Discount Evaluation of Preliminary Versions of Systems Dedicated to Users with Cerebral Palsy: Simulation of Involuntary Movements in Non-disabled Participants

Yohan Guerrier, Janick Naveteur, Christophe Kolski, Françoise Anceaux

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Discount evaluation of preliminary versions of systems dedicated to users with Cerebral Palsy: simulation of involuntary movements in non-disabled participants

Yohan Guerrier[1][0000-0003-1040-0799], Janick Naveteur[1,2][0000-0001-5348-5820], Christophe Kolski[1][0000-0002-7881-6435], Françoise Anceaux[1][0000-0002-5458-9573]

[1]LAMIH UMR CNRS 8201, Université Polytechnique Hauts-de-France, F- 59313 Valenciennes cedex 9
firstname.lastname@uphf.fr
[2]Univ. Lille, EA 4072 – PSITEC – Psychologie : Interactions, Temps, Emotions, Cognition, F-59000 Lille, France
firstname.lastname@univ-lille.fr

Abstract. Simulation of disabled user characteristics can be useful in two cases: (1) during preliminary tests of interactive systems, (2) to train designers and make them understand the difficulties encountered by these users with special needs. This paper describes a case study involving a preliminary user test of a system called ComMob (Communication and Mobility). It is a communication aid for people with motor disabilities of the dyskinetic Cerebral Palsy type. This software is usable in mobility and may be installed on a wheelchair. A preliminary discount evaluation was carried out in the laboratory with non-disabled participants in whom involuntary movements were induced. These movements were characteristic of users with a dyskinetic Cerebral Palsy disability. The paper focuses on the principles of the discount evaluation that was implemented. The first results are promising and show the feasibility of the approach, leading to numerous research perspectives.

Keywords: disabled user, discount evaluation, user test, simulation, cerebral palsy, involuntary movement, communication support.

1 Introduction

In the field of disability, there are user profiles (for instance Locked-in Syndrome people, dyskinetic Cerebral Palsy people…) for which it may be difficult to have a large number of participants during the preliminary evaluation stages (user tests, in the sense of Nielsen [1] or Rubin [2]). More, when the system is preliminary and may contain software bugs and basic usability problems, it is often not useful to involve these users and consequently their caregivers. Bad and buggy versions may discourage them, they have no time to loose with preliminary versions and it is more relevant to involve them in the evaluation of the next and more advanced version(s) of the system. The envisaged solution involves simulating the characteristics (or rather some of the characteristics) of these disabled users. Such a strategy can also be useful in helping designers better understand the difficulties encountered by disabled users.

This paper is part of a research project aimed at evaluating systems dedicated to the field of disability, with simulation of one or more user characteristics. It describes a step in this context, devoted to a preliminary evaluation of a communication aid called ComMob. Its target users are people with dyskinetic cerebral palsy [3] [4] [5]. ComMob was created during the doctoral thesis of the first author of this paper, who has dyskinetic cerebral palsy himself [6]. The software uses pictograms (as in [7] for instance) to allow users to formulate sentences simply and quickly. Figure 1 shows two situations of use of ComMob. Picture (a) shows a use of ComMob in a mobility situation, in a store with a tablet installed on the wheelchair [8]. Picture (b) shows a situation of interaction in the user's home, with control of a virtual keyboard visible on a screen placed on a desk. In both cases, the virtual keyboard is controlled using a joystick installed on the wheelchair. In the context of this paper, we are focused on one of its preliminary (early) versions containing software bugs and basic usability problems.

Fig. 1. Use of ComMob (a) in mobility (installed on a tablet), (b) at home (on a personal computer).

The following section is devoted to the background of this research. The paper then describes the principles of a preliminary evaluation of ComMob with simulation of user characteristics, to show the feasibility of such discount evaluation (in the sense of Nielsen [9], Curtis and Nielsen [10], Yao and Gorman [11]). As explained by Maurer and Ghanam [12]: "*While no one explicitly denied the benefits of conducting usability tests prior to releasing products, many did not adopt it due to the commonly perceived fact that it was expensive and time-consuming. In attempt to correct this perception, Nielsen and other usability practitioners coined the term* Discount Usability *in the early 1990s [13]. By introducing low-cost and easily accessible usability testing methodologies that value observation and interpretation over complex statistics, and value flexibility of procedure, space and time over expensive test labs and sophisticated experimentation, a new perception of usability engineering has* *emerged.*” In our case, the difference between the discount evaluation described in this paper and a classical evaluation is that we mechanically and at low cost induce involuntary movements in non-disabled participants. The user test results are provided afterwards. We close the paper by drawing the main conclusions and subsequent research perspectives.

2 Background

This section focuses first on users with dyskinetic cerebral palsy. Then, it deals with the principle of discount evaluation by simulation of disabled user characteristics. Finally, the preliminary version of the system used as a study framework for the proposed discount evaluation is described.

2.1 Users with dyskinetic cerebral palsy

Cerebral palsy (CP) comprises a group of abnormal movement, tone and posture causing activity limitation. Spastic CP, mostly characterized by stiffness in the limbs, is the dominant neurological profile. Dyskinetic CP is less researched but it is one of the most disabling motor types of CP with disorders arising predominantly from a lack of inhibition in motor control [14]. There is evidence for substantial inter-individual differences in the motor profile. The involuntary movements may be associated with both hypertonia and hypotonia. Primitive reflexes persist and spasticity is often present, but not as a dominating feature [15]. About 40% of dyskinetic CP people are in wheelchairs [4]. Additionally, dysarthria [16] causes speech problems that limit speech intelligibility. People with dysarthria pronounce words incorrectly, but they generally have no problem formulating correct sentences. This speech problem has been the subject of much research. Thus, communication aids facilitate simple requests such as "I want to eat" but, in everyday life, each person needs to formulate much longer and more complex sentences to express various requests and feelings. The optimization of communication is also important in various fields such as medicine or justice.

The involuntary movements typical of people with dyskinetic cerebral palsy are due to neurological damage caused by a lack of oxygen at birth, an epileptic seizure or a head injury. These movements vary in amplitude depending on the degree of disability. Other factors (stress, fatigue, environment...) can influence the intensity of involuntary movements in certain circumstances [17]. People suffering from the most serious form of this pathology may have great difficulty (or even find it impossible) to manipulate devices for interaction with computers (in the broadest sense of the term), such as mice, joysticks, or physical keyboards. This is due to their excessive involuntary movements, as well as to a more or less significant lack of precision in the movements.

2.2 Evaluation by simulation of disabled user characteristic

Simulating a motor or sensory problem in non-disabled people is a strategy that has already been implemented to test devices or treatments. Examples include: the use of participants temporarily deprived of vision to test a vibratory guidance device [18] [19] or dragged haptic bumps [20]; the wearing of an ageing simulator by young participants to test a rehabilitation system [21]. The Figure 2 illustrates a user test with low-cost simulation of blind user interacting with a system.

This approach has its limitations. For example, as Marks points out [22]: "Despite the value of demystifyng impairments, it is important to add a cautionary note regarding certain forms of 'awareness training' and, in particular, 'disability simulation'. Simulation exercices attempt to give non-disabled people an insight into the experience of impairment. This might be done by getting shop assistants to use wheelchairs, attach weights to their arms or wear blindfolds in training sessions in order to increase their appreciation of barriers to shopping. However, such training often fails to capture some of the most difficult aspects of their impairment, such as the effect of cumulative frustration, pain, fatigue or social isolation. On the other hand, simulation can also over-estimate some aspects of difficulties […]." See also [23] about blindness simulation.

This is why our paper does not try to cover all aspects of a disability: it focuses on a specifically targeted user characteristic (in our case: involuntary movements leading to difficulties in using the user interface).

Fig. 2. Illustration of user test with low-cost simulation of blind user

There is no literature on interactive system evaluation with simulation of user characteristics related to the dyskinetic cerebral palsy profile. As part of a series of preliminary evaluations of the communication support system called ComMob, a first step in this regard is presented in the third section. We present below the HCI principles of ComMob, the system at the heart of the discount evaluation described.

2.3 Presentation of the user interface of the tested preliminary system and design principles

The ComMob software mainly allows the user with cerebral palsy to build sentences from pictograms organized by theme and category in a library [24]. The disabled user also has the possibility of preparing a dialogue in advance to make the exchanges with his or her future interlocutor(s) more fluid. An advanced version of ComMob is described in [6].

During the implementation of ComMob user interfaces, we complied with the following rules. Above all, we paid attention to the size of the buttons. Inspired by Fitts' law [25], we determined the size of the buttons by looking for compromises: since a user with dyskinetic cerebral palsy generally has little precision in the movements of the mouse, he or she has difficulty in pointing to a small icon on the screen. However, we could not make the buttons too large because the software must work both on a classic computer and on a small touch tablet installed on the wheelchair (Fig. 3). The pictograms were also designed to be large so that they are easily accessible and also clearly visible. The user must therefore be able to find the desired pictogram easily. We created a tree structure with the different themes grouping all the pictograms. Since, in this study, we focused on public transport (or more generally on mobility), the tree structure does not have a significant depth. This prevents the disabled user from wasting time navigating through the different levels. In addition, we implemented several functions to produce a sentence as quickly as possible: we can cite as an example the display of pictogram proposals in relation to the previously selected pictograms.

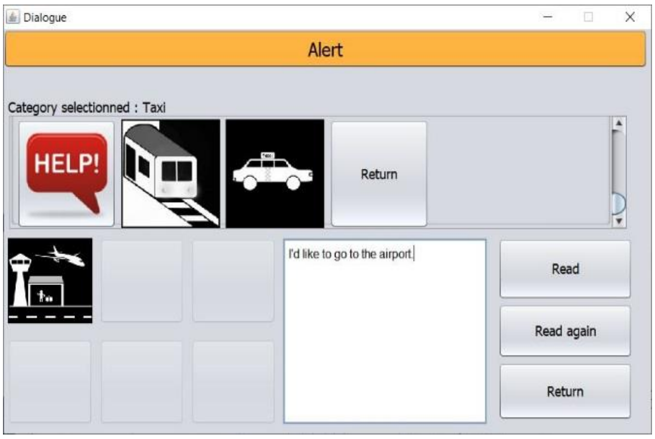

Fig. 3. User interface of the "communication aid" module used to generate sentences from pictograms.

We created a module to prepare a dialogue in advance (see Fig. 4). As a result, the future dialogue should be more fluid. Once the user has finished preparing the dialog, he or she can save it and then open it at the appropriate time and launch a voice-over speech. Another module is called: Reading a prepared dialogue. First, it proposes to choose a theme and then it displays all the dialogues recorded in that theme. Once the dialogue has been selected, the sentences are displayed one below the other. The user can have ComMob read either the entire dialogue or a sentence by placing the pointer on it. The user can modify the dialogue at any time during playback. To create or modify a dialog, the user uses a virtual keyboard (as for the example of sentence visible in Fig. 4). He or she can choose his or her usual virtual keyboard (ComMob does not impose one).

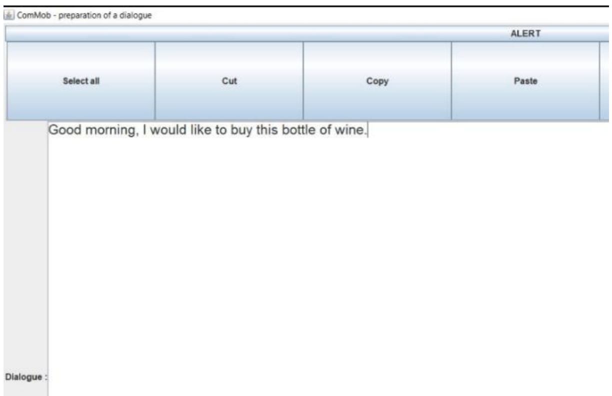

Fig. 4. User interface of the "Preparation of a dialogue" module.

The last module is called: Programming assistance. It helps the user to enter Java code to create software applications. It may be useful for programmers with cerebral palsy. This module looks like a classic text editor, but pictograms help the disabled user to create the code. It also includes a set of usual functions, i.e. copy-paste, cut-paste, etc. This module also offers a set of reusable Java codes, organized into several categories, which are chosen by the user. Each code module selected by the user can be automatically inserted into the code being created.

All the modules described above were evaluated during the preliminary tests described in the following section. The overall purpose of this evaluation was to improve the modules dedicated to users with dyskinetic cerebral palsy.

3 Discount evaluation with simulation of involuntary movements: Illustration of a usable method

In this section, we present the discount evaluation method proposed in this paper. To illustrate it, we explain how it was used for the preliminary evaluation of the ComMob software, following an original approach.

We had difficulty in recruiting participants with dyskinetic CP so we involved non-disabled people by simulating disability. To this end, we induced uncontrolled movements of the arm in charge of the action on the joystick. The arm was also weighted. This approach is essentially exploratory. The main interest of this user test is to find out if people with disabilities who are not familiar with ComMob can use the device easily.

3.1 Participants

A total of 10 volunteers participated in this preliminary user test, but one of them was discarded for technical reasons. The participants (6 women and 3 men) were all doctoral students in different disciplines. The ages ranged from 23 to 29 years old. One woman and one man were left-handed. The volunteers had varying levels in computing. Their previous expertise in manipulating a joystick was also variable. No participant had extensive theoretical knowledge about cerebral palsy. Each participant signed a consent form. The participants may also be referred to as testers (of the preliminary version of ComMob system) in the following sections.

3.2 Equipment used for this discount evaluation approach

The equipment included a laptop computer, a joystick installed on the wheelchair, and a device to connect this joystick to the computer (see Fig. 5a). One camera was used to film the computer screen and another was used to record the tester’s facial expressions. The other components were designed to simulate a characteristic of cerebral palsy. A 1.5 kg weighted bracelet (see Fig. 5b) made the arm heavier, making it more difficult to move. The bracelet was attached to a rope, itself attached by a hook to a metal pulley structure placed behind the tester's chair. This device was operated by an experimenter who pulled the rope, thereby inducing a lift of the tester's wrist.

3.3 Procedure

The user test takes place in the laboratory. The participant (tester) sits in a seat next to an observer with a dyskinetic CP profile (in this case: first author). The observer can thus observe the interactions, and then give an opinion on them. The observer has also the possibility to observe how the involuntary movements are simulated. The tester handles the joystick with his or her right hand. The joystick is controlled by a box called Easy Rider (from the HMC company) fixed on the wheelchair. This box is the link between the joystick and the computer via infrared technology.

As regards how to pull the rope, it would have been inappropriate to determine a procedure independently of the way the tasks went. As pointed out above, the movement disorders of CP individuals are exacerbated by different factors such as cognitive load, emotions, stress or pain. The prior observation of the first author during his own manipulations of the joystick suggested the occurrence of about ten involuntary movements per minute. However, this ratio was only used as a guidance and was modulated according to the tester behaviour. The rope was pulled preferably when a difficulty was encountered, as deduced from the observation of the computer screen and/or the observation of the tester reactions. The experimenter in charge of the rope was an athlete with a good control and feedback of his own body. These qualities warrant the homogeneity of the procedure. The observer also retrospectively expressed a positive opinion on how the movements were induced, including in terms of amplitude (the hand was rarely raised above the shoulder) and speed (of a large range in order to mimic a choreoathetosis profile). These upward movements with a slight tilt to the left were nevertheless simpler and less diversified than the ones he produces. Several components such as contortion or rotation were missing in order to fit both dystonia and choreoathetosis that are often present in people with CP [26], including the first author of this paper. Nevertheless, the main goal, i.e., to made more difficult to use the joystick, was reached.

(a) (b)

Fig. 5. a) Back view of the experimental station. The participant is in the center, and the experimenter at the back operates the pulley system. b) Position seen from above. A participant activates the joystick on the arm of the experimenter's armchair to her right; in the circle: focus on the weighted bracelet [27].

The oral instructions given before the user test are reduced to a minimum. He or she was initially informed that arms movements will be induced. The instruction specified that he or she had to perform the tasks at best despite of them, without playing a game of strength against pull-ups. The tester was invited to perform a set of sequential tasks according to a scenario described on a sheet of paper placed next to the computer screen. This scenario was designed to force the tester to perform a set of actions that require the use of almost all the ComMob functions:

- The first part is a *communication* task performed with ComMob. First, the tester must create a new theme, then several categories. Then, the tester must insert two pictograms in each theme. Following this action, the tester must prepare a dialogue and then have it read by ComMob. At this point, the tester issues two alerts. This part of the test ends with the deletion of the categories and themes previously created.
- The second part of the test concerns the *Programming assistance* module. It is called *programming* task in the following description. The tester must first create a new document (i.e. program), then insert a *for* loop (control structure) into the document. Then, he or she must insert a code proposed by ComMob. Finally, the tester must search for text in the document and save the document. It is important to note here that the *Programming assistance* module is intended for users with Cerebral Palsy, who are also programmers: code entry can be seen as text entry, with predefined structures (*while*, *for*, *case*…), as here with the *for* loop. It allows to write code faster (in our case essentially *Java* code).

No time constraint is imposed on the participants. The user test ends with a collection of subjective data using a questionnaire. The main purpose is to obtain the tester's opinion on ComMob, and to detect usability problems and software bugs.

The first experimenter (in this case: first author of this paper), called also observer, remains in his wheelchair to the right of the participant during the entire part of the user test involving the use of ComMob. He observes all the manipulations carried out by the participant. At the end of the test, the observer evaluates the test by completing a questionnaire. The evaluations of the tester and the first author are done independently and the results are not compared during the user test.

The second experimenter is always in the background. This experimenter induces involuntary movements by pseudo-randomly (without pre-fixed frequency) pulling the rope and monitors the test to note any problems that may occur during the procedure. As mentioned previously, involuntary movements do not follow a particular standard pattern. Therefore, we decided to induce it mechanically in this way, simply to get closer to reality, to roughly simulate it (*discount* approach).

At the end of the user test, the participant is invited to comment freely on it. He or she receives additional information about the performed evaluation and about cerebral palsy. The total duration of a session was approximately one hour per participant.

3.4 Data collection and analysis

From the videos, an analysis of the activity was carried out using the Actogram Kronos software. This tool allows chronological observations of the event code / time stamp type to be processed on the basis of a categorization carried out by the user by defining a description protocol in advance. Thus, the two phases of use of ComMob were analyzed with reference to the different stages of the specifications (scenario of tasks to be performed). A total statement of the number of clicks was also extracted for the entire session, distinguishing in particular between performing clicks (allowing progress in the completion of the task) and non-performing clicks. The clicks are categorized into icon clicks and keyboard clicks; the use of keyboard shortcuts is also quantified. Finally, the movements from the keyboard to the icons and from the icons to the keyboard are collected. The data distribution allowed parametric processing. ANOVA were performed, followed by post-hoc comparisons using the Neuwman-Keuls test. Two-by-two comparisons were made using the Student t-test. Correlations were calculated using Bravais-Pearson's r.

4 Results

4.1 Chronometric analysis

A chronometric analysis was carried out on the *communication* and *programming* tasks (described in the scenario to be followed by the testers).

***Communication* task.** All the participants successfully completed this task. The completion of the full *communication* task took in average 34 minutes (± 9; range: 23 to 42 minutes). Fig. 6 shows the duration of the different phases of this task. These data were submitted to a one-factor ANOVA with 6 levels corresponding to the 6 phases of the task. A significant effect arose: $F(5.40) = 39.79$, $p < .001$. The completion duration for adding pictograms as well as for dialogue preparation exceeded 10 minutes. Post-hoc comparisons show that the former was significantly longer that the latter ($p < .05$). These two tasks lasted significantly longer than each of the four remaining phases (all ps < .001) that do not differ from each other (less than 5 minutes each).

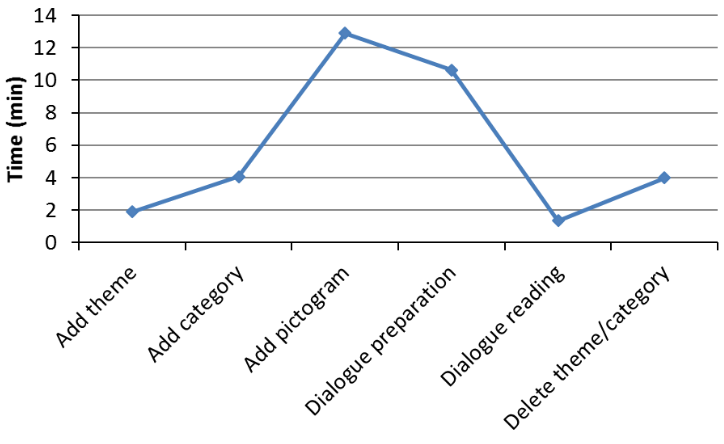

Fig. 6. Average duration of each phase of the *communication* task.

Fig. 7 shows the individual chronograms. The overall time profile is found in all participants except three of them for theme/category deletion due to a bug that caused ComMob to stop. It is important to mention/recall that the detection of this bug, occurring only under particular use conditions, is considered as an interesting result in such a user test with a preliminary version of the system.

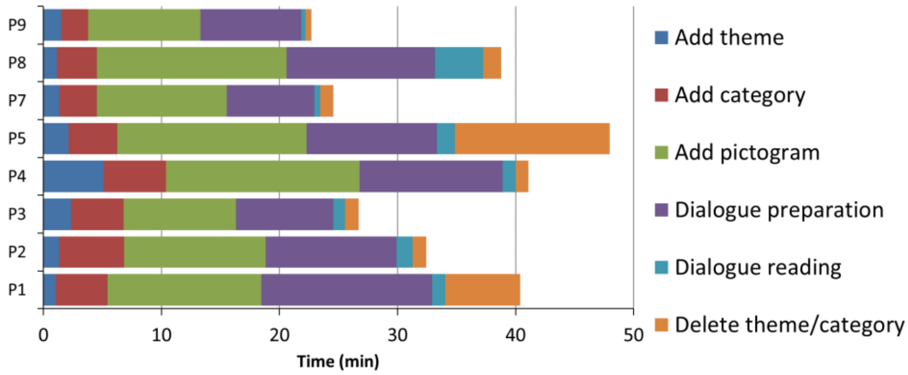

Fig. 7. Duration of each phase of the *communication* task performed using ComMob for each participant (P: participant) with simulated cerebral palsy.

***Programming* task**. All participants successfully completed this task. The completion of the full *programming* task took in average 7.3 minutes (± 1.5; range: 5.7 to 9.9 minutes). Fig. 8 shows the duration of the different phases of this task.

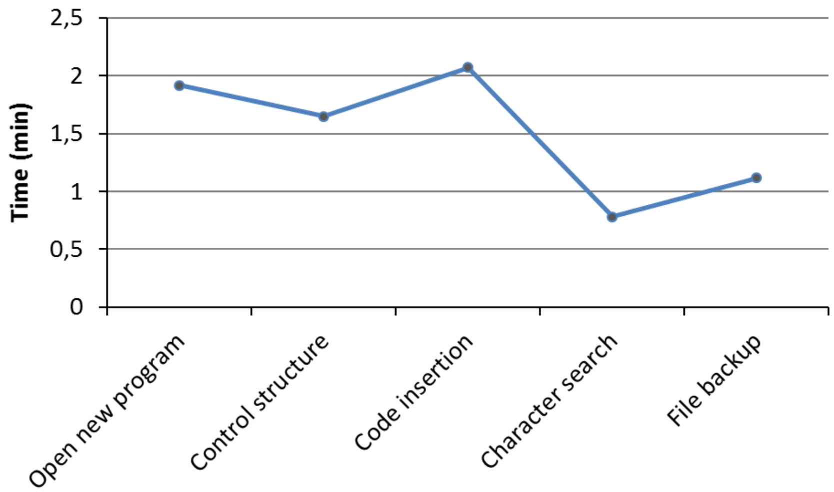

Fig. 8. Average duration of each phase of the *programming* task.

These data were submitted to a one-factor ANOVA with 5 levels corresponding to the 5 phases of the task. A significant effect arose: $F(4.32) = 7.20$, $p < .001$. With a risk of error inferior to .05, post-hoc comparisons show that participants spent significantly more time opening a new program and inserting codes than searching for characters and saving the file. The durations of the first three phases do not differ from each other but the time taken to insert the "for" loop (control structure) does not differ significantly from the file saving time ($p = .07$), while its difference with the character searching time is significant. Fig. 9 shows the individual chronograms for the *programming* task.

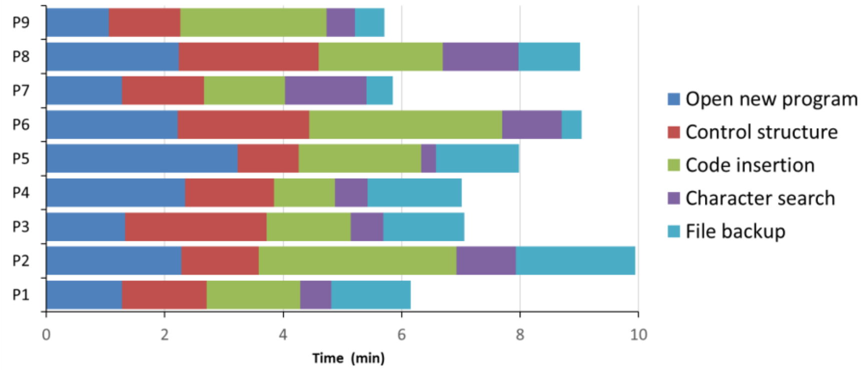

Fig. 9. Duration of each phase of the *programming* task performed using ComMob for each participant (P: participant) with simulated cerebral palsy.

Comparison of total move time on the keyboard and on the interface. For both tasks together, participants spent a total of 16.8 minutes (± 2.6) on keyboard moves and clicks and 26 minutes (± 5.2) on interface moves and clicks; this difference is significant ($t(8) = 5.74$; $p < .001$).

4.2 Quantification of clicks

All tasks together, the whole group of participants performed 342 clicks (with an average of 38 clicks per participant), in addition to which 18 keyboard shortcuts were used. Overall, an average of 25.3 unsuccessful clicks was recorded (± 7.3; range: 15 - 35), so less than 5% of the total number of clicks. Fig. 10 summarizes the distribution of the different types of clicks and use of shortcuts.

Although the number of inter-support clicks is a fortiori equivalent on the interface and on the keyboard, the total number of clicks made on the interface tends to be higher than that made on the keyboard (184.5 ± 19 versus 157.4 ± 23.1; $t(8) = 2.30$; $p = .051$). However, the trend disappears if the use of keyboard shortcuts is associated with this support ($t(8) = 0.87$; $p = .41$).

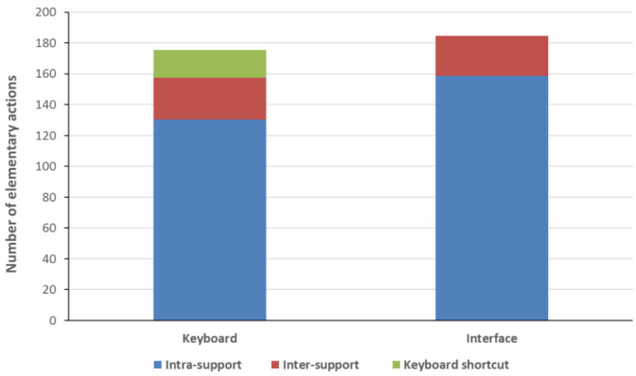

Fig. 10. Number of elementary actions (clicking or using a shortcut) performed on the keyboard and on the interface (clicking on icons) during both tasks (*communication* and *programming*) by participants with simulated cerebral palsy. Inter-support action: from the interface to the keyboard for clicks on the keyboard and vice versa for clicks on the interface.

4.3 Subjective assessments and link with the use of the device

Placed in a simulated cerebral palsy situation, participants asked to rate the usability of ComMob on a scale from 0 to 10 provided an average rating of 8.77 (± 1.1; range: 7 - 10). Correlational analysis shows that the participants with the highest usability ratings are those who clicked most on the icons (r(8) =.71; p <.05; see Fig. 11). It is also interesting to note a positive correlation between the number of icon clicks and the use of keyboard shortcuts (r(8) =.73, p <.05), even if the direct link between this latter item and the estimated usability of the device was not found (r(8) =.24, ns). No correlation between the usability rating and the duration measures reaches the significance level. When asked to assess the ease of moving the cursor with the joystick without simulating cerebral palsy (during a phase of familiarization with the equipment), and with the simulation of cerebral palsy, the scores provided by the participants were respectively 7.77 (± 1.71; range: 6 - 10) and 6.11 (± 2.71; range: 2 - 10); this difference is significant (t(8) = 2.58; p <.05).

Also asked about the ease of the *communication* task (without simulating cerebral palsy, and with the simulation of cerebral palsy), the observer with dyskinetic CP profile gave average ratings of 7.11 (± 1.16; range: 5 - 8) and 4.66 (± 1.41; range: 3 - 7); the difference is significant (t(8) = 2.67; p <.05). A 2 x 2 ANOVA with combining the data obtained from both the participants and the observer with dyskinetic CP confirms an overall effect of movement induction (F(1/16) = 30.25; p <. 001) but no significant effect of the respondent (tester vs observer, p =.19) or interaction between the respondent and movement induction (p =.31). Overall, participants report that they used the keyboard quite well (average rating: 6.89/10 ± 1.53) and that they had no major difficulties in navigating the tree structure (average rating: 2/10 ± 1.22). Also, when asked about this aspect of the task, the observer gave an average difficulty rating of 3.00 ± 2.06 which was not significantly different from that of the participants (t(8) = 1.34; p =.21).

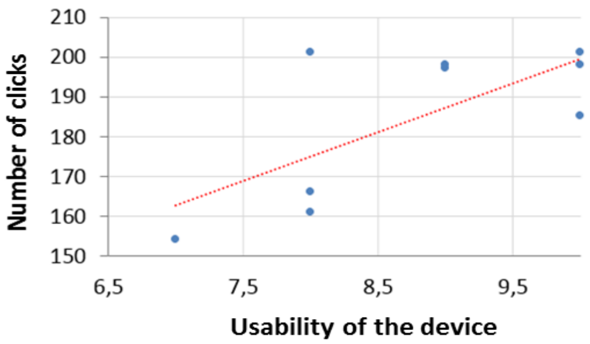

Fig. 11. Judgement of the device's usability according to the number of clicks on the interface icons by participants with simulated cerebral palsy.

As regards the *communication* task proper, 4 participants (see Table 1) reported difficulties (written in the Table in red colour), all concerning the addition of pictograms, but none of them stood out in requiring a longer period to complete this task (see Fig. 7). Table 1 shows that the observer with a dyskinetic CP profile is more critical than the participants regarding the occurrence of difficulties during this task.

Table 1. Tasks considered difficult according to each participant (P: participant) with simulated cerebral palsy and the observer with dyskinetic CP profile.

	Point of view of the participant	Point of view of the observer with CP profile
P1	Addition of pictogram	Addition of pictogram
P2	Addition of pictogram	Addition of pictogram
P3	No difficulty	Addition of pictogram
P4	No difficulty	Addition of pictogram
P5	No difficulty	Click
P6	No difficulty	No difficulty
P7	Addition of pictogram	No difficulty
P8	Addition of pictogram	Addition of pictogram
P9	No difficulty	Addition of pictogram

In addition, when asked to compare the time taken to complete the task by the tester with the time the observer considers necessary for a user of his/her profile (score from 0 to 10, ranging from an equivalent to a much longer duration), the observer gave an average rating of 3.55 (± 2.00; range: 0-6). He therefore suggests that he estimated that the task could require about 23 minutes (as compared with 34 minutes recorded during the user test, see above). This evaluation is positively related to the time taken by the participant to add pictograms and to prepare the dialogue (respectively, $r(8) = .73$ and $r(8) = .76$; $ps < .05$). In the *programming* task, no difficulties were reported by the participants, Once again however, the observer with dyskinetic CP profile is more critical. He concluded that there was no difficulty for only two participants. On the other hand, he noted difficulties in entering a file name for one participant, difficulties in inserting a code for two participants and in finding characters for four participants.

5 Discussion

The purpose of this user test was to verify the usability of a preliminary version of ComMob through a discount evaluation approach. In the absence of available disabled people (with a dyskinetic CP profile) for such preliminary stage, we recruited non-disabled people and simulated the disability. To this end, we created uncontrolled movements on their weighted arm in charge of actions on the joystick.

With regard to the *communication* assistance module, we found that participants spent the most time adding pictograms and preparing a dialogue. When adding pictograms, the user loses time because he or she has to add the pictograms one by one. Even if the observer with a CP profile (first author) considers himself faster than the participants in these phases, we would like to create a function that allows several pictograms to be added at the same time in the next version of ComMob. Concerning the preparation of a dialogue, each participant had to enter all the words with a virtual keyboard. Subsequently, we would like to establish a direct link between the function "preparation of a dialogue" and the function "formulation of sentences with pictograms". In this way, the user will have the possibility of formulating a dialogue with pictograms.

Concerning the *programming* assistance module, we were able to observe that the *creating a new file* sub-task took a considerable amount of time. We believe that this time is due to the lack of knowledge about the software environment. Indeed, when the participant begins on this new interface, he or she takes the time to look at the position of the specific buttons. And only then does he or she start the action. The obstacle should therefore no longer be present in users who are familiar with the device, but this aspect must be taken into account in familiarization phases. The second longest task is the insertion of Java codes. The user must find their place in the code tree. This action is not obvious *a priori* for a person who is not a computer scientist. However, the test shows that all users successfully completed the task. This module is therefore more easily accessible than initially envisaged.

During the evaluation, the participants who made the most positive judgments about ComMob were those who made the most clicks. This result may seem counter-intuitive because having to perform many manipulations on software often leads to a poor appreciation of it. In this case, however, it is possible that the number of clicks was related to faster progress in the task. Therefore, it made the task more pleasant. This interpretation would require confirmation in future user tests. Through this evaluation method, we have tried to get as close as possible to the conditions of dyskinetic CP disability. In addition to the fact that motor constraints are not integrated into the internal patterns of action in volunteers (participants), modeling has not enough integrated the fact that the involuntary movements of people with dyskinetic CP are strongly linked to emotions. It would have been difficult to include a controlled induction of emotions in the procedure (and this was not one of the goals of such discount evaluation). However, in the first estimate, the pulling of the rope is close to the conditions of occurrence observed in the observer with dyskinetic CP profile. The imposed motor constraints therefore provide a heuristic basis for further user tests of this type with non-disabled people. It is thus possible to gather initial user feedback to improve the system in question. We will then carry out further evaluation campaigns with targeted disabled users.

6 Conclusion

This paper showed the feasibility of discount evaluation approach with simulation of disabled user characteristics. The scope of the study included a preliminary evaluation of a communication support system, called ComMob (Communication and Mobility), intended for users with a dyskinetic Cerebral Palsy profile. A first simulation of dyskinetic Cerebral Palsy disability was implemented through involuntary movements using a pulley system. Participants had to perform a set of tasks with ComMob, while being handicapped by involuntary movements caused by an experimenter. This approach was very useful in collecting initial data (usability problems, bugs) and improving the system, before conducting evaluations with users of the targeted profile. The first results obtained are promising and it is a question of going further into depth in the analysis of the results with a view to modeling involuntary movements and studying their impact in terms of human-machine interaction.

Concerning the preliminary evaluation method that we implemented, with the introduction of involuntary movements, we aim to improve it according to the following stages:

- Work with one or more experts, from the healthcare and/or rehabilitation domains, specialized in Cerebral Palsy disability, to optimize the modeling of involuntary movements.
- Contact several users with dyskinetic cerebral palsy to help this modeling but also to deepen the knowledge of the feelings and the inter- and intra-individual variability of the use limits, with the final objective of categorizing the impacts in terms of accuracy and fatigue. The additional opinions of people present in their ecosystem (in the sense of Guffroy *et al*. [28, 29]) could prove useful to better characterize the situations concerned.
- Carry out user tests following this model by approaching ecological conditions of use, i.e. with situations requiring realistic tasks involving dialogues between disabled people and one or more interlocutors, for example: purchase of a transport

ticket, request for information about a product on a store shelf, writing a Java program (only for programmer users), etc.

- Another perspective is to use this principle for the training of interactive system designers in order to raise their awareness of the characteristics of users with disabilities, by facing them directly.
- In the longer term, it would be possible to propose a robot (or a robotic articulated arm), capable of simulating involuntary movements, in order to support such evaluations. To do so, a control model would first have to be developed. This one should be configurable particularly in terms of frequency, amplitude and speed of the involuntary movements. Such an approach would move away from discount evaluation approaches.

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