Multimedia **A**uthoring and **M**anagement using your **E**yes and **M**ind

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D6.4 – Interim report on pilot experiments based on half the subjects, including updated clinical requirements and definitions of clinical trials

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Abstract: This interim report provides a detailed description on pilot experiments based on a sample of 34 able – bodied and patient participants, and includes updated clinical requirements and definitions of clinical trials. In particular, the report will describe: (1) Three sets of results and analyses of experiments conducted in three clinical sites, (2) Recommendations for modifications of methods for the second set of pilot studies with the participation of patients, (3) Recommendations for trials related to WP7 (Monitoring social inclusion).

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Executive Summary

MAMEM is a platform designed to aid people with physical disabilities to use digital devices, in order to create optimal conditions for digitally and socially inclusive activities that promote their quality of life. The first phase of the clinical trials was designed to evaluate the MAMEM platform in a controlled environment. The purpose was to investigate the feasibility and usability of the MAMEM system and the propensity of the study participants to adopt it. More specifically, Phase I of the trials was targeted at systematically investigating and monitoring the use of MAMEM by prospective users, and at examining how the training with MAMEM, allows them to carry out tasks related to social inclusion. A sample of 34 participants was trained to use MAMEM in a half-day training session supervised by experimenters. There were 18 able-bodied participants and 16 patients. The patient sample included 5 Parkinson's disease participants, 5 participants with spinal cord injury and 6 participants with neuromuscular disease, and all had physical disabilities hindering their use of digital devices. During these clinical trials, most patients expressed strong interest in trying this innovative technology using the mind and eyes. All participants were (with the exception of 2 drop outs) able to learn to use the device in the basic, intermediate and advanced training tasks, while also showing improvement in the use of the device after practicing in more tasks. Results show that patients learned to use the MAMEM system similarly to able-bodied participants. The total sample of patients were able to successfully carry out dictated digital tasks (composing and sending e – mail, posting on social media, watching a video and uploading a photo) defined as important for social inclusion. Their performance on these tasks (as measured by time taken to carry out and accuracy) was similar to able-bodied participants. More importantly, the current findings point out that with the MAMEM system, their physical disability tends to not be a hindrance in the use of a computer. Finally, the patients in the sample tended to express satisfaction and further interest in using the system, despite some technical difficulties that had some of the patients recalibrate the apparatus repeatedly.

Half of the participants were exposed to the persuasive and personalization design elements, and participant testimonials showed that these elements added to the fun and enjoyment of MAMEM usage. However, these persuasive design elements did not seem to make a difference in participant's acceptance and use (performance) of the MAMEM system. The persuasive design elements did not get the chance to have a clear and visible impact because motivation to use MAMEM was already high, and remained high during the half-day system trial. The persuasion design elements are expected to make a difference in motivation to learn and use the system when MAMEM is used at home for the duration of a month.

The findings of Phase I trials represent the first evidence that the MAMEM system can be used effectively and efficiently by individuals with physical impairments. It is shown that individuals with disabilities can use MAMEM as effectively as able-bodied individuals. The Phase I trials present evidence that individuals with physical disabilities are able to master digital tasks conducive to social integration, and also tend to express interest in using it further. The next steps, following Phase I trials, include: a) optimizing the platform for Phase II trials, and the relevant recommendations are presented in Chapter 3, b) optimizing the protocol so as to create optimal conditions for MAMEM to exert impact on social inclusion when used at home and the relevant recommendations are presented in Chapter 4, c) the persuasion and

personalized design elements to be further developed, and deliverable D5.1 will outline their update.

Abbreviations and Acronyms

AD	Assistive Devices
DBS	Deep Brain Stimulation
EEG	Electroencephalography
NMD	Neuromuscular Diseases
PD	Parkinson's Disease
SCI	Spinal Cord Injury
SUS	Standard User Satisfaction questionnaire
QUEST	Quebec User Evaluation of Satisfaction with Assistive Technology
ADL	Activities of daily living
SMA	Spinal Muscular Atrophy

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Tables and figures

1. INTRODUCTION

MAMEM was created with the objective to facilitate the integration of people with physical disabilities actively into society, offering them the opportunity to manage and author multimedia content, using their mind and eyes, bypassing the necessity of using their hands or voice. The objective of MAMEM is to stop physical disability from being a parameter that inhibits socially inclusive activities. It is not just physical impairment that defines disability, but most importantly the consecutive socially constructed limitations in asserting an independent life and socially fulfilling roles and interactions (Rimmerman, 2013). The design and structure of digital devices has consistently neglected the specific needs of persons with disability (Goggin & Newell, 2000; Kanayama, 2003; Ransom, 1994). This has meant that unless provided with specific assistive technologies, many persons with disabilities are significantly excluded from digital environments (Stephanidis & Savidis, 2001). This digital inclusion is at the heart of an individuals' access to opportunities in life, in work, education, health as well as in personal relationships. Thus, MAMEM has sought to reshape radically the human- computer interaction with the purpose of offering a technology that will enable individuals with disabilities to fully use software applications so as to perform multimedia-related tasks using their eyes and mind. In this way, individuals with physical disability challenges will have equal chances of a more fluid use of digital devices enabling their social participation.

The development of MAMEM has been driven by three key prerogatives: a) to create the technology that shifts emphasis from fingers and spoken words to eye movements and to the mind, via electrical signals and bio measurements, creating a new paradigm in human computer interaction b) to be tested and optimized over a series of pilot clinical trials, employing prospective users who are diverse with respect to the etiology and symptoms of their disability, yet all share a degeneration of their neuromuscular system, c) finally, to assess the impact of the technology on social inclusion parameters. These parameters were defined in D7.1 (MAMEM Consortium, 2016).

This document presents the findings of the first phase of the clinical trials, which was designed to evaluate the platform in a controlled environment. Phase I of the trials was designed as a feasibility study with the purpose of investigating the usability of the system, its perceived usefulness, and the propensity of the participants exposed to it, to adopt it. Phase I trials are called in to provide information and insights that will be used towards optimizing the platform for Phase II, where it will be evaluated for maximizing the capacity of users to manage and author multimedia content that aids their being socially included.

The main research questions asked at Phase I of the trials were: 1) Are people with physical disabilities able to learn to use the MAMEM system? 2) Are they able to learn and use it as efficiently as able-bodied people might be? 3) Do they perceive that they can use it with ease and comfort? 4) Do they believe that the use of MAMEM could facilitate their interaction with other people? 5) Following the trial would people with disability be prone to adopt it?

To answer the above questions, a total of 16 individuals with disabilities were engaged in the Phase I trials, more specifically, 5 patients with Parkinson's disease, 6 with neuromuscular diseases, and 5 with spinal cord injuries. Using primarily qualitative tools, the following areas of MAMEM use were evaluated: 1) the receptivity of people with disability to the platform, 2)

their ability to learn to use it, 3) reaching competence in performing basic, intermediate, advanced and dictated digital tasks, 4) their motivation to adopt the use of MAMEM in their daily life. In addition, 16 able-bodied individuals participated in the study and were also evaluated for their ability to learn the system and to reach competence in completing digital tasks. The objective of the usage of a control group of able-bodied individuals was to evaluate whether with MAMEM, people with disabilities are able to carry out digital tasks at the same level of digital competence with able-bodied individuals, thus potentially enjoying equal opportunities for digital inclusion.

The pieces of apparatus in the Stage I trials consisted of a number of already approved and widely used instruments which allow electroencephalography (EEG) reading, gaze analyses and capturing the galvanic skin response. These were used to train participants to perform every day activities like browsing, email, photo editing and social networks.

This report presents the findings of the clinical trials across the three patient cohorts, against the able - bodied subjects.

2. DESCRIPTION OF THE THREE SETS OF RESULTS AND ANALYSES OF EXPERIMENTS CONDUCTED IN THE THREE CLINICAL SITES

2.1 Outline of the clinical trials

This deliverable describes the results of the first phase of the clinical trials which was designed to evaluate the platform at a qualitative level, in a controlled environment, to address its feasibility and usability. In these trials, the participants were exposed to a training process on how to use the platform, they performed two exploratory EEG-related tasks and subsequently their ability to operate the platform using dictated tasks was evaluated.

In addition, half the participants across both the able - bodied and the patient samples, were exposed to the MAMEM system with a version of the training software that included all persuasive and personalization design features. The other half of the participants, were exposed to the training software with these elements removed as far as possible. The objective was to evaluate whether the persuasive and personalization design features would make a difference in the propensity and motivation of the participants to use MAMEM.

The interested reader is referred to Nikolopoulos et al. (2017) for the full technical description of the clinical trials.

2.1.1 The participants

Participants in the trial were 34 individuals (N = 34). There were 16 participants with disabilities, namely, 5 with Parkinson's disease, 6 with Neuromuscular disorders and 5 with Spinal Cord Injuries. There were 2 dropouts in the total sample of participants with physical disabilities. One participant from the SCI group was removed from the study due to inability to operate the eye-tracker. One participant from the Parkinson's disease group was unable to participate due to symptoms obstructing their ability to use the eye tracker smoothly.

There were 18 able - bodied participants in the sample matched in socio demographic profile.

2.1.2 The procedure

The first part of the trial included training in basic, intermediate and advanced tasks until a predefined threshold was passed, which indicated that the participant operated MAMEM at a satisfactory level (e.g., minimal errors, sufficient low values of execution time).

Having reached a satisfactory level of MAMEM operation, the participants were asked to perform dictated tasks: writing an e-mail, photo editing, instant messaging and watching a movie online. The participants' performance was assessed by measuring: a) success rate (including mistakes), b) time to complete each step, and c) number of successful completed steps. Half of the participants were exposed to the MAMEM device along with persuasive design elements.

The outcome measures included accuracy in terms of percent of successes in performing each step of each task, time taken to complete each step of each task. Speed of usage and learning curves were also tracked.

The perceived usability and user satisfaction of the device was measured using SUS (Brooke, 1996) a standard usability questionnaire, and QUEST 2.0, a widely used and reviewed user satisfaction questionnaire (Demer et al., 2002). Finally, patient participants went through a questionnaire based on the widely researched Technology Acceptance Model (Davis, 1986 and Venkatesh, 1996), which aimed at evaluating the perceived ease of use and perceived usefulness.

Through each clinical trial the experimenter team kept a diary of observations, serving as groundwork for the qualitative analysis and integration of findings.

The Phase I study protocol was somewhat different from the one described in D6.2 (MAMEM Consortium, 2015) and D6.3 (MAMEM Consortium, 2016) . The main difference was the fact that two exploratory EEG-related tasks were added to the protocol to assess the feasibility of using EEG data to operate the platform. These were the SMR task and the Errps task. The SMR task included measuring EEG data while instructing the participants to clench their fists or to imagine that they are clenching their fists. Later the ability of the platform to classify the EEG signals while performing the same tasks was tested. The Errps task involved asking the participants to use the platform to type a few sentences in conditions that promoted mistakes while measuring EEG, HR and GSR signals in order to later assess whether it is possible to identify error related potentials in these signals.

2.1.3 Apparatus

The apparatus of Phase I trials included both the heavyweight and the lightweight MAMEM apparatus and a standard desktop computer.

The heavyweight MAMEM apparatus EEG part included the EBNeuro's EEG device, which consists of a BePlusLTM Bioelectric Signal Amplifier (64 channels) together with an EEG prewired head cap in elastic fabric (61+2 channels: 10-10 ICNS system + Ref. and GND), able to read EEG signals.

The MAMEM gaze reading part included an eye tracking system used for gaze behavior analysis (SMI REDn Scientific). The SMI REDn Scientific eye-tracker is a commercial product that conforms to the medical and safety regulation across Europe and rest of the device.

Finally, the MAMEM platform also included a galvanic skin response and HR variability measuring system. This was the Shimmer3 GSR+ Unit, which is also a commercial product that has received the necessary medical and safety regulations. The stress levels of participants were calculated by using algorithms based on GSR and HR signals.

2.1.4 Analysis of the findings

The qualitative analysis of findings

The small sample of patients and healthy participants in Phase I clinical trials mandated a qualitative analysis of the results. In proceeding with the analysis, D6.1 [ref] provided a framework of patient needs, which have been mapped in detail. This framework of patient needs was used towards creating a set of qualitative MAMEM evaluation parameters for the Phase I trials. More specifically, D6.1 has documented extensively the restrictions and needs of patients in relation to computer use. The common elements found across all three groups of patient participants were:

Strain and fatigue

Across all three patient groups effort, as outlined in D6.1, fatigue, postural strain and often pain, tended to curb or slow down the use of the computer for longer stretches of time. Consecutively, ease and competence in learning and using MAMEM became the focus of Phase I trials evaluation.

Slow use and lack of motivation

As evidenced in D6.1, slow use of the computer due to physical disability tended to dump the motivation for its more extensive use, across all three cohorts explored. Consecutively, in Phase I trials the motivation to use the system was evaluated.

Lack of independent use of the computer

As shown in D6.1, lack of independence in using the computer tended to be disheartening, due to a lack of privacy and caretaker imposition reported as uncomfortable. Consecutively, the potential of MAMEM for independent use was explored in Phase I trials.

The three clusters of qualitative evaluation parameters were organized on the basis of the stage of training and usage:

1) Pre usage stage: the receptivity and interest of participants in this new technology was evaluated, and its impact on the motivation to learn the system was noted.
2) Device usage stage: all parameters that were tracked in D6.1 like “ease of use” and “competence in using”, were taken into account.
3) Post usage stage: post training, the potential of MAMEM to be used independently was noted and evaluated. Independent use of digital devices was a major need outlined in the D6.1 study of digital usage needs.

Table 1 summarizes the three clusters of qualitative evaluation parameters, and their definition:

Table 1. Qualitative Evaluation Parameters

PRE USAGE STAGE	
Receptivity	Definition: to what extent the individual was to be eager to learn to the device and to be positive with regards to adopting it for personal use at home.
DEVICE USAGE STAGE	
Ease of learning	Definition: whether and to what extent did each of the participants experience MAMEM as easy to learn, as observed by the experimenters and reported by the participants in their testimonials.
Competence in learning the device	Definition: to what extent was each of the participants able to fully and completely learn how to use MAMEM so as to carry out specific digital tasks (as evidenced by monitored data and observed by the experimenters and reported by the participants).
Competence in using the device	Definition: how much and to what extent were the participants able to competently carry out specified digital tasks (according to Venkatesh et al., 2003 the expectation to do well using a new technology has been shown to be the stronger predictor of the intention to use it).
Enjoyment and fun	Definition: to what extent was the usage of MAMEM pleasurable and fun for the participants in the study (described as "hedonic motivation" by Holbrook & Hirschman, 1982).
POST USAGE OF THE DEVICE	
Potential for independent use	Definition: to what extent do the patients involved in the study believe that they could use the device on their own, without external help and support?

Input sources for the qualitative analysis

Experimenter observations and diaries were one source of input. Patient testimonials were also used.

Additional input sources

Usage Acceptance Questionnaire: Participants completed a usage acceptance questionnaire based on the TAM model (Davis, 1986), following their MAMEM training experience. The usage acceptance questionnaire included items that measure: the level of comfort using the device, the level of enjoyment and pleasure in using the device, the ease of use of the device, their projected ability to use the device independently, the sense of control that the user has over the device, how motivating is it to use the device, and, finally, the intention to further use it were it available. The Usage Acceptance Questionnaire was fully in line with the need analysis

presented in D6.1. (MAMEM Consortium, 2015)

Monitored data provided measures of accuracy and time in carrying out basic, intermediate, advanced and dictated tasks using MAMEM. This data, is very useful for illustrative purposes, however it needs to be kept in mind that the sample was small and qualitative data complements it.

Learning curves: The improvement of participants' performance (on time and accuracy) within the training tasks and dictated tasks was evaluated, and differences between able-bodied and patient participants were noted.

That is, the development of user performance on task completion time was analyzed:

- For basic task 1 and basic task 2, the improvement that participants exhibited in terms of completion time after repetitions of these tasks was evaluated. This evaluation was carried out across able-bodied and patient participants, and across those exposed to the persuasive design elements and those not exposed to it.
- For Intermediate task 2 and for the dictated tasks (which mainly consisted of typing using the keyboard), the improvement of typing speed was evaluated.

Also, the development of user performance on task accuracy was analyzed:

The improvement in relative accuracy scores, over the 9 different tasks, for healthy and patient participants will be presented further in Chapter 2.3 of this report.

2.1.5 Overview of the Phase I clinical trial findings

Patients during Phase I clinical trials tended to express high interest in trying MAMEM, as an innovative technology using the mind and eyes. They were able to learn to use the device for basic, intermediate and advanced digital tasks, while progressively improving in the use of the device. They were shown to be as capable to learn to use the device as able-bodied participants. The sample of patients were able to carry out dictated digital tasks defined as important for social inclusion, namely, composing and sending mail, posting on social media, watching a video and uploading a photo. They learned to do so at a speed and accuracy rate similar to able-bodied participants. This finding points out that with MAMEM their physical disability tends to not be a hindrance in the use of a computer. Finally, the patients in the sample tended to express satisfaction and interest in using the device, despite some technical difficulties, which had some of the patients, recalibrate the apparatus repeatedly.

Persuasive design : Half of the participants were exposed to the persuasive and personalization design elements, and participant testimonials showed that these elements added to the fun and enjoyment of MAMEM usage. Results show that these persuasive and personalization design elements did not seem to make a difference in participants' acceptance and use of the MAMEM system. This can be explained by the fact that participants tended to come to the trial lab with rather high interest and motivation to use MAMEM, and the innovativeness of the technology seems to have kept that motivation high throughout the hours that the participants had the chance to learn and use it. Moreover, the presence of experimenters during the trial boosted the motivation to do well and earn recognition. It was shown that when motivation to learn a device is high, the persuasion design elements do not

register an impact on performance and appeal. The persuasion design elements will be called in to exercise their impact during the one month of MAMEM usage at home, in Phase II of the trials. It is when users will be without the comfort and habit of their current devices, that the persuasive design elements are expected to kick off their impact.

Overall, Phase I clinical trials, which focused on exploring the feasibility and usability of MAMEM, point out that people with disability tended to be able to learn and use it smoothly and expressed high motivation to, and interest in, using it. Several insights were gleaned from the Clinical Trials towards improving the user experience before Phase II trials. These insights focused on 3 areas: offering an eye tracking interface that can be as sensitive and therefore as precise as possible when using the eyes and mind to handle a computer, the next one had to do with customization features, especially related to the agile use of the keyboard, and the final one had to do with optimizing the persuasive design and personalization elements.

2.2 Results

2.2.1 Parkinson disease

Six patients with Parkinson's disease (PD) and six able - bodied control individuals participated in the clinical trial. Their socio-demographic characteristics are presented in Table 2a-c:

Table 2a. Distribution of socio-demographic characteristics of participants by group and in total.

	Able - bodied		PD		Total	
	N	% / mean (standard deviation)	N	% / mean (standard deviation)	N	% / mean (standard deviation)
Age	6	53.33 (10.5)	6	64.0 (6.7)	12	58.7 (10.1)
Education	6	15.7 (2.9)	6	15.3 (3.3)	12	15.5 (3.0)
Gender						
Male	5	83.8	5	83.8	10	83.8
Female	1	16.7	1	16.7	2	16.7
Marital Status						
Married	6	100.0	6	100.0	12	100.0
Single	0	0.0	0	0.0	0	0.0
Children No.						
0	1	16.7	0	0.0	1	8.3
1	0	0	3	50.0	3	25.0
2	5	83.3	3	50.0	8	66.7
3	0	0.0	0	0.0	0	0.0
Working						
Full time	6	100.0	2	33.3	8	66.7
No	0	0.0	4	66.7	4	33.3
Hand preference						
Right	6	100.0	6	100.0	12	100.0
Left	0	0.0	0	0.0	0	0.0

Patients with Parkinson's disease had disease duration of 10.2 ± 5.4 years, age at disease onset of 58.83 ± 10.1 years and they were on 2.2 ± 0.4 stage of disease (Hoehn and Yahr stage). Detailed clinical characteristics of PD patients are shown on Tables 2a, 2b.

Table 2b. Distribution of clinical characteristics of PD participants.

	Tongue		Jaw		Neck		Shoulders		Arms		Elbows		Wrists		Hands		Fingers	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Bradykinesia																		
No	6	100	6	0.0	2	33.3	1	16.7	1	16.7	0	0.0	0	0.0	0	0.0	0	0.0
Partial	0	0.0	0	0.0	4	66.7	5	83.3	4	66.7	2	33.3	1	16.7	1	16.7	1	16.7
Complete	0	0.0	0	0.0	0	0.0	0	0	1	16.7	4	66.7	5	83.3	5	83.3	5	83.3
Tremor																		
No	6	100	5	83.3	6	100.	5	83.3	2	33.3	1	16.7	0	0.0	0	0.0	0	0.0
Mld/mod	0	0.0	1	16.7	0	0.0	1	16.7	3	50.0	4	66.7	4	66.7	4	66.7	5	83.3

	Tongue		Jaw		Neck		Shoulders		Arms		Elbows		Wrists		Hands		Fingers	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Severe Dyskinesias	0	0.0	0	0.0	0	0.0	0	0.0	1	16.7	1	16.7	2	33.3	2	33.3	1	16.7
No	6	100	6	100	5	83.3	5	83.3	4	66.7	4	66.7	4	66.7	4	66.7	4	66.7
Mild/Mod	0	0.0	0	0.0	1	16.7	1	16.7	2	33.3	2	33.3	2	33.3	2	33.3	2	33.3
Severe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

2.2.1.1 Overview of findings

Qualitative data from patient testimonials and experimenter diaries was synthesized and input from the Usage Acceptance Questionnaire filled in by the PD participants, show the following:

Pre-usage stage

Receptivity and interest: It seemed that the PD participants came to the trials with a rather high degree of interest. All patient participants in the sample expressed fascination at a device that could be operated with the eyes and mind. The PD participants had a mean age of 64 years. According to their testimonials, MAMEM represented modern and up to date technology and they tended to be eager to show that at their age they could keep up with it. To some extent, being able to master the use of MAMEM meant, for these participants, that they were able to keep up with, and live up to, modern evolution of technology. As one PD participant mentioned, “I have told my friends that today I will be using a computer with my eyes… it kind of impressed them”. So, interest and motivation for MAMEM, upon starting the trial, was rather high.

Device usage stage

Ease of learning: The PD participants were able to learn to use the platform as easily as the able-bodied participants. The sample of the able-bodied participants was matched for age. There seemed to be no notable differences that were a result of their clinical condition.

Competence in learning: All PD participants were able to learn to use MAMEM effectively, and there seemed to be no notable differences between the able-bodied and the PD participants in learning competence. The PD participants responded with a median 9.5 on a 10-point scale to the item “I could complete the training tasks using the MAMEM system if someone showed me how to do it first”. The able-bodied responded with a similar 7.5 median on a 10-point scale, on this specific item (Table 10).

Competence in using: The PD participants were able to demonstrate their learning to use MAMEM, by successfully performing the dictated tasks. According to an experimenter’s diary note, *“a participant was able to use MAMEM to upload his photo using the device, on his Facebook profile page. He expressed great pride at being able to achieve this using an innovative device, because for him it meant that he is not left behind, using conventional devices only, but, despite his progressing years, he is able to keep up with the times, and keep up with the technology”*. PD participants responded with a median of 5.5 on a 7-point scale to the statement “I have the knowledge and skill necessary to use the MAMEM system”. This response is an above average reaction (Table 12).

Enjoyment and fun: The PD participants rather enjoyed using the MAMEM platform and assigned median responses of 6.0 and 7.0 on a 7-point scale to the questions regarding the

enjoyment and fun of using MAMEM (Table 12, questions 1 and 6). The PD participants expressed pleasure at using MAMEM regardless of the tediousness of the apparatus. The impression of the experimenters was that for the older PD participants (median age was 64 years) the opportunity to be included in the training of a technology perceived as state of the art, innovative and progressive, was rewarding in itself. According to an experimenter's diary note: *"the PD participants took the learning of MAMEM as a challenge that would prove them able to be part of the modern day world and the newer technologies."*

Post-usage stage

Potential for independent use: PD participants responded with a median 6.0 on a 7-point scale to the item "I found it was easy to get the MAMEM system to do what I want it to do". They also reacted with a median 5.5 on a 7point scale to the item "I had control over using the MAMEM system"(Table 12).

2.2.1.2 Primary outcomes measures

Training tasks

Basic tasks

PD participants' were able to complete basic tasks. There is a difference between able-bodied and PD participants in the first basic task, where PD participants take longer to complete this task (Table 3). There are no notable differences in the second basic task.

Table 3. Descriptive statistics for training basic tasks by group (able - bodied vs. PD).

	Able - bodied		PD	
	N	Median	N	Median
Focus on several locations				
Time (sec)	6	38.5	6	120.5
Accuracy (%)	6	12.1	6	4.2
Score (x100,000)	6	4.8	6	4.7
Focus long enough on sequence of locations				
Time (sec)	5	32.0	2	31.5
Accuracy (%)	5	25.0	2	25.0
Score (x100,000)	5	0.8	2	0.6

Intermediate tasks

Participants' exhibited competence in the training of the three intermediate tasks as shown in Table 4. There tended to be no notable differences between the group of patients (PD) and the group of able - bodied participants, except in time taken to zoom and type on the keyboard, in which PD participants took slightly longer.

Table 4. Descriptive statistics for training intermediate tasks by group (able - bodied vs. PD).

	Able - bodied		PD	
	N	Median	N	Median
(1)Use of scrolling, finger-point button and go backward				
Time (sec)	6	47.0	6	71.0
Accuracy (%)	6	100.0	6	83.3
Score (x100,000)	6	7.6	6	6.4
(2)Zooming and keyboard typing				
Time (sec)	6	271.5	6	370.5
Accuracy (%)	6	80.0	6	80.0
Score (x100,000)	6	6.6	6	16.3
(3)Select, copy and paste				
Time (sec)	4	141.0	5	136.0
Accuracy (%)	4	87.5	5	83.3
Score (x100,000)	4	6.5	5	6.6

Advanced tasks

Participants' achieved competence in the four advanced tasks. All participants were able to complete the tasks with acceptable competence. Moreover, fair competence was there in completing the advanced tasks both among the PD group and also among the group of able - bodied participants (see Table 5).

Table 5. Descriptive statistics for training advanced tasks by group (able - bodied vs. PD).

	Able - bodied		PD	
	N	Median	N	Median
(1)Gaze visualization toggling				
Time (sec)	6	74.5	6	70.5
Accuracy (%)	6	53.3	6	100.0
Score (x100,000)	6	8.1	6	8.2
(2)Input URL and abort				
Time (sec)	6	52.5	6	77.5
Accuracy (%)	6	100.0	6	92.3
Score (x100,000)	6	8.7	6	8.1
(3)Use the word prediction				
Time (sec)	6	118.0	6	141.0
Accuracy (%)	6	100.0	6	100.0
Score (x100,000)	6	8.0	6	7.6
(4)Bookmark				
Time (sec)	6	52.0	6	52.5
Accuracy (%)	6	100.0	6	100.0
Score (x100,000)	6	9.1	6	9.1

Errps and SMR tasks

The experimenters were asked to rate the performance of the participants using a subjective score based on their impression of how well the participants performed the Errps and SMR tasks. These rates were evaluated using a Likert scale ranging from 1 (not good) to 5 (very good). Generally, the performance in both tasks was reasonably fair, and there were no notable differences across PD and able-bodied participants. The Errps and SMR tasks performance rating scores are presented in Table 6.

Table 6. Descriptive statistics for the Errps and SMR tasks by group (able - bodied vs. PD).

	Able - bodied		PD	
	N	Median	N	Median
Errps score	6	4.0	5	4.0
SMR score	6	2.0	5	3.0

Dictated tasks

Participants' competence in the four dictated tasks was fair. Namely, all participants were able to complete the task acceptably**.** PD and able-bodied competence (as shown by time needed, accuracy rate, composite score) in the four dictated tasks is presented in Table 7, and the two groups were shown to perform similarly.

Table 7. Descriptive statistics for dictated tasks by group (able - bodied vs. PD).

	Able - bodied		PD	
	N	Median	N	Median
E-mail				
Time (sec)	6	242.5	5	285.0
Click Accuracy (%)	6	35.42	5	42.86
Photo Edit				
Time (sec)	5	148.0	5	130.0
Click Accuracy (%)	5	57.1	5	66.67
Social networks				
Time (sec)	6	200.0	5	230.0
Click Accuracy (%)	6	87.5	5	60.0
YouTube				
Time (sec)	6	135.0	5	165.0
Click Accuracy (%)	6	100.0	5	100.0

2.2.1.3 Secondary outcomes

User acceptance and evaluation of persuasive design

The user acceptance and evaluation of persuasive design questionnaire – Part I, was passed right after the platform training part. In Questions 1-4 the participants were asked to report whether the platform made them feel scared, nervous, un-pleasant or uneasy by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). In question 1 the order of the answers was reversed to be compatible with the other questions.

PD participants did not express discomfort or unease with regards to MAMEM assigning a 2.5 median on a 7-point scale (very uncomfortable/uneasy) to the respective questionnaire items. Moreover, they assigned a median 7.0 on a 7-point scale to the item “MAMEM did not scare me at all”, and a 5.5 median on a 7-point scale to the item “MAMEM system made me nervous”. There tended to be no notable differences between PD and able-bodied participants. (Tables 8). There were no notable differences between able-bodied and PD participants on the basis of persuasive design (Table 9).

Table 8. Descriptive statistics for answers on questions 1 to 4 of User Acceptance Questionnaire Part1 among PD participants

	Able - bodied		PD	
	N	Median	N	Median
The MAMEM system did not scare me at all	6	7.0	6	7.0
Operating the MAMEM system made me nervous	6	7.0	6	5.5
The MAMEM system made me feel uncomfortable	6	1.5	6	2.5
The MAMEM system made me feel uneasy	6	1.0	6	2.5

Table 9. Descriptive statistics for answers on questions 1 to 4 of User Acceptance Questionnaire Part1 among PD participants by design (persuasive vs. non-) PD participants.

	Non-persuasive		Persuasive	
	N	Median	N	Median
The MAMEM system did not scare me at all	3	7.0	3	7.0
Operating the MAMEM system made me nervous	3	5.0	3	6.0
The MAMEM system made me feel uncomfortable	3	3.0	3	2.0
The MAMEM system made me feel uneasy	3	2.0	3	5.0

Question 5 asked the participants whether they believe they could operate the platform after they learned to use it alone, using the games or demonstrated how to use it by an instructor, by indicating whether they agree or disagree with corresponding statements on a scale of 1 (completely not sure) to 10 (completely sure). The results (Table 10) indicate that when PD participants are first shown how to do the training tasks, they tend to be more confident (9.5 median on a 10 point scale). Their confidence falls below average (4.0 median on a 10 point scale) when “there is no one around to tell me what to do”. This is an important indication to be taken into consideration in the preparation and execution of Phase II trials. Persuasive design seemed to exert an impact in that participants who had used the software with persuasive design elements tended to feel less the need for someone to show them what to do (Table 11).

Table 10. Descriptive statistics for Answers on question 5 of the User Acceptance Questionnaire Part1 among PD participants.

		N	Median
I could complete the training tasks using the MAMEM system…	…if there was no one around to tell me what to do.	6	4.0
	…if I had just the build-in practice games for practicing	6	5.0
	…if someone showed me how to do it first.	6	9.5

Reactions to user acceptance questionnaire part 1, Question 5, tended to show no notable differences by design, persuasive or not. (Table 11).

Table 11. Descriptive statistics for answers on question 5 of the User Acceptance Questionnaire Part1 among PD participants by design (persuasive vs. non- persuasive).

		Non-persuasive		Persuasive	
		N	Median	N	Median
I could complete the training tasks using the MAMEM system…	…if there was no one around to tell me what to do.	3	5.0	3	3.0
	…if I had just the build-in practice games for practicing	3	5.0	3	4.0
	…if someone showed me how to do it first.	3	10.0	3	6.0

Questions 6-14 asked the participants to report on various aspects of the platform such as its ease of use or pleasure in addition to whether they believe they have enough knowledge to operate it or they believe they had control over it by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). PD participants assigned a median 6.0 rating to the attributes “enjoyable” and “pleasant”. According to their responses they found the MAMEM system above average in “enjoyable to use”. With regards to control over the system the PD participants assigned a median 5.5 rating to the item “I had control over using MAMEM” and a median 6.0 to the item “I find it easy to get MAMEM to do what I want it to do”. In terms of confidence, they assigned a 5.5 median rating to the item “I have the skills and knowledge necessary to use the MAMEM system” (Table 12).

Reactions to user acceptance questionnaire part 1, by design (persuasive or not), are presented in Table 13 and it seems that there are no notable differences across participants who were exposed to the persuasive design elements and those not.

Table 12. Descriptive statistics for answers on question 6-14 of the User Acceptance Questionnaire Part1 among PD participants.

	N	Median
I had control over using the MAMEM system	6	5.5
I have the skills and knowledge necessary to use the MAMEM system	6	5.5
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	6	5.5
My interaction with the MAMEM system was clear and understandable	6	6.0
I find the MAMEM system to be easy to use	6	5.0
I find it was easy to get the MAMEM system to do what I want it to do	6	6.0
I find using the MAMEM system enjoyable	6	6.0
The actual process of using the MAMEM system was pleasant	6	6.0
I had fun using the MAMEM system	6	7.0

Table 13. Descriptive statistics for answers on questions 6-14 of the User Acceptance Questionnaire Part1 among PD participants by design (persuasive vs. non-)

	Non-persuasive		Persuasive	
	N	Median	N	Median
I had control over using the MAMEM system	3	6.0	3	2.0
I have the skills and knowledge necessary to use the MAMEM system	3	6.0	3	5.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	3	7.0	3	5.0
My interaction with the MAMEM system was clear and understandable	3	7.0	3	6.0
I find the MAMEM system to be easy to use	3	6.0	3	5.0
I find it was easy to get the MAMEM system to do what I want it to do	3	6.0	3	6.0
I find using the MAMEM system enjoyable	3	6.0	3	6.0
The actual process of using the MAMEM system was pleasant	3	6.0	3	6.0
I had fun using the MAMEM system	3	7.0	3	6.0

Questions 15-17 asked the participants to report on the personalization of the system and whether they believe the games that were used in the training stage motivated them. Finally, question 18 asked the participants whether they would use the system if it were available to them in the future. This was done by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). PD participants assigned a median 6.0 to the items: "the training tasks motivated me to train my skills in MAMEM" and "I had the feeling that messages in MAMEM were intended for me". There did not seem to be any notable differences in reactions, by design, persuasive or not (Tables 14 and 15).

Table 14. Descriptive statistics for answers on question 15-18 of the User Acceptance Questionnaire Part 1 among PD participants

	N	Median
The training tasks motivated me to train my MAMEM skills (e.g., focus with my eyes, scroll the screen down, etc.)	6	6.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	6	6.0
I had the feeling that the messages of the MAMEM system were intended for me	6	6.0
Assuming I had access to a MAMEM system, I intend to use it.	6	6.5

Table 15. Descriptive statistics for answers on questions 15-18 of the User Acceptance Questionnaire Part1 among PD participants by design (persuasive vs. non- persuasive).

	Non-persuasive		Persuasive	
	N	Median	N	Median
The training tasks motivated me to train my MAMEM skills (e.g., focus with my eyes, scroll the screen down, etc.)	3	6.0	3	5.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	3	6.0	3	6.0
I had the feeling that the messages of the MAMEM system were intended for me	3	6.0	3	5.0
Assuming I had access to a MAMEM system, I intend to use it.	3	7.0	3	6.0

User acceptance and evaluation of persuasive design – Part II

The user acceptance and evaluation of persuasive design questionnaire – Part II, was passed right after the dictated tasks part. The following table presents the averages and standard deviations of this questionnaire results.

In Questions 1-3 the participants were asked to report whether the platform could provide better interaction, abilities and output for similar tasks that were tested in the dictated tasks. PD participants assigned a very positive median 7.0 on a 7-point scale to the item “MAMEM will result in my interacting more and better with people and groups” and “using MAMEM will increase my productivity on such kinds of tasks (Table 16). There did not seem to be any notable differences in reactions, by design, persuasive or not (Table 17).

Table 16. Descriptive statistics for answers on question 1-3 of the User Acceptance Questionnaire Part 2 among PD participants by group (able - bodied vs. PD).

	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	6	7.0
Using MAMEM will increase my productivity on such kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	6	7.0
Using MAMEM will improve my ability to effectively carry out these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	6	6.5

Table 17. Descriptive statistics for answers on questions 1-3 of the User Acceptance Questionnaire Part 2 among PD participants by design (persuasive vs. non-)

	Non-persuasive		Persuasive	
	N	Median	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	3	7.0	3	7.0
Using MAMEM will increase my productivity on such kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	3	7.0	3	7.0
Using MAMEM will improve my ability to effectively carry out these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	3	7.0	3	6.0

Questions 4-8 asked the participants to report on whether they found the platform useful, relevant for the type of tasks that were tested in the dictated tasks, whether they found the platform cumbersome, whether they would use the platform if it was available to them in the future and whether they think that most people would learn how to use it fast. The PD participants expressed a high intention to use MAMEM (a median 7.0 on a 7 point scale), while they did not find it cumbersome (a median 1.0 on a 7 point scale (Table 18) There did not seem to be any notable differences in reactions, by design, persuasive or not (Table 19)

Table 18. Descriptive statistics for answers on question 4-8 of the User Acceptance Questionnaire Part2 among PD participants

	N	Median
I find using MAMEM to be useful for these kinds of task (send an email, use social media, watch a YouTube video, and edit a photo)	6	7.0
The use of MAMEM is relevant for these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	6	6.0
Assuming I had access to a MAMEM system, I intend to use it.	6	7.0
I found the MAMEM system very cumbersome to use.	6	1.0
I would imagine that most people would learn to use the MAMEM system very quickly.	6	4.5

Table 19. Descriptive statistics for answers on questions 4-8 of the User Acceptance Questionnaire Part 2 among PD participants by design (persuasive vs. non-persuasive).

	Non-persuasive		Persuasive	
	N	Median	N	Median
I find using MAMEM to be useful for these kinds of task (send an email, use social media, watch a YouTube video, and edit a photo)	3	7.0	3	7.0
The use of MAMEM is relevant for these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	3	6.0	3	6.0
Assuming I had access to a MAMEM system, I intend to use it.	3	6.5	3	3.0
I found the MAMEM system very cumbersome to use.	3	1.0	3	1.0
I would imagine that most people would learn to use the MAMEM system very quickly.	3	4.0	3	5.0

System Usability (SUS), User Satisfaction Questionnaire (QUEST)

The SUS scores were calculated according to the standard way of calculation of this questionnaire (Brooke, 1996) namely by assigning a relative score to each item and performing a calculation with their sum. The quest scores were calculated by averaging the first part of the questionnaire that concerns the different physical and usability aspects of the assistive system. The perceived usability SUS score was 58.7%, a score slightly above average. The QUEST score was a "rather satisfied" 4.40 on a 5-point Likert scale (Table 20).

Table 20. Descriptive statistics for scores on the QUEST 2.0 and SUS questionnaires among PD participants.

	N	Median
Quest 2.0 score	6	4.40
SUS score	6	58.7

Scores on the QUEST 2.0 and SUS questionnaires did not seem to differ by design, persuasive or not (Table 21).

Table 21. Descriptive statistics for scores on the QUEST 2.0 and SUS questionnaires among PD participants by design (persuasive vs. non-persuasive).

	Non-persuasive		Persuasive	
	N	Median	N	Median
Quest 2.0 score	3	4.4	3	2.6
SUS score	3	65.0	3	52.5

2.2.1.4 Physiological outcomes

The stress levels were assessed using the GSR signals that were monitored throughout the study. To calculate stress levels using these signals, an algorithm was used for stress detection that scanned the GSR signals in an unsupervised manner and computed 4 different thresholds categorizing the stress level of the participant in 5 levels. Thus, the result of the algorithm can be one of the following values [1, 2, 3, 4, and 5]. Before generating the figures a mean filter (1-minute length) has been applied to the result of the algorithm for smoothing. The data shown in each figure, corresponds to the first 4 phases of the trial:

(a) Training

(b) Errp task - Heavy conf.

(c) SMR task - Heavy conf.

(d) Dictated task

The results regarding physiological outcomes are presented in Table 22 and in Figures 1a and 1b. It seems that among the able-bodied participants the stress levels became lower after a point, while in the case of PD participants the stress levels were kept fairly high through the training. However, these results, for PD participants cannot be considered conclusive, given the

small sample and the short duration of the trial. It can be hypothesized that PD patients may need slightly longer than able-bodied individuals to become comfortable with the system, but this is only a hypothesis at this stage.

Table 22. Descriptive statistics for physiological results by group (healthy vs. patients) for PD cohort

	N	Median	N	Median
	Patients (PD)		Healthy	
GTW Stress (mean)	5	1,9	6	3,0
Errp Stress (mean)	5	2,5	6	4,0
SMR Stress (mean)	5	2,5	6	1,8
Dictated Stress (mean)	5	4,1	6	2,1

Figure 1a. Stress levels, PD participants

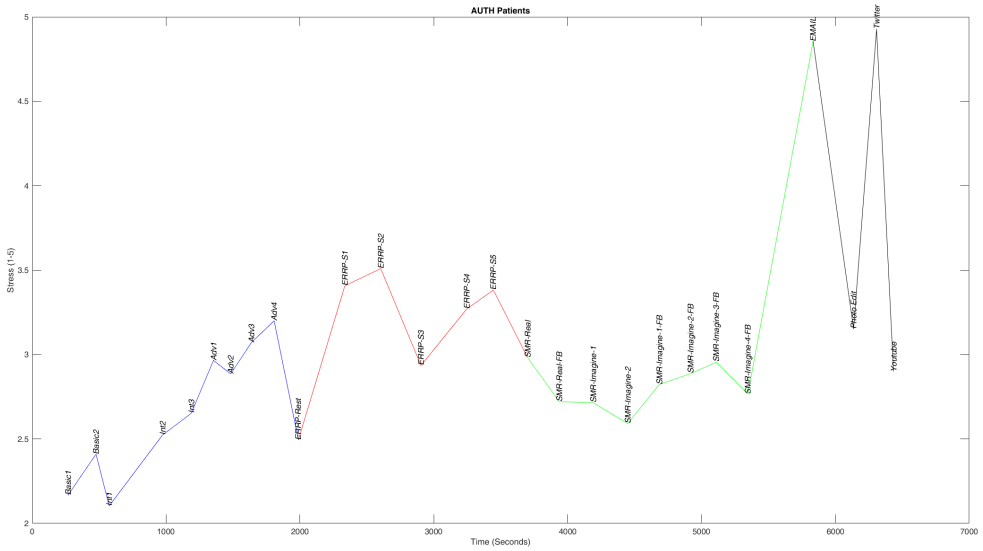
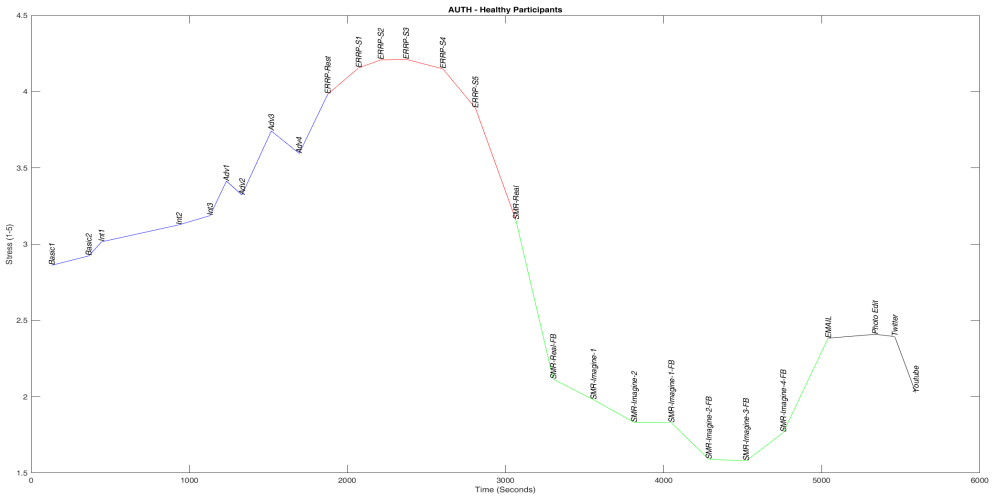


Figure 1b. Stress levels, healthy participants



2.2.1.5 Patient Testimonials

Receptivity to the experiment

All participants showed great interest in the platform and they were eager to participate. They were fascinated with the new technology and especially with the idea of writing and editing text, operating the computer with the eyes. So they accepted the duration of the trial, about for 4-6 hours, without any complains.

Reactions to the process and equipment

In general participants' feedback for the platform was positive. Some of them, especially the PD patients, were so enthusiastic that they started sending mails to their friends about the new technology miracle that enabled them to write with their eyes. The eye tracker worked well in almost all participants. One patient had a problem, particularly when he was looking down, because of minor eyelid ptosis due to an old injury and another one because of slanted body and head posture. The process of heavyweight equipment fitting and the use of gel were somewhat uncomfortable, and some participants complained, but nevertheless, they were eager to proceed with the task.

Issues and concerns

1) The lack of Greek language support was a challenge for some of the participants. With older people English language fluency can be an issue.
2) Vision can be an issue: PD patients are older and often wear glasses, something that can be a challenge in eye calibration. A big screen is an asset with older PD participants because they are better able to see and focus on specific areas and keys when the images are bigger.

2.2.1.6 Experimenter's diary

The PD cohort presented two issues; one was the eye dropping and one with the head of a participant leaning towards the right side. In both cases, the eye tracker could not identify the

eyes easily and several re calibration steps were required. In addition, when participants used glasses it was difficult to reach sufficient levels in the calibration procedure. Finally, there were cases that the EPOC head cup was moving during the experiment and the staff had to replace it. As a result, we cannot be sure that the cup was placed in the exact same position each subsequent time.

It seemed that it was difficult for the majority of the participants to focus on the upper left corner as well as on the rhombus in the basic tasks. Moreover, the response time of the space and backspace button was different from the rest of the buttons making it difficult for the participants to realize whether these buttons were pressed or not. Lastly, the decision time on the keyboard was fixed (1 second) and there were cases that this time was not enough or was too much for some individuals. Making this keyboard time adjustable could make the user experience a lot better.

2.2.1.7 Discussion

Competence at MAMEM learning

PD patients were able to learn the MAMEM system efficiently, and there did not seem to be evidence of differences in the competence with which PD and able-bodied participants learned and performed the MAMEM tasks.

Intention to use MAMEM

The PD participants reacted positively to the technology, and expressed interest to use it. What tended to be the more motivating element for them was the innovativeness of the technology, which makes them feel included in a society that speeds forward. They feel not left behind but progressing along with it.

Impact of persuasive design

The persuasive design elements did not seem to make an impact on the usability and acceptance of the MAMEM technology. It seems that the novelty of the technology itself was a strong motivating factor, and even in the absence of persuasive design elements the participants seemed to be very motivated to do the tasks and accomplish them as best as they could.

Limitations of the study

A bigger sample would allow for a more detailed study of the impact of age, degree of disability, and degree of existing computer usage on the reactions to, and the impact of, the MAMEM system on participants.

2.2.2 Spinal Cord Injury

The Sheba sample included six participants with an SCI and six able - bodied subjects. Their socio-demographic characteristics are as follows (Table 23 a-c):

Table 23a. Distribution of socio-demographic characteristics of participants by group and in total.

	Able-bodied		SCI		Total	
	N	% / mean (standard deviation)	N	% / mean (standard deviation)	N	% / mean (standard deviation)
Age	6	43.5 (16.5)	6	45 (16.4)	12	44.2 (15.7)
Education	6	17 (4.1)	6	17.1 (4.7)	12	17 (4.2)
Gender						
Male	5	83.8	5	83.8	10	83.8
Female	1	16.7	1	16.7	2	16.7
Marital Status						
Single	3	50.0	2	33.3	5	58.3
Married	3	50.0	4	66.7	7	41.7
Children No.						
0	3	50	3	50	6	50
1	0	0	2	33.3	2	16.7
2	2	33.3	0	0	2	16.7
3	1	16.7	1	16.7	2	16.7
Working						
Full time	4	66.7	5	83.3	9	75
No	2	33.3	1	16.7	3	25
Hand preference						
Right	5	83.3	5	83.3	10	83.3
Left	1	16.7	1	16.7	2	16.7

Table 23b. Distribution of clinical characteristics of SCI participants.

	N	**%** / mean (standard deviation)
SCI level of injury		
C3 complete	1	16.7
C3 incomplete	1	16.7
C4 incomplete	1	16.7
C5 complete	1	16.7
C5 incomplete	2	33.3
SCI reason		
Assault	1	16.7
Fall	1	16.7
Transport	4	66.7
Wheel chair – type		
motorized	5	83.7
regular	1	16.7
Own a Car		
Yes	5	83.7
No	1	16.7
Drive		
No	5	83.7
Yes	1	16.7
Hours in bed	6	10.3 (4.6)
Financial support		
Ministry of defence	3	50
salary	1	16.7
Social security	2	33.3
Months in Rehabilitation	6	12.3 (5.8)

Table 23c. Distribution of clinical characteristics of SCI participants.

	Tongue		Jaw		Neck		Shoulders		Arms		Elbows		Wrists		Hands		Fingers	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Immobilization																		
No Symptom	0	0.0	0	0.0	4	66.7	3	50.0	1	16.7	1	16.7	1	16.7	0	0.0	0	0.0
Partial	0	0.0	0	0.0	2	33.3	1	16.7	2	33.3	2	33.3	2	33.3	3	50.0	3	50.0
Complete	0	0.0	0	0.0	0	0.0	2	33.3	3	50.0	3	50.0	3	50.0	3	50.0	3	50.0

2.2.2.1 Overview of findings

Qualitative input from patient testimonials, from experimenter diaries, as well as from the usage acceptance questionnaire show the following:

Pre-usage stage

Receptivity and interest: It seemed that the SCI participants came to the experiment with a

reasonable degree of interest, somewhat lower than the able-bodied participants. This is probably due to the fact that arriving to the hospital for these participants is quite an effort while most of these participants have already tried several solutions for operating a computer in their situation and have found a solution that works for them. Therefore, testing a new platform was not as exciting for them as for the able-bodied participants who had not encountered anything like MAMEM.

Device usage stage

Ease of learning: For the SCI participants, the impression was that learning how to use the platform was as easy as it was to the able-bodied participants and that there were no differences in this category that were a product of their clinical state. One minor issue concerning the training phase was related to the fact that SCI participants seemed to get tired earlier than the able-bodied participants. However, this was due to the study's' protocol that imposed a strict time line in a onetime visit, something that will be easily avoided in phase two or in natural conditions.

Competence in learning: All the Sheba participants who arrived to the training part, including the SCI participants, were able to master it and learned how to effectively use the MAMEM platform. They responded with medians of 8-9 on a 10 point Likert scale to the statements concerning their perception of how users will be able to learn how to use MAMEM, with assistance or even on theory own (Table 29, question 5). These results indicate that the participants found the learning of the MAMEM easy and effective.

Competence in using: The SCI participants who finished the learning part were competent in using the MAMEM platform, demonstrating this by successfully performing the dictated tasks and by responding with a median of 6 on a 7-point scale (reversed) to the statement "I have the knowledge and skill necessary to use the MAMEM system" (Table 29, question 7).

Enjoyment and fun: The SCI participants moderately enjoyed using the MAMEM platform resulting in median scores of 4.0 on a 7-point scale regarding the enjoyment and fun of using MAMEM (Table 29, questions 10,11). The impression of the experimenters is that these results are most likely not related to the platform itself but are possibly the product of some of the less-enjoyable parts in the study such as the part of putting on the heavy weight EEG equipment cap. Moreover, for the SCI participants, the effort of leaving their homes to come to the hospital was taxing, and may have colored the results in this aspect.

Post-usage stage

Potential for independent use: Although the SCI participants indicated high levels of confidence that they could learn how to use the platform independently and use appropriately for their own needs, they expressed rather low confidence in having control over the system. They responded with a median 3.0 on a 7-point Likert scale to the question "I had control over using the MAMEM system". This indicates that they would need a comparatively longer period to become fully comfortable with using the system. These results are discussed further in this document.

2.2.2.2 Primary outcomes measures

Training tasks

Basic tasks

SCI and able-bodied competence (time needed, accuracy rate, composite score) in the two basic tasks are presented in Table 24. The differences observed between able bodied and SCI participants in basic tasks were very slight and not worth noting (Table 24).

Table 24. Descriptive statistics for the two basic training tasks by group (able-bodied vs. SCI).

	Able-bodied		SCI	
	N	Median	N	Median
Focus on several locations				
Time (sec)	6	29.5	6	19.5
Accuracy (%)	6	18.9	6	23.8
Score (x100,000)	6	4.8	6	4.8
Focus long enough on sequence of locations				
Time (sec)	6	32.0	6	32.0
Accuracy (%)	6	22.8	6	20.8
Score (x100,000)	6	0.8	6	0.79

Intermediate tasks

SCI and able-bodied competence (time needed, accuracy rate, composite score) in the three intermediate tasks are presented in Table 25. SCI patients tended to take a bit more time with the first intermediate task, but differences evened out in the rest of the intermediate tasks.

Table 25. Descriptive statistics for three intermediate training tasks by group (able-bodied vs. SCI).

	Able-bodied		SCI	
	N	Median	N	Median
Use of scrolling. finger-point button and go backward				
Time (sec)	6	49.0	5	97.0
Accuracy (%)	6	100.0	5	100.0
Score (x100,000)	6	7.5	5	7.1
Zooming and keyboard typing				
Time (sec)	6	377.5	4	416.5
Accuracy (%)	6	80.0	5	80.0
Score (x100,000)	6	5.2	4	4.7
Select. copy and paste				
Time (sec)	4	170.0	3	155.0
Accuracy (%)	6	62.99	4	77.27
Score (x100,000)	4	5.7	3	6.1

Advanced tasks

Participants' competence in the four advanced tasks was good. That is, all participants were able to complete the task with acceptable competence. Good competence was found both for the SCI group and also for the groups of able - bodied participants. SCI and able-bodied competence (time needed, accuracy rate, composite score) in the four advanced tasks are

presented in Table 26. SCI participants took slightly more time to complete the second advanced task, but otherwise differences between able-bodied and SCI participants were not notable.

Table 26. Descriptive statistics for the four advanced training tasks by group (able-bodied vs. SCI).

	Able-bodied		SCI	
	N	Median	N	Median
Setting button. general menu. change gaze visualization. back. menu. cancel gaze visualization				
Time (sec)	6	66.0	4	82.5
Accuracy (%)	6	58.3	4	83.3
Score (x100,000)	6	8.3	4	7.9
Tab overview. new tab. type without text predictor. abort action				
Time (sec)	6	85.0	4	146.0
Accuracy (%)	6	96.1	4	96.1
Score (x100,000)	6	7.8	4	7.0
Tab overview. edit URL. type with text predictor. submit				
Time (sec)	6	101.5	4	176.5
Accuracy (%)	6	100.0	4	100.0
Score (x100,000)	6	8.3	4	7.0
Tab overview. bookmark. new tab. visit bookmark manager. choose and visit bookmark				
Time (sec)	6	86.0	4	94.5
Accuracy (%)	6	66.6	4	100.0
Score (x100,000)	6	8.5	4	8.4

Errps and SMR tasks

The experimenters were asked to rate the performance of the participants using a subjective score based on their impression of how well the participants performed the Errps and SMR tasks. These rates were performed using a Likert scale ranging from 1 (not good) to 5 (very good). Generally, the performance in both tasks was reasonable, with a small advantage to the able-bodied group. Errps and SMR tasks performance rating scores are presented in Table 27.

Table 27. Descriptive statistics for the Errps and SMR tasks by group (able-bodied vs. SCI).

	Able-bodied		SCI	
	N	Median	N	Median
Errps score	6	4.0	4	3.0
SMR score	6	4.0	5	3.0

Dictated tasks

Participants' competence in the four dictated tasks was decent. Namely, all participants were able to complete the task with acceptable performance**.** Good competence was found both for the SCI group and also for the groups of able - bodied participants. SCI and able-bodied competence (time needed, accuracy rate, composite score) in the four dictated tasks are presented in Table 28.

Table 28. Descriptive statistics for dictated tasks by group (able-bodied vs. SCI).

	Able-bodied		SCI	
	N	Median	N	Median
E-mail				
Time (sec)	6	227.0	4	271.0
Click Accuracy (%)	6	100.0	4	87.5
Photo edit				
Time (sec)	6	154.0	4	66.6
Click Accuracy (%)	5	153.5	4	80.0
Social media				
Time (sec)	6	291.5	4	338.0
Click Accuracy (%)	6	46.4	4	51.4
YouTube				
Time (sec)	6	199.5	4	218.5
Click Accuracy (%)	6	67.5	4	100.0

2.2.2.3 Secondary outcomes

User acceptance and evaluation of persuasive design

The user acceptance and evaluation of persuasive design questionnaire – Part I, was passed right after the platform training part. Table 29 presents the medians of the SCI questionnaire results.

In Questions 1-4 the participants were asked to report whether the platform made them feel scared, nervous, un-pleasant or uneasy by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). In question 1 the order of the answers was reversed to be compatible with the other questions. Question 5 asked the participants whether they believe they could operate the platform after they learned to use it alone, using the games or demonstrated how to use it by an instructor by indicating whether they agree or disagree with corresponding statements on a scale of 1 (completely not sure) to 10 (completely sure). Questions 6-14 asked the participants to report on various aspects of the platform such as its ease of use or pleasure in use, in addition to whether they believe they have enough knowledge to operate it or they believe they had control over it by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). Questions 15-17 asked the participants to report on the personalization of the system and whether they believe the games that were used in the training stage motivated them. Finally, Question 18 asked the participants whether they would use the system if it will be available to them in the future. This was done by indicating whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). Reactions of participants who were exposed to the persuasive design elements were similar to those who were not (Table 30).

Table 29. Descriptive statistics for Answers on questions of User Acceptance Questionnaire Part I among SCI participants.

	N	Median
The MAMEM system did not scare me at all	5	7.0
Operating the MAMEM system made me nervous	5	1.0
The MAMEM system made me feel uncomfortable	5	1.0
The MAMEM system made me feel uneasy	5	2.0
I could complete the training tasks using the MAMEM system:		
if there was no one around to tell me what to do	5	8.0
if I had just the build-in practice games for practicing	5	8.0
if someone showed me how to do it first	5	9.0
I had control over using the MAMEM system	5	3.0
I have the skills and knowledge necessary to use the MAMEM system	5	1.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	5	3.0
I find using the MAMEM system enjoyable	5	4.0
The actual process of using the MAMEM system was pleasant	5	4.0
I had fun using the MAMEM system	5	4.0
The training tasks motivated me to train my MAMEM skills	5	3.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	5	4.0
I had the feeling that the messages of the MAMEM system were intended for me	5	4.0
Assuming I had access to a MAMEM system, I intend to use it	5	7.0

Table 30. Descriptive statistics for Answers on questions of User Acceptance Questionnaire Part I among SCI participants by design (persuasive vs. non- persuasive)

	Non-persuasive		Persuasive	
	N	Median	N	Median
The MAMEM system did not scare me at all	6	7.0	5	7.0
Operating the MAMEM system made me nervous	6	2.0	5	2.0
The MAMEM system made me feel uncomfortable	6	1.0	5	1.0
The MAMEM system made me feel uneasy	6	3.0	5	7.0
I could complete the training tasks using the MAMEM system…				
if there was no one around to tell me what to do	5	2.0	6	5.5
if I had just the built-in practice games for practicing	5	7.0	6	6.0
if someone showed me how to do it first	5	9.0	6	9.0
I had control over using the MAMEM system	5	2.0	5	2.0
I have the skills and knowledge necessary to use the MAMEM system	5	1.0	6	1.5
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	5	2.0	6	2.0
I find using the MAMEM system enjoyable	5	2.0	6	2.0
The actual process of using the MAMEM system was pleasant	5	3.0	6	2.5
I had fun using the MAMEM system	5	2.0	6	2.0
The training tasks motivated me to train my MAMEM skills	5	3.0	6	3.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	5	2.0	6	2.5
I had the feeling that the messages of the MAMEM system were intended for me	5	3.0	6	4.0
Assuming I had access to a MAMEM system, I intend to use it	5	4.0	5	3.0

User acceptance and evaluation of persuasive design – Part II

The user acceptance and evaluation of persuasive design questionnaire – part II, was passed right after the dictated tasks part. The following table presents the medians of the SCI questionnaire results.

In Questions 1-3 the participants were asked to report whether the platform could provide better interaction, abilities and output for similar tasks that were tested in the dictated tasks. Questions 4-8 asked the participants to report on whether they found the platform useful, relevant for the type of tasks that were tested in the dictated tasks, whether they found the platform cumbersome, would they use the platform if it was available to them in the future and whether they think that most people would learn how to use it fast. The participants were asked to indicate whether they agree or disagree with corresponding statements on a scale of 1 (fully agree) to 7 (fully disagree). Reactions of participants who were exposed to the persuasive design elements were similar to those who were not (Table 32).

Table 31. Descriptive statistics for Answers on questions of User Acceptance Questionnaire Part II among SCI participants.

	SCI	
	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	4	4.0
Using MAMEM will increase my productivity on such kinds of tasks	4	6.5
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	4	6.5
I find using MAMEM to be useful for these kinds of task	4	6.0
The use of MAMEM is relevant for these kinds of tasks	4	1.5
Assuming I had access to a MAMEM system, I intend to use it	4	6.5
I found the MAMEM system very cumbersome to use	4	6.0
I would imagine that most people would learn to use the MAMEM system very quickly	4	1.0

Table 32. Descriptive statistics for answers on questions of User Acceptance Questionnaire Part II among SCI participants by design (persuasive vs. non-persuasive)

	Non-persuasive		Persuasive	
	N	Median	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	5	3.0	5	1.0
Using MAMEM will increase my productivity on such kinds of tasks	5	6.0	5	2.0
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	5	4.0	5	2.0
I find using MAMEM to be useful for these kinds of task	5	2.0	5	1.0
The use of MAMEM is relevant for these kinds of tasks	5	1.0	5	1.0
Assuming I had access to a MAMEM system, I intend to use it	5	4.0	4	3.5
I found the MAMEM system very cumbersome to use	5	6.0	5	7.0
I would imagine that most people would learn to use the MAMEM system very quickly	5	1.0	5	1.0

System usability (SUS) and user satisfaction questionnaires (QUEST 2.0)

The SUS scores were calculated according to the standard way of calculation of this questionnaire (Brooke, 1996), namely by assigning a relative score to each item and performing a calculation with their sum. Results show that the median SUS score among the SCI participants (n=5) was 75, which is considered an above average score.

The QUEST 2.0 questionnaire (Demer et al., 2002) was answered only by those who tested the light weight configuration (n=3), namely, half of the SCI participants, and these participants were instructed that they should answer this questionnaire only in relation to the lightweight configuration. The quest scores were calculated by averaging the first part of the questionnaire that concerns the different physical and usability of the assistive device. Results show that the median score of the first part answers were 4.25, which is between "very satisfied" and "quite satisfied".

Table 33. Descriptive statistics on the QUEST 2.0 and SUS questionnaires by group (Able-bodied vs. SCI).

	SCI	
	N	Median
QUEST 2.0 score	5	4.25
SUS score	5	75.0

2.2.2.4 Physiological outcomes

The stress levels were assessed using the GSR signals that were monitored throughout the study. To calculate stress levels using these signals, an algorithm was used for stress detection that scanned the GSR signals in an unsupervised manner and computed 4 different thresholds categorizing the stress level of the participant in 5 levels. Thus, the result of the algorithm can be one of the following values [1, 2, 3, 4, and 5], with "1" indicating low and "5" high stress situation. Before generating the figures, a mean filter (1-minute length) has been applied to the result of the algorithm for smoothing. The data shown in each figure, corresponds to the first 4 phases of the trial:

(a) Training (purple color)

(b) Errp task - Heavy conf. (red color)

(c) SMR task - Heavy conf. (yellow color)

(d) Dictated task (blue color)

The horizontal axis corresponds to the real-time scale of the experiment. Missing parts are when the recording was paused. E.g. between training and the Errp task the EEG cap was put on the participants so there is a large pause in between them. Events have also been included in the figures, indicating the beginning of each task during training and dictated tasks.

The following figures show the stress levels of all the participants, the able-bodied group and of the SCI group, throughout the study. It is possible to see that among the able-bodied participants, there is much variability throughout the study, but generally a decline of stress pattern can be observed. However, the results of the SCI participant demonstrate that stress, as measured by the GSR levels is high during most of the study.

Figure 2a. Stress levels of the able-bodied participants in Sheba throughout the study

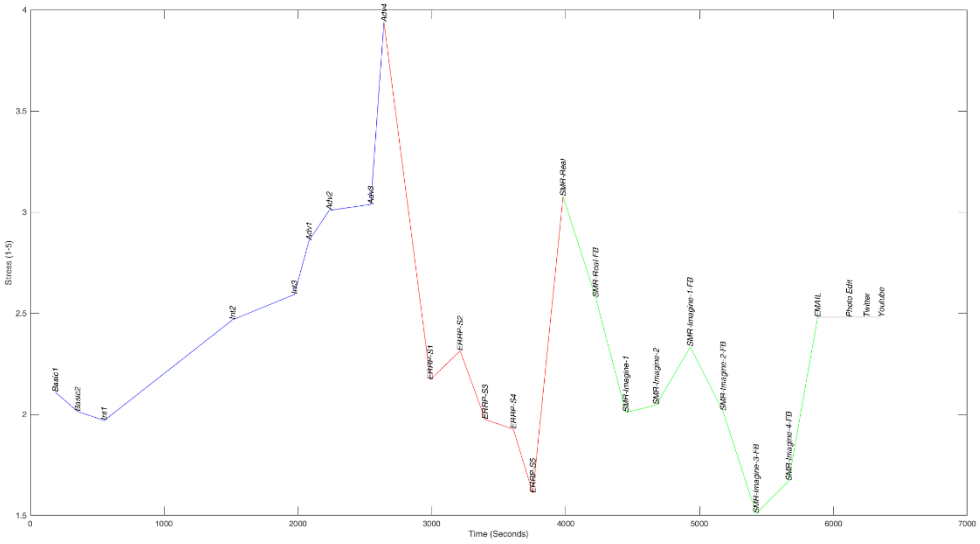
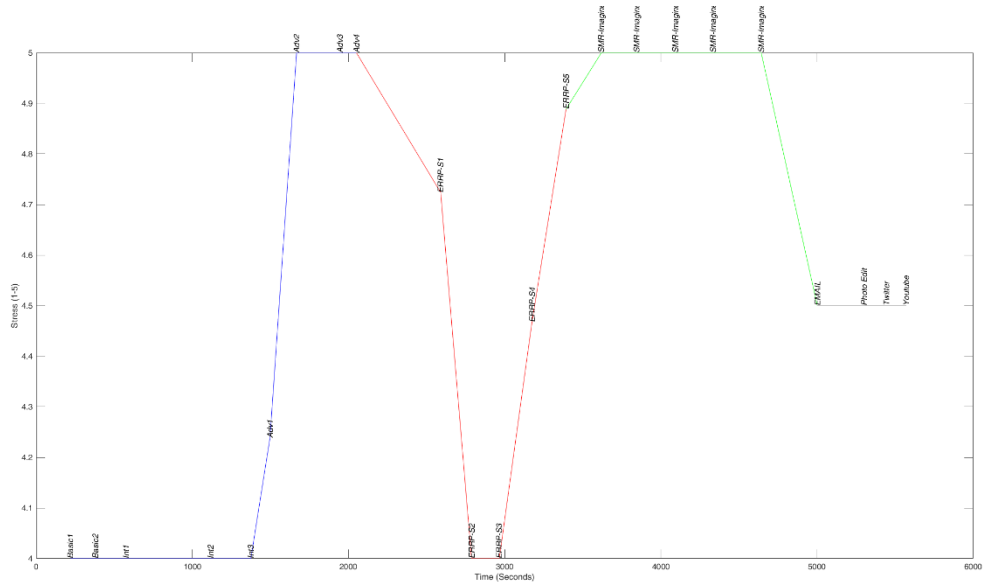


Figure 2b. Stress levels of SCI participants in Sheba throughout the study



Concerning the result that GSR levels were high during the whole study among SCI participants, the relation between GSR and tetraplegia is still unknown and no relevant papers were found in the literature. However, according to SCI experts in Sheba there is a possible explanation for this outcome. The GSR is controlled by the sympathetic nervous system and reacts to

emotional stimulation and arousals (Boucsein, 2012). This control occurs over the sweat gland in the hand (where the GSR sensors were placed in the current study) by nerves that originate in the spinal cord. These nerves' main task is to regulate the sweat glands, mostly by suppressing them. In additions, these nerves originate from various levels of the spinal cord. Considering this, the elevated level of GSR measured in the current study, may be the product of the injury in the spinal cord, which disrupted the tasks of the nerves that suppress the GSR levels, and therefore, high levels of stress were observed among the SCI participants. However, the study sample is too small to arrive to conclusive results.

2.2.2.5 Patient Testimonials

Receptivity to the trial

As mentioned before, general Receptivity to the trial in Sheba was high although it seems that it were the able-bodied participants who were more receptive to the experiment than the SCI participants. This is probably due to the fact that for the SCI participants, arriving to the experiment demanded them to leave their homes and to travel to the hospital, which for them is a complicated and difficult task since it involves physical effort and complicated logistics.

Reaction to the process and equipment

Concerning the reaction of the participants to the process and equipment, the able-bodied participants seemed to have a positive reaction to the platform, and especially to the eye-tracker technology, which they found impressive. However, most of the SCI participants reported that they already know of this technology and some even said that they tried it and were skeptical about it for operating computers. Concerning the EEG cap, all participants found putting it on and applying the gel uncomfortable, especially the part of removing it and cleaning away the gel afterwards. Those who tested the lightweight configuration reported that the EPOC was a significant improvement over the cap, while some said its electrodes feel uncomfortable after wearing it for more than an hour. Concerning the eye tracker, for most participants, it worked very well, mainly for the able-bodied participants. However, some participants found it less precise in reading their eye movements and they found this frustrating. This was true mainly for the SCI participants and 2 of them were dropped out of the study due to an inability to use the eye-tracker.

Overall feedback towards MAMEM and the trial

The feedback that was received by the SCI participants in Sheba was generally positive. All of the participants indicated that the idea to provide an assistive device for people with movement disabilities that can allow them to manage and author multimedia in order to participate more in social activities is very welcome. Most of the able-bodied participants and some of the SCI participants reported that the MAMEM platform seems to be a satisfactory solution for a person with physical disabilities to interact with a computer. Concerning the training and dictated tasks, most of the participants reported that it seemed to them to be an efficient way to train people in how to use the system and that performing the dictated tasks was quite easy for them. Some participants indicated that the error potentials task, while somewhat frustrating, was also a productive way to learn how to efficiently type using the MAMEM platform keyboard. Finally, the SCI participants indicated that during the years, they have managed to find a solution for their disability related problems in operating computers.

Therefore, a new assistive device must distinctly further improve the way they use computers, for them to consider changing from their current solution.

Issues and concerns

All participants indicated that they were missing the Hebrew language support. Moreover, many participants indicated beforehand, that they were excited to see whether the computer will be able to read their thoughts, yet, they later acknowledged that the actual experiment with the heavyweight equipment was somewhat tedious, while the lightweight equipment was less precise in successfully “guessing their thoughts”.

2.2.2.6 Experimenter's diary

As mentioned before, there were severe problems in the calibration of the eye-tracker with 2 SCI participants to the point that they were dropped out of the study. One SCI participant was sitting while leaning to the left in his wheelchair due to his injury, which caused his eyes to be not in the same level. This may have caused the problems with the eye tracker. For the second SCI participant, his eyes were constantly swollen and partly closed. This may have caused the problem for the eye tracker to properly identify the eyes’ gaze behavior.

In cases where the participants had long hair (women) or thick hair, there were some problems in achieving low impedance levels while applying gel in the EEG cap. Also, removing the gel in these cases was not pleasant for the participants.

People with SCI find it difficult and tiresome to sit for extended periods of time, and therefore it was impossible for them to complete the heavyweight and lightweight testing in one session. Also, even the heavyweight testing part was difficult for them since it sometime took 4-5 hours. It seemed to cause them to become very tired in the last parts of the study.

2.2.2.7 Discussion

Competence at MAMEM learning and usage

Generally, the outcomes of the study in Sheba show that the physical conditions of people with a SCI do not prevent them from using the system, since they were able to operate it at the same level of performance as able-bodied participants. Due to the high rate of success in performing the dictated tasks, it can also be concluded that the training tasks are efficient tools to train people on how to use the system. In addition, these results indicate that the MAMEM platform is an effective tool for people with a SCI to operate a computer and to perform actions that can allow them to author multimedia content and participate in social networks.

Finally, it can be to some extent concluded that the system that was tested in Phase I demonstrated feasibility and usability to the extent that it can be further evaluated in the Phase II trials. However, as mentioned above, two participants were unable to operate the eye tracker and were removed from the study. Therefore, it seems that the inclusion/exclusion criteria of the next trials should be updated to be able to exclude such participants that would not be able to use the system and to evaluate it. In the future, these inclusion/exclusion criteria could indicate which people with a SCI can benefit from the platform, and who cannot.

The intention to use MAMEM

One of the results in the questionnaires regarding the question whether the participants will use the platform if it were to be available to them in the future shows that the SCI participants who are already using an assistive device, tended to be more doubtful (according to their testimonials) as to how helpful the system could prove for them. One possible reason for this outcome may be the fact that according to the findings in the questionnaire study reported in D6.2 (MAMEM Consortium, 2015) most of SCI participants who use assistive devices to operate computers, usually, at some point, find one that is good enough for their purposes and they "stick with it". Since changing an assistive device to a different one requires time, effort and causes inconvenience, a new assistive device either needs to ameliorate the effort of transition so as to facilitate adoption, or it needs to clarify in advance that the effort to get used to the device will later be rewarded with ease of use and speed. Eventual ease of use will compensate for the initial discomfort. Our estimation is that in the training session, the participants were able to achieve a high level of proficiency in using the MAMEM system but the duration of use was not sufficient to discover any superior usefulness over other assistive devices. It is proposed that their comparing MAMEM with assistive devices with which they have grown comfortable over years of use, needs to be taken into consideration in planning the Phase II trials.

Impact of the persuasive design

The analyses of the study's outcome measures regarding those who were trained on how to use the system with persuasive design elements and those who were not, did not seem to have an apparent pattern, one that can enable to draw significant conclusions from. Moreover, it may be that existing high motivation to test and evaluate the MAMEM system did not allow the persuasive design elements to unfold their full impact.

Limitations of the study

Concerning limitation of the study, the trial was targeted to assessing the MAMEM system in a controlled setting, and therefore it cannot indicate the actual usefulness and usability of the platform in everyday settings, i.e. in the participants' homes. In addition, the controlled setting obligated the participants to use the platform for a long time while wearing the EEG cap, which they did not find comfortable, a fact that may have influenced their performance on the dictated tasks and on their scores in the questionnaires. Phase II trials will solve some of these limitations by allowing participants to use MAMEM at home, with a lightweight device, for the interval of a month.

2.2.3 Neuromuscular disorders

The sample included six participants with neuromuscular diseases and six able - bodied participants, and their profiles are as follows (Table 33a-c)

Table 33a. Distribution of socio-demographic characteristics of participants by group and in total.

	Able - bodied		NMD		Total	
	N	% / mean (standard deviation)	N	% / mean (standard deviation)	N	% / mean (standard deviation)
Age	6	38.0 (6.7)	6	34.2 (6.2)	12	36.1 (6.5)
Education	6	14.5 (2.0)	6	15.7 (5.7)	12	15.1 (4.1)
Gender						
Male	3	50.0	4	66.7	7	58.3
Female	3	50.0	2	33.3	5	41.7
Marital Status						
Single	3	50.0	5	83.3	8	66.7
Married	2	33.3	1	16.7	3	25.0
Divorced	1	16.7	0	0.0	1	8.3
Children No.						
0	4	66.7	6	100.0	10	83.3
1	1	16.7	0	0.0	1	8.3
2	1	16.7	0	0.0	1	8.3
Working						
Full time	5	83.3	3	50.0	8	66.7
No	1	16.7	3	50.0	4	33.3
Hand preference						
Right	6	100.0	6	100.0	12	100.0

Table 33b. Distribution of clinical characteristics of NMD participants.

	N	%
Wheel chair - type		
motorized	4	66.7
regular	2	33.3
Car		
Yes	4	66.7
No	2	33.3
Drive		
No	6	100.0
Hours n bed		
5	1	16.7
8	1	16.7
10	2	33.3
11	1	16.7
12	1	16.7
Financial support		
Financial support from state	5	83.3
Salary/Paralympic	1	16.7
Diagnosis		
Duchene Muscular Dystrophy	1	16.7
Muscular dystrophy	1	16.7
Muscular dystrophy type II	1	16.7
SMA III	1	16.7
Tunisian Muscular Dystrophy	2	33.3
Self-movement		
No	4	66.7
Yes	2	33.3
Rehabilitation		
No	6	100.0

Table 33c. Distribution of clinical characteristics of NMD participants.

	Tongue		Jaw		Neck		Shoulders		Arms		Elbows		Wrists		Hands		Fingers	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Immobilization																		
No Symptom	4	66.7	4	66.7	2	33.3	1	16.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Partial	2	33.3	2	33.3	3	50.0	3	50.0	4	66.7	3	50.0	3	50.0	3	50.0	3	50.0
Complete	0	0.0	0	0.0	1	16.7	2	33.3	2	33.3	3	50.0	3	50.0	3	50.0	3	50.0

2.2.3.1 Overview of findings

Qualitative input from patient testimonials, from experimenter diaries, as well as from the usage acceptance questionnaire show the following:

Pre-usage stage

Receptivity and interest

All of the NMD participants came to the lab with a rather high degree of interest in the new

technology. They expressed that the most intriguing element of the trial, for them, was *"the ability to use my eyes and not my hands to use the device"*. One of the patients was a graphic artist who uses the mouse to carry out sophisticated work on Photoshop. She expressed that she was eager to see if the device would offer her higher speed and agility at using the computer. Another one of the patients stated that he is using an assistive device at home with which he has grown comfortable. He stated: *"I am very curious to find out if MAMEM can exceed the comfort level that I have achieved with my current device".*

Device usage stage

Ease of learning

Patient participants were shown to adjust fairly easily to the learning demands of MAMEM. Moreover, the sample of patients responded with a median of 6.0, on a 7 point Likert scale, on the statement: "Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the system" (Table 38, question 8). One of the patients expressed *"I found this easy to learn, and the next thing that I want is to improve my speed at using the keyboard in this new way".*

Competence in learning

All patients in the NMD sample were able to master the learning process of using MAMEM as shown by being able to complete dictated tasks like emailing, uploading, posting. They responded with a median of 9.0 on a 10-point Likert scale to the statement "I could complete the training tasks using the MAMEM system if someone showed me how to do it first" (Table 39, question 5). Moreover, patients rated the item "I would imagine that most people would learn to use MAMEM rather quickly" with a median of 6.5 (rather/very likely) on a 7 point Likert scale (Table 41, question 8).

Competence in using

All patient participants were able to master the learning tasks and use MAMEM effectively. The patients responded with a median of 6.5 on a 7-point scale to the statement "I have the knowledge and skill necessary to use the MAMEM system" (Table 39, question 7). Also, NMD users rated the reverse statement "I found the MAMEM system very cumbersome to use" with a median of 1.0 on a 7 point scale (Table 41, question 7), and this finding is an indication of a user friendly system that may well allow the NMD user to feel competent in using it.

Enjoyment and fun

Despite the fact that putting on the MAMEM system was taxing and tedious at the stage of the Phase I clinical trials, the patients still expressed joy and fun in using the system. They responded with a median of 6 on a 7-point scale to the statement "I find using the MAMEM system enjoyable". They also rated the statement "I had fun using the MAMEM system" with a 6.5 median, on a 7 point scale (Table 39, questions 9,11). One of the patient participants stated *"I find it especially intriguing and fun that I can direct my actions with my eyes, rather than with my hands"*.

Post-usage stage

Potential for independent use

This element was found to be very important in the D6.1 study and it is here shown that MAMEM fosters independent use to a fair extent, according to the sample with NMD. In Phase I of the trials, and after a few hours of training the patients rated with a median of 5.5 on a 7 point Likert scale the statement "I had control over using the MAMEM system" (Table 39, question 6), which is related to their ability to use it independently.

2.2.3.2 Primary outcomes measures

Training tasks

Basic tasks

Participants were able to carry out the basic tasks successfully, as evidenced by time needed, accuracy rate, and composite score. Both the able-bodied and the NMD participants were able to comparably achieve the basic tasks as is shown in Table 34.

Table 34. Descriptive statistics for training basic tasks by group (able - bodied vs. NMD).

	Able-bodied		NMD	
	N	Median	N	Median
Focus on several locations				
Time (sec)	6	47.0	6	89.0
Accuracy (%)	6	12.4	6	8.9
Score (x100,000)	6	4.6	6	4.6
Focus long enough on sequence of locations				
Time (sec)	6	32.0	6	32.0
Accuracy (%)	6	26.5	6	19.3
Score (x100,000)	6	0.8	6	0.8

Intermediate tasks

Participants were able to carry out the intermediate tasks with fair competence, as was seen by time needed, accuracy rate, and composite score. Both the able-bodied and the NMD participants were able to comparably achieve the intermediate tasks as is shown in Table 35.

Table 35. Descriptive statistics for training intermediate tasks by group (able - bodied vs. NMD).

	Able-bodied		NMD	
	N	Median	N	Median
Use of scrolling. finger-point button and go backward				
Time (sec)	6	38.5	6	31.0
Accuracy (%)	6	100.0	6	100.0
Score (x10.000)	6	8.0	6	8.4
Zooming and keyboard typing				
Time (sec)	6	230.0	6	236.5
Accuracy (%)	6	100.0	6	100.0
Score (x10.000)	6	7.1	6	7.0
Select. copy and paste				
Time (sec)	6	96.5	6	157.0
Accuracy (%)	6	74.1	6	50.0
Score (x10.000)	6	6.6	6	5.9

Advanced tasks

Participants were able to carry out the advanced tasks fairly well, as was shown by time needed, accuracy rate, and composite score. Both the able-bodied and the NMD participants were able to comparably carry out the advanced tasks as is shown in Table 36.

Table 36. Descriptive statistics for training advanced tasks by group (able - bodied vs. NMD).

	Able-bodied		NMD	
	N	Median	N	Median
Setting button. general menu. change gaze visualization. back. menu. cancel gaze visualization				
Time (sec)	6	45.5	6	41.0
Accuracy (%)	6	83.3	6	100.0
Score (x10.000)	6	8.8	6	9.0
Tab overview. new tab. type without text predictor. abort action				
Time (sec)	6	45.5	6	39.5
Accuracy (%)	6	100.0	6	100.0
Score (x10.000)	6	8.9	6	9.0
Tab overview. edit URL. type with text predictor. submit				
Time (sec)	6	77.5	6	67.5
Accuracy (%)	6	100.0	6	100.0
Score (x10.000)	6	8.7	6	8.9
Tab overview. bookmark. new tab. visit bookmark manager. choose and visit bookmark				
Time (sec)	6	34.5	6	28.0
Accuracy (%)	6	100.0	6	100.0
Score (x10.000)	6	9.4	6	9.6

Remarks for Error Related Potentials (Errps) and SMR experiment

The experimenters were asked to rate the performance of the participants using a subjective score based on their impression of how well the participants performed the dictated tasks. There was comparable competence in Errps and SMR experiments between the group of

patients (NMD) and the one of able - bodied participants (Table 37). A rating of 5.0 and 3.5 of the NMD participants is above average, on a 5-point scale.

Table 37. Descriptive statistics for Errps and SMR experiments by group (able - bodied vs. NMD)

	N	Median	N	Median
	Able - bodied		NMD	
Errps	6	5.0	6	5.0
SMR	6	2.5	6	3.5

Dictated tasks

Participants were able to carry out the four dictated tasks rather well, as evidenced by time needed and accuracy. Both the able-bodied and the NMD participants were able to comparably achieve the dictated tasks as is shown in Table 38.

Table 38. Descriptive statistics for dictated tasks by group (able - bodied vs. NMD).

	Able-bodied		NMD	
	N	Median	N	Median
E-mail				
Time (sec)	6	187,5	6	152,5
Accuracy (%)	6	60,0	6	50,0
Photo edit				
Time (sec)	6	87,5	6	105,0
Accuracy (%)	6	73,3	6	80,0
Social media				
Time (sec)	6	160,0	6	180,0
Accuracy (%)	6	75,0	6	75,0
You tube				
Time (sec)	6	87,5	6	102,5
Accuracy (%)	6	100,0	6	100,0

2.2.3.3 Secondary outcomes

User acceptance and evaluation of persuasive design

Part I of the questionnaire explored reactions to usage elements of MAMEM. The NMD participants responded with a median of 7 on a 7-point scale on the statement "MAMEM did not scare me at all". They also responded with medians of 1.5 and 1.0 and 1.0 respectively to the reverse statements: "Operating the MAMEM system made me nervous", "the MAMEM system made me uncomfortable" and "the MAMEM system made me feel uneasy". According to the testimonial of one of the patients, *"MAMEM does not make me nervous, it makes me excited, even if I have to have gel on my air, and a cap on, it is very fascinating"*. These results provide an indication that MAMEM is a user-friendly device for individuals with NMD related physical disabilities. Moreover, the patients in the sample also tended to find the MAMEM system enjoyable. They rated with a median of 6.5 on a 7-point scale the statements "the actual process of using MAMEM was pleasant", and "I had fun using the MAMEM system". The following Table 39 summarizes how NMD patients rated the items of the part I of the usage questionnaire:

Table 39. Descriptive statistics for answers on User Acceptance Questionnaire Part 1

	NMD	
	N	Median
The MAMEM system did not scare me at all	6	7.0
Operating the MAMEM system made me nervous	6	1.5
The MAMEM system made me feel uncomfortable	6	1.0
The MAMEM system made me feel uneasy	6	1.0
I could complete the training tasks using the MAMEM system:		
if there was no one around to tell me what to do	6	4.5
if I had just the build-in practice games for practicing	6	8.0
if someone showed me how to do it first	6	9.0
I had control over using the MAMEM system	6	5.5
I have the skills and knowledge necessary to use the MAMEM system	6	6.5
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	6	6.5
I find using the MAMEM system enjoyable	6	6.0
The actual process of using the MAMEM system was pleasant	6	6.5
I had fun using the MAMEM system	6	6.5
The training tasks motivated me to train my MAMEM skills	6	4.5
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	6	4.5
I had the feeling that the messages of the MAMEM system were intended for me	6	4.0
Assuming I had access to a MAMEM system, I intend to use it	6	5.5

Reactions to Part I of the user acceptance questionnaire were similar by design among NMD participants as is shown in Table 40. The sample is very small for the results to be either conclusive or even indicative. Nevertheless it is important to keep in mind research results, which show that fatigue with a new technology settles in over time, and not immediately. Philips and Zhao, (1993) show that abandonment of assistive devices takes place some time after the initial use. On the basis of this research it is hypothesized that an impact of persuasive design might be shown after MAMEM is used for some time, and would not be as probable to

show up in the first few hours of use. Table 40 presents NMD patients' evaluation of MAMEM by design. The responses of participants who were exposed to the persuasive design were similar to those who were not.

Table 40. Descriptive statistics for Answers on questions of User Acceptance Questionnaire Part 1 by design (persuasive vs. non-persuasive) among NMD participants.

	Non-persuasive		Persuasive	
	N	Median	N	Median
The MAMEM system did not scare me at all	4	6.5	2	7.0
Operating the MAMEM system made me nervous	4	2.5	2	1.0
The MAMEM system made me feel uncomfortable	4	1.0	2	1.0
The MAMEM system made me feel uneasy	4	1.5	2	1.0
I could complete the training tasks using the MAMEM system…				
if there was no one around to tell me what to do	4	1.5	2	9.0
if I had just the built-in practice games for practicing	4	6.5	2	9.5
if someone showed me how to do it first	4	8.0	2	10.0
I had control over using the MAMEM system	4	5.5	2	5.5
I have the skills and knowledge necessary to use the MAMEM system	4	6.0	2	7.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	4	6.0	2	7.0
I find using the MAMEM system enjoyable	4	6.0	2	6.0
The actual process of using the MAMEM system was pleasant	4	6.5	2	6.0
I had fun using the MAMEM system	4	6.5	2	5.5
The training tasks motivated me to train my MAMEM skills	4	5.5	2	3.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	4	4.5	2	4.5
I had the feeling that the messages of the MAMEM system were intended for me	4	4.5	2	3.0
Assuming I had access to a MAMEM system, I intend to use it	4	5.5	2	5.5

Part II of the user acceptance questionnaire is summarized in Table 41 and includes statements relevant to social inclusion and productivity. NMD patients show positive reactions to their MAMEM experience, as evidenced by their ratings on the part II items of the questionnaire. The patients assign a median rating of 6.0 on a 7 point scale, reflecting a "rather likely" response to the core social inclusion item: "using MAMEM will result in my interacting more and better with people and groups, online and off". Also, NMD patients rated with a median of 6 (rather true) on a 7 point scale the statement "I find using MAMEM to be useful and relevant to these kinds of (digital) tasks". In the items "using MAMEM will increase my productivity on such kinds of tasks" and "using MAMEM will improve my ability to effectively carry out these kinds of tasks" patients assigned a median 5.5 and 5.0 rating, respectively, on a 7-point scale. This indicates a moderately positive response. With regards to MAMEM's impact on digital productivity, three of the six NMD patients in the sample expressed that they are currently using assistive devices of various types with which they are very comfortable. They stated that they can see the potential of MAMEM but they would need time more time with the device to get to see its potential in making use of the computer easier and more independent. *"Right now I am able to do everything in my computer, using my hand, no matter its limited ability to move… I like the fact that I can still move my hands a little, even just to use the mouse…. Using*

my hands on the mouse helps me feel normal, I want to see if eventually MAMEM can help me use the computer faster and easier, and then it makes sense to use the computer with my eyes and not my hands".

Table 41. Descriptive statistics for answers on questions of User Acceptance Questionnaire Part 2 among NMD participants

	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	6	6.0
Using MAMEM will increase my productivity on such kinds of tasks	6	5.5
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	6	5.0
I find using MAMEM to be useful for these kinds of task	6	6.0
The use of MAMEM is relevant for these kinds of tasks	6	6.0
Assuming I had access to a MAMEM system, I intend to use it	6	6.5
I found the MAMEM system very cumbersome to use	6	1.0
I would imagine that most people would learn to use the MAMEM system very quickly	6	6.5

In part II (Table 42) of the usage acceptance questionnaire there was no clearly notable difference in the responses of NMD patients by design, persuasive or not. It can be said that given the use of MAMEM for a few hours only, in a lab environment, conditions of fatigue or discomfort were not there to kick off the impact of persuasive design elements. This limited time frame seems to not give patients the opportunity to use the system in conditions where persuasive design would make a difference, as will be the case in Phase II trials where users utilize MAMEM for a month at home.

Table 42. Descriptive statistics for answers on questions of User Acceptance Questionnaire Part2 by design (persuasive vs. non-persuasive) among NMD participants.

	Non-persuasive		Persuasive	
	N	Median	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	4	6.0	2	4.5
Using MAMEM will increase my productivity on such kinds of tasks	4	5.5	2	5.0
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	4	5.0	2	4.5
I find using MAMEM to be useful for these kinds of task	4	6.0	2	6.5
The use of MAMEM is relevant for these kinds of tasks	4	6.0	2	6.5
Assuming I had access to a MAMEM system, I intend to use it	4	6.5	2	6.0
I found the MAMEM system very cumbersome to use	4	1.0	2	2.5
I would imagine that most people would learn to use the MAMEM system very quickly	4	5.5	2	7.0

System usability (SUS) and user satisfaction questionnaires (QUEST)

The perceived usability (SUS median score) for NMD participants was over 70.0, an above average score (Table 43). The median user satisfaction score was 3.1 for the NMD participants, indicating a "moderately satisfied" response on a 5-point Likert scale.

Table 43. Descriptive statistics for System usability (SUS) and user satisfaction questionnaires (QUEST) among NMD participants by design (persuasive vs. non-persuasive).

	N	Median
SUS score	6	75.0
QUEST score	6	3.1

2.2.3.4 Physiological outcomes

The stress levels were assessed using the GSR signals that were monitored throughout the study. To calculate stress levels using these signals, an algorithm was used for stress detection that scanned the GSR signals in an unsupervised manner and computed 4 different thresholds categorizing the stress level of the participant in 5 levels. Thus, the result of the algorithm can be one of the following values [1, 2, 3, 4, and 5], with "1" indicating low and "5" high stress levels. Before generating the figures a mean filter (1-minute length) has been applied to the result of the algorithm for smoothing. The data shown in each figure, corresponds to the first 4 phases of the trial:

(a) Training

(b) Errp task - Heavy conf.

(c) SMR task - Heavy conf.

(d) Dictated task

There does not seem to be a pattern of differences in stress levels among the able-bodied and the NMD participants (Table 44). The stress levels of patients and able-bodied participants are depicted in Figures 3a-b.

Table 44. Descriptive statistics and for physiological results by group (able-bodied vs. patients)

	N	Median	N	Median
	Patients (NMD)		Able-bodied	
GTW Stress (mean)	5	4.4	6	2.3
Errp Stress (mean)	5	3.4	6	2.4
SMR Stress (mean)	5	4.8	6	2.6
Dictated Stress (mean)	5	3.1	6	2.2
Errp Stress (mean)	3	3.4	2	3.9
SMR Stress (mean)	3	1.9	2	4.9
Dictated Stress (mean)	3	1.9	2	3.5

Figure 3a. Stress levels, NMD participants

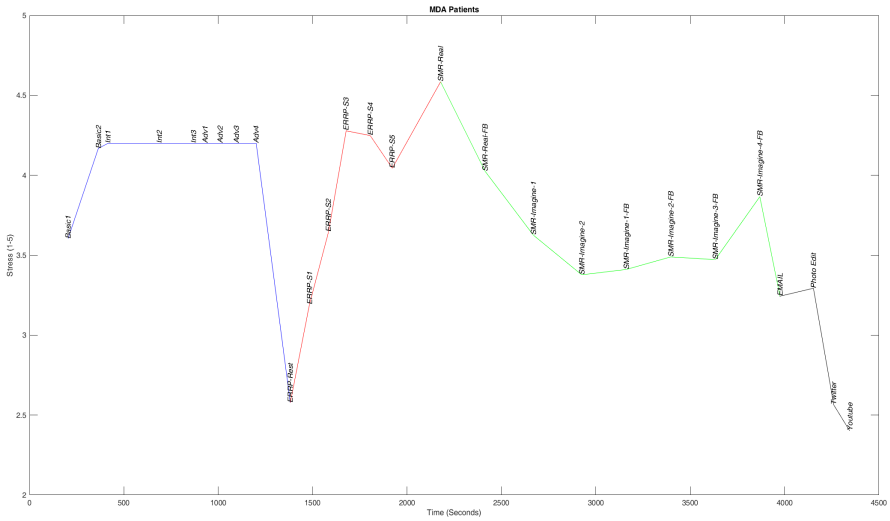
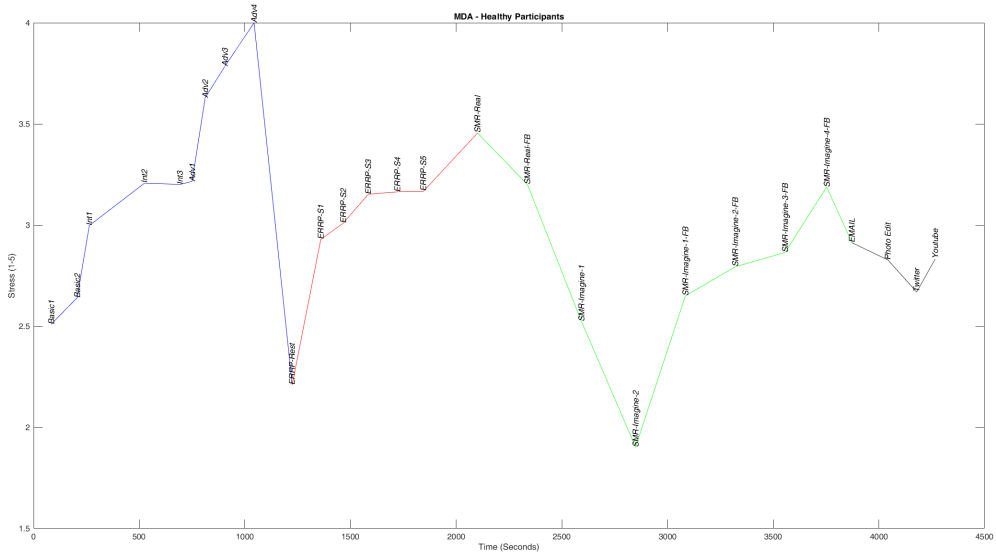


Figure 3b. Stress levels, able-bodied participants



2.2.3.5 Patient Testimonials

Receptivity to the experiment

All participants arrived with eagerness to participate and exhibited a high level of receptivity to the training process. The participants of both samples were eager to be exposed to a technology which “can read the mind” and “where the eyes can click on the keyboard”. The fascination with the technology created a positive environment for the trial and though the average time required for each participant for a single session was between 3, 5 to 4 hours, all participants dedicated the requisite time with patience and dedication to carrying out the tasks.

Reactions to the process and equipment

The heavyweight equipment fitting was long and tedious, and having to have gel used on their hair for the heavyweight part of the trial process and then have it removed for the light equipment trial was tedious but acceptable. The light equipment was used consistently after the heavyweight one and was better accepted in terms of the fitting process. However the participants complained that it was less accurate and precise in "reading their mind".

Overall feedback about the trial

a) English fluency: those more fluent in the English language expressed higher satisfaction with the training process and the usage of MAMEM. They became comfortable with the commands and tasks with more ease. The NMD participants were more fluent in English, overall, and had fewer problems with the language.

b) Digital literacy and efficacy: the participants who already use digital devices extensively seemed to be quicker in adapting to the trial's learning process. About half of the NMD participants were highly digitally savvy, using other assistive devices, and this made them both eager to learn and test something new, but also more demanding and with high expectations. *"I operate a mouse on my forehead, which works with infrared technology, and now I am very well used to it, to the point that I am really fast when I use it. MAMEM is heavier and a bit more complex to put on the equipment, and I need to know that it will be easier and faster to use, to make sense for me".*

c) Level of hand mobility: It seems that NMD participants who still have even partial usage of their hands, want to keep using their hands, with a handheld mouse, if possible. They feel that if they stop using their hand, then they may gradually speed up the process of losing whatever little movement they do have in their hand.

2.2.3.6 Experimenter's diary

In the NMD cohort there were two users who were constantly moving their upper body in their effort to breathe, creating problems with the eye-tracker in that it could not always locate and identify their eyes, as well as the EEG recording that is expected to be relatively noisy. Moreover, some of the NMD participants had small fingers that made the GSR adjustment nearly impossible. Furthermore, in cases with participants wearing glasses there were significant problems regarding the eye-tracker calibration process. Finally, EPOC head cup did not remain in the original position when participants move their upper body and the experimental staff had to replace it.

Another category of problems is related to the fixation points of the eye-tracker and the keyboard. More specifically, it was difficult for the participants to focus and select the space/ backspace buttons and the ones placed on the upper corners of the screen. In addition, the decision time of the letter selection on the keyboard was pre-defined and many participants could even use the keyboard with a smaller amount of time provided to them.

2.2.3.7 Discussion

With regards to the MAMEM trials, in the training tasks, the intermediate tasks and the advanced tasks the NMD participants were able to learn to use the device efficiently, and were

also able to use it to carry out tasks. The NMD participants were as able as the healthy participants to learn and use the device. Though the research sample for the clinical trials was small, the result is fairly conclusive that both able - bodied and NMD individuals are similarly able to learn and to use the technology, and to carry out key digital tasks, from sending an e mail, to using social media and YouTube.

Reactions to, and acceptance, of MAMEM technology

Both the able - bodied and NMD participants expressed a favorable attitude to the usage of MAMEM. The perceived usability score (SUS) for MAMEM was above average, for both able - bodied and NMD study participants, while in satisfaction the participants scored “moderately satisfied to satisfied”. Qualitative feedback obtained during the trials has shown that both NMD participants and able - bodied participants were eager to be exposed to the MAMEM technology, and were fascinated by the prospect of using a system that could use the eyes and mind to handle a keyboard”.

The intention to use MAMEM

It was found that NMD participants were positive to the MAMEM technology but participants who are comfortable with other assistive devices are hesitant to go into the process of becoming comfortable and adept with a new device. This is in line with the findings of the SCI cohort.

Areas for future consideration

Given that the next step is Phase II, with MAMEM used at home, the most important consideration, for the NMD study participants is to create the conditions that would enhance willingness and preference to use MAMEM for the whole stretch of a month, over their existing assistive device, with which they have grown to be very comfortable. The MAMEM NMD triers at Phase II will need to be encouraged to persist in using the MAMEM device, during the learning process, rather than reverting to their current habits, when due to the learning stage the usage of the computer is not as fast as they have been used to.

Limitations of the study

Parameters that may influence MAMEM adoption and would enrich this analysis if the sample were bigger, would be 1) age of participants, 2) degree of physical disability and areas of physical disability, 3) degree of digital literacy and digital savvy. The lightweight equipment tended at times to be weak in precision, during usage, and this needs to be tackled, as much as possible, for Phase II of the trials. Moreover, the Phase I trials took place in an artificial laboratory environment. It will be important to track reactions to the system when it is used at home, over a longer period of time.

2.3 Results in ALL the three cohorts and analysis outcomes

2.3.1 Overview

The Phase I trials, across the three cohorts, show that patients (N=16) were able to learn and use MAMEM at a speed and accuracy level comparable to that of able-bodied participants (N=18), with no notable differences between them. Consecutively, the responses of the patients on the user acceptance questionnaire Part I and Part II, tended to be rather favorable with regards to the ease of learning and use, and with regards to the perceived usefulness of the device. There was no evidence that the persuasive design made a difference in learning, usage and acceptance of MAMEM, and this can be attributed to the high degree of motivation that participants shared. It seems that persuasive and personalized design elements cannot further increase motivation to accept and use the MAMEM system, when the user is already highly motivated.

Table 45. Overview of qualitative findings

Pre-usage stage	
Receptivity	Participants tended to come to the trial with a high degree of receptivity to MAMEM and to the trial itself: PD were the most eager to go through the trial, SCI patients experienced moderate eagerness to participate given the ordeal of reaching the premises, and NMD patients were eager but skeptical because (like SCI patients, too) many of them have already become comfortable with other assistive devices.
Device usage stage	
Ease of learning	Patients were able to adjust to the equipment well and learn to use it effectively.
Competence in learning the device	All patients tended to be able to go through the basic, intermediate, advanced and dictated tasks with fair ease.
Competence in using the device	All patients were able to master the device and use it with competence within the framework of 3 to 4 hours of training.
Enjoyment and fun	Patients found MAMEM to be fairly fun and pleasurable to use.
Post-usage stage	
Potential for independent use	The majority of patients expressed the intention to use the device, assuming it were available for them to use at home. Those already comfortable with other assistive devices mentioned that they would want to test and see if it might make computer use faster and easier versus their current solution.

Pre-usage stage

Receptivity: Overall, patients came to the trials with a positive attitude and interest in the

MAMEM device. The PD patients were the older group, in terms of age, and they were receptive to the trial, in that they tended to be eager to prove that they could tackle newer technology. For the SCI patients to come to the hospital for the trial was a challenge in itself, given their condition, so they came in with fair but not very high interest. The NMD patients came to the trials with high interest and receptivity. It is interesting to note that their disease is progressive, so even though they may be comfortable with other solutions at the moment, they are ever on the lookout for the next device that can make digital life easier for them, especially in view of their progressing symptoms.

DEVICE USAGE STAGE

Ease of learning: participants found MAMEM easy to learn. Some of the PD patients had initial challenges in figuring out the learning steps, but overall, all patient groups tended to report that learning the device was easy. Patients responded with a median 6.0 on a 7-point Likert scale to the item "given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use it" (Table 51, question 8).

Competence in learning: starting from basic and finishing with dictated tasks, patients were able to understand and learn to use the system. It must be noted that during the learning process the presence of the experimenter and technician was instrumental. They showed the steps, answered questions, and explained the process over and over if they had to. This was also expressed in the questionnaire, in item "I could complete the training tasks using the MAMEM system if someone showed me how to do it", to which patients assigned a median 9.0 on a 10 point scale. While, on the other hand, patients assigned a median 5.0 on a 10-point scale to the item ""I could complete the training tasks using the MAMEM system if there was no one around to tell me what to do". The indication is that in Phase II these learning conditions need to be replicated in each participant's home, to ensure smooth learning of the system (Table 51, question 5).

Competence in using: patients did achieve mastery in using the MAMEM system, specifically in tasks related to social inclusion, like emailing, uploading, posting. At the end of the trial they were all able to use the system successfully. It must be noted however, that there were some precision issues with the lightweight apparatus and this made some tasks taxing for participants at some points. On occasion, they had to repeat carrying out specific tasks to ensure that they were carried out successfully. This is reflected in the responses to the user acceptance questionnaire. Patients assigned a median 6.0 on a 7-point scale to the item "I have the skills and knowledge to use the MAMEM system", yet they also assigned a more moderate 5.0 median on a 7-point scale to the item "I have control over using the MAMEM system" (Table 51, questions 6 and 7).

Enjoyment and fun: the novelty of the device was an important element of enjoyment involved in its use. This element was especially important for the PD patients, who tend to be older and less aware of technology updates, and they expressed interest in MAMEM as a state of the art technology. Overall, patients reported a fair element of fun and enjoyment, assigning a median 6.0 on a 7-point scale to the respective questions "I find using the MAMEM system enjoyable" and "I had fun using the MAMEM system" (Table 51, questions 12 and 14). It must also be noted that on the motivation to train, the patient population was more moderate, and

assigned a median 5.0 on a 7-point scale to the item “the training tasks motivated me to train my MAMEM skills” (Table 51 question 15).

Post-usage stage

Potential for independent use: Patients across cohorts tended to agree that the system could foster independent use. Many SCI patients as well as NMD patients have been using other assistive devices, with which they have become adept, competent, and comfortable. These participants mentioned that MAMEM would have to prove its superiority in speed and ease, so as to be meaningful to adopt it over their other assistive device.

2.3.2 Primary outcomes measures

Training tasks

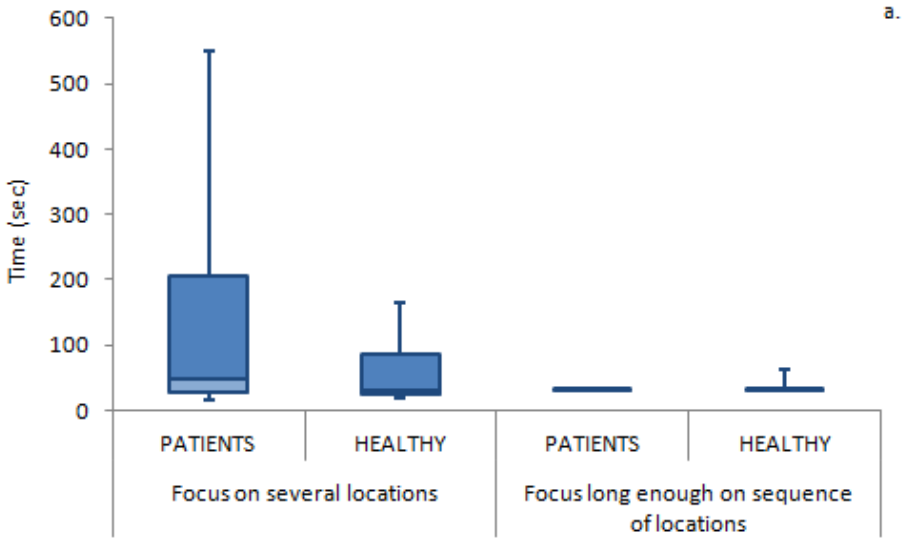
Basic tasks

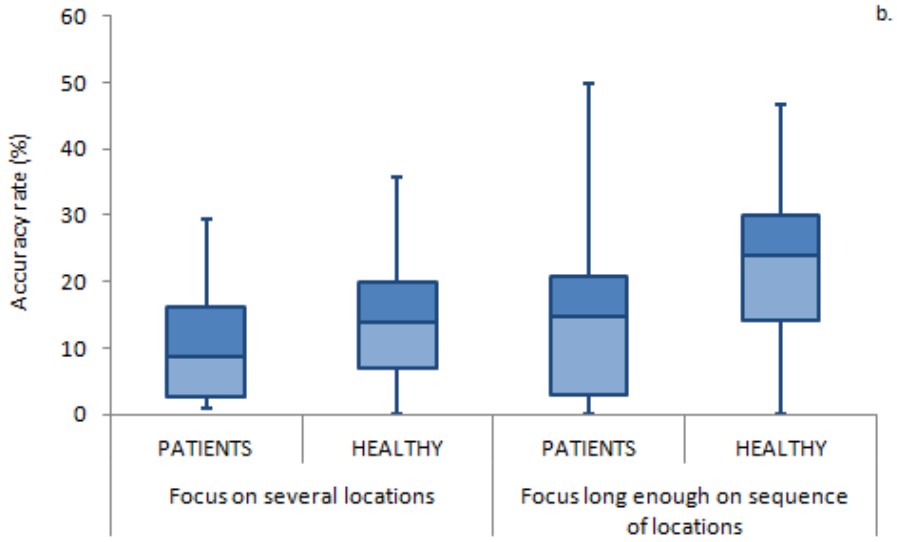
With regards to the basic tasks both patients and able-bodied participants were able to carry them out well, and there did not seem to be notable differences in the reactions between the two groups (Table 46, Figure 4 a-c).

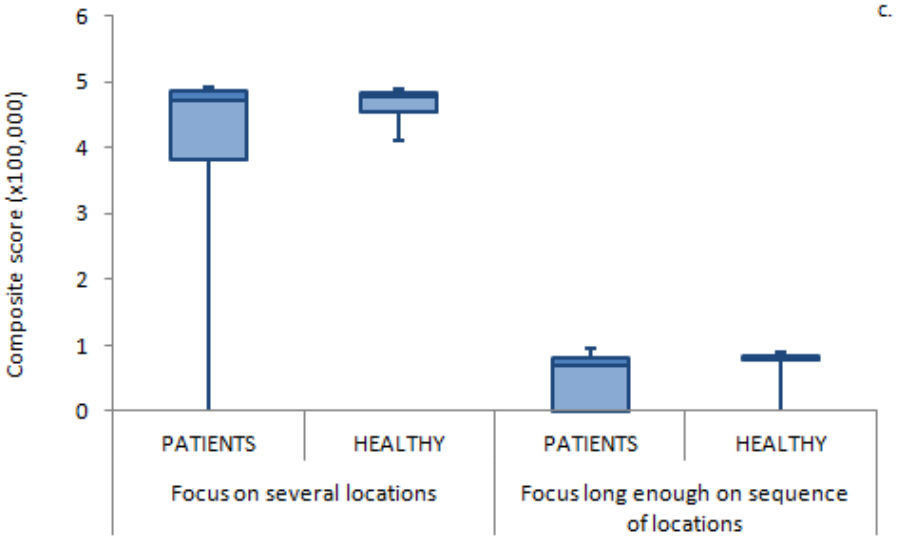
Table 46. Descriptive statistics for training basic tasks by group (able - bodied vs. patients).

	Patients		Able - bodied	
	N	Median	N	Median
Focus on several locations				
Time (sec)	16	47.5	18	31.5
Accuracy (%)	15	8.6	18	13.9
Score (x100,000)	17	4.7	18	4.8
Focus long enough on sequence of locations				
Time (sec)	11	32.0	15	32.0
Accuracy (%)	15	14.7	18	24.0
Score (x100,000)	17	0.7	18	0.8

Figure 4 a-c. Competency in training basic tasks by group (able - bodied vs. patients) using boxplots.







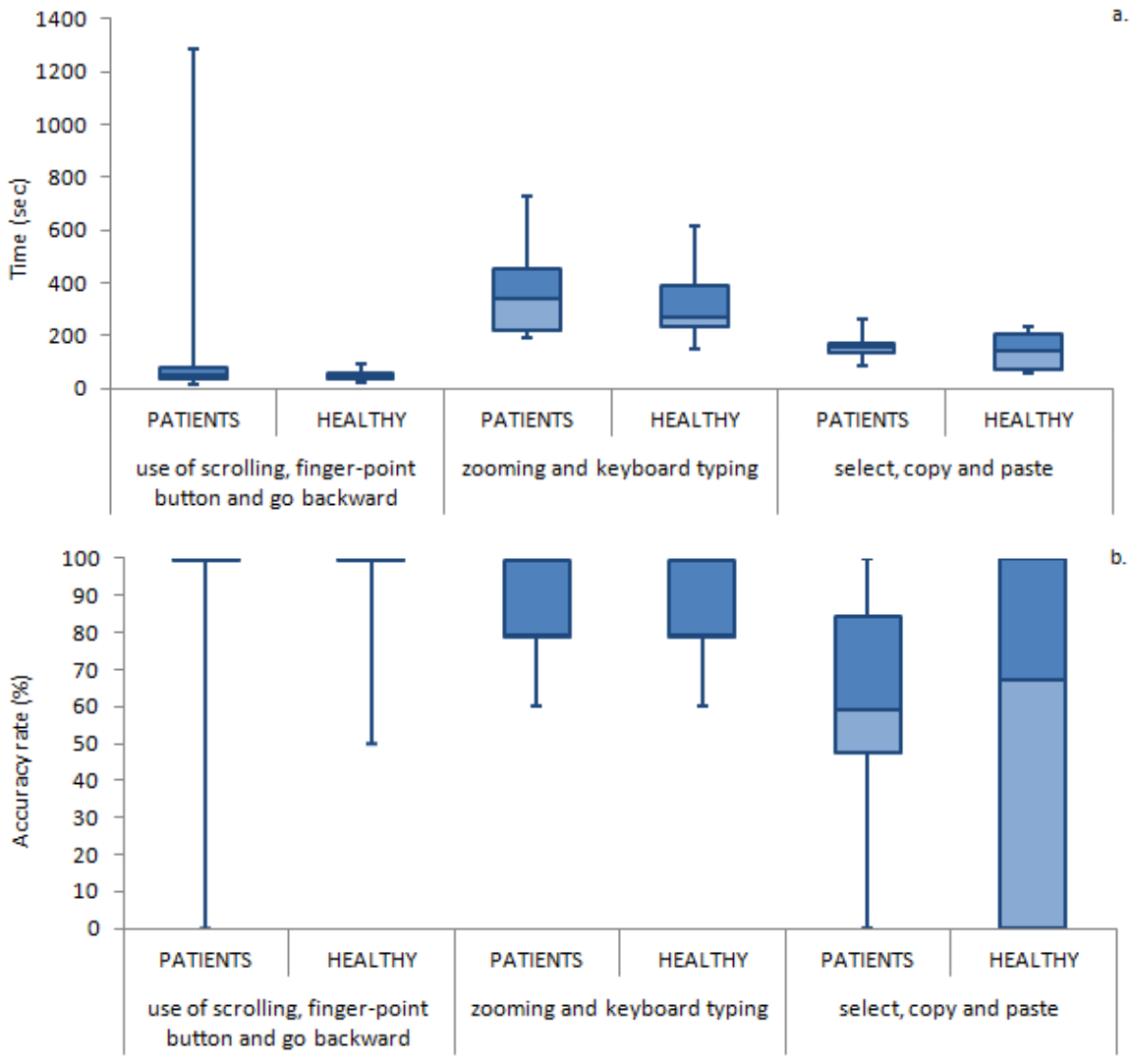
Intermediate tasks

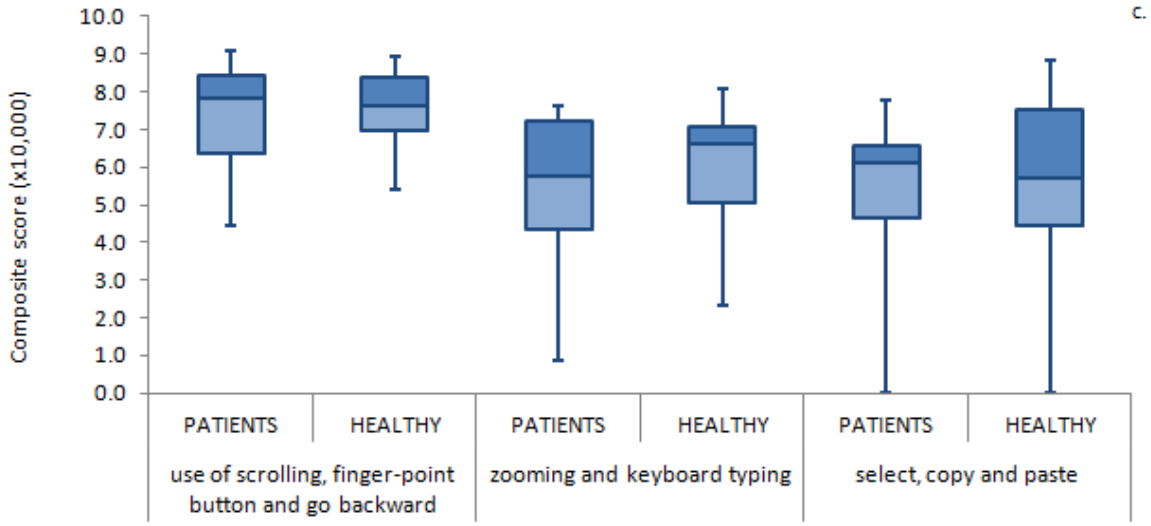
Participants developed competence in the three intermediate tasks and both groups were able to achieve competence at comparable time and accuracy (Table 47, Figures 5 a-c).

Table 47. Descriptive statistics for training intermediate tasks by group (able - bodied vs. patients).

	Patients		Able - bodied	
	N	Median	N	Median
Use of scrolling, finger-point button and go backward				
Time (sec)	17	52.0	18	47.0
Accuracy (%)	17	100.0	18	100.0
Score (x10,000)	15	7.8	18	7.6
Zooming and keyboard typing				
Time (sec)	16	337.0	18	271.5
Accuracy (%)	17	80.0	18	80.0
Score (x10,000)	16	5.8	18	6.6
Select, copy and paste				
Time (sec)	13	154.0	13	144.0
Accuracy (%)	16	59.0	18	67.0
Score (x10,000)	15	6.1	16	5.7

Figure 5 a-c. Competency in training intermediate tasks by group (able - bodied vs. patients) using boxplots.





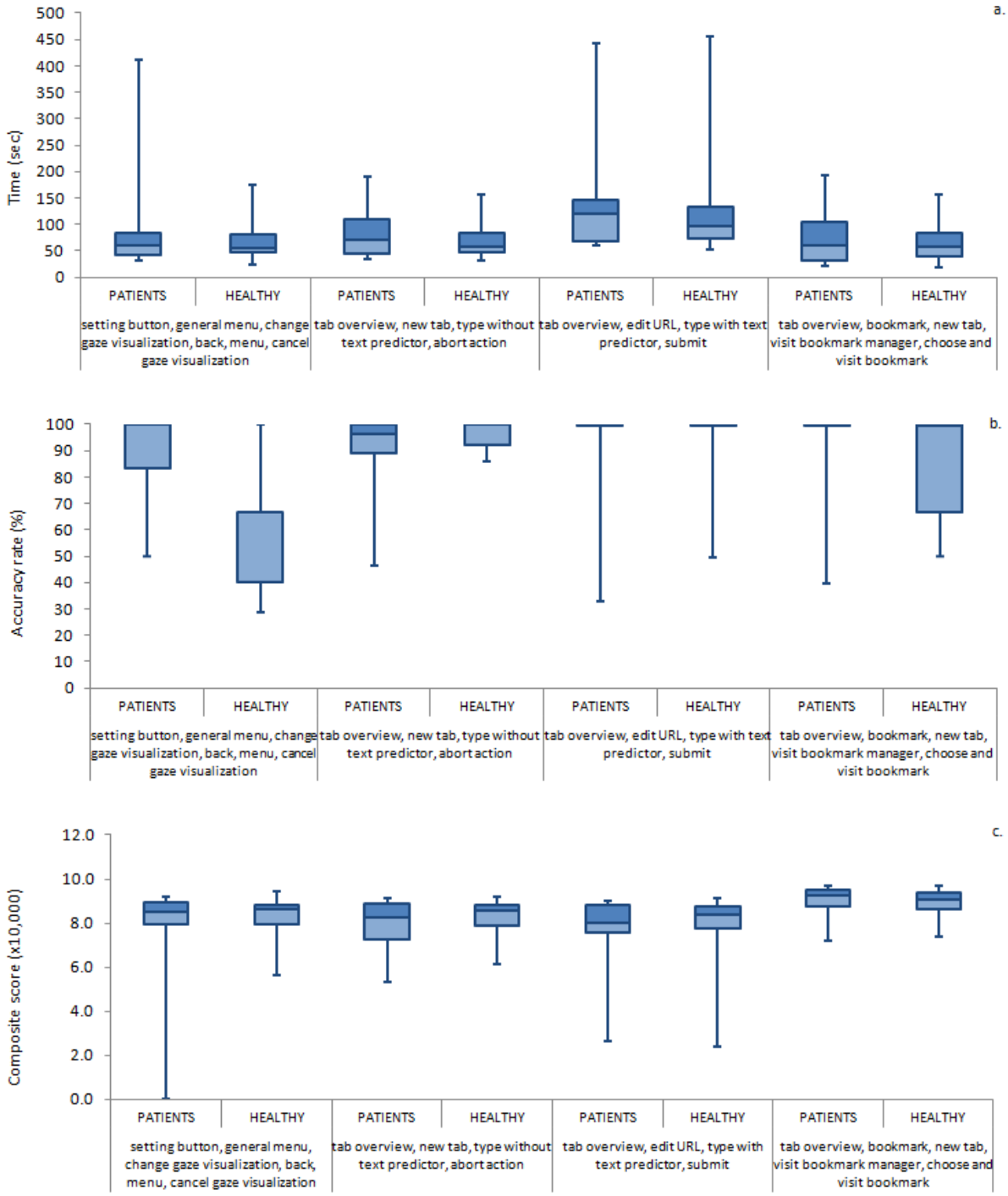
Advanced tasks

Participants were able to carry out the four advanced tasks with competence and there seemed that both the group of patients and the one of able – bodied did similarly in time and accuracy across tasks, apart from accuracy rate on the first advanced task – where patients accomplished a notably higher accuracy rate versus the able-bodied. (Table 48, Figures 6 a-c).

Table 48. Descriptive statistics and for training advanced tasks by group (able - bodied vs. NMD).

	Patients		Able - bodied	
	N	Median	N	Median
Setting button, general menu, change gaze visualization, back, menu, cancel gaze visualization				
Time (sec)	16	60.5	18	54.0
Accuracy (%)	16	100.0	18	66.7
Score (x10,000)	16	8.5	18	8.6
Tab overview, new tab, type without text predictor, abort action				
Time (sec)	16	69.5	18	56.0
Accuracy (%)	16	96.2	18	100.0
Score (x10,000)	16	8.3	18	8.6
Tab overview, edit URL, type with text predictor, submit				
Time (sec)	16	119.5	18	97.5
Accuracy (%)	16	100.0	18	100.0
Score (x10,000)	16	8.0	18	8.4
Tab overview, bookmark, new tab, visit bookmark manager, choose and visit bookmark				
Time (sec)	16	59.5	18	57.0
Accuracy (%)	16	100.0	18	100.0
Score (x10,000)	16	9.3	18	9.0

Figure 6 a-c. Competency in training advanced tasks by group (able - bodied vs. NMD) using boxplots.



Remarks for Error Related Potentials (Errps) and SMR experiments

Participants carried out the Errps and SMR experiments and competence was similar between the group of patients and the one of able – bodied (Table 49).

Table 49. Descriptive statistics for Errps and SMR experiments by group (able - bodied vs. NMD) and design (persuasive vs. non-).

	N	Median	N	Median
	Able - bodied		Patients	
Errps	18	4.0	15	4.0
SMR	18	3.0	16	3.0

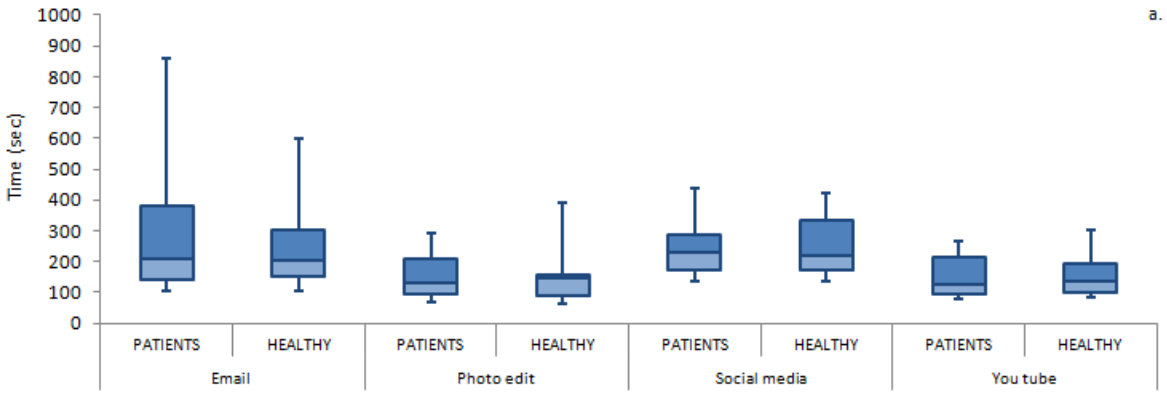
Dictated tasks

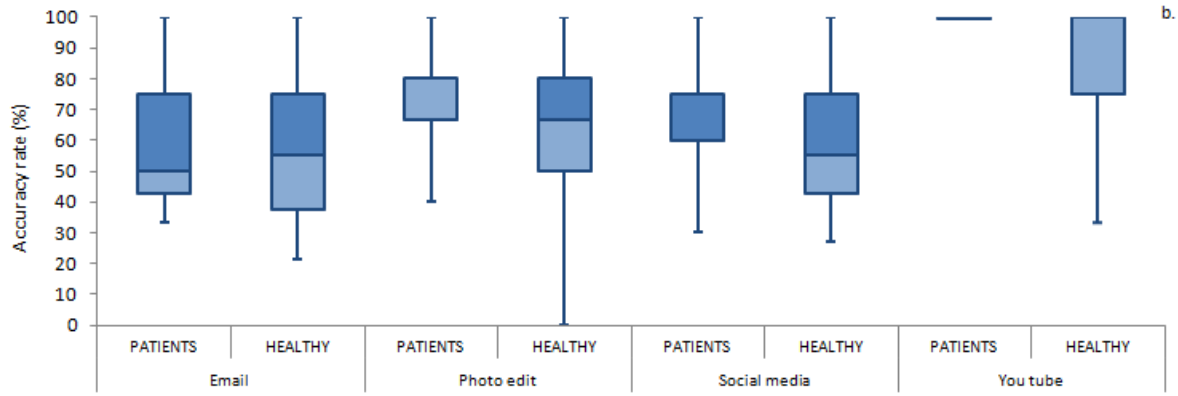
All participants were able to carry out the dictated tasks. The competence with which the four dictated tasks were carried out (time needed, click accuracy rate) seemed to be similar between the group of patients and the one of able - bodied (Table 50, Figures 7 a-b).

Table 50. Descriptive statistics for dictated tasks by group (able - bodied vs. NMD).

	Patients		Able - bodied	
	N	Median	N	Median
E-mail				
Time (sec)	15	210.0	18	202.5
Accuracy (%)	15	50.0	18	55.0
Photo edit				
Time (sec)	15	130.0	17	148.0
Accuracy (%)	15	80.0	18	66.7
Social media				
Time (sec)	15	230.0	18	220.0
Accuracy (%)	15	60.0	18	55.0
You tube				
Time (sec)	15	125.0	18	135.0
Accuracy (%)	15	100.0	18	100.0

Figure 7 a-b. Competency in dictated tasks by group (able - bodied vs. patients) using boxplots.





Learning curves relative to training and dictated tasks

Because of the diversity within and between the different tasks, three parameters that may describe the relative progression of the participants' performances throughout the study were generated, and as such were used in learning curve analyses: (1) relative accuracy scores in the training tasks, (2) clicking accuracy in the dictated tasks and (3) overall typing speed across the study.

Relative accuracy scores in the **training tasks** were calculated relative to the highest score obtained by the best performing participant (for each task). For example, in basic training task # 1 (focus on several locations) the best score obtained was a 35.7% accuracy. Now, if one particular participant scored 9.62% on that task, the relative accuracy score of that participant was calculated as 9.62 / 35.71. Another example: in intermediate training task #1 (use of scrolling, finger point button and go backward): the best score obtained was 100, while another participant scored 80, so his relative accuracy score was 80%. Using this strategy, we were able to construct a measure for performance (accuracy) that was independent of the difficulty of the task and thereby we were able to compare the progress in performance (accuracy) of participants over the series of tasks.

Since the dictated tasks did not have a built-in scoring mechanism (assessing performance/accuracy) as the training tasks did, for the learning curves on dictated **tasks** we used **Relative Clicking Accuracy.** This measure was calculated as the actual performance (numbers of clicks performed by the participant in order to complete the task) relative to the optimal performance (optimal number of clicks required to perform the dictated task). For instance, if the email task required 10 clicks to perform optimally, clicking 20 times produced a 50% of clicking accuracy. It is important to note that although the different tasks demanded a different number of clicks, calculating relative clicking accuracy for each task diminished the difference.

Finally, **Typing speed** was calculated by averaging the speed of typing i.e. characters per second (y axis in Figure 12), across the participants in each number of typed characters data points. This method allows viewing the typing speed as a function of time since, as the study progressed, the participants were asked to type in almost all of the tasks. The difficulty in these tasks was identical since in all of these typing tasks, the MAMEM keyboard was used in the same way. However, since eventually every participant typed a different amount of characters, the higher the character count the less participants were included in the sample. Nevertheless,

using this method, it is possible to depict typing speed learning curves, which can be considered as proficiency in using the platform since typing is one of the basic functions the platform provides.

The above three measures were chosen since they are all calculated in a relative way and therefore can make the tasks' time points comparable. In addition, these measures were calculated over consecutive tasks, thus fulfilling the demand to show improvement over time. Hence, these measures can show the relative progression on the performance of the participants throughout the study. It should be mentioned that as the study progressed, the tasks were not necessarily more difficult (even though the training tasks were named basic, intermediate and advanced) since they all demanded following a similar procedure of using the gaze to control the platform to perform different tasks.

Figures 8, 9 and 10 present the training tasks learning curves created from the relative accuracy scores for the entire study sample and for the disabled and able-bodied participants.

Figure 8. Training tasks learning curve for all participants

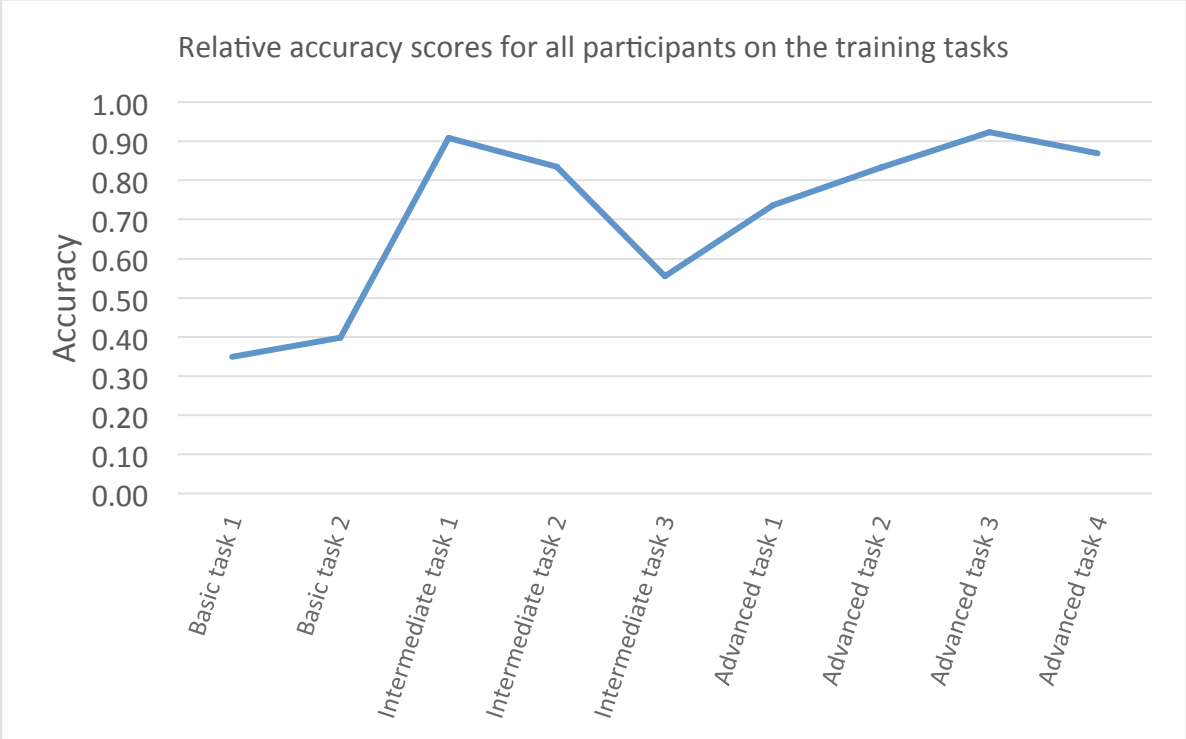


Figure 9. Training tasks learning curve for the disabled participants

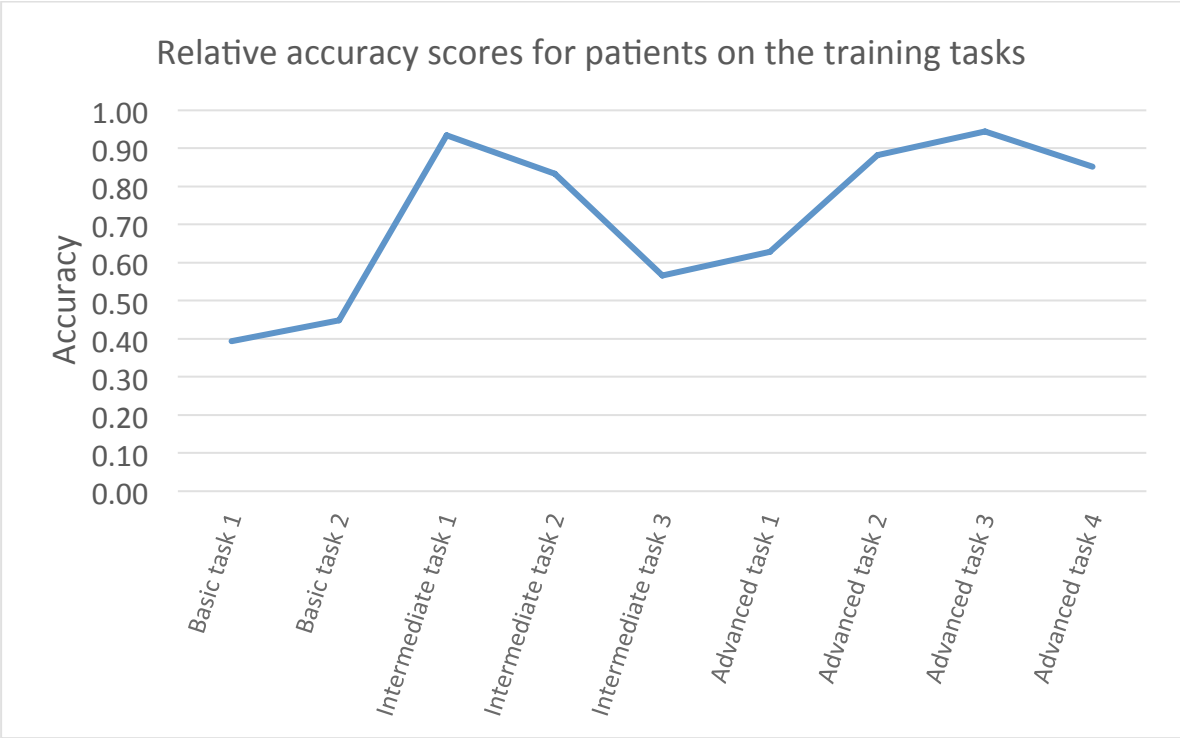
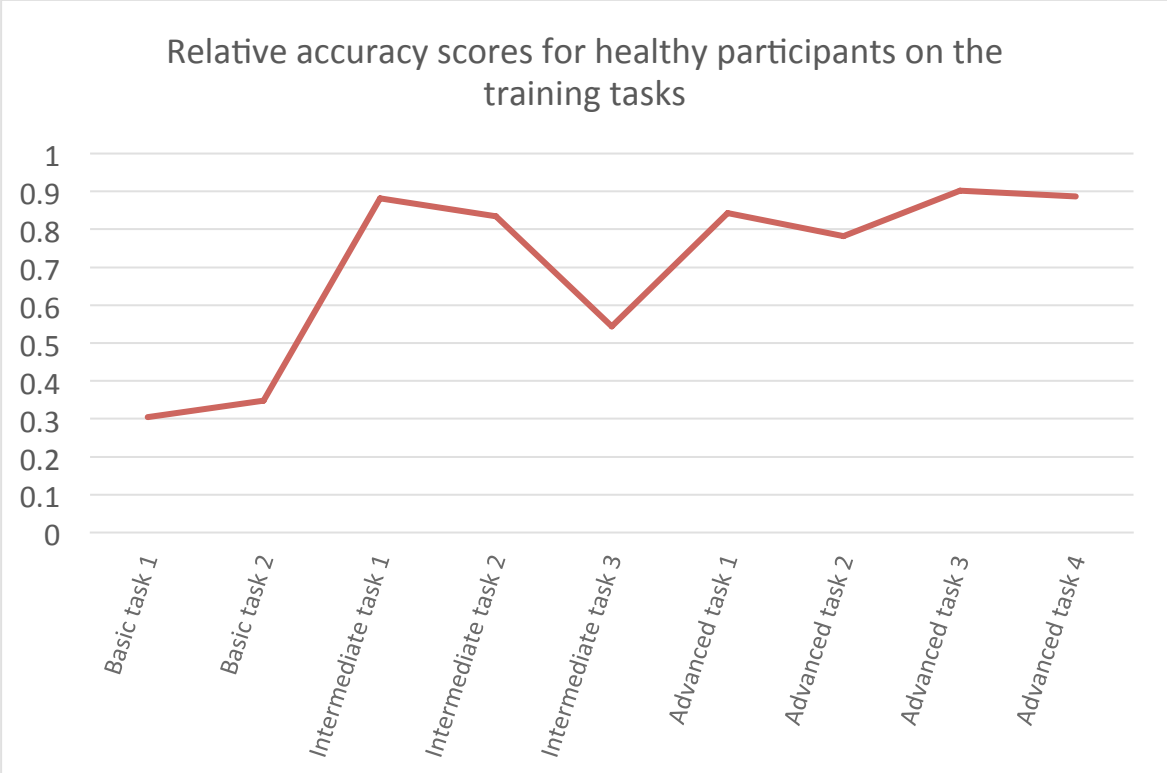


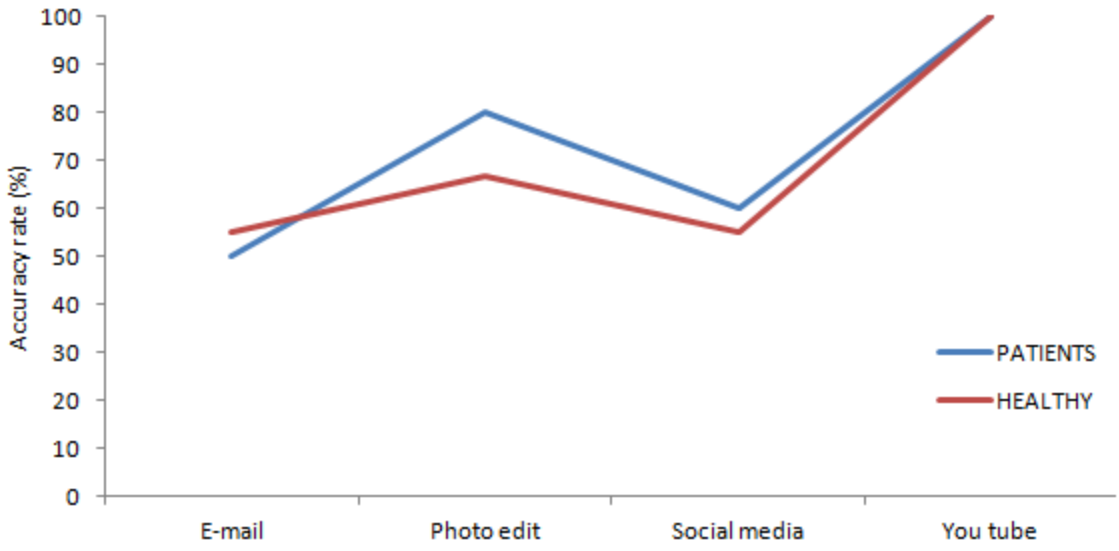
Figure 10. Training tasks learning curve for the able-bodied participants



Examining these learning curves shows that there is a tendency for a rise in accuracy rates across the learning tasks, apart from a small decline in intermediate task 3 which is most probably a product of a software bug (in that task) that impaired the performance of some of the participants in this task. In addition, it seems that there is no difference between the able-bodied participants and patient samples, meaning that the patient participants' disabilities do not hinder their ability to learn how to use the system.

Figure 11 presents the dictated tasks clicking accuracy learning curves of both able-bodied participants and patient ones.

Figure 11. Dictated tasks learning curve for able-bodied (blue) and disabled (red) participants



Similarly to the above learning curves, it is possible to see a tendency for a steady rise in performance over time and that able-bodied participants perform fairly similarly to the patient ones. Thus, in this case as well, it is possible to draw the same conclusions as before, namely, that users become better (increased performance/accuracy) at using the MAMEM system after using it more, and that the disabilities of the patient participants did not hinder their abilities to operate the system and that the system accommodates various levels of disabilities.

Finally, Figures 12 and 13 depict the overall typing speed learning curve and the learning curves of the able-bodied participants together with those of the patients. The y-axis presents characters-per-second units and the x-axis presents the number of characters typed.

Figure 12. Typing speed learning curve for all the participants

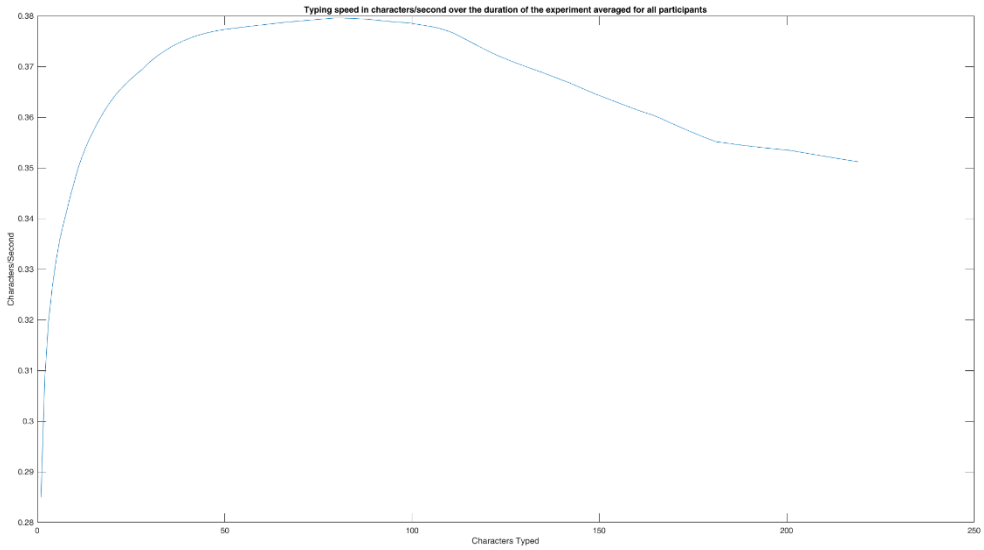
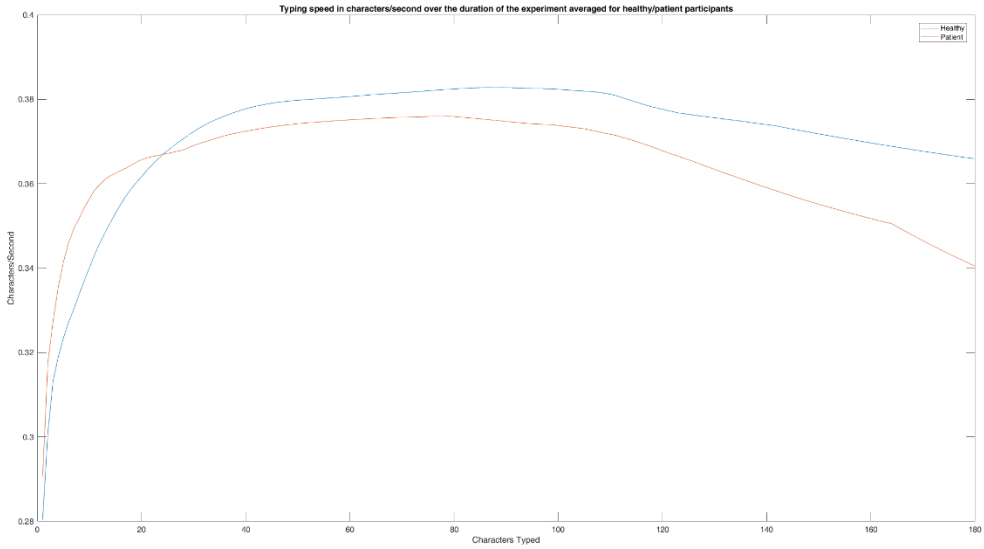


Figure 13. Typing speed learning curves for able-bodied (blue) and disabled (orange) participants



Examining the typing speed learning curves (figures 12 and13), here too, it is possible to see a typically shaped learning curve indicating a short learning period in which proficiency rises fairly quickly to the point of a plateau in which performance becomes steady. In addition, it is possible to see that the learning curves of able-bodied participants are similar to those of the patient participants, indicating that patients with disabilities are able to learn how to operate the system and reach similar performance as able-bodied participants in the typing skill, which is one of the most important abilities that MAMEM can offer people with disabilities.

2.3.3 Secondary outcomes

User acceptance and evaluation of persuasive design

Part I of the User Acceptance Questionnaire evaluated the reactions to the usage elements of MAMEM:

The overall experience of MAMEM

The patients responded with a median of 7.0 on a 7-point scale on the statement “MAMEM did not scare me at all”. They did respond with a median of 6.0 on a 7-point scale on the item “MAMEM system made me nervous”. This could be attributed to MAMEM being a new technology for them, needing to build a new skill set to use it. The patients responded with medians of 2.0 and 2.0 respectively to the reverse statements: “the MAMEM system made me uncomfortable” and “the MAMEM system made me feel uneasy”. These results provide an indication that MAMEM is a fairly user-friendly device for individuals with NMD related physical disabilities.

Sense of using MAMEM independently

With regards to the patients’ sense of competence, using MAMEM, they responded with a median of 9.0 on a 10-point scale on the item “I could complete the training tasks of MAMEM if someone showed me how to do it”. However, patients responded with a median of 5.0 on a 10-point scale on the item “I could complete MAMEM tasks if there was no one around to tell me what to do”. This provides an indication that there needs to be thorough support to the participants in Phase II trials, to ensure that they reach a good level of MAMEM competence, before they start using it on their own for a month. Support at hand needs to be available throughout that month.

Sense of confidence using MAMEM

Patients responded with a median 6.0 on a 7 point scale on items like “ Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use it” and “I have the skills and knowledge necessary to use the MAMEM system”, and this shows fairly high confidence in using MAMEM. The item “I had control over using the MAMEM system” got a median 5.0 response on the 7-point scale, which is above average but is slightly less confident. This raises again the point that MAMEM requires a familiarization period, which needs to be taken into account in Phase II trials, providing support and troubleshooting readily at hand to the participants.

Enjoyment in using MAMEM

The patients in the sample tended to find the MAMEM system enjoyable. They rated with a median of 6.5 on a 7-point scale the statements “The actual process of using MAMEM was pleasant”, and “I had fun using the MAMEM system”, “I find using the MAMEM system enjoyable”. As it has been noted already, the element of enjoyment has been shown in research to be associated with high technology adoption rates (Venkatesh et al., 2003)

Motivation to use MAMEM

Patients assigned a median 5.0 to items like “the training tasks motivated me to train my MAMEM skills” and “games in the training tasks motivated me to do those tasks”. Patients

assigned a median 4.0 on a 7-point scale to the item “messages in the MAMEM system were intended for me”. This response was above average but ideally work needs to be done further to align the MAMEM messages with the needs of the patients. And finally, patients assigned a median 6.0 on a 7-point scale to the item “Assuming I had access to MAMEM I intend to use it”.

The following table (Table 51) summarizes how patients across the three cohorts rated the items of part I of the usage questionnaire:

Table 51. Descriptive statistics for answers on User Acceptance Questionnaire Part 1

	Patients	
	N	Median
The MAMEM system did not scare me at all	17	7.0
Operating the MAMEM system made me nervous	17	6.0
The MAMEM system made me feel uncomfortable	17	2.0
The MAMEM system made me feel uneasy	17	2.0
I could complete the training tasks using the MAMEM system… if there was no one around to tell me what to do	17	5.0
if I had just the build-in practice games for practicing	17	8.0
if someone showed me how to do it first	17	9.0
I had control over using the MAMEM system	17	5.0
I have the skills and knowledge necessary to use the MAMEM system	17	6.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	17	6.0
I had control over using the MAMEM system	17	6.0
I have the skills and knowledge necessary to use the MAMEM system	17	5.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	17	6.0
I find using the MAMEM system enjoyable	17	6.0
The actual process of using the MAMEM system was pleasant	17	6.0
I had fun using the MAMEM system	17	6.0
The training tasks motivated me to train my MAMEM skills	17	5.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	17	5.0
I had the feeling that the messages of the MAMEM system were intended for me	17	4.0
Assuming I had access to a MAMEM system, I intend to use it	17	6.0

There were no notable differences by design, persuasive or not (Table 52). The presence of persuasive design elements did not get reflected in clear differences in the responses to the User Acceptance Questionnaire. There are some indications to make note of, as in the item “I could complete the training tasks using the MAMEM system if there was no one around to tell me what to do”, where those exposed to the persuasive design respond with a median 8.0 out of 10 and those not exposed to it respond with a 2.0 out of 10. However, overall, there seemed to be no notable differences. Persuasive design elements may not have been able to generate clearly discernible differences, due to an already existing rather high level of motivation. In addition, participants operated MAMEM in the presence of technicians and experimenters, and this setup in itself was motivating them, to do well anyway.

Table 52. Descriptive statistics for answers on questions of User Acceptance Questionnaire Part1 by design (persuasive vs. non-)

	Non-persuasive		Persuasive	
	N	Median	N	Median
Patients				
The MAMEM system did not scare me at all	9	7.0	8	4.5
Operating the MAMEM system made me nervous	9	5.0	8	6.0
The MAMEM system made me feel uncomfortable	9	3.0	8	2.0
The MAMEM system made me feel uneasy	9	2.0	8	3.0
I could complete the training tasks using the MAMEM system				
if there was no one around to tell me what to do	9	2.0	8	8.0
if I had just the build-in practice games for practicing	9	5.0	8	8.0
if someone showed me how to do it first	9	9.0	8	10.0
I had control over using the MAMEM system	9	6.0	8	4.0
I have the skills and knowledge necessary to use the MAMEM system	9	6.0	8	5.5
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	9	6.0	8	5.5
I had control over using the MAMEM system	9	6.0	8	5.5
I have the skills and knowledge necessary to use the MAMEM system	9	5.0	8	5.0
Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	9	6.0	8	5.5
I find using the MAMEM system enjoyable	9	6.0	8	5.5
The actual process of using the MAMEM system was pleasant	9	6.0	8	5.5
I had fun using the MAMEM system	9	7.0	8	6.0
The training tasks motivated me to train my MAMEM skills	9	6.0	8	3.0
The games in the training tasks (e.g., collecting points) motivated me to do those tasks	9	5.0	8	3.5
I had the feeling that the messages of the MAMEM system were intended for me	9	5.0	8	4.0
Assuming I had access to a MAMEM system, I intend to use it	9	6.0	8	6.0

The Part II of the user acceptance questionnaire includes 8 questions, which cover the perceived usefulness of the device and the intention to use it. Patient responses are charted in Table 53. Patient participants gave full marks (a median of 7.0 in a 7 point scale) to items such as “using MAMEM will increase my productivity”, and “assuming I had access to a MAMEM system I intend to use it”

Impact on social inclusion

Patients responded with a median 6.0 on a 7-point scale to the item “using MAMEM will result in my interacting more and better with people and groups, online and off”. It seems that patients perceive favorably the impact that MAMEM may have in social participation.

Productivity in social tasks

Patients respond with a median of 6.0 on a 7 point scale in items like: “using MAMEM will improve my ability to carry out such tasks”, “will be useful”, “will be relevant” for these kinds of tasks.

Learning and using MAMEM

Patients assigned a median 1.0 on a 7-point scale to the statement “I find MAMEM cumbersome to use”; while they assign a median 5.0 on a 7-point scale to the statement “I would imagine that most people would learn to use MAMEM system very quickly”.

Table 53. Descriptive statistics for answers on questions of User Acceptance Questionnaire Part 2

	Patients	
	N	Median
Using MAMEM will result in my interacting more and better with people and groups, online and off	15	6.0
Using MAMEM will increase my productivity on such kinds of tasks	15	7.0
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	15	6.0
I find using MAMEM to be useful for these kinds of task	15	6.0
The use of MAMEM is relevant for these kinds of tasks	15	6.0
Assuming I had access to a MAMEM system, I intend to use it	15	7.0
I found the MAMEM system very cumbersome to use	15	1.0
I would imagine that most people would learn to use the MAMEM system very quickly	15	5.0

With regards to persuasive design, there tended to be no notable differences between those exposed to it, and those not (Table 54). Indeed the sample is small to arrive to conclusive results, however, it can still be surmised that the high incidence of motivation to learn and use MAMEM may have evened out the effect of persuasive design. It can be hypothesizes that persuasive design will play a stronger role in Phase II of the trials, where participants will use the device at home for a month.

Table 54. Descriptive statistics and for Answers on questions of Persuasive questionnaire Part 2 by design (persuasive or not)

	Non-persuasive		Persuasive	
	N	Median	N	Median
Patients				
Using MAMEM will result in my interacting more and better with people and groups, online and off	9	6.0	6	4.5
Using MAMEM will increase my productivity on such kinds of tasks	9	7.0	6	6.5
Using MAMEM will improve my ability to effectively carry out these kinds of tasks	9	6.0	6	6.5
I find using MAMEM to be useful for these kinds of task	9	6.0	6	6.5
The use of MAMEM is relevant for these kinds of tasks	9	6.0	6	6.0
Assuming I had access to a MAMEM system, I intend to use it	9	7.0	6	6.0
I found the MAMEM system very cumbersome to use	9	1.0	6	2.5
I would imagine that most people would learn to use the MAMEM system very quickly	9	4.0	6	5.0

System usability (SUS) and user satisfaction questionnaires (QUEST)

The SUS scores were calculated according to the standard way of calculation of this questionnaire (https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html), namely by assigning a relative score to each item and performing a calculation with their sum. Results show that the median SUS score among the patient participants (n=16) was 72.5, which is considered an above average score.

The QUEST 2.0 questionnaire was answered only by those who tested the lightweight configuration (n=14), and participants were instructed that they should answer this questionnaire only in relation to the lightweight configuration. The QUEST scores were calculated by averaging the part of the questionnaire that concerns the different physical and usability elements of the device (Table 55). Results show that the median QUEST score was 4.2 on a 5-point scale, which is between "very satisfied" and "quite satisfied".

Table 55. Descriptive statistics for system usability (SUS) and user satisfaction questionnaires (QUEST)

	N	Median
	Patients	
SUS score	17	72.5
QUEST score	14	4.2

2.3.4 Physiological results

The stress levels were assessed using the GSR signals that were monitored throughout the study. To calculate stress levels using these signals, an algorithm was used for stress detection that scanned the GSR signals in an unsupervised manner and computed 4 different thresholds categorizing the stress level of the participant in 5 levels. Thus, the result of the algorithm can be one of the following values [1, 2, 3, 4, and 5], with "1" indicating low and "5" high stress levels. Before generating the figures a mean filter (1-minute length) has been applied to the result of the algorithm for smoothing. The data shown in each figure, corresponds to the first 4 phases of the trial:

(a) Training (purple color)

(b) Errp task - Heavy conf. (red color)

(c) SMR task - Heavy conf. (yellow color)

(d) Dictated task (blue color)

Table 56 shows that there were notable differences in stress patterns among patients and able-bodied, with patient participants experiencing slightly higher stress.

Table 56. Descriptive statistics for physiological results by group (healthy vs. patients) and design (persuasive vs. non-)

	N	Median	N	Median
	Patients		Able-bodied	
GTW Stress (mean)	14	3,9	17	2,3
Errp Stress (mean)	14	3,3	17	3,0
SMR Stress (mean)	14	4,8	17	2,2
Dictated Stress (mean)	14	3,8	17	2,2

Figure 14. Stress levels, patient participants

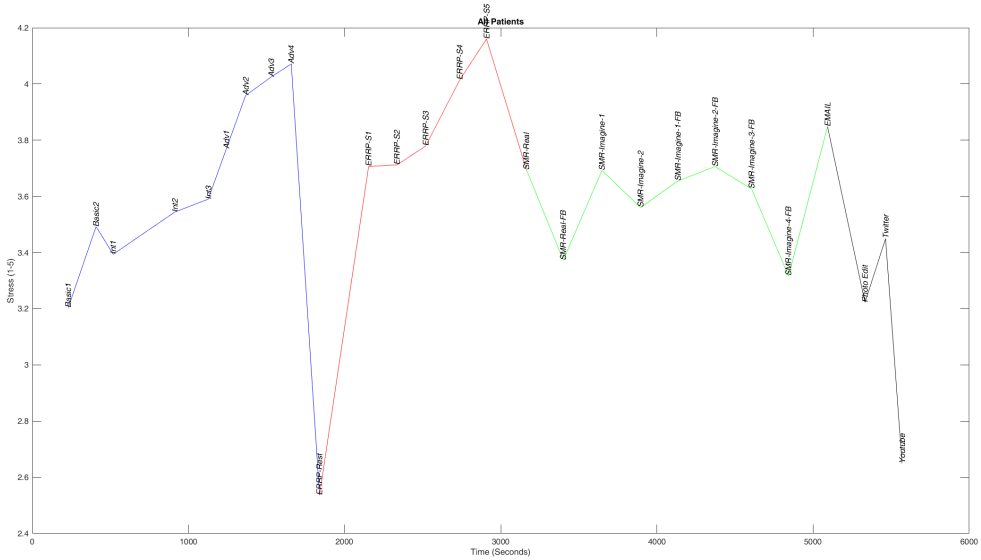
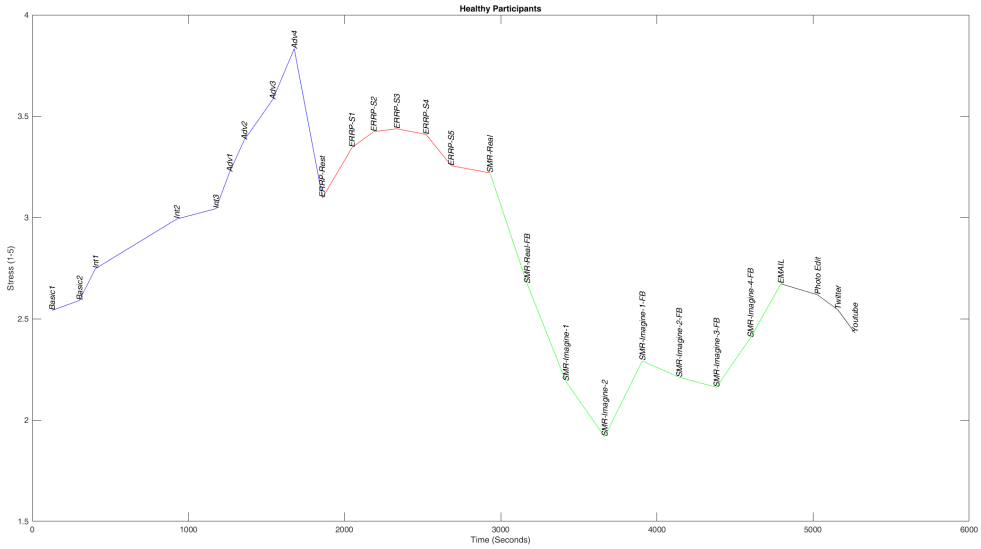


Figure 15. Stress levels, able-bodied participants



2.3.5 Discussion

In this clinical trial 18 able-bodied participants and 16 patients went through MAMEM training and carried out specified dictated digital tasks relevant to social inclusion, using the system.

Participants' competence in MAMEM tasks

Participants' competence (time needed, accuracy rate, composite score) in the two basic tasks, in the three intermediate tasks and in the four advanced tasks was similar between the group of patients and the one of the able – bodied participants, apart from accuracy rate on the first advance task which was higher among patients. Moreover, participants' competence (time needed, click accuracy rate) in the four dictated tasks (e-mail, photo edit, social media, YouTube) was similar between the two groups of patients and able – bodied participants. This finding indicates that MAMEM can be considered an assistive device. It is shown, in this clinical trial, that individuals with disability can achieve usage competence similarly to able-bodied individuals. It is shown in the trials that with the use of MAMEM, physical disability stops tends to not be a parameter in how competent an individual can be in performing digital tasks, given "speed" and "accuracy rates" as key metrics of performance.

With regards to learning curves, participants' accuracy rate in training and digital dictated tasks improved from the first basic task (focus on several locations) to the last advanced task (tab overview, bookmark, new tab, visit bookmark manager, choose and visit bookmark). Moreover, the difference of accuracy rate between first basic and last advanced training tasks were similar between the group of patients and that of able - bodied, being greater for patients.

Participants' competence in Error related potentials and SMR experiments were similar across the group of patients and that of the able-bodied.

Persuasive design evaluation

Half of the participants were exposed to MAMEM in the context of a persuasive design setup, while the rest of the participants were not. It was found that competence in the basic, intermediate, advanced and dictated tasks was similar according to the design (persuasive or not) for the two groups - able-bodied and patient separately. Learning curves did not differ according to the design (persuasive or not), and this was also the case for the two groups – able-bodied and patient's separately.

The following hypotheses may explain why persuasive design did not seem to generate a distinctive impact all across the training and dictated tasks:

There are several possible explanations for this result:

1) Due to the nature of the current study, in which a new state of the art platform is being tested, the motivation of the participants was most likely high, especially during the first part that was the training part. The celling effect means that the persuasive design was not able to create a difference in the motivation levels due to already existing high levels of motivation. Malone & Lepper, (1987) discuss the notion of "intrinsic motivation", a type of activating force that derives directly from an activity or situation. It has also been described as "hedonic, novelty seeking motivation" by Venkatesh et al. (2012). Participants across all cohorts came in for the experiment with the excitement

and eagerness of testing a novel device that “can read the mind”. They were intrinsically motivated to explore, try it out and do well, no matter the persuasive design or not

2) Perhaps the most relevant explanation for the lack of distinct differences in learning and using the MAMEM system across groups with or without persuasive design is the short duration of the training session. It is estimated that the motivation to perform at their best is highest for the first training session, and before the novelty of the device wanes. Persuasive design may play a stronger role in Phase II of the trials, when each participant will use the device in a routine, day to day way, without observers, and having to overcome other, competing habits of computer use, in favor of using MAMEM consistently, on a daily basis. It is possible that the persuasive designs’ advantages can only be manifested when the platform is tested for a longer period of time, over multiple sessions.

3) Social facilitation: Aiello and Douthitt (2001) have postulated that people make a harder, more dedicated effort, in the presence of others, and especially so when they are observed. The experimental environment of the Phase I trials included several technicians and experimenters and can be assumed to have favored recognition seeking behavior. Thus, it can be assumed that participants were motivated to try their best in this social environment, no matter the persuasive design.

4) According to the social comparison theory, first presented by L. Festinger in 1954, people want to know how they compare to others, and this is a strong influence on their behaviors. The participants in the trial came with eagerness to try a state of the art new technology not wanting to be left behind in how they did with it. The assumption is that they were motivated to as best as they could, also knowing that there was a set of both healthy and patient individuals undergoing the training against which they were compared.

User acceptance evaluation

Part 1 of the user acceptance questionnaire included 18 statements. Reactions were overall positive for MAMEM on a 7 grade Likert scale, and they were similar between the group of patients and the group of able - bodied participants, or between the design groups, nor among able - bodied or patients separately. User acceptance questionnaire part II included 8 questions, which covered the perceived usefulness and intention to use of the device. Results were similar patients and able-bodied participants, with the exception of the statements “using MAMEM will increase my productivity on such kinds of tasks” and “using MAMEM will improve my ability to effectively carry out these kinds of tasks” with which agreed more the group of patients than the group of able - bodied. On the basis of the findings, both able-bodied and patient participant groups, tended to see the merit and usefulness of the device. The majority responded favorably to the items in the user acceptance questionnaires, despite the tedious process of the heavyweight system, and the occasional imprecisions of the lightweight system.

Implications for social inclusion

The Phase I clinical trial was called in to evaluate MAMEM at its current state of development

as also to evaluate its potential to foster social inclusion. In the user acceptance questionnaire, the statement “using MAMEM will increase my productivity in such kinds of tasks” and “using MAMEM will improve my ability to effectively carry out these kinds of tasks” elicited a slightly more positive reaction among patients versus able-bodied participants. Moreover, the statement “using MAMEM will result in my interacting more and better with people and groups, online and off” elicited an agreement average evaluation among patients. These results are promising with regards to the potential of MAMEM in relation to enhancing social inclusion for people with disabilities.

3. RECOMMENDATIONS FOR MODIFICATIONS OF THE PROTOCOL AND THE PLATFORM FOR PHASE II OF PILOT STUDIES

In the second Phase an almost identical protocol that was used in Phase I will be applied for the training of the participants in their homes (see D6.3 (MAMEM Consortium, 2016). The lightweight apparatus will be provided to the participants for usage for one month. The apparatus will be installed to the participant's house by an experimenter, in a half-day visit, in which the participant will also receive training in using the apparatus. Technical support will be available.

Phase I points out to some minor changes in the protocol as follows:

3.1.1 Inclusion / Exclusion Criteria

PD sample: The element that needs to be added in inclusion criteria is the ability of a Parkinson's disease prospective Phase II trials participant to hold their body posture upward for at least a stretch of time of 15 minutes. This is in light of the fact that in Phase I, one PD participant had trouble holding their body posture on a vertical axis and this meant that he frequently lost eye calibration with the eye tracker and the device had to be re–calibrated repeatedly.

NMD sample: According to D6.2, the inclusion criteria involve individuals suffering from Duchene and MSA. Exclusion criteria used in Phase I: involuntary eye movements and twitches, implanted devices, brain and cognitive functioning conditions that may interfere with the EEG signals. Following Phase I, ideally the sample needs to include individuals who have impaired mobility of their hands. It was seen that individuals who have any ability to use the mouse with their hands were rather reluctant to adopt MAMEM and "stop exercising their hands". It is hypothesized that the more extensive the physical disability the stronger difference MAMEM will make in the participant's life. However, it needs to be seen whether the MDA population can currently fulfill this criterion or not. Would there be an endless population of NMD individuals available, we would need to ideally prefer individuals who are not already fully digitally functional through other assistive devices.

SCI sample: considering Phase I and the removal of two SCI participants due to their inability to operate the eye-tracker, the inclusion/exclusion criteria of should be changed to be able to exclude such SCI participants beforehand. One of the SCI participants was excluded since he sat leaning to the left due to his injury and this made it impossible to the eye tracked to read his eyes. The reason that the other SCI participants was removed was because his eyes were constantly swollen and partly closed which also made it impossible for the eye-tracker to track his eyes. These two cases indicate that the following exclusion criteria need to be added: "partly closed eyes or unbalanced sitting posture that could result in an inability to operate an eye-tracker".

3.1.2 Apparatus

Only the lightweight configuration will be used in Phase II. There are two major issues with this configuration that need to be considered:

Precision and responsiveness: many participants complained that this apparatus lacks precision and responsiveness. They had to calibrate and recalibrate to be able to use it effectively, and even then, there were still some problems. In addition, it seems that the participants who were more digitally savvy, and who were already using other assistive devices, had a lower frustration tolerance level, meaning that in phase two could have a higher chance to stop using the MAMEM platform. In light of this, care needs to be taken at the second phase of the study to inform the Phase II participants that they will be evaluating MAMEM as "work in progress" rather than as a fully optimal version of the system.

GSR and SCI: Due to the possible problem in assessing GSR among SCI participants, its use in this group should be re-considered. More specifically, SCI patients tended to exhibit elevated GSR levels that can be accounted to their injury. The GSR is controlled by the sympathetic nervous system and reacts to emotional stimulation and arousals (Boucsein, 2012). The elevated level of GSR measured in the current study, may be the product of the injury in the spinal cord that disrupted the tasks of the nerves that suppress the GSR levels and therefore, high levels of stress were observed among the SCI participants.

3.1.3 Training and dictated tasks Procedure

It became evident in Phase I that participants need clear instructions about how to use MAMEM. The device is not readily intuitively figured out. Clear guidelines and directions are very important in leading the user to a successful learning experience. It must be ensured that a user's "manual" accompanies them at home, after the half-day installment and training period, for quick and accessible reference. Access to technical support over the phone and in person, which can provide feedback and point to solutions will be important, until users become proficient in the use of the device.

The training tasks in the Phase I procedure were very smoothly accepted for the most part, and so the training procedure for Phase II can build further on them.

Concerning the persuasive design elements, the results of Phase I indicate that its impact has not been made fully evident, in the training and usage of MAMEM. It is possible that in the few hours that participants learned how to use the device, their motivation to learn an innovative technology was high anyway, to the extent that that the persuasive design did not make a difference i.e. there was a ceiling effect of motivation. However, it is hypothesized that in the context of one month of home use, where they user will have to become adept at the technology on their own, it may indeed make a difference. In general, research shows that abandonment of assistive (Phillips & Zhao, 1993) takes place some time after the initial usage of the technology. So, in the home context of using the MAMEM system for one month, the psychological changes leading to abandonment can develop.

3.1.4 Outcome measures

Concerning outcome measures in Phase II, since the outcome measures in Phase I were formulated and finalized in regard to the final procedure and results that the platform could produce, the outcome measures in Phase II trials do not need updating.

3.1.5 Update user requirement

Following the results of Phase I, the user requirement categories that were reported in D6.1 (MAMEM Consortium, 2015) can now be updated to reflect the insight that we have arrived to. The following user requirement needs to be updated:

Physiology: an important update for this category can be made in light of the fact that two SCI participants were removed because they were unable to operate the eye-tracker and one PD participant could not keep his posture on a vertical axis. The update is to take into consideration the needs of users that are leaning, cannot maintain their eyes on the same level and users whose eyes are constantly partly closed.

Interoperability: interoperability was not addressed in Phase I so no update regarding this requirement is needed.

Emotion/motivation: emotion and motivation was addressed in Phase I by including the persuasive design elements. Due to the limited conclusions that were drawn concerning this design, no updates regarding this requirement is needed.

Performance: in seems that the platform, in some respects, was not fully precise and responsive as noted by several participants. This means that precision and responsiveness are important requirements that need to be addressed in all computer assistive devices in the future, including the MAMEM platform. For example, the use of the keyboard was slow for some participants. They would lift their gaze from the key too quickly before the device had time to click it. In addition, some participants mentioned that there was less flexibility in the device: they could not just look at the text they had written, because gazing at the text would mean that keys would be clicked here and there.

Adaptation: the participants felt that at the moment it was not possible to fully personalize the use of the device, but could see how this might be solved further down the road, as the MAMEM technology progresses. Personalizing was addressed in Phase I only in regard to the persuasive design elements, which included some personalization. Due to the limited conclusions drawn concerning this, no updates regarding this requirement is needed.

Usability: the potential users in Phase I indicated that they would welcome MAMEM calibrating their computer usage style, and becoming responsive to it. For example: they would like MAMEM to be able to calibrate the speed, at which they read, the speed at which they need to type. They wish it were possible to have frequent tasks that they perform calibrated in such a way that they are carried out at top speed and ease. In addition, it seems that concerning usability, some modification should be made to the platforms' interface, such as to change the layout of the buttons and to improve the virtual keyboard. Moreover, the ability to copy-paste and to select certain areas on the screen needs some adjustments and drop down menus support should be added. The calibration process needs to be easier and to be supported in the interface itself and not by an outside program. Finally, users indicated that it would be welcome it if it was possible to choose between "active gazing" where the eyes activate the keyboard and "passive gazing", where the eyes look at the screen and read, but without activating any digital function.

Improvement of the persuasive and personalization design of the MAMEM training software will be elaborated in the deliverable D5.4.

3.2 Technical modifications of the Platform for Phase II trials

- Troubleshooting should be performed for allowing the eye-tracking devices to work simultaneously with OpenVibe (http://openvibe.inria.fr), since during the trials concurrent use of these programs has caused the eye-tracking devices to crash.
- Further integration could be allocated in unifying all different Lab-Streaming-Layer (LSL) plugins under a single plugin that would make the interconnection with the LabRecorder more straightforward for the experimenter.
- Further integration effort could be also allocated in having one master-executable program that would minimize the probability for the experimenter to neglect initiating one or more of the software programs responsible for capturing the generated signals.

3.2.1 Things that don't work

- Copy and paste function during the training tasks was tough for many participants. There were some complaints about slow speed in typing letters on the keyboard (especially with regards to the "space" key). As mentioned, selection of certain areas on the screen was problematic. In addition, some parts had bugs in the trainings software.
- There were complaints with the regards to the comparative inaccuracy in the usage of the lightweight device (in respect to the SMR experiment). With regards to the tasks to be performed with the lightweight device, specifically when it came to moving the ball, many participants were frustrated because they were repeatedly unsuccessful with this task.

3.2.2 Things that are too tedious or error-prone

- The heavyweight equipment fitting was very tedious. Fortunately, the lightweight equipment was much less so. Proneness to error was found to be very dependent on how much each participant was well practiced in cognitive tasks. Many NMD participants did better in some tough tasks (e.g. in concentrating and imagining a movement) versus the able - bodied subjects.
- During the training process, the size of the markers has proven to be rather small making the training process more challenging for the subjects.
- Pressing the space has been particularly challenging for both patient and able-body subjects, mainly due to the fact that the bottom area of the screen is the least accessible when using the eye-tracker. Different options can be considered such as giving the space button a different position, or moving-up the keyboard so as to lie in the center of the screen.
- The copy – paste function tended to be error prone.
- The most error prone tasks were the typing and use of keyboard. Users would welcome it if it were possible to choose between "active gazing" where the eyes activate the keyboard and "passive gazing", where the eyes look at the screen and read, but without activating any digital function. They would welcome having a choice between active

and passive gazing at the screen.

3.2.3 Things that need to be overcome for making MAMEM meaningful

- We need to overcome the low frustration toleration level of people with disabilities. It is hypothesized that they will not be willing to stick to using MAMEM for the full period they have it at home, should they experience frustrations or lack of speed, as is normally the case during the learning stage of adopting a new technology. We need to provide the optimal conditions for the trial that will encourage them to stick to using MAMEM to reach competence levels meaningful for social inclusion considerations.
- It must be ensured that during the training all questions are answered and the participants are able to demonstrate a full understanding of, and proficiency in the usage of MAMEM.
- We need to provide a short guide presenting visually the key functions of the system, along with a troubleshooting section for usage at home, for quick reference.
- It has been defined in D6.2 that there will be technical support available to the participants. In this context, scheduled follow up calls to the participants need to be done, as an additional measure with the purpose of generating participants' commitment to the project and to evaluate the usage of MAMEM and their progress and comfort levels using it.
- In the case that the participant is using other assistive devices, currently, ensure the full presentation of the MAMEM advantages once it has been mastered and used at home, so that the participant does not revert to using their existing device if frustrated with MAMEM while learning it.

4. RECOMMENDATIONS FOR PHASE II TRIALS RELATED TO SOCIAL INCLUSION

Advancements in technology are insufficient on their own to bridge the gap of social inclusion of persons with disabilities. They need to be operationalized for socially inclusive usage. Phase I of the clinical trials, described in this document, aims at optimizing the device itself as well as the adoption process of MAMEM in the Phase II trials, for optimal impact on the social inclusion indicators related to physical disability.

Evidence for sharing social content

The analysis of the data from the Phase I trials indicates that MAMEM is a technology that can assist people with disabilities to author multimedia content. The sample of patients across three cohorts was shown to achieve competence in multimedia interaction tasks through MAMEM, in a similar way to the able-bodied control group. The question that arises on the brink of Phase II trials is the extent to which the users with physical disabilities will use the device consistently and systematically, at home, to create and share social content and to engage in activities that promote their inclusion in society.

Self Determination Theory proposes that the degree to which an activity supports an individual's needs for autonomy, competence, and relatedness will determine if it will be and remain intrinsically motivating and therefore will be engaged in, in the longer run (Deci & Ryan, 2002). Phase I trials showed that MAMEM use provided a sense of competence to the users. The learning curves showed a distinct and fair improvement from first to last task carried out. It also gave them a sense of achievement in a modern, state of the art technology that they were eager to try.

Subsequently, the challenge for Phase II trials, in relation to MAMEM usage was shown to be twofold: a) individuals with physical disabilities who have already become comfortable with an assistive device need to be encouraged to stick to MAMEM usage to the point that proficiency in it starts to reward them with benefits of superior speed and ease in authoring multimedia content, and brings their comfort and ability for social content to new higher levels, b) individuals who have become used to lower engagement in digital social activities because of disability barriers need to be "re-awakened" to the potential that MAMEM may open up for them if they stick to using it consistently and systematically.

Thus, the challenge for digital social engagement in Phase II, via MAMEM, is actually the consistent and systematic use of the device, to the point that users are able to use it with ease and proficiency. The usability and utility of a system (Venkatesh & Davis, 2000) has been shown to influence acceptance and use of the technology greatly, and the respective user acceptance questionnaires used in this study have shown above average acceptance.

There is one more factor to be considered, and this is "technology trust", the belief that the device will help them accomplish their goals in situations of uncertainty (Lee & See, 2004). In Phase I participants expressed fair trust in the new technology, and in the controlled environment where the trials took place, they received every support and encouragement in using the device. Thus, when taking the device to use at home, their trust in it needs to be propagated and kept alive. The following considerations can forward a positive usage process

during the one-month Phase II trial:

a) Ensure that the sample inclusion and exclusion criteria (3.1.1) shape a sample that has a true need for the device. When prospective users have lost mobility in their hands they have a higher motivation to adopt the new technology. Participants with glasses, with shaky body postures, or swollen eyes will be at times frustrated with eye calibration. Having to re-calibrate the device frequently to achieve tasks is going to undermine trust in the technology.

b) Provide a very clear explanation about the "learning period" which will be required in order to become able to enjoy the full benefits of the MAMEM technology. The participants in Phase II need to become "inoculated" against giving up too soon when initially their usage of a keyboard through their gaze is slow. They need to understand in advance that MAMEM, just as every technological device, will provide its full benefits once its usage has been well mastered.

c) Social facilitation will be instrumental to the success of Phase II, in the sense that follow-ups and encouragement by experimenters will be instrumental. This involved a "manual" of usage to refer to, so as to feel confident about a source of help and troubleshooting, while follow up calls and even visits during Phase II trial, will support the participants to keep going.

Input from questionnaires related to social inclusion

Overall reactions to the user acceptance and persuasive design evaluation questionnaire were positive. The patient population in the study tended to agree that "using MAMEM will increase my productivity in such kinds of tasks" and "using MAMEM will improve my ability to effectively carry out these kinds of tasks" as well as that "using MAMEM will result in my interacting more and better with people and groups, online and off". The SCI patients believed less that MAMEM would increase their ability to author multimedia content and perhaps this was a side effect of the tediousness of the heavy weight device and the occasional imprecisions of the lightweight device. In the context of a half-day trial the wide majority of the patients reacted to the device with enthusiasm and excitement. However, in Phase II, when participants will be using the device at home, on their own and for a month, they will require top efficiency of the device, to enable them to feel confident in engaging in socially inclusive digital tasks. This needs to be the priority in the further optimization of the lightweight device, till Phase II trials.

Methodological issues in posing questions

There are two issues to be considered in posing questions in Phase II of the trials.

1) The lightweight device to be used at home, may still have minor technical issues by the time it reaches the home of Phase II trial participants (e.g. in precision levels). Any technical issues must be identified during the first day of installation and training at home, and the user needs to be notified that the device is at Beta development stage, and needs to respond to the questionnaire, assuming that the specific issues are taken care of. It will be important to make sure that minor technical issues do not overly color the participant's experience and usage of the device.

2) The participants will be able to use the device at home for one month. This is a fair but not ample amount of time to test if the device can foster digitally inclusive activities. It is not certain that the participants will have achieved enough familiarity with the device, to the point

of exhausting its potential in aiding them to use a digital environment. Venkatesh et al. (2003) described three levels of exposure to technology based on the passage of time: post-training was when the system was initially available for use, 1 month later, and 3 months later. Habit has been defined as the extent to which people tend to perform behaviors automatically because of learning (Limayem et al. 2007). It can be possible that participants achieve full learning within one month, but even then it can be theorized that within the month the impact on social inclusion activities may not roll out fully. Taking this into consideration, the Technology Acceptance Model questionnaire (Venkatesh & Bala, 2008) which will be used in Phase II, and explores perceived usefulness will allow the participants to express whether they believe the system could prove helpful in social inclusion, even if they themselves, have not yet reached a usage proficiency point where they can make full and comfortable use of it.

5. Ethics auditing

In-line with our commitment in the Description of Action to perform a yearly ethics audit of our activities, we have resorted to the nominated ethics auditor Prof. Georgio Kyriazis for performing an ethics screening of our activities, including the execution of Phase I trials. The results of this process are provided in Appendix II.

6. CONCLUSIONS

The Phase I clinical trial of MAMEM purported to evaluate its use among able-bodied and patient populations, to test prospective user acceptance as well as its potential in enabling socially inclusive use of digital devices. This clinical trial provided positive indications for MAMEM as an assistive device and showed that able – bodied and patient participants learned and used the technology in similar ways.

The clinical trials of Phase I were conducted in a controlled environment, which, through the presence of experimenters and the novelty of the technology motivated participants to try their best, as is shown by the analysis of results. The study showed that MAMEM accomplished its objective of offering efficient use of technology to a sample with physical, mobility impairments. The participants were able to achieve competence in doing dictated socially inclusive tasks, like writing email, using social media, YouTube, etc. It became clear that in the next stage of in home use their needs to also be there effective steps to enable the participants to make successful use of the MAMEM technology. The challenges in the next stage will be:

a) To encourage participants with physical disabilities to consistently and systematically use MAMEM against existing digital habits and other favorite assistive devices to which patients are used to and are comfortable with.

b) To encourage participants at the next stage to persist to use the device until they become proficient and comfortable with it. Lazar et al. (2007) in their studies on the adoption of new assistive technologies have pointed out that people with disabilities may drop the use of a device if they experience feelings of frustration and anger, especially when the device does not function as expected.

c) Encourage “pride of usage” as a way to sustain systematic usage at home. Individuals with disabilities are motivated to be fully digitally active. The implication for MAMEM is that in Phase II every effort has to be made to make the MAMEM experience at home seamless and efficacious, while enhancing the intrinsic motivation to keep using the device that “reads the eyes and mind”. Sherrer and Galvin (1996) found that people with acquired disabilities tended to see assistive tools as reminders of what they can no longer do on their own. The case of MAMEM is different in that it is indeed an assistive technology, but it is at the same time a state of the art, progressive technology that can offer pride of ownership and use.

d) MAMEM will need to substantiate to potential users the kinds of improvement in speed, ease and comfort that will improve their life, offering them equal opportunities for social inclusion. It is hypothesized that this perception of MAMEM may aid in prospective MAMEM users with disabilities sticking to the process of integrating the technology to their lives, resulting in adoption and daily use.

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APPENDIX I

I.1 User acceptance and User evaluation of the persuasive design questionnaire (part 1)

Part 1: To be completed right after finalizing the MAMEM trial phase 1 training tasks.

This questionnaire pertains to the first part of the training and consists of 18 questions. Most of these questions present a statement (e.g., "I like strawberries") after which you can indicate whether you agree with that statement or not, by encircling (with a pen or pencil) the number that corresponds to your answer.

		Strongly disagree	Moderately disagree	Somewhat disagree	Neutral (neither agree nor disagree)	Somewhat agree	Moderately agree	Strongly agree
1	The MAMEM system did not scare me at all	1	2	3	4	5	6	7
2	Operating the MAMEM system made me nervous	1	2	3	4	5	6	7
3	The MAMEM system made me feel uncomfortable	1	2	3	4	5	6	7
4	The MAMEM system made me feel uneasy	1	2	3	4	5	6	7

The next question is a bit different. Please indicate a number between 1 and 10 to indicate how confident you are that

			Not at all confident			Moderately confident				Totally confident		
5	I could complete the training tasks using the MAMEM system…	…if there was no one around to tell me what to do.	1	2	3	4	5	6	7	8	9	10
		…if I had just the build-in practice games for practicing	1	2	3	4	5	6	7	8	9	10
		…if someone showed me how to do it first.	1	2	3	4	5	6	7	8	9	10

The next questions again present a statement, and you can indicate your agreement or disagreement.

		Strongly disagree	Moderately disagree	Somewhat disagree	Neutral (neither agree nor disagree)	Somewhat agree	Moderately agree	Strongly agree

6	I had control over using the MAMEM system	1	2	3	4	5	6	7
7	I have the skills and knowledge necessary to use the MAMEM system	1	2	3	4	5	6	7
8	Given the skills and knowledge it takes to use the MAMEM system, it was easy for me to use the MAMEM system	1	2	3	4	5	6	7
9	My interaction with the MAMEM system was clear and understandable	1	2	3	4	5	6	7
10	I find the MAMEM system to be easy to use	1	2	3	4	5	6	7
11	I find it was easy to get the MAMEM system to do what I want it to do	1	2	3	4	5	6	7
12	I find using the MAMEM system enjoyable	1	2	3	4	5	6	7
13	The actual process of using the MAMEM system was pleasant	1	2	3	4	5	6	7
14	I had fun using the MAMEM system	1	2	3	4	5	6	7
15	The training tasks motivated me to train my MAMEM skills (e.g., focus with my eyes, scroll the screen down, etc)	1	2	3	4	5	6	7
16	The games in the training tasks (e.g., collecting points) motivated me to do those tasks	1	2	3	4	5	6	7
17	I had the feeling that the messages of the MAMEM system were intended for me	1	2	3	4	5	6	7
18	Assuming I had access to a MAMEM system, I intend to use it.	1	2	3	4	5	6	7

I.2 User acceptance and User evaluation of the persuasive design questionnaire (part 2)

Part 2: To be completed right after finalizing the MAMEM trial phase 1 **dictated tasks**.

		Strongly disagree	Moderately disagree	Somewhat disagree	Neutral (neither agree nor disagree)	Somewhat agree	Moderately agree	Strongly agree
1	Using MAMEM will result in my interacting more and better with people and groups, online and off	1	2	3	4	5	6	7
2	Using MAMEM will increase my productivity on such kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	1	2	3	4	5	6	7
3	Using MAMEM will improve my ability to effectively carry out these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	1	2	3	4	5	6	7
4	I find using MAMEM to be useful for these kinds of task (send an email, use social media, watch a You Tube video, and edit a photo)	1	2	3	4	5	6	7
5	The use of MAMEM is relevant for these kinds of tasks (send an email, use social media, watch a YouTube video, and edit a photo)	1	2	3	4	5	6	7
6	Assuming I had access to a MAMEM system, I intend to use it.	1	2	3	4	5	6	7
7	I found the MAMEM system very cumbersome to use.	1	2	3	4	5	6	7
8	I would imagine that most	1	2	3	4	5	6	7

	people would learn to use the MAMEM system very quickly.							

I.3 Quebec User Evaluation of Satisfaction with assistive Technology – QUEST (Version 2.0)

The purpose of the **QUEST** questionnaire is to evaluate how satisfied you are with your assistive device and the related services you experienced. The questionnaire consists of 12 satisfaction items.

• For each of the 12 items, rate your satisfaction with your assistive device and the related services you experienced by using the following scale of 1 to 5.

• Please circle or mark the **one number** that best describes your degree of satisfaction with each of the 12 items.

• D**o not** leave any question unanswered.

• For any item that you were not "very satisfied", please comment in the section ***comments***.

ASSISTIVE DEVICE

How satisfied are you with,

1. The **dimensions** (size, height, length, width) of your assistive device?	1	2	3	4	5
2. The **weight** of your assistive device?	1	2	3	4	5
3. The **ease in adjusting** (fixing, fastening) the parts of your assistive device?	1	2	3	4	5
4. How **safe and secure** your assistive device is?	1	2	3	4	5
5. The **durability** (endurance, resistance to wear) of your assistive device?	1	2	3	4	5
6. How **easy** it is to use your assistive device?	1	2	3	4	5
7. How **comfortable** your assistive device is?	1	2	3	4	5
8. How **effective** your assistive device is (the degree to which your device meets your needs)?	1	2	3	4	5

SERVICES

How satisfied are you with,

9. The **service delivery** program (procedures, length of time) in which you obtained your assistive device?	1	2	3	4	5
10. The **repairs and servicing** (maintenance) provided for your assistive device?	1	2	3	4	5
11. The quality of the **professional services** (information, attention) you received for using your assistive device?	1	2	3	4	5
12. The **follow-up services** (continuing support services) received for your assistive device?	1	2	3	4	5

• Below is the list of the same 12 satisfaction items. PLEASE **SELECT THE THREE ITEMS** that you consider to be **the most important to you**. Please put an X in the **3 boxes** of your choice.

- ☐ Dimensions
- ☐ Comfort
- ☐ Weight
- ☐ Effectiveness
- ☐ Adjustments
- ☐ Service delivery
- ☐ Safety
- ☐ Repairs/servicing
- ☐ Durability
- ☐ Professional service
- ☐ Easy to use
- ☐ Follow-up services

I.4 System Usability Scale (SUS)

		Strongly disagree				Strongly agree
1	I think that I would like to use this system frequently	1	2	3	4	5
2	I found the system unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5

5	I found the various functions in this system were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this system	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the system	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this system	1	2	3	4	5