CHAPTER 3

A PILOT STUDY ON THE DESIGN CONSIDERATIONS AND USER IMPRESSIONS OF AN ASSISTIVE AFFORDABLE DEVICE

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PRESSMATIC is a portable electromechanical device which was designed to assist people whose manual dexterity has been impaired for any reason (ageing, illness, paralysis, etc.). Its goal is restoring the loss of functionality of the thumb and forefinger in certain tasks that require pinching movements (e.g. grabbing scissors, tweezers, etc.). In this paper, a study on design considerations and user experience of PRESSMATIC is presented. For that purpose, pilot trials were conducted at healthcare facilities. Target users evaluated several prototypes of PRESSMATIC and their opinions were registered. Based on this, the original design specifications were reviewed. First, the methodology used in the study is presented. Participants, devices and tasks are described too. Then, trial results are shown and the system requirements will be discussed taking into account user experience. Finally, the study conclusions are shown.

1 Introduction

Currently, in Spain and the rest of the world there are millions of people who have some kind of functional diversity (WHO, 2011). According to their level of mobility many of them are in a situation in which, while retaining much of the functionality of their upper limbs, they have difficulty to perform tasks that require some manual dexterity. Thereby, employing little tools used in daily living activities (DLA) such as scissors, tweezers,

nail clippers, etc. is difficult or even impossible for people with this kind of injury. Among the causes of this situation are spinal cord injuries, osteoarthritis, paralysis by stroke, etc. This population requires help from third parties to perform basic activities of daily living. Therefore, to develop systems to increase their independence is a need.

Related to this, arose the PRESSMATIC assistive device to restore the ability to grip of their users through automatically generate opening and closing movements. It includes several exchangeable tools suitable for activities of daily living.

In this paper, a pilot study focused on reviewing the original design specifications based on user experience is presented. First, the methodology used in the study is explained also describing testers, devices and trials. Then, the test results are shown and the usefulness of the system elements will be discussed considering the user opinions. Finally, the study conclusions are presented.

2 Methodology

The portable assistive device PRESSMATIC has been designed to automatically generate opening and closing movements in their tip. It is aimed to assist people, who lack manual dexterity required for using everyday tools such as scissors, nail clippers or tweezers. Through its technology this device is able to restore the lost ability by the user. From the design and specifications defined in (Barroso, 2012) and (Jardón, 2013), three prototypes with some morphological differences, but keeping the same functionality, were developed.

A pilot study to investigate the impressions of individuals using PRESSMATIC in some common activities is conducted at two healthcare facilities. First trial was conducted at Asociación de Parapléjicos y Personas con Gran Discapacidad Física de la Comunidad de Madrid (ASPAYM-MADRID) where individuals with different levels of spinal cord injury participated. Second trial was conducted at Laboratorio de Análisis del Movimiento, Biomecánica, Ergonomía y Control Motor (LAMBECOM) where other individuals participated, whose physical conditions and the inclusion criteria will be detailed in the next section.

2.1 Participants

A total of twelve individuals participated in this study, of which nine were individuals with both restricted mobility and dexterity manual problems.

The remaining three individuals were medical professionals from the healthcare facilities. Trials were performed in two sessions and two different healthcare centers. The first trial was performed at ASPAYM-MADRID facility, which specializes in the care and support for people with spinal cord injuries. People with this kind of lesion may retain some motor functionality depending on the exact localization of injury at spinal cord. A previous study in (Barroso, 2012) suggests that potential users to employ PRESSMATIC present a level of injury between C5 and C7, including some cases of C4. On this basis, five individuals who have spinal cord injury between level C5 and C6 were selected by medical professionals to compose the Group 1.

However, after completing the test with the first group it was revealed that generally the main requirement for a person to use PRESSMATIC is to be able to hold it and to maintain the same cognitive ability which is necessary to control a smartphone. On this basis, the individuals that were part of Group 2 were selected according to the following inclusion criteria, which Group 1 also satisfies:

a) Affectation of the upper extremity,
b) Gripping ability,
c) Spasticity according Modified Ashworth Scale ≤ 2,
d) Ability to understand Mini-mental test instructions ≥ 24.

Four individuals participated in the second trial carried out in LAMBECOM. Three of the subjects had hemiparesis, in two cases caused by a hemorrhagic stroke and the other in the aftermath of brain tumor. The fourth subject had akinetic-rigid syndrome caused by neurodegenerative Parkinson's disease. Demographic data and the experience on controlling a smartphone, of the participating groups in the study, are shown in Table 1. Besides, the group of medical professionals, who were present during the performance of the tests, is added.

Table 1. Demographics of the groups which participated in the study.

Group	**Avg. Age (Std. Dev.)**	**Gender**		**Smartphone experience**		
		Female	**Male**	**Beg***	**Inter.***	**Adv.***
Group 1	34 (4.18)	0	5	0	1	4
Group 2	47.5 (16.4)	2	2	0	1	3
Healthcare professionals	34.7 (2.89)	2	1	0	0	3

*Beg – Beginner (call); *Inter – Intermediate (multimedia, use simple apps); *Adv – Advanced (email, phone settings).

2.2 The portable assistive device PRESSMATIC

The PRESSMATIC original idea, consists of three basic elements: main body, exchangeable tool heads and control interfaces. These elements are described as follows:

i) *Main Body*: is the device itself, it hosts the actuator, transmission, control interface, battery and charger circuits (in the corresponding model). Also, it allows to connect the tool heads by means of special anchor docks and it moves them in linear guide. The external shape of the body was designed also to be ergonomic and functional.

ii) *Exchangeable tool heads:* thanks to diverse attachable tool heads the tip and therefore the functionality of PRESSMATIC changes from scissor tool, to small gripper, to tweezers or to whatever small tool, adapted to be mounted on the device. In this way, the same aid could develop a huge variety of tasks that require fine grasping abilities.

iii) *Control Interface:* PRESSMATIC by default is commanded by an embedded touch panel interface, which presents a menu of choices related with the attached tool head. For example, first the user chooses the type of tool connected depending on the task she/he wants to perform, and then the touch screen presents the right options to perform automatic pre-programmed movements in a suitable way for such tool.

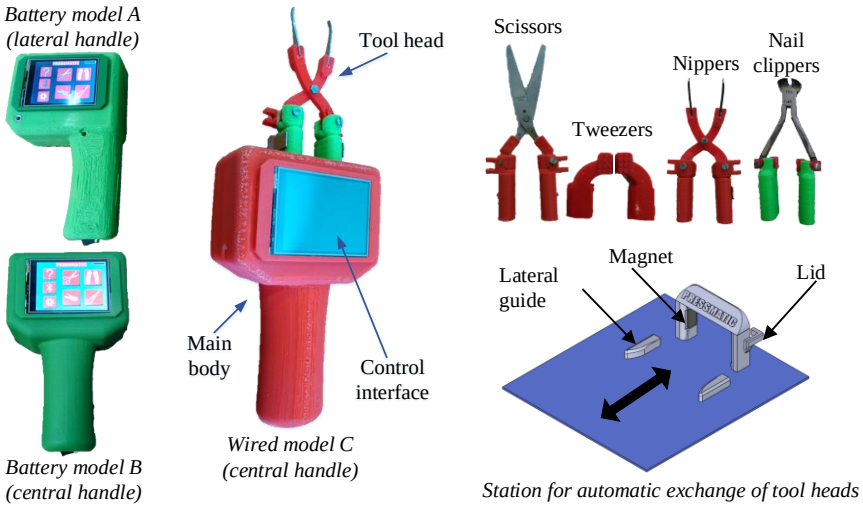

Fig. 1. PRESSMATIC system with complete tool heads set and station for automatic exchange of tool heads.

PRESSMATIC system and all its components is shown in Figure 1. Currently, there are three prototypes with morphological differences among them while keeping the same functionality (See Fig. 1 left). Models A and B are battery powered and their handle is placed either laterally or in the center, respectively. Model C is mains-powered and it has central handle. Moreover, there are four tool heads as accessories: scissors, nippers, tweezers and nail clippers (See Fig. 1 upper right corner). An automated system for exchanging tools (See Fig, 1 lower right corner) has been implemented to facilitate the use of them.

A tool-oriented functionality has been implemented to control the device (See Fig. 2). That is, the user chooses the type of tool head connected depending on the task she/he wants to perform, and then the device generates automatic pre-programmed movements in a suitable way for such tool head.

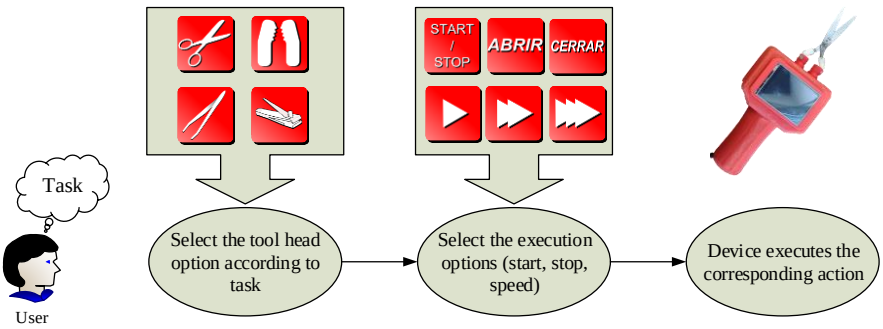

Fig. 2. Description of tool-oriented functionality of PRESSMATIC.

There are two ways to choose the tool heads to operate them: through embedded touch screen or through a app. The previous two options are mutually compatible and its graphical interface was developed under accessibility and usability criteria. The mechanical design, device functionality, the graphical interface and the app are described in detail in (Jardón, 2016).

2.3 Design of the trials

Three tasks were proposed to perform, two of them using two different tool heads, and the last one to evaluate the automated system for exchanging tool heads. The first proposed task was to cut several simple geometric figures printed on a sheet using PRESSMATIC with the scissors tool head.

At first, the individual tries to place the tool head by herself/himself. In case of not being able, an evaluator should place the tool head for her/him.

Related to controlling the device, the individuals could choose between the touch screen or the app. As second task and using either the tweezers or nippers tool heads, it was proposed to pick up a series of small objects placed inside a box, and then put them out. In this way, both the comfort to manipulate PRESSMATIC and if the device eases the tasks performance, were assessed. Finally, the third task consisted of tool heads exchange by using the station for automatic exchange. The functionality of the system was evaluated.

3 Pilot study results

The PRESSMATIC features and its control interfaces were individually evaluated by each user, who expressed their opinions via a range of satisfaction scores, from -2 to +2. Regarding the number of users for a proper usability assessment, (Virzi, 1992) and, more recently (Turner, 2006) have published influential articles on the topic of the sample size in usability testing. According to these authors, five is a proper number for usability testing. Taking into account this criteria, and since one subject was unable to attend the second trial, the results have been processed as an only group. Questions were classified on four categories and the results are summarized in the Figure 3.

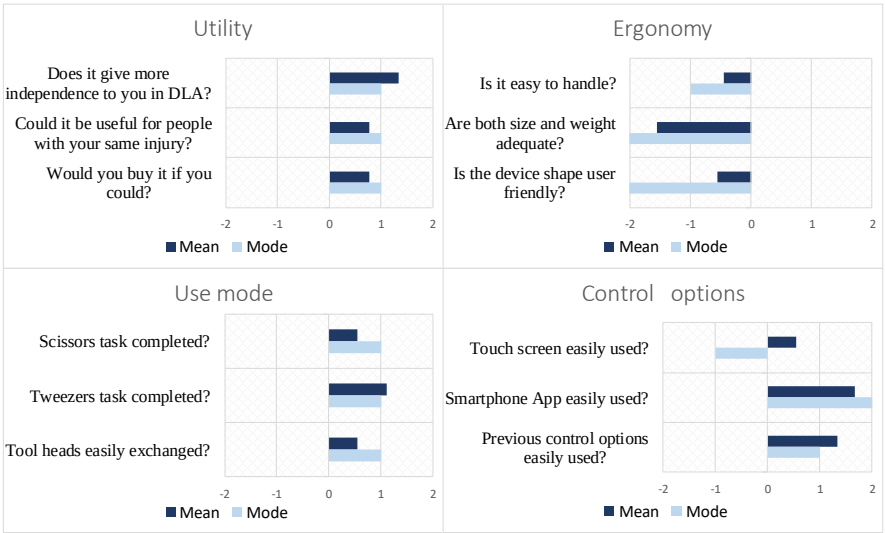

Fig. 3. Results for the usability questionnaires.

On one hand, the best results were obtained in both categories "Utility" and "Control options". Thus, PRESSMATIC was found easy to control by the individuals and that it could be useful in their daily living activities. Also, a favorable result is achieved for the "Use Mode" category, and it has an added value, when the fact that all participants were able to perform the proposed tasks is considered. On the other hand, the "Ergonomy" category has obtained the worst results. All the participants agreed on that current device weight decreases its usability.

a) b) c)

Fig. 4. Participants performing the tasks proposed.

Some pictures of participants performing the tasks proposed in tests are presented in Figure 4. Some activities such as picking up a small object by controlling PRESSMATIC through a smartphone (See Fig. 4-a), cutting a sheet (See Fig. 4-b) or exchanging a tool heads using the automated station (See Fig. 4-c) are shown.

4 Discussion

The PRESSMATIC approach to improve user independence in their daily living activities was positively accepted. While the tests were performed, the participants raised suggestions and comments, which provided insight into a range of general design opportunities and user-experience requirements of PRESSMATIC.

4.1 Alternative design considerations

One part of the study was focused on gathering the opinion of the participants, that could be included in the next version. A general conclusion was

the integrated touch screen removal, since using the app the control was better. It was suggested, that a handle support such as a strap that wraps around either the hand or forearm could be included. Other suggestion was that PRESSMATIC could be fixed to a desk, allowing the users to free their hands.

4.2 Assessment design specifications

The original system requirements are mentioned as follows: a) Performs automatic grip movements; b) Multi-tool; c) Portable; d) Ergonomic; and e) Lightweight. All prototypes comply the previous items.

These considerations were reviewed through user experience. A system made up of a main body and exchangeable tool heads is strongly accepted and the multi-tool approach is highlighted by participants. The tool head set is positively valued but an extension with more tools is requested. The device portability of both models A and B is well appreciated, but the wired condition of model C does not decrease its usability.

Regarding device weight, all participants ask for its reduction. The current device weight is 630 grams, though not optimal, it allowed manipulate PRESSMATIC properly. For that purpose, to remove the touch screen is a good option. As shown in previous Table 1, all participants had some experience using a smartphone. The idea of controlling PRESSMATIC from their own smartphone was highlighted.

The reformulation of original design requirements based on impressions and user experience are summarized in Table 2. As shown in this table, the device portability and its operating principle do not change regarding to the originals. Also, ergonomy, weight and multi-tool function do not change, but the users marked them as important. Besides, two new specifications were added as result of this study. One of them, is to remove the embedded touch screen in order to control the device only with a smartphone. The other one, is to include the station for automatic tool heads exchange approved by users.

Table 2. New system requirements for design.

Remain	Important	New
a. Performs automatic grip movements	b. Multi-tool	f. Control by smartphone (without touch screen)
c. Portable	d. Ergonomic	g. Station for automatic exchange of tool heads
	e. Lightweight	

5 Conclusions

In this paper, a pilot study on the design considerations and user experience of an assistive device is presented. For that purpose, usability trials were conducted at two different healthcare facilities. A total of nine subjects performed a series of tasks such as picking up small objects, cutting a sheet of paper or exchanging tool heads. All tasks were performed using PRESSMATIC and an appropriated tool head.

From trials, some suggestions to improve the PRESSMATIC functionality were proposed by participants, such as tool head set extension, weight decrease and touch screen removal.

Based on the user experience, the original design specifications were reformulated. Thus, new requirements were obtained. It must be highlighted, participants think that embedded touch screen could be removed, and a better way for controlling the device is through the app. This consideration could reduce size and weight of the device.

A new version of the app is currently under development. This version includes user experience, since controlling PRESSMATIC through a smartphone was positively accepted. Besides, introducing new technology to reduce the device current weight is also considerate.

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