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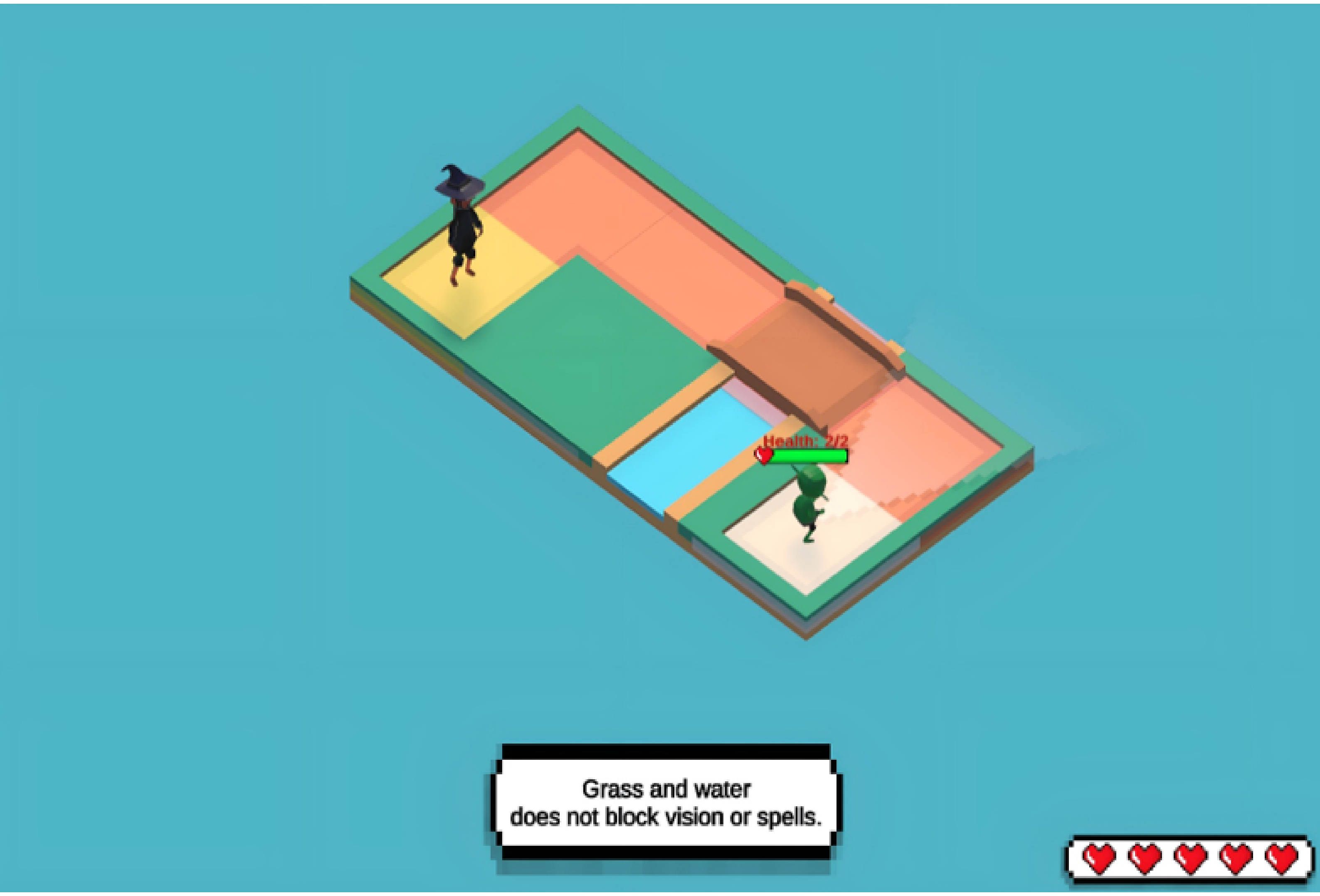

BCI Turn Based Strategy game

Making training engaging for CP Rehabilitation

Supplementary Material

BACHELOR'S PROJECT

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Contents

Chapter 1

Supplementary material

1.1 The Use of VR in rehabilitation

Virtual reality (VR) has shown potential for improving cognitive rehabilitation by supporting carefully personalized, ecologically valid tasks through accessible technologies. VR can be used as an enhancement to conventional therapy for patients with conditions ranging from musculoskeletal problems, to stroke-induced paralysis, to cognitive deficits. This approach is called "VR-augmented rehabilitation". Alternately, VR can replace conventional interventions altogether, in which case the rehabilitation is "VR-based". If the intervention is done at a distance, then it is called "telerehabilitation". [1]

Simulation exercises for post-stroke patients have been developed using a "teacher object" approach or a video game approach. Simulations for musculoskeletal patients use virtual replicas of rehabilitation devices (such as rubber ball, power putty, peg board). Phobia-inducing virtual environments are prescribed for patients with cognitive deficits. [2] [1]

The advantages of using virtual reality in rehabilitation include patient motivation, adaptability and variability based on patient baseline, transparent data storage, online remote data access, economy of scale, and reduced medical costs. However, there are also challenges in VR use for rehabilitation such as lack of computer skills on the part of therapists, lack of support infrastructure, expensive equipment (initially), inadequate communication infrastructure (for telerehabilitation in rural areas), and patient safety concerns. [2]

1.2 Eye-tracking & gaze control

In Human-Computer Interaction (HCI) there are normal user inputs such as keyboard, mouse, and joystick. A less common input is gaze control, which uses eye-tracking to have the user use their eyes almost like a cursor. It works by track-

ing the users eyes to predict the view location on the screen for the location of the cursor.
It can be used for pointing, aiming, zooming, selection, manipulating, scrolling, and commands. Studies show that gaze control shows a 30% decrease in selection compared to mouse-click, 9.8 times quicker than joystick, and in general faster than hand-based pointing control. It is effectively used as input in drawing, typing, gaming, and browsing. The problems of gaze control is positional tolerance (inaccuracy), sensor lag (delay), and Midas Touch (unintended commands). Actions of gaze control can be blinking, dwell (continually looking at an area over a period of time), and gaze gesture (move eyes in a specific pattern). **??**

1.3 VR and BCI

Multiple studies have shown that Virtual Reality can be helpful, when rehabilitating patients. It can help because it can visualize the users exercises without them being restricted by their physical capabilities, and it is very customizable both in difficulty and in feedback. [5]

An article written by a team at the university of southern California described a study conducted to investigate the effects of a BCI with VR on stroke patients with severe motor impairments. The study found that the BCI-VR system improved the patients' motor function and quality of life. The system allowed the patients to control a virtual arm with their brain signals and receive visual feedback from the virtual environment. The results of the study suggest that the BCI-VR system could be a promising tool for stroke rehabilitation. [7]

1.4 Performance accommodation Mechanisms

A performance accommodation mechanism (PAM) is defined as "A game mechanism to increase the player's enjoyment by lowering the game's challenge level to accommodate for poor performance of the player, input device or system." [6] [4]

Through article review, a paper described a possible method for augmenting player inputs to both improve the player's perceived level of success and control. This system described as PAMs covers a wide range of previously tested game mechanics that either reduce the effect of a perceived failure, fake a correct input when an incorrect input is given, change the rules in order to define the player's input as successful, share control with the computer augmenting player input to produce success at a level better than what would have occurred given a successful input. [6]

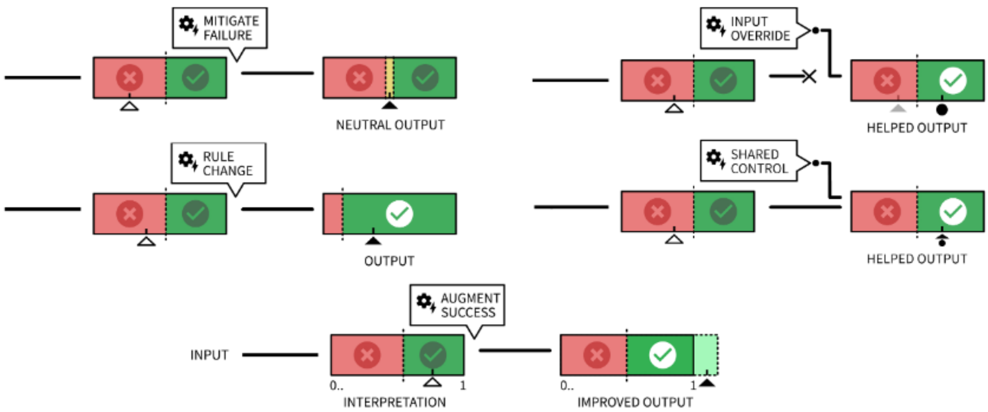


Figure 1.1: Performance accommodation framework [6]

A study by Jochumsen et al. implemented different types of PAMs in a BCI rehabilitation game, the aim was to evaluate perceived control and frustration due to the PAMs. They had 4 conditions, (1) No help, (2) Augmented successful BCI attempt, provides an outcome that is better than what you would normally expect from a successful input, (3) Mitigated failure, turned unsuccessful BCI inputs into a neutral output, and (4) Override input, turned an unsuccessful input into a successful output. [4]
The PAM that frustrated users the most was the input override PAM, the users wanted to do the tasks themselves, or they blamed themselves for being unable to trigger the BCI attempt. With the mitigated failure PAM, the same tendency in frustration was seen, because the participants knew that they could not trigger the BCI. Both these PAMs also reduced their perceived control. Augmented success did not increase frustration or reduce the participant's perceived control. Generally, when people received more help, their perceived control was reduced. [4]
Using EEG and eye-tracking, a study researched the agency and frustration effect in BCI (motor imagery) on post-stroke patients. They used fabricated input to fake the feedback given to the user in two different games. One game with a rubber ball that would get squeezed on successful inputs, and one with a running kiwi that would jump and successful inputs. Each condition would consist of 20 trails, with a negative and positive feedback rate of 0-100%, 30-100% (30% fabricated input), 0-50% (control limited), and 30-80% (control limited, 30% fabricated input).
It showed that fabricated inputs increases perceived control and decreased frustration of both healthy and stroke patients. However, stroke patients did not reach as much as healthy. Some of the participants were falsely convinced some specific actions would increase the success rate, as mentioned in the question from P2 "Do I need to press [my eyelids] harder for it [the game] to react?". [3]
Another experiment that consisted of two tests were also performed. The exper-

iment was a within-subject study and tested three different levels of fabricated inputs, Namely 0%, 15% and 30%. A 50% baseline was added for comparison with earlier works. It was performed on 20 university students between 22 and 32 years old. They were told to control the game by blinking and nothing else. The game was controlled through blinking even though blinking is commonly seen as noise with BCI, but by using blinking they could get a ground truth using a Tobii eye-tracker. The participants thought they controlled the game with BCI even though it was the eye-tracker that controlled it. Their results showed that higher fabrication rates, had a lower level of frustration and a higher level of perceived control, but only significantly different between 0% and 30%. 9 out of the 20 participants figured out that the test manipulated the responsiveness. A second experiment were conducted, this time with 26 university employees. They were told they were testing a BCI device and some new algorithms, when in truth the Tobii eye-tracker was used again. Participants played through 5 conditions each with 20 trails, totaling 100 trials per participant. Again the results showed that an increased fabrication rate, gave a lower frustration rate and a higher sense of control. This time the only significant difference were between 30% and the 50% baseline. While participants said that sometime the feedback and input was not always the same, they still felt control over the game. The results also showed an important trade-off in the size of the BCI input window. Shorter input windows will give the user fewer attempts, but also make fabricated inputs easier as the feedback can have better timing, thus increasing the sense of control.

1.5 SOTA Table

1.6 PAM design

During the design process, it was considered to have PAMs in the game, in order to make the game more enjoyable for the users, since the BCI can be a fragile system. However in order to be able to test our game the best, it was decided not to use any PAMs in this iteration of the game.

The implementation of PAMs can help the player to reach the optimal difficulty level to have the game stay interesting, but not irritating them. As mentioned in background research, they increase chances of success or the outcome.

As the game has two different BCI pacing types as mentioned in section **??**, there are different types of approaches to the PAMs. They are listed underneath. Interval has "critical hit" that allows the player to reach critical hit, to damage more than standard when attacking. "Miss hit" when attacking activates when a BCI repetition fails, so instead of failing, and losing health. The player will however lose health from the enemy, but not due to the BCI attempt. The battery type is focused on mana instead. The user can now get a critical charge when charging mana, to

	Interval	Battery
Augmented success	Critical hit	Double mana
Mitigated failure	Miss hit	No gain
Overwrite input	*No feedback*	*No feedback*
Rule change	*No feedback*	*No feedback*
Shared control	*Won't use*	*Won't use*

Table 1.1: PAM design in the video game

get double mana, and instead of losing mana, they don't gain any, when failing. Neither type has any specific feedback in terms of the "overwrite input" PAM as it just changes to the standard success of BCI. Shared control, will not be implemented, to reduce game complexity and not introduce further testing variables.

1.7 BCI hardware

The implementation of the BCI hardware was done with help from the supervisor and a BCI expert. Both software and hardware for simulating and reading BCI input was handed over by the supervisor. However, the BCI hardware that was given did not work as expected. After multiple trails and errors, it was decided that the product would proceed without a real implementation of the BCI, but only a simulation. As the evaluation focuses on how the user perceives and prefer the metaphors and pacings, it was agreed that a simulation could give similar results.

1.8 Evaluation material

On the next pages, the questionnaire and introduction from the evaluation is shown.

Questionnaire

Questions about <u>first</u> trail

The facilitator will explain which of the two metaphors you've just tried.

What do you think about this metaphor?

(1) ❍ Dislike

(2) ❍ Slightly dislike

(3) ❍ Neutral

(4) ❍ Slightly like

(5) ❍ Like

How many motor imagery attempts do you think you performed?

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
Successfully	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍	(8) ❍	(9) ❍	(10) ❍	(11) ❍	(12) ❍	(13) ❍	(14) ❍	(15) ❍	(16) ❍	(17) ❍	(18) ❍	(19) ❍	(20) ❍	(21) ❍	(22) ❍	(23) ❍	(24) ❍	(25) ❍	(26) ❍
Failed	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍	(8) ❍	(9) ❍	(10) ❍	(11) ❍	(12) ❍	(13) ❍	(14) ❍	(15) ❍	(16) ❍	(17) ❍	(18) ❍	(19) ❍	(20) ❍	(21) ❍	(22) ❍	(23) ❍	(24) ❍	(25) ❍	(26) ❍

I felt the pacing of the game was ..

(5) ❍ Too slow

(1) ❍ Slow

(2) ❍ Neutral

(3) ❍ Fast

(4) ❍ Too fast

	Strongly disagree	Disagree	Somewh at disagree	Neutral	Somewh at agree	Agree	Strongly agree
Performing motor imagery was frustrating.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
Performing motor imagery broke my engagement.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
I could concentrate while performing motor imagery.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
The timing of the motor imagery made sense.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
It felt natural to perform motor imagery in this context.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
I found the triggers for motor imagery logical.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍

Please, play the second version..

Current played version

(1) ❍ "Attack"

(2) ❍ "Mana"

Questions about <u>second</u> trail

The facilitator will explain which of the two metaphors you've just tried.

What do you think about this metaphor?

(1) ❍ Dislike

(2) ❍ Slightly dislike

(3) ❍ Neutral

(4) ❍ Slightly like

(5) ❍ Like

How many motor imagery attempts do you think you performed?

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
Successfully	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍	(8) ❍	(9) ❍	(10) ❍	(11) ❍	(12) ❍	(13) ❍	(14) ❍	(15) ❍	(16) ❍	(17) ❍	(18) ❍	(19) ❍	(20) ❍	(21) ❍	(22) ❍	(23) ❍	(24) ❍	(25) ❍	(26) ❍
Failed	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍	(8) ❍	(9) ❍	(10) ❍	(11) ❍	(12) ❍	(13) ❍	(14) ❍	(15) ❍	(16) ❍	(17) ❍	(18) ❍	(19) ❍	(20) ❍	(21) ❍	(22) ❍	(23) ❍	(24) ❍	(25) ❍	(26) ❍

I felt the pacing was ..

(5) ❍ Too slow

(1) ❍ Slow

(2) ❍ Neutral

(3) ❍ Fast

(4) ❍ Too fast

	Strongly disagree	Disagree	Somewh at disagree	Neutral	Somewh at agree	Agree	Strongly agree
Performing motor imagery was frustrating.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
Performing motor imagery broke my engagement.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
I could concentrate while performing motor imagery.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
The timing of the motor imagery made sense.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
It natural to perform motor imagery in this context.	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍
I found the triggers for motor imagery	(2) ❍	(1) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍

logical.

The two versions of metaphor for motor imagery

"Attack"
Perform motor imagery to attack enemies.

"Mana"
Perform motor imagery to charge mana.

You have now tried both version

	Highly "Attack"	"Attack"	Neutral	"Mana"	Highly "Mana"
Which version did you like the most?	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
Which pacing did you like the most?	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍

<u>Questions for the overall game</u>
Please fill out the following questions about what you think about the games in general, without thinking about the metaphors.

I lost myself in this experience

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I was absorbed in the experience

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I felt frustrated while playing the game

(1) ❍ Strongly Disagree	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍ Strongly agree

I found the game confusing to play

(1) ❍ Strongly Disagree	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍ Strongly agree

The game was aestheically appealing

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

The game was attractive

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

Playing the game was worthwhile

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I felt interested in the game

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I found the controls of the game straightforward

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I did not care to check events that happend in the real world during the game

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I felt detached from the outside world while playig the game

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I think the game was fun

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I felt bored while playing the game

(1) ❍ Strongly Disagree	(2) ❍	(3) ❍	(4) ❍	(5) ❍	(6) ❍	(7) ❍ Strongly agree

I was focused on my performance while playing the game

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

I wanted to do as well as possible during the game

(1) ❍ Strongly agree	(2) ❍ null	(3) ❍ null	(4) ❍ null	(5) ❍ null	(6) ❍ null	(7) ❍ Strongly disagree

Questions about your video game experience

What types of games do you normally like to play?

(1) ❑ Sandbox

(2) ❑ Real-time/turn based strategy

(11) ❑ Shooters

(3) ❑ Multiplayer online battle arena

(4) ❑ Role-playing

(5) ❑ Simulation and sports

(6) ❑ Puzzlers

(7) ❑ Party games

(8) ❑ Action-adventure

(9) ❑ Survival and horror

(10) ❑ Platformer

(12) ❑ Other

How many hours a week do you play video games?

(1) ❍ 0 - 3 hours

(2) ❍ 4 - 7 hours

(5) ❍ 8 - 11 hours

(6) ❍ 12 - 15 hours

(7) ❍ 16+ hours

(4) ❍ Don't know

Please, hand over the survey to the facilitator ..

Udfyld "Na" hvis ikke udflugt.

Which version do you like the most? Why?

____
____
____
____
____
____

What do you think about the two metaphors?

"Attack" (Likes)	____ ____________________ ____ ____________________ ____ ____________________ ____ ____________________ ____ ____________________ ____ ____________________

"Attack" (Dislikes)	
"Mana" (Likes)	
"Mana" (Dislikes)	
General	

	______________ __________________________ ______________ __________________________ ______________ __________________________ ______________

What do you think about the pacing in the two versions?

"Attack"	__________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________
"Mana"	__________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________ __________________________ ______________
General	__________________________ ______________ __________________________ ______________ __________________________ ______________

Motor imagery

Which metaphor do you think "motor imagery" was easiest to perform with? Why?	
How do you think the metaphor and pacing effected your ability to concentrate when performing "motor imagery"?	
Which version did you feel you had the most control over?	

____
____
____
____

Could you imagine a version with both metaphors in it?

____
____
____
____
____
____

To what degree did you feel in control of performing motor imagery?

____
____
____
____
____
____

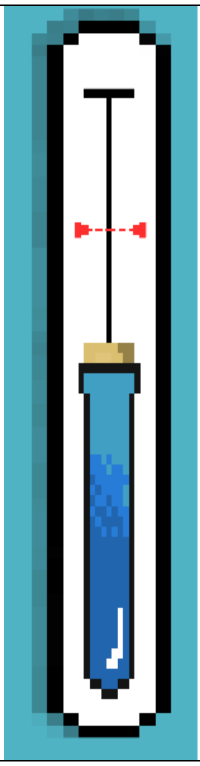
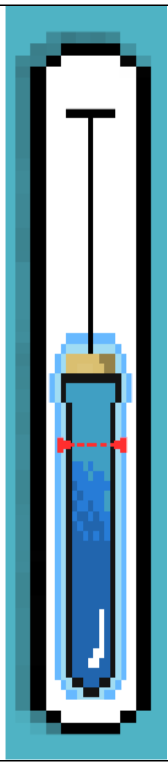
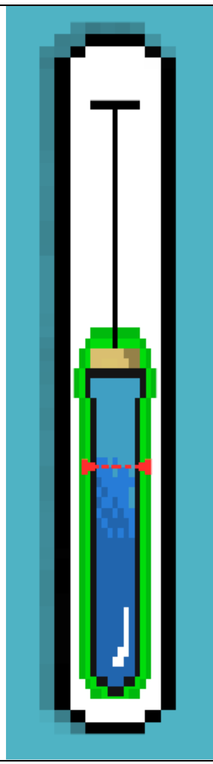
Evaluation Introduction

First and foremost, thank you for agreeing to participate in our test. We are a group of bachelor's students who are working on making the training of motor imagery recall more exciting. Specifically, recall of closing your hand and the sensation of doing so *(without actually closing your hand)*. Our goal is to make this experience as enjoyable as possible. You will be testing a prototype level of our game together with an introductory tutorial.

BCI prompt:

When prompted in a game you are to try and imagine closing your hand, which will hopefully be registered by the brain computer interface cap which will have to be worn throughout the test.

The in-game prompt for all "thought events" appears as follows:

		
Relax	**Recall the sensation of closing you hand – (remain still)**	**Successful**

Remain Still → No movement **Including blinking** as this will create excess noise that can effect the program prefromance

Test procedure

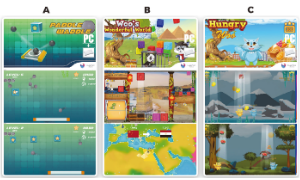
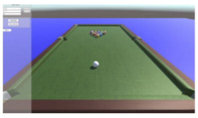
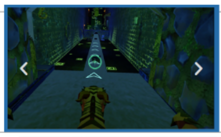
You will be asked to play through the game twice from start to finish. After each play through there will be a questionnaire to answer. After the second playthrough we will pose a series of interview questions relating to your experience with the program

What are we recording?

During the test we will be recording the computer screen (*<u>No camera video or audio</u>*); Certain in game events; a constant stream of measurements from the brain computer interface, as well as the answers provided during the questionnaire and interview. This data will be anonymized and deleted after exam completion **(DD/MM/YYYY).**

You can at any time ask for the test to be stopped and for your data to be deleted.

Do be aware that once the BCI system is put on and calibrated, to remove it or adjust it would be to stop the test completely. **This is fine and is more than understandable so do not feel bad about doing so**. Please, if possible, let us know before we begin calibration if any adjustments need to be made for the BCI, for it to sit comfortably.

	Screenshots	Kræver oplevelsen en særlig type motor funktion / kognitiv funktion? Hvordan kommer det til udtryk i oplevelsen?	Hvad genre var oplevelsen?	Hvor lang tid varer oplevelsen?	Var oplevelsen designet til underholdning eller træning? Hvilken slags?	Krævede oplevelsen ekstern involvering? Fra hvem (pårørende/terapeuter/akademikere)?Hvordan (er det bare hjælp til setup, eller er det også under selve oplevelsen)?	Er det et kommercielt produkt eller en videnskabelig prototype?	Hvad medie benyttes der (VR, tablet, skærm..) og hvordan styres det? (Joystick, keyboard,..) Hvorfor?	Bruges mere end 1 form for styring? (Fx eye-tracking+keyboard, BCI+gamepad..) hvad bliver hver ting brugt til?	Er der ting som forfatterne ikke argumenterer for eller som står uklart? Noget i diskussion som de kan se er shortcomings osv	Særlig type CP, eller til en særlig aldersgruppe? Hvordan kommer det til udtryk i oplevelsen?
Personalized balance games for children with cerebral palsy: A pilot study		Oplevelsen kan tilpasses den enkelte person i sværhedsgrader. Det er balance spil med et balance board, så nøjagtigheden kan skrues ned.	Balance?	Så længe du gider lol	Designet til balance træning. Også derfor den kan tilpasses til personlige motor skills.	Den kræver ikke mere end setup. En therapist kan stå og hjælpe i svære tilfælde. Men ellers kan behandleren se data på deres progress.	Tror det er lukket ned. Der står det er et sted med en masse spil til træning af forskellige ting, men kilden på artiklen har et link der ikke virker, og google søgning hjælper heller ikke.	Man styrer med et wii fit board. som er connected til en computer. Platformen spillet er fra er GABLE online	Nej, Balance boarded styres ved at ligge vægt på den ene eller anden fod.	Deres to test grupper, brugte ikke boardet lige lang tid, og det kan have gjort resultaterne mere positive for eksperiment gruppen, Men der er ikke noget på selve spillet	Det er testet på børn med gennemsnit alder på 10-11 år. Målgruppen er børn. Man kan se det på animationerne og de simple opgaver.
Design of a Brain-Controlled Video Game based on a BCI System https://www.matec-conferences.org/articles/matecconf/abs/2019/39/mateccconf_mse2019_01019/mateccconf_mse2019_01019.html		Der kræves en neutral og aktive (push) trænings session	Binær?	Ind til kuglerne alle er i	Er lavet til at kunne udarbejde videre til patienter med stroke eller ADHD	Der kræves ikke noget eksternt	Videnskabelig prototype	Computer, BCI og 3-axis gyroscope	BCI bliver brugt til stryke af skudet. Gyroscope bliver brugt til skud direction	De begrunder ikke selve spil design valg særlig meget.	Meget bred målgruppe
Dragon escape: www.viribusvr.com		Postural control, control game by leaning forward and sitting up straight	Runner	n/a	Designet til - Postural control & muscle strength men sjovt i mellemtiden	Help putting on controller suit	Kommercielt produkt	VR oplevelse styret af Viribus VR hand trigger & sensor suit	Både en gyroscope forbundet sensor vest + 2 controller		Ikke specificeret med ligner at det er målrette de yngere pacienter da den følger endless runner genren
VR game improves motor skills in cerebral palsy https://www.youtube.com/watch?v=Ei2xQC3jj3s&t=107s&ab_channel=UniversityofCopenhagenUCPH		Brugeren bevæger sig fysisk med handsker på for at styre laser pistoler	Shooter	Uviden. Sværhedsgraden adapter sig til brugeren	Udviklet til at "presse" og træne patienter til at bevæge sig mere	Hjælp til at få handsker på hænderne og sætte HMD på hovedet	Videnskabelig prototype fra København Universitet	VR og hand-tracking	Nej	Valg af spil genre	CP patienter som har svær men stadig bevægelse i armene. Må gerne sidde i kørestol. Stille siddende spil hvor man kun bevæger armene og kigger rundt
https://www.oculus.com/exp		Kræver at du kan bevæge	Streching - skal hjælpe	Så længe du vil	Den er designet til	Nej, patienten kan	Kommercielt.	VR og vr controller	Altså VR til hoved	NA	

https://www.oculus.com/experiences/quest/6119989094742166/ https://www.cognihab.com/blog/vr-games-exercises-for-cerebral-palsy/		Kræver at du kan bevæge din arm med nogen lunde almindelig førlighed	Streching - skal hjælpe patienter med at strække musklerne ud og bruge hele motor funktionen af armen.	Så længe du vil	Den er designet til underholdning som tennis spil. Men den er blevet set brugt til strække øvelser til cerebral palse patienter "All this leads to increased participation from the patients towards the game. Which in turn increases the number of repetitions. The increase in repetitions is what is actually needed from the patients to make their brains adapt to healthier and proper body movements"	Nej, patienten kan gøre det selv, og behandleren kan se data over computer fra ekstern sted.	Kommercielt.	VR og vr controller	Altså VR til hoved rotation og controller til at slå racket med, og bevæge sig i spillet på.	NA	Står der ikke noget om, Men de skal have nok førlighed til at bruge det.
Rumble with rumble: www.viribusvr.com		Posture control and muscel memmory	Sports game	n/a	Postural control – muscle memory men en gentagende process så den underholder mens den træner	Help putting on controller suit	Kommercielt produkt	VR oplevelse styret af Viribus VR hand trigger & sensor suit	Både en gyroscope forbundet sensor vest + 2 controller		Ikke specificeret med ligner at det er målrette de yngere pacienter da den andvender maskotter og overnaturlig miljøer
Infinite horizon: www.viribusvr.com		Postural control, upper extremities – muscle memory Hold correct posture to power the ship. Move your arm left, right and middle to fire weapons and defend the ship.	First person space ship game	n/a	Postural control, upper extremities – muscle memory	Help putting on controller suit as well as compensation for any lacking motor control	Kommercielt produkt	Viribus VR hand trigger & sensor suit	Både en gyroscope forbundet sensor vest + 2 controller		Ikke specificeret med ligner at det er målrette de yngere pacienter da den andvender maskotter og overnaturlig miljøer
Game therapy: Serious video games help children with cerebral palsy https://braceworks.ca/2017/02/14/health-tech/game-therapy-serious-video-games-help-children-with-cerebral-palsy/		Grov motorik af arme	Action runner	N/a	Det er udviklet for at CP patienter bedre kan spille generalt flere spil	Nej controlleren pauser selv, når brugeren tager sine hænder af den	Videnskabelig produkt	Custom made controller, som er en bold man kan dreje på frem for en lille kontroler der kræver fin motorik	Udelukkende custom controller		CP patiernter med specifice arm position og bevægelse i armene

— 53% +

Game therapy: Serious video games help children with cerebral palsy https://braceworks.ca/2017/02/14/health-tech/game-therapy-serious-video-games-help-children-with-cerebral-palsy/	 	Grov motorik af arme	Action runner	N/a	Det er udviklet for at CP patienter bedre kan spille generalt flere spil	Nej controlleren pauser selv, når brugeren tager sine hænder af den	Videnskabelig produkt	Custom made controller, som er en bold man kan dreje på frem for en lille kontroler der kræver fin motorik	Udelukkende custom controller		CP patiernter med specifice arm position og bevægelse i armene
https://www.dovepress.com/analysis-of-motor-performance-in-individuals-with-cerebral-palsy-using-peer-reviewed-fulltext-article-NDT	 	Man skal nogenlunde kunne bevæge sine arme. Spillet går ud på at du skal bevæge dine arme hen og gribe de faldende bolde i takt til et stykke musik.	Motor performance.	8 minutter. 4 sange af 2 min	Research . træning	Nej.	Videnskabelig prototype	Skærm og webcam	Nej kun arm bevægelser.		Nej, de testede på børn og unge 6-19 år, de havde spastic hemiparetic functional impairment, det kan man se på den måde de skal bevæge armene på. De eksluderede dem der ikke forstod opgaven efter 3 forklaringer. Så de kræver man kan comprehende opgaven.
https://www.semanticscholar.org/paper/Games-for-Children-with-Cerebral-Palsy-Deligiannidis/8cf9000f00ccf2c3cb70ca228c70da50d804bbee		Det er lavet til at man kan sætte forskellige controllers til, så man kan tilpasse det til brugerens færdigheder.	movement/exploration		Udviklet til at gøre træning sjovere og til at booste deres selvtillid	Kun hjælp til setup, men flere ting interegerede med dem i vrikeligheden, fx skulle de kramme en bamse til sidst.	Videnskabelig prototype	skærm, forskellige controllers. Der bruges også en blæser til når de flyver i spillet og en bamse der ligner en karakter fra spillet de skal kramme.	Kun en controller		Det er lavet til børn, og det kan godt mærkes med den pædagoiske tilgang alle karakterene i spillet har.

Bibliography

[1] G C Burdea. 2003. Virtual rehabilitation–benefits and challenges - PubMed. *Methods of information in medicine* 42, 5 (Jan 2003).

[2] Ana Lúcia Faria, Andreia Andrade, Luísa Soares, and Sergi Bermúdez I Badia. 2016. Benefits of virtual reality based cognitive rehabilitation through simulated activities of daily living: a randomized controlled trial with stroke patients. *Journal of neuroengineering and rehabilitation* 13, 1 (Nov 2016), 96. DOI: http://dx.doi.org/10.1186/s12984-016-0204-z

[3] Bastian Ilsø Hougaard, Hendrik Knoche, Mathias Sand Kristensen, and Mads Rovsing Jochumsen. 2022. Modulating Frustration and Agency Using Fabricated Input for Motor Imagery BCIs in Stroke Rehabilitation. (2022).

[4] Mads Rovsing Jochumsen, Bastian Ilsø Hougaard, Mathias Sand Kristensen, and Hendrik Knoche. 2022. Implementing Performance Accommodation Mechanisms in Online BCI for Stroke Rehabilitation: A Study on Perceived Control and Frustration. (2022).

[5] Alma Merians, David Jack, Rares Boian, Grigore Burdea, Sergei Adamovich, Michael Recce, and Howard Poizner. 2002. Virtual Reality-Augmented Rehabilitation for Patients Following Stroke. *Physical therapy* 82 (10 2002), 898–915. DOI:http://dx.doi.org/10.1093/ptj/82.9.898

[6] Ingeborg Goll Rossau, Rasmus Bugge Skammelsen, Jedrzej Czapla, Bastian Ilsø Hougaard, Hendrik Knoche, and Mads Rovsing Jochumsen. 2021. How can we help? Towards a design framework for performance-accommodation mechanisms for users struggling with input. In *CHI PLAY 2021 - Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play*. Association for Computing Machinery, United States, 10–16. DOI:http://dx.doi.org/10.1145/3450337.3483497 CHI PLAY 2021 ; Conference date: 18-10-2021 Through 21-10-2021.

[7] Athanasios Vourvopoulos, Octavio Marin Pardo, Stéphanie Lefebvre, Meghan Neureither, David Saldana, Esther Jahng, and Sook-Lei Liew. 2019. Effects of

a Brain-Computer Interface With Virtual Reality (VR) Neurofeedback: A Pilot Study in Chronic Stroke Patients. *Frontiers in human neuroscience* 13 (Jun 2019), 210. DOI:http://dx.doi.org/10.3389/fnhum.2019.00210