not considered because they do not incorporate evaluation characteristics related to such applications.

In the literature there is a multitude of tests on the usability of web sites evaluated on people with disabilities (Manzari, 2006) (D Rømen&Svanæs, 2008) (DagfinnRømen&Svanæs, 2012), where Manzari carried out a heuristic study to measure the website usability.

Jafari, Adams, Tavakoli, Wiebe, & Janz (2017) developed a robotic system with virtual assistance. The system is designed to perform the activity of painting a geometric figure. This study is interesting because it incorporates a usability inspection and shows the evaluation characteristics. However, these are included arbitrarily and without support.

An, Kim and Kim (2013) examine the evaluation of a virtual keyboard powered by biological signals, including testing six people (two healthy people, two people with severe motor problems and two people with amyotrophic lateral sclerosis). The results are grouped into four themes: system appearance, comfort level, purchase intent and level of satisfaction. The results of this study are subjective and, therefore, manipulable according to the developer's point of view.

Another study (Hornof & Cavender, 2005) is aimed at supporting the development of a software application that allows the user to make drawings through ocular movement. The evaluation of the application is considered through a series of questions prior to its initial use. After its use is completed, new questions are posed, which provide feedback to developers to create a new version of the software application.

A formally constituted method to evaluate these types of software applications was not found in the literature review. This research includes the heuristic approach of Nielsen (1994a). This approach is used in research that develops a weighted heuristic based on the preferences of adults (Lynch, Schwerha, & Johanson, 2013). This article adapts this method to construct a new heuristic evaluation for software specialized for people with motor disabilities.

2.4. Usability

ISO 25010:2011 defines usability as "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*". The ISO 9241-11 standard (1998) defines usability in terms of efficiency, effectiveness and user satisfaction (Seffah, Donyaee, Kline, & Padda, 2006).

Nielsen (1994) specifies five breakdowns that describe the term usability, namely: ease of learning, efficiency, recall over time, error rate and satisfaction.

2.5. Heuristic evaluation

This is a method of evaluating usability through inspection that expert judges make based on previously established principles. The heuristic evaluation aims to measure the quality of the interface so that a group of users in a specific context can test it (Abran, Khelifi, Suryn, & Seffah, 2003).

3. WEIGHTED HEURISTIC EVALUATION FOR SOFTWARE USABILITY INSPECTION

Multiple models have been developed for usability inspection (J Nielsen, 1994a, Holzinger, 2005, Bradford, 1994, Camargo, Wendling, & Bonjour, 2014, Macleod & Rengger, 1993). However, these models were designed to inspect general purpose software. There is a growing need for a model that quantitatively measures a software application's capacity to be usable with a greater level of importance given to certain heuristics categorized by the user (Lynch et al., 2013).

The first step in developing a new evaluation method was to decide which guidelines to use as heuristics. Subsequently, elements from various sources were collected and a list of ten desirable characteristics was built into a support system for people with motor disabilities. This was done through a Delphi study where seven authors featured in Scopus provided two characteristics. Subsequently, each expert was sent the characteristics that other authors considered relevant for the purpose of evaluating these items, giving a rating of 1 (non-contributing) to 5 (highly contributing) (the score for a feature to be incorporated was 18/30). These characteristics were grouped into four categories, namely: efficacy, efficiency, satisfaction and learning ability (ISO, 2009). Table 2 details the characteristics.

Next, a collection of user data was performed. These patients had neuromuscular diseases whose motor activity is severely affected, and symptoms such as spasticity and muscular rigidity were evident. It became apparent during the process that some features have a greater impact on usability than others (Lynch et al., 2013). For example, a software application offering autonomy in the tasks performed has a greater effect on usability than a set of aids while the user trains. To determine the value of the weights of each heuristic, a survey was carried out on five people with different levels of motor involvement (Faulkner, 2003). The surveys were distributed via email following acceptance of informed consent by the individual or a relative of the individual in order to ensure confidentiality (Lorda, 1993). The relative was responsible for transmitting the questions to the person with the disability, if his condition prevented him from doing so autonomously. The statistical analysis of this survey is shown in **Tabla 3**.

After the weights were assigned, five specialized software applications were selected to provide access to people with motor disabilities. Two experts then evaluated them. The heuristic method used produced a percentage score in the four categories measured (efficiency, efficacy, learning capacity and satisfaction) to generate a total score. The calculation of the score included the presence score assigned by experts and which is characterized by numbers 2, 1 or 0, with 2 being the total presence of the feature in the software and 0 the total lack of the feature. The total score is the product of the presence score and the score assigned by the user (Ferré Grau, 2010).

TABLE 2. HEURISTIC EVALUATION FORMAT. SOURCE: CREATED BY AUTHORS

Efficiency	Presence?	Weight	Score
Minimum action principle			
Efficiency when executing a specific task			
Prevention of potential errors when executing a task			
Return period between action and response			
		Total efficiency score	
		Contribution to efficiency usability	
Efficacy	Presence?	Weight	Score
Effort to complete a task			
		Total efficacy score	
		Contribution to efficacy usability	
Learning capacity	Presence?	Weight	Score
Help while user trains			
Short training time			
		Total learning capacity score	
		Contribution to learning capacity usability	
Satisfaction	Presence?	Weight	Score
User adaptability			
Autonomy in tasks completed			
No add-ons required to run the software			
		Total satisfaction score	
		Contribution to satisfaction usability	

TABLE 3. WEIGHTS FOR HEURISTIC CHARACTERISTICS

	Mean	Mode	Min	Max
Minimum amount of user movements to perform a task	2.8	2	2	4
The software is efficient (The number of activities per unit of time that the user can perform using the system, Ferré Grau, 2010)	2.8	2	2	4
The software anticipates and corrects errors that users make	4	4	3	5
The software responds quickly to the actions performed by the user	2.6	3	2	3
The software requires low effort for the user to perform a task	4	4	3	5
The software has tutorials on management of the same	2.4	2	2	3
The time it takes to train in the software is short	1.8	2	1	2
The software takes the needs of each user into account	3.6	4	3	4
The software offers the user autonomy from the beginning of the system	4.4	4	4	5
The software does not require additional equipment to be purchased for use	3.2	3	2	4

4. RESULTS AND DISCUSSION

Software applications were evaluated using the new heuristic method described in Section 3, which is characterized by replacing input peripherals such as the mouse and keyboard. Two independent evaluators rated all five applications. The results of both were averaged as shown in **Table 4**. In the table shows that a high usability index was rated from 80% to 100%, a moderate usability index was 70% to 90% and a low usability index was 0% to 70%.

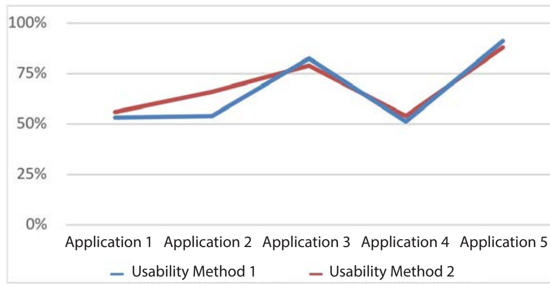
The total usability reflected in **Table 4** was obtained following the Lynch method. However, from the point of view of the authors, the arithmetic average applied to obtain the total usability of the five applications is an inadequate method in this case because it assigns equal importance to a characteristic of usability that contains one item (efficacy) to another that has four items (efficiency). To avoid this we used a weighted average (see **Equation 1**).

$$\sum_{i=0}^{m} a_i * n_i = \frac{a_1 * n_1 + a_2 * n_2 ... + a_m * n_m}{\sum n} \tag{1}$$

Equation 1. Weighted average (where n is the number of heuristics in each characteristic).

The largest change using the weighted average was in the total usability of application 2, which went from a total usability of 54% to 66%. It is important to highlight the usability reduction in applications 3 and 5 of 4 and 3 percentage points each (see **Figure 1**).

Figure 1. Comparison of the two methods



5. CONCLUSIONS

Research in human-factor engineering, psychology and other similar fields related to person-computer interaction has still seen little work conducted (Trewin & Pain, 1999, Barreto, Scargle, & Adjouadi, 1999, Istance, Spinner, & Howarth, 1996, An et al., 2013). Thus, there is a gap in this area's specialized literature. Regarding the usability of software applications that guarantee access to people with motor disabilities, studies are limited to evaluations targeted at specific separate devices, but they do not consider the perception of the users of these types of applications.

TABLE 4. USABILITY INDEX FOR SOFTWARE APPLICATIONS EVALUATED USING THE NEW METHOD

Applications	Efficiency	Efficacy	Learning Capacity	Satisfaction	Total
Application 1	75%	50%	55%	33%	53%
Application 2	80%	0%	70%	66%	54%
Application 3	90%	100%	90%	50%	83%
Application 4	55%	0%	75%	75%	51%
Application 5	85%	100%	100%	80%	91%

This is why, in this article, we designed and tested the heuristics against performance metrics and quantitative usability studies using people with motor disabilities. The research generated a usability index that is the first of its kind to assign a weight and presence score to each heuristic and is used to quantitatively classify the usability of specialized software for people with motor disabilities. It is important to emphasize that, according to the study, the different types of software evaluated have low usability, which results in their not being used by the end users. To improve this aspect of the software, users must be incorporated into the design stage in order to extract the what is required from them.

This study marks a starting point in this field for use by software designers: it demonstrates how end users can assign weights to the heuristics, indicating which are the most important for them. The heuristic with the highest average is that in which the software application offers autonomy to the user from the beginning of the system. This not only indicates that it is the metric with greater weight in the heuristic method that was proposed, but from the psychological point of view of the user, it is showed that autonomy is a fundamental part of the quality of life of the user with some motor disability.

5.1. Future work

For the continuation of this research, some lines of future work are proposed:

- Increase the number of heuristics to obtain a better score.
- Increase the number of users to improve heuristic weight adjustment.
- Correlate the analyzed usability categories with standards-based usability sub-characteristics like ISO/IEC 25000. Establish the relationship between the metrics corresponding to this standard with the evaluation generated, and adapt the results to applications that guarantee access for individuals with motor disabilities..

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