Instituto Politécnico de Setúbal
Escola Superior de Saúde

COLLABORATIVE DESIGN APPROACH FOR STROKE UPPER LIMB REHABILITATION USING VIRTUAL REALITY AND BRAIN COMPUTER INTERFACE

Miguel Marques Russo

DESENHO COLABORATIVO PARA REABILITAÇÃO DO MEMBRO SUPERIOR APÓS AVC UTILIZANDO REALIDADE VIRTUAL E INTERFACE CÉREBRO COMPUTADOR

Dissertação de Mestrado de Prática Avançada de Fisioterapia em Neurologia

Orientação Professora Doutora Carla Pereira

Co-orientação Professora Ana Isabel Almeida e Professor Doutor Athanasios Vourvopoulos

Novembro 2023

Projeto de Investigação apresentado para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Fisioterapia em Neurologia, realizado sob a orientação científica de Professora Doutora Carla Mendes Pereira e coorientação de Professora Ana Isabel Almeida e Professor Doutor Athanasios Vourvopoulos.

Declaro que este Relatório de Projeto de Investigação é o resultado da minha investigação pessoal e independente. O seu conteúdo é original e todas as fontes consultadas estão devidamente mencionadas no texto, nas notas e na bibliografia.

O candidato, , Lisboa , 14 de Novembro de 2023

Declaro que este Relatório de Projeto de Investigação se encontra em condições de ser apresentado a provas públicas.

O candidato, , Lisboa , 14 de Novembro de 2023

Acknowledgements

I would like to express my appreciation and gratitude for Escola Superior de Saúde do Instituto Politécnico de Setúbal for accepting me into the master's degree, and hospitality from all its staff. The school fostered an environment of comradery and collaboration that lead each student to feel they had relevant experience and/or information to share with the class.

Of the school's staff I would like to specially thank my thesis' supervisors for guiding me towards the correct methods and tasks, while also encouraging me when the lonely work felt exhausting and never-ending.

My classmates were, with no exception, kind humans that were always available to help and support each other. In particular I have to show my appreciation for Mara Matos, that always had a helping ear and kind word when some frustration built up. However, the most important elements of this life stage were my teammates Maria Patriarca, Daniela Fonseca and Inês Agostinho.

The four of us formed a group to tackle the demands and activities of the master's degree, but the greatest phenomenon was how we matched each other both in silliness and dedication to study and class participation. Without this dynamic the semesters would have been much more tedious and challenging. My deepest gratitude for this three ladies showing me the value of friendship.

I also have to appreciate all my friends and family that showed interest in this academic endeavour and constantly gave me words of encouragement, small deeds do make a difference. A special thanks to Edgar, Edgar and Inês.

Lastly and most importantly, I have to acknowledge my life partner Nuno Fernandes, for dealing with my absence with grace and patience. Having a warm meal waiting for me after hours of studying allowed me to pursue this academic journey while maintaining full-time employment, with some degree of sanity.

My deepest gratitude to all of you.

Resumo

Desenho colaborativo para reabilitação do membro superior após AVC utilizando Realidade Virtual e Interface Cérebro Computador

Miguel Russo[1], Ana Isabel Almeida[1], Athanasios Vourvopoulos[2], Carla Mendes Pereira[1]

[1]Escola Superior de Saúde do Instituto Politécnico de Setúbal

[2]Instituto Superior Técnico da Universidade de Lisboa

Palavras-chave: Reabilitação, AVC, Imaginética, Membro Superior, Realidade Virtual

Introdução: A disfunção do membro superior é uma causa comum de incapacidade após Acidente Vascular Cerebral (AVC), deixando 60% dos pacientes com uma mão não-funcional. Intervenções de Interface Cérebro-Computador (ICC) mostraram ser um acréscimo eficaz à reabilitação convencional e podem ser bastante benéficas para pacientes com défice motor severo. No entanto, as intervenções de ICC mostraram muita variabilidade e não existindo ainda princípios orientadores para estas intervenções.

Objetivos: Desenvolver princípios orientadores para futuras intervenções de ICC que utilizem realidade virtual para a reabilitação de pacientes com défice motor severo, recolhendo o conhecimento tácito e raciocínio clínico de peritos de reabilitação e também a experiência pessoal de pacientes.

Metodologia: Estudo qualitativo com múltiplas perspetivas que utilizou workshops para o desenho colaborativo, baseando-se na revisão da literatura. Foi utilizada análise temática indutiva.

Resultados: Foram realizados quatro workshops online síncronos com dez peritos de reabilitação e oito pacientes de AVC. Os dois temas identificados foram “Seleção da tarefa” (incluindo os subtemas: Características da tarefa, Variabilidade da tarefa e Princípios para progressão da tarefa) e “Considerações relacionadas com o paciente” (com os subtemas: Avaliação inicial do utente, Considerações para a configuração e Fatores de personalização).

Dentro destes subtemas, vários tópicos foram abordados: simplicidade da tarefa, familiaridade da tarefa, inclusão de pacientes, forma e momento para a progressão, considerações para a representação visual, traços clínicos de cada paciente, entre outros.

Conclusão: Algumas recomendações podem ser retiradas deste estudo. A personalização é crucial para a inclusão de pacientes e acomodar as suas características clínicas. A significância, variabilidade e progressão da tarefa são de elevada importância para a atividade cerebral e adesão dos pacientes. Adicionalmente, são preferenciais as tarefas unilaterais e assimétricas. A intervenção deve permitir que os profissionais de saúde personalizem o plano de treino e cada sessão, tendo em consideração a opinião do paciente.

Abstract

Collaborative design approach for stroke upper limb rehabilitation using virtual reality and brain computer interface

Miguel Russo[1], Ana Isabel Almeida[1], Athanasios Vourvopoulos[2], Carla Mendes Pereira[1]
[1]Escola Superior de Saúde do Instituto Politécnico de Setúbal
[2]Instituto Superior Técnico da Universidade de Lisboa

Introduction: Upper limb impairment is a common disability after stroke, leading to a non-functional hand on 60% of patients. Brain Computer Interface (BCI) interventions have showed to be an effective complement to conventional rehabilitation and could be highly valuable in patients with severe motor impairments. However, there is high variability in the intervention and there is a lack of guiding principles for BCI interventions.

Objectives: To develop recommendations for future BCI interventions using virtual reality with stroke patients with severe upper limb impairment, by gathering tacit knowledge and clinical reasoning from clinical experts and adding patients' first-hand experience.

Methods: A multi-perspective qualitative study was conducted using workshops to support collaborative design, based on a literature review. Inductive thematic analysis was used.

Results: Four online synchronous workshop sessions were carried out with ten rehabilitation experts and eight stroke patients. Two main themes were identified: "Task selection" (with subthemes: Characteristics of tasks, Variability of tasks and Principles to task progression) and "User related considerations" (with the subthemes, Initial patient assessment, Set-up considerations and Features of personalization). Within these subthemes, numerous topics were approached: simplicity of tasks, familiarity of tasks, patient inclusivity, timing and approach for progression, considerations for visual representation, clinical traits of each patient, among others.

Conclusion: Some recommendations can be drawn from this study. Personalization is crucial for patient inclusivity and accommodation of their clinical features. Task meaningfulness, variety and task progression are of great importance for brain activity and patient engagement. Additionally, unilateral, and asymmetric tasks should be preferred. The intervention should allow for the health professionals to personalize the training plan and each session, while including the patients' input.

Keywords: Stroke Rehabilitation, Motor Imagery, Upper Extremity, Virtual Reality, Participatory design

Index

List of tables

List of figures

List of abbreviations

ADL – Activities of Daily Living

AVC - Acidente Vascular Cerebral

BCI - Brain computer interface

ICC – Interface Cérebro-Computador

FMA – Fugl-Meyer Assessment

MEP - Motor Evoked Potential

MI – Motor imagery

MP – Mental Practise

OM – Outcome Measure

UL – Upper Limb

VR – Virtual Reality

1. Introduction

1.1. The impact of stroke

Approximately one in four people will experience a stroke during their lifetime (GBD 2016 Lifetime Risk of Stroke Collaborators et al., 2018), and currently there are 101 million people living who have experienced stroke (Feigin et al., 2022). Stroke represents the second greatest cause of death worldwide (Feigin et al., 2021), and also the second major cause of disability in individuals over 25 years (Abbafati et al., 2020). One study found the disability rate of post stroke patients to be 45% five years after stroke (Yang et al., 2016).

A study of 32 European countries estimated the overall (in healthcare, social care, and lost productivity) stroke costs to total 60 billion euros a year (Luengo-Fernandez et al., 2020), while the estimated global cost is over 891 billion US dollars, representing 1,12% of the global gross domestic product (Owolabi et al., 2022). A recent study found the most significant expenditure post stroke was inpatient hospital care (44,5% of overall cost). However, the economic burden is mainly associated with social care (300%), with recommendations for personalized care and support for as long as the person may need being highlighted (Lucas-Noll et al., 2023).

In Portugal, stroke affects around 15200 inhabitants every year and is the leading cause of death, even though the incidence has fallen in recent years (OECD, 2019). In 2015, stroke represented 6,1% of age adjusted incapacity (Wilkins et al., 2017). It is estimated that approximately 40–45% of Portuguese stroke survivors may present with mild to moderate neurological impairment, and around 20% may have a severe degree of disability (Marques et al., 2021). Stroke associated disability leads to a direct loss of productivity, with stroke patients losing on average 27% of their work days in the first-year post-stroke, and caregivers losing 5% (Marques et al., 2021).

Stroke rehabilitation has different phases, with a recent framework clarifying these chronologic stages based on the underlaying biological processes. The acute phase is defined as the one to seven days post-stroke, the early subacute phase from the seventh day to three months, the late early subacute phase from three to six months and the chronic phase from six months onwards (Bernhardt et al., 2017).

1.2. Upper limb impairment

Limb motor deficit is the most common symptom post stroke, being present in 61,7% of patients, followed by dysarthria at 45,2%, incontinence at 29,2%, dysphasia at 25,7%, sensory loss at 24,8%, visual field defect at 20,8 %, neglect at 19,6%, and dysphagia at 15,4% (Clery et al., 2020b), while other studies reported upper limb (UL) weakness in 59% of stroke patients (Simpson et al., 2021). UL impairment translates into a not-functional hand for activities of daily living (ADL) for 60% of six-month post-stroke patients (Allison et al., 2016; Dobkin, 2004), and 71,7% of patients one year after stroke had not regained dexterity in the upper limb (Kong et al., 2011).

Upper limb movements are goal directed movements that require accurate sensorimotor integration, further explaining the added difficulty associated with recovering functional use of the UL compared with the lower limb (Edwards et al., 2019). On the other hand, lower limb movement might not depend on ipsilesional corticomotor function, since alternative descending pathways might be sufficient for motor function (Stinear, 2017).

1.3. Outcome measures

To understand the most commonly used outcome measures (OM) in the research of UL rehabilitation a literature review was conducted, the details can be viewed in appendix 1. The most representative outcome measures were, in order of number of mentions in the searched literature reviews, Fugl Meyer Assessment, Functional Independence Measure, Barthel Index, Action Research Arm Test, Wolf Motor Function Test, Motor Activity Log, Box and Block Test, and Stroke Impact Scale. A review article analysed OM for the UL after stroke and highlighted the following OM: Fugl-Meyer Assessment, Action Research Arm Test, Box and Block Test, Chedoke Arm, Hand Activity Inventory, Wolf Motor Function Test and ABILHAND (Murphy et al., 2015).

The American Physical Therapy Association published a recommendation of OM to be used in rehabilitation of stroke patients, highlighting 14 OM that received a rating of highly recommended in at least two rehabilitation settings. These included the following OM's: Fugl-Meyer Assessment of Motor Performance–Lower Extremity Subscale, Functional Independence Measure, Functional Reach Test, Goal Attainment Scale, Motor Activity Log, Stroke Impact Scale, Stroke Rehabilitation Assessment of Movement–Limb Subscales (Sullivan et al., 2013).

A more recent study highlighted a shorter list of the most relevant OM for motor assessment for the rehabilitation of stroke patients: Fugl-Meyer Assessment of Motor Performance–Lower Extremity Subscale, Action Research Arm Test, Functional Independence Measure, Barthel Index and Stroke Impact Scale (Pohl et al., 2020).

1.4. Rehabilitation potential

The severity of impairments at stroke onset is a reliable predictor of rehabilitation, and one marker of stroke severity is the inability to produce a motor evoked potential (MEP). When patients can elicit a motor evoked potential, they are estimated to recover 70% of the possible improvements. In patients without this marker, the recovery shows big variation with only a few reaching the 70% mark (Prabhakaran et al., 2008; Stinear, 2017; Winters et al., 2015). The recovery of patients with severe impairment appears to be more dependent on rehabilitation intervention than for patients with moderate impairment (Teasell et al., 2018).

This expectation of recovering 70% of the possible improvement for patients with preserved MEP is referring to conventional therapy, and when adding novel interventions to the rehabilitation of stroke patients, it might be possible to achieve increased results, particularly for those patients that cannot produce MEP.

Transcranial magnetic stimulation is commonly used to measure a patient's ability to produce MEP, however there are clinical signs of preserved corticospinal tract, namely the selective movement of digits and the capacity of two points discrimination on the hand (Stinear et al., 2017). A clinical case study describing a three-week intervention on a stroke patient using Brain Computer Interface (BCI) was effective in recovering the ability to perform individual digit extension (Daly et al., 2009). This result reveals the potential benefit for recovery superior of BCI since this patient was able to produce a clinical sign of functional corticospinal tract after the intervention, that is related to an increased expected rehabilitation.

Despite clear data of greater amount of recovery occurring up to 20 weeks post-stroke, followed by an apparent plateau (Douiri et al., 2017), there is evidence of brain plasticity and recovery after 6 months of stroke (Cramer et al., 2011; Sun et al., 2018). Intensive therapy showed non-transient improvements in chronic patients (Ballester et al., 2019; Dawson et al., 2020; Ward et al., 2019), justifying the investment in their rehabilitation.

A recent guideline for stroke rehabilitation highlighted two principles for the rehabilitation of the upper limb (Teasell et al., 2020). To increase motor control and sensorimotor function, patients should participate in training that is meaningful, engaging, repetitive, progressively adapted, task-specific, and goal-oriented (Teasell et al., 2020). The training should encourage the patients to use their affected limb during functional tasks and resemble a portion or complete skill required for ADL (Teasell et al., 2020).

1.5. Motor imagery

Motor Imagery (MI) (or mental practise) is the deliberate rehearsal of an action without actual physical movement with the goal of enhancing motor learning or increasing the performance of the physical task (Monteiro et al., 2021).

Previous findings from systematic reviews and meta-analysis on chronic stroke patients have showed that MI is an effective complementary intervention to conventional therapy, either when used independently or with neurofeedback, for example with a Brain-Computer Interface (BCI) system (Aprigio et al., 2022; Barclay et al., 2020; Herranz-Gómez et al., 2020; Monteiro et al., 2021; S. W. Park et al., 2018; Song et al., 2019). For a brief summary see Appendix 1.

These meta-analyses showed some variety in the outcomes and heterogeneity in the sample (Aprigio et al., 2022; Herranz-Gómez et al., 2020; Monteiro et al., 2021; Park, 2020), leading the authors to suggest that the parameters of these interventions could be optimized (task selection and dosage of training) (Aprigio et al., 2022; Herranz-Gómez et al., 2020). However, one limitation of MI used in isolation, is the difficulty to directly assess the patients' execution of the mental practise, while indirect methods (like measuring changes in heart and breath rate) are rarely used (Monteiro et al., 2021). Using a device, such as brain computer interface (or brain machine interface) that can measure the patients' brain activity to ensure effective activation in each repetition would be an effective way of increasing the consistency of MI.

1.6. Brain Computer Interface

Brain-Computer Interfaces (BCI) allows the detection of the patient's brain activity, as such it can provide an alternative for stroke survivors to engage in a brain training intervention, especially for those who lack volitional movement (Marquez-Chin et al., 2021). The most common technology used in BCI is electroencephalography. The detected brain activity can either be MI or motor intention (also called movement attempt), involving the activation of motor-related brain regions (Daly & Wolpaw, 2008; Marquez-Chin et al., 2021).

BCI interventions reinforce MI by providing feedback. This sensory feedback can be given via robot supported movement (that supply passive or assisted movement to the patients' limbs), electric muscle stimulation (that provoke muscle contraction), visual representation via screen or via virtual reality (VR) (that supply a visual representation of the movement being imagined), haptic stimulus (sensory stimulation of vibration given on the patients' skin) or in a combination of these feedback systems (Mansour et al., 2022; Marquez-Chin et al., 2021). Multimodal feedback appears to increase motor learning (Sigrist et al., 2013).

This feedback promotes cortical plasticity and restoration of motor function by strengthening the ipsilesional sensorimotor loop from movement planning to sensory perception of the movement (Nojima et al., 2022) through coincident activation of presynaptic and postsynaptic neurons (Monge-Pereira et al., 2017). Interventions using BCI most often are an adjuvant of therapy (Marquez-Chin et al., 2021), as it has shown to provide greater benefits in combination with conventional therapy, when compared with isolated BCI (Monge-Pereira et al., 2017). Adding haptic stimulus, might have benefits in inducing greater neuronal plasticity, by decreasing the feedback delay and by further activating sensorimotor areas (Grosse-Wentrup et al., 2011; Subramanian et al., 2010).

A clinical case study using a simple design, used BCI supported MI with VR and haptic stimulation as feedback showed positive preliminary effects (Vourvopoulos et al., 2019), showing the current need for recommendations, since studies are currently being performed with this technology.

The effectiveness of BCI interventions on the UL motor function of both acute and chronic stroke patients, has been shown in recent meta-analysis (Bai et al., 2020; Kruse et al., 2020; Mansour et al., 2022; Nojima et al., 2022; Shou et al., 2023),for additional details from these meta-analyses see Appendix 3. One study (Shou et al., 2023) also reported a significant effect of BCI interventions over sham BCI interventions for functional independence (measured through the Modified Barthel Index).

Four meta-analyses reported no adverse effects, only some discomfort felt by some patients (nausea, headaches, fatigue) (Bai et al., 2020; Kruse et al., 2020; Mansour et al., 2022; Nojima et al., 2022). One study referenced that most patients felt fatigue after 20-30 minutes (Nojima et al., 2022), while another recommended including a small break after 15-20 minutes of training to decrease the risk of this discomfort symptoms (Bai et al., 2020).

Diminishing returns of interventions with longer duration were described (Bai et al., 2020; Kruse et al., 2020), since the first weeks of the interventions were associated with the majority of the improvement, while the last weeks provided small additional benefit.

Motor observation was reported to be no less effective than MI for the improvement of stroke patients' UL function (Bai et al., 2020). Furthermore, the importance of observing activities lead another author to recommend the addition of video demonstration to instructions (Mansour et al., 2022).

Two studies highlighted a larger, even though not significantly, effect for movement attempt over MI. Both authors suggest that more research needs to be done on the comparison from these two forms of brain activation, while recommending prioritizing movement attempt interventions over MI interventions (Bai et al., 2020; Mansour et al., 2022).

In relation to BCI's feedback system, three of the meta-analyses compared the results of the interventions with different feedback systems and found the functional electrical stimulation to have the greater effect. This increased effect of electrical stimulation was related to the impact on cortex excitability, however, further studies with direct comparison of the different systems were recommended (Bai et al., 2020; Mansour et al., 2022; Nojima et al., 2022). Often, VR feedback systems were grouped with other visual representation systems, for example in screens, meaning that this subgroup analysis is not a clear representation of BCI-VR interventions, since there is evidence of an increase effect of VR systems over monitor display systems (Batista et al., 2023).

Due to the need of calibration of the system and focus from the patient, simplicity is recommended while the importance of personalized interventions has been showed previously (Nojima et al., 2022).

The lack of standard of BCI training protocol and patient instructions was highlighted (Kruse et al., 2020; Shou et al., 2023), while the wide heterogeneity in the studies and patients' characteristics was noted (Nojima et al., 2022), as factors that limit the reviews' ability to draw conclusions from the existing data. One author advised future research to take into account patient characteristics including age, hemisphere and area of lesion and type of stroke (Kruse et al., 2020).

The need for further research was reinforced, to allow for additional subgroup analysis and to optimize BCI according to the differences in BCI feedback, performed brain activity (movement attempt or MI) and stroke characteristics (Mansour et al., 2022).

1.7. Virtual Reality

Virtual Reality (VR) is an immersive and interactive visual representation that allows the user to engage in environments that feel realistic and boost motivation (Iruthayarajah et al., 2017). Therapeutic VR interventions can receive inputs from the patient by movement capture via camera or sensors or controlling a joystick or controller (Laver et al., 2017).

VR has been used in the rehabilitation of the UL of stroke patients, using either commercial or custom systems, having been reviewed by nine literature reviews with meta-analysis in the last five years. VR interventions have shown to provide additional benefits over conventional therapy (Al-Whaibi et al., 2022; Aminov et al., 2018; Chen et al., 2022a; Cortés-pérez et al., 2021; Domínguez-Téllez et al., 2020; Hao et al., 2023; Jin et al., 2021; Le Wang et al., 2022; Wu et al., 2021). All of these studies reported great heterogeneity as a limitation to the data analysis, in terms of intervention type as well as outcome measures and follow-up procedures.

When comparing non-immersive interventions and immersive VR, the immersive intervention was more effective (Hao et al., 2023; Jin et al., 2021). In regard to custom therapy virtual environments and commercial systems, the custom systems showed an increase benefit (Aminov et al., 2018; Chen et al., 2022; Hao et al., 2023; Le Wang et al., 2022). There is not a clear dose-effect relationship for VR interventions, meaning that longer interventions did not provide more substantial results, however the immediate results of the intervention were preserved in the follow-up assessment (Aminov et al., 2018).

The success of VR interventions has been hypothesized to be linked to four components: intensive interventions, motivation through gamification, stimulation of motor learning and positive feedback to the patient response to stimulus (Domínguez-Téllez et al., 2020). There seems to be a relation between the patients' well-being and motor learning, revealing an inter-relationship between motor and cognitive systems, since motor-based rehabilitation using VR might have cognitive benefits (Aminov et al., 2018).

Embodiment describes the perception of ownership over the virtual avatar and has shown to promote additional benefits over interventions with no embodiment (Matamala-Gomez et al., 2022). Embodiment appears to have three subcomponents sense of self-location, sense of agency, and sense of body ownership(Kilteni et al., 2012). Embodiment increases the patients' arousal and increase their change in vital signs when imagining a movement like walking up a hill (Kokkinara et al., 2016), showing that the motor observation can impact the body's responses when there is a sense of body ownership.

There might be a possible disadvantage with VR interventions by focusing on the repetitions and compromising quality of task performance (Al-Whaibi et al., 2022), however, if the VR intervention provides enhanced feedback for UL kinematics it can lead to improved results, although the selection of the type of feedback and schedule of feedback requires further research (Levin & Demers, 2021).

Additionally, in most current VR interventions patients with severe UL dysfunction cannot participate, since it requires the patient to be able to operate a controller (Le Wang et al., 2022).

Current research was not able to review the aspects that lead VR intervention to having the most impact on functioning, which should be addressed by future research, possible novelty and engagement may play a role, as well as the ability to adjust difficulty and to provide rewards (advancement in levels in gameplay) (Aminov et al., 2018).

One author reviewed a motion caption system that does not require the use of controls, allowing the reproduction of realistic hand gestures during the intervention. This motion caption system allowed the detection of hand position, as opposed to systems that capture mostly the global UL movements (Cortés-pérez et al., 2021).

In future additional benefits could be achieved by individualizing the intervention to the patients' clinical features, in regard to the duration, intensity, difficulty, types of feedback and of positive reinforcements (Domínguez-Téllez et al., 2020).

1.8. Neuroplasticity and training principles

Considering the viewpoint mentioned from different authors of the importance of trying to understand the underlying neuroplastic mechanisms that support these interventions, a review was performed. The procedures and list of principles can be found in Appendix 5. There was some variation between authors, however some concepts were frequently present: goal-oriented practise, ample repetitions, feedback, and task-specific practise (Bo Nielsen et al., 2015; R. G. Braun & Wittenberg, 2021; Kleim & Jones, 2008; Levin & Demers, 2021; Maier, Ballester, et al., 2019; Page & Peters, 2014).

The salience of the task being practised, meaning how relevant and important it is to the patient, was considered an important factor in rehabilitation (Kleim & Jones, 2008; Page & Peters, 2014). Placing the patient in the main role of their rehabilitation process was also considered a factor relevant for neuroplasticity (Bo Nielsen et al., 2015; Page & Peters, 2014). Rehabilitation should adequately challenge the patient regularly to optimize the intervention results (Levin & Demers, 2021; Page & Peters, 2014), while within task-exercise variety increases motor learning (Timmermans et al., 2010).

This training principles, that lead to increased neuroplasticity to support rehabilitation and motor learning, provided a baseline for interventions design, even though they require adaptation to the specific intervention being planned.

1.9. Evidence gap

The rehabilitation of stroke patients presents diminishing returns after the patients enter the chronic phase, which may be compensated by novel interventions. As mentioned in the section "Rehabilitation potential", patients with severe impairments at stroke onset can expect a more severe disability after rehabilitation. If novel interventions could shift this paradigm, the chronic and severe patients may have the most range to potentially achieve additional recovery.

As mentioned in the sections "Motor imagery", "Effectiveness of BCI" and "Virtual reality" there is considerable heterogeneity in the current evidence, limiting the data analysis and restricting the ability of the authors to make recommendations, either for further research or for clinical implementation.

Authors recommend to take into account the underlying mechanisms supporting BCI interventions while also pointing out that these principles are not well understood (Bai et al., 2020; Kruse et al., 2020; Mansour et al., 2022; Nojima et al., 2022). Currently, to our knowledge, there is no systematic approach on designing BCI-based training for stroke rehabilitation that considers the underlying principles of neurorehabilitation. The diminishing gains after the initial sessions of BCI might also be minimized with how the training programme is designed, with features such as variability and progression.

Recommendations for conventional neurorehabilitation, training principles and neuroplasticity rules are designed for interventions that involve muscle activity from the patient and usually task oriented practise. EEG provides poor special resolution (Saha et al., 2021; Yadav et al., 2020), as such BCI interventions based on EEG will provide feedback to the brain activity that is unspecific, meaning that general recommendations might not apply to BCI-VR interventions. The lack of movement implies the patients won't have knowledge of performance or of result precluding the optimization of muscle synergies, interactions with objects or adaptations to shifts in body weight.

The optimization of the design of BCI interventions considering the relevant principles of neurorehabilitation may increase the efficiency of BCI interventions. Taking into account the underlying mechanisms of neurorehabilitation during the design of the intervention could steer the results, that have previously showed some variance, towards a more beneficial effect.

This study will focus on BCI interventions, that are based on MI, and provide feedback through VR. The different forms of providing feedback in BCI interventions might have different benefits, this study focused on VR over robot assisted movement or FES. Using VR on BCI interventions, leads to an increased freedom of design, since itis not limited by the technical features of the robotic system or the specificity of the muscle stimulation through FES. Additionally, using VR could harness the rehabilitation potential both from MI and action observation.

2. Methods

2.1. Study aims

The aim of this study was to contribute to the development of a set of recommendations for the design of more effective interventions for the rehabilitation of the UL of chronic stroke patients using BCI supported with VR.

To attempt to answer the gaps in the existing evidence, the study aimed to explore the perspectives of i) rehabilitation experts about the most effective factors and the principles of neurorehabilitation and neurophysiology that may be relevant to adapt for BCI intervention; and of ii) stroke patients in order to inform recommendations concerning mainly motivation and acceptability.

2.2. Type of study

A qualitative study was selected to draw from the tacit knowledge of experts and experience from stroke patients. One of the purposes of a standalone qualitative study is to inform intervention design or evaluation methods, or clarifying decision making (Ayre & McCaffery, 2022), justifying the usage in this study that focuses on design and supporting decision making.

The involvement of experts was centred on bringing the richness of experience with conventional rehabilitation intervention with stroke patients into the BCI-VR intervention debate, while the patients' participation was focused on making the intervention pleasant, motivating and to diminish possible negative aspects.

The development of this study followed the Medical Research Council Framework for developing and evaluating complex interventions to improve health, based on published research evidence, expertise guidance, and combining principles of the person-based approach (O'Cathain et al., 2019). Thus, a collaborative design process was used, including clinical rehabilitation experts and stroke patients. The choice of a collaborative design process was made not only to integrate the input from different groups, but also because collaborative approach is suitable to take into account the complexity of the topic being studied, with a number of interacting components (O'Cathain, Croot, Duncan, et al., 2019).

2.3. Study design

A reflexive thematic analysis was used in this qualitative study, with the data collection method selected being workshop (Braun & Clarke, 2021). The workshop method was selected for being ideal for design processes with multiples interested parties, as it allows to build an atmosphere that supports collaborative approach (Ozkaynak et al., 2021). Workshops can create and delineate the knowledge needed to improve the efficacy of an intervention, specifically health technology interventions that have diverse end-users. One clear benefit of workshops is to bring to light tacit knowledge (Ozkaynak et al., 2021), which is one of the goals on the collaboration with clinical experts in this study.

This study started with a search of the literature available to familiarize with the topic and identify the gaps of evidence. Initially this search focused on literature reviews with meta-analysis in the stroke population, including the MeSH terms “physical therapy” and “upper extremity”, published in the last 5 years. Later, randomized control trials including Brain Computer Interface” in the tittle or abstract, as well as the MeSH terms “stroke” and “upper extremity”, were viewed, if published in the last two years.

For this study, online workshops were planned since it allowed the participation of geographically dispersed participants (Richard et al., 2021), and requires less incentives to produce a high rate of attendance (Reisner et al., 2018). Two workshops with rehabilitation experts and one workshop with stroke patients were planned. Initially, a third workshop was also planned, aiming to set priorities in situations of conflicting principles and contribute to future prototyping. However, due to time constraints, this was not included in this thesis.

To support the planning of the workshops a deeper review of literature was performed, including the effectiveness of interventions. The main results of this literature review were mentioned in the introduction of this thesis. This analysis of previous evidence lead to lifting of possible topics of discussion (that can be viewed in Figure 1) and was further selected into the final topics of discussion (Figure 2).

Task selection	Virtual environment
• Rhythmic movement or triggered clear start and finnish • Familiar or novel tasks • Focus on distal component or whole limb • Complex or simple tasks • Bimanual or unilateral • Exercise progression, if so, how soon and how frequent • Symetric or asymetric movement • Complex task practised as a whole or in smaller movements • Precise movement or forgiving • Amount of repetitions	• Enriched or simple • Realistic or stylised • Objects with one purpose or varied purposes) • Mundane or fantasy • Same task with variation of context or fixed context (variety?) • if adding variety, how soon and how frequent • Visual representation during break moments • Motor intention or motor imagination

Figure 1 Topics identified in the literature to be considered during workshop planning

- Bimanual or unilateral
- Symetric or asymetric movement
- Familiar or novel tasks
- Enriched or simple environment
- Rhythmic movement or task with clear start and finnish
- Task repetition with variation or without
- Mundane or fantastic envirnoment
- Focus on distal component or whole limb

Figure 2 Final topics to enhance rehabilitation debate on workshop 1.1 and 1.2

The researcher performed skill training for moderating workshops, for which a test workshop was held with five physiotherapists working with stroke patients. This test workshop also allowed the opportunity to refine the structure of the workshop session.

2.4. Workshop structure

The first workshop with rehabilitation experts was held in two separate moments, to allow the inclusion of a greater number of participants since the first moment (Workshop 1.1) was held with 4 participants. The addition of the second moment (Workshop 1.2) allowed to include 4 additional experts. These sessions had the same structure and activities.

Before each session of workshop 1, the participants were provided with a digital pamphlet explaining some of the terms and concepts that are a part of this study. This aimed to support the preparedness of the rehabilitation experts for the session (this document can be view in appendix 4).

The second workshop (Workshop 2) pooled participants from the previous sessions, including a participant from the test workshop and a new participant, with a total of 7 participants. For the stroke patients there was held a single workshop (Workshop 3) that was composed of 8 participants.

All workshops were held in digital setting with sound and image (through zoom colibri) with the average duration of 90 minutes. Each workshop had a short introduction phase with four moments. At first the moderator clarified the goals and etiquette of the session as well as the participants’ rights, followed by a review of the goal of the study and clarification of relevant concepts to allow an effective session by contributing to clarity.

Then the research team introduce themselves and invited each participant to do the same. After this formal moment, a more casual, ice-breaking activity was performed between the participants to enhance participation. The main goal of the sessions was to allow free conversations of the participants, however, to decrease hesitation, boost interventions and steer the debate in the direction of the topics more relevant to the study, some slides were prepared.

These visual aids had some “conversation starters” to kickstart, or re-direct the debate. For the first session topics of discussion of two opposite concepts were presented using few words and images. For workshop 2, these slides included a short summary of the conclusions from workshops 1.1 and 1.2 and some questions to promote a deeper debate.

For workshop 3 the visual aids consisted of questions with some possible answers to initiate the interventions (either for identifying with one of the possible answer or because of strong disagreement). View appendix 5 for the three visual aids.

Each workshop finished with an open invite for any further comment, even unrelated to the specific topics raised, that could be relevant for the study. Finally, a sincere gratitude was expressed, and the participants were informed of the opportunity to give feedback through the online questionnaire, later submitted via e-mail. The overall organization of the workshop is presented in Table 1.

Table 1 Overall study structure

	Participants	Goal	Concepts
Workshop 1	Rehabilitation experts	Define the most important tasks and virtual environment characteristics for relevant brain activity	Task components, inter-limb modulation, movement patterns, richness of environment, familiarity, variety, progression, neuroplasticity
Workshop 2	Rehabilitation experts	Designate the more relevant adaptations and patient exclusion factors. Establish prioritization between the characteristics defined in workshop 1	Patients’ specific needs (spatial awareness deficit, communication deficits, cognitive deficits, pain, postural instability) Outcome measures to assess patient inclusion in Brain computer interface intervention

Workshop 3	Stroke patients	Delineate users' priorities for intervention design and factors of motivation and engagement	Task selection preferences, environment preference (during task and during rest period) Factors for motivation (drawing from conventional rehabilitation experience)

2.5. Ethics

The study was approved by the Ethics Committee of the Polytechnic Institute of Setúbal (CE-IPS 35/2023). All participants were informed of the aims of the study, procedure, risks, and confidentiality through an invitation letter (Appendix 6 and 7). Prior to taking part in this study the participants signed the informed consent form (Appendix 8).

Participants were also informed that workshops would be recorded, their identity would be kept confidential and that they had the right to withdraw from this project at any time without any prejudice.

2.6. Sample and recruitment

To ensure the participants would make significant contributions, inclusion and exclusion criteria were defined. Experts were included if they had experience with stroke patients in a rehabilitation setting at least in the last ten years, ten years of experience is accepted as a general benchmark for experts (Ericsson et al., 1990), and is considered one of the requirements to apply for the title of specialist in Portugal.

Stroke patients were included if they had a stroke-caused impairment of the UL movement, were over 18 years old at the time of stroke and had participated in at least 20 post-stroke rehabilitation sessions. Potential participants were excluded if they had a diagnosis of cognitive impairment or diagnosis of impaired communication (for example, aphasia), that limited their ability to understand complex instructions and to report their experience with stroke rehabilitation.

The recruitment took place between January and April 2023, using a purposive sample, meaning that the participants were selected based on the researcher's judgement about their contribution to the study (Moser & Korstjens, 2018). Since the data collection method is through workshops, the priority in participant selection were the participants' richness of contributions and good communication skills.

The rehabilitation experts were pooled from the professional network of the researchers, either directly or through a common colleague, ensuring the inclusion criteria would be met. There was initially an informal contact to gauge the willingness to participate, which was then followed by a formal contact, including the invitation letter, consent form and scheduling options. In total 22 experts were contacted to participate in the study, 18 showed interest and ultimately ten experts were able to take part in the workshops in a mutually agreeable schedule.

The patients were also recruited using a purposive sample through contacting physiotherapists from the research team professional network, who invited their patients to participate. This communication was aided by a summary image to facilitate the task of explaining the study to the patients (present in Appendix 9).

Additionally, a national stroke patient association ("Portugal AVC - União de Sobreviventes, Familiares e Amigos") was contacted and accepted to aid with patient recruitment by disseminating the study through their network contacts.

After the initial informal contact, the e-mail or phone number of the interested patients was provided to the research team. A formal invitation, by phone or email, was presented while offering any further and needed clarifications. After receiving the written information, the scheduling options were presented. Initially 14 patients showed interest in participating, however, after resolving the scheduling difficulties the workshop included eight patients.

2.7. Data collection

The workshops were held through a zoom group meeting, using the waiting room feature to ensure that only the participants could attend. All participants got a reminder of the workshop a few days before and received the link one day before or on the day of the meeting, to decrease the chance of exposure.

Additionally, an online questionnaire was used to collect data about participants' sociodemographic and professional characteristics. For the experts the form included socio-demographic information and clinical expertise. For the experts the form included socio-demographic data and clinical information relating to the impact of stroke.

After each workshop, participants had the opportunity to give feedback on the experience of participating in the session, through an online form with closed and open questions (Appendix 10). The closed questions had a Likert-scale format, from 1 to 5. The score of 1 was labelled as either negative, not productive, not adequate, or not valuable, while the score of 5 was labelled as either positive, very productive, very adequate, or very valuable.

2.8. Data analysis

An inductive thematic analysis was used, based on the data from the transcripts as opposed to being based on theoretical assumptions or previously set frameworks (Braun & Clarke, 2021). The *six-phase process* of thematic analysis was followed: data familiarization, systematic data coding, generating initial themes, developing themes, refining, and naming themes and producing the report (Braun & Clarke, 2021).

The workshops were transcribed verbatim, using initially the Microsoft Office Word transcribe feature and then manually reviewed and corrected. Each transcript was scanned for relevant quotes that were lifted into a codebook, allowing to group them into preliminary themes according to the study's goals.

The preliminary themes were combined and reassembled into different themes and subthemes, with the perspective of the research supervisor to validate the main author's interpretation, until achieving the final thematic map (view appendix 11).

The submissions of the workshops' feedback questionnaires were analysed, allowing to calculate the average score for the close questions, for the study overall and each individual workshop.

2.9. Researcher characteristics and reflexivity

Pertaining to researcher reflexivity, it should be stated that the research team was comprised of three physiotherapists and one biomedical engineer, with clinical experience or research experience in the field of stroke of rehabilitation. There might be bias for believing in patients' potential to improve, and on the importance of rehabilitation interventions.

More specifically on the intervention with stroke patients, the main author considers that the patient should have an active role in their rehabilitation, and that the therapists should have a deep knowledge of the neurophysiologic principles of neurorehabilitation to support the adequate task selection for the patient's specific impairment.

On top of the aforementioned ethic concerns, all the tasks performed during this study, including designing the workshop sessions, constructing the debriefing pamphlets, and performing the thematic analysis, the focus was on the study's aims. There was an introspective concern, throughout the study, to keep the attention on the research question and relevant framework.

Even though the participants were recruited through the professional network of the research team, there was none or very limited previous contact and no personal relationship with the participants. The rehabilitation experts that chose to participate in this study, were informed about the study aims and procedures, and reflected carefully before choosing to take part. All participants were aware of the time investment that participating in the study would entail.

During the sessions, there was a care to foster an environment for free participation of all participants, of any relevant topics for this study. This required a balance of embracing the participants experiences, allowing them time to express it, while using the researcher's judgment of topics or depts of discussion that not serving the interests of the study.

To ensure the quality of the study, meetings were held throughout the study, for discussion of the methodology, supervision of the analysis and review of the text. This step reduced possible bias from the researcher and increased the scientific rigor.

3. Results

This section outlines the characteristics of the participants, the feedback that participants gave after participating in each session, and the thematic analysis of data from the workshops. This last analysis resulted in two themes and six subthemes, with each subtheme being further explored into topics.

3.1. Characterization of participants

A total of 18 participants were included in the study. The first three workshops relied on the participation of rehabilitation experts, with an average clinical experience of 17,0 years (SD = 6,63) working with stroke patients, in a variety of settings and backgrounds, as showed on Table 2.

Table 2 Description of the participants - Rehabilitation experts (10)

Gender	7 male; 3 female
Geographical distribution	1 Braga, 1 Faro, 7 Lisboa, 1 Viseu
Field of rehabilitation	1 Speech and language therapist 3 Occupational Therapists 6 Physiotherapists
Clinical experience with stroke patients (Mean±SD)	17,0±6,63 years minimum 12; maximum 34 years
Phase of stroke of the patients treated	4 Mostly acute 5 Equally acute and chronic 1 Mostly chronic
Work context (most participants work concurrently in different contexts)	9 Hospital 2 Homecare 2 Private clinic 2 Public clinic 2 Rehabilitation center
Current teaching role	2 Occasional or minimal 2 Moderate proportion of workload 6 Most of the workload
Previous experience with virtual reality	1 None 6 Slight contact 3 Some experience 0 Frequent use
Familiarity with technology for rehabilitation (gamification, for example)	1 None 6 Slight contact 2 Some experience 1 Frequent use

SD – Standard deviation

The participants presented with varied characteristics in the majority of the aspects inquired, however, the majority had some teaching experience and familiarity with virtual reality. The fourth workshop was held with eight chronic stroke patients, who presented different levels of dependency and upper limb movement capacity (see Table 3).

Table 3 Description of the participants - Stroke patients (8)

Age (Mean±SD)	57±6,70 years; min 46, max 66 years
Gender	2 male; 6 female
Time since stroke	7,75±4,43 years, min 2; max 14 years
Perceived dependency	1 Completely independent 3 Slightly dependent 2 Moderately dependent 2 Highly dependent 0 Completely dependent
Current ability to move the hemiplegic upper limb	0 Movement mostly useful and functional 2 Movement moderately useful for ADL's 4 Some movement although not useful for ADL's 2 Unable to move
Experience with virtual reality	2 Yes, before the stroke 2 Yes, after the stroke 4 No

SD – Standard deviation, Min - minimum, Max – maximum, ADL – Activities of Daily Living

The stroke patient participants had an average age of 57 years, were all chronic stroke patients according to the time since their stroke (2 or more years). Most participants described their upper limb impairment as severe, with six not being able to move their upper limb in a useful manner.

3.2. Workshop feedback

The feedback was provided through an online questionnaire and was filled by 12 of 23 individual workshop participants. Even though, this study had 18 participants, since some rehabilitation experts took part in more than one session, the total possible amount of feedback answers were 23. A summary of the results are presented in Table 4 and Table 5.

Table 4 Participant feedback - scores from closed questions

Likert-scale scoring	W 1.1	W 1.2	W 2	W 3	Total
n/N	3/4	3/4	3/7	3/8	12/23
Q1. How would you rate the experience of participating in this workshop?	4,67± 0,58	5 ± 0	4,67± 0,58	4,33± 1,15	4,67± 0,65
Q2. Would you consider the execution of this workshop to be aligned with the goals of the study that it belongs to?	4,67± 0,58	5 ± 0	4,67± 0,58	4,33± 1,15	4,67± 0,58
Q3. How would you rate the moderation of this workshop?	4,67±	5 ± 0	4,67±	4,33±	4,67±

	0,58		0,58	1,15	0,65
Q4. How would you rate the planning of this workshop?	4,67± 0,58	5 ± 0	4,67± 0,58	4,33± 1,15	4,67± 0,65
Q5. Do you consider that this workshop was a valuable use of your personal time?	4,67± 0,58	5 ± 0	4,67± 0,58	4,33± 1,15	4,67± 0,65

N - Number of participants present in each workshop, n - number of participants that filled out the feedback form after each workshop, W 1.1 – Workshop 1.1, W1.2 – Workshop 1.2, W 2 – Workshop 2, W 3 – Workshop 3. Each question had a score from 1 to 5, 1 was labelled as either negative, not productive, not adequate, or not valuable, while the score of 5 was labelled as either positive, very productive, very adequate, or very valuable.

Table 5 Participant feedback - topics from open questions

Topics of importance	Room for improvement in the workshop
Adapting the intervention to each patient	Expand the icebreaker activity and the explanation of the project
Context in which the task is performed	More discussion time
What would be the ideal patients that would benefit the most from Brain Computer Interface interventions	Better moderation of the workshop session

The lowest score given by the participants on any question was a score of 3 (from 1 to 5), and the average score was above 4, reflecting a positive evaluation of the workshops. The open questions had overall positive comments.

3.3. Thematic analysis

The participants debated the factors that would lead to a more effective BCI intervention that is based on motor imagery, for the rehabilitation of the upper limb of chronic stroke patients. This deliberation took into account the factors that would lead to the most relevant brain activation to increase neuroplasticity and ultimately contribute to the patients' rehabilitation. Two core themes emerged from data analysis: "Task selection" and "User related considerations", and within each theme three subthemes were defined. Further categorization was made inside each subtheme in a total of 15 topics (see **Erro! A origem da referência não foi encontrada.** for overview).

The different aspects to consider when deciding the task or tasks to include in the training programme, were included in **"Task selection"** (Theme 1). This includes the initial task features, which represents the basis for the latter addition of variety and progression to the training sessions.

The participants considered the most relevant aspects of the "*characteristics of tasks*" (subtheme 1.1) to be the bimanuality of the task, the complexity of the task and the familiarity of the task to the patient. While addressing the "*variability of tasks*" (subtheme 1.2) the participants stated it should be added gradually and as soon as possible, according to the patients' tolerance. The participants' viewpoints on the "*principles to task progression*" (Subtheme 1.3) included which components may contribute to task difficulty and the concept that progression should be added as soon as possible to promote learning and increase motivation.

Moreover, participants mentioned the importance of taking into account **"User related considerations"** (Theme 2), either in regard to their personal preference or concerning their clinical features, to allow for personalization of the intervention plan. This includes "*initial patient assessment"* (subtheme 2.1) which will allow an objective evaluation to support assessing patients' eligibility for the intervention, adapting to their characteristics, and measuring the patients' improvement. The "s*et-up considerations*" (subtheme 2.2) may accommodate patient-specific needs and contribute for the effectiveness of the intervention, for example in the sitting position and visual field settings.

The specific adaptations to minimize the impact of the patients' deficits on the intervention's results were considered a key component for the *"features of personalization"* (subtheme 2.3). Adjusting the task and environment to each patient's interests, according to the participants, has benefits for brain activation, motivation, and transference. Since this personalization addresses the task, it is related to Theme 1.

Table 6 Overall view of themes and subthemes

1. Task selection	1.1. Characteristics of tasks

	– Simplicity of task and environment – Activities of daily living – Familiarity of the task to the patient – Unilateral and asymmetric tasks
	1.2. Variability of tasks – Degree of variety – Contribution of variety for engagement
	1.3. Principles to task progressions – Components of the task to progress – Timing and approach for applying progressions
2. User related considerations	2.1. Initial patient assessment – Objective evaluation of the patient – Patient inclusivity
	2.2. Set-up considerations – Enhancing instructions with video – Physical position of the patient – Considerations for visual representation
	2.3. Features of personalization – Clinical traits of each patient – Meaningfulness for the patient

3.4. Theme 1. Task selection

This theme includes the principles that were highlighted by participants to support the decision of task selection, including the initial characteristics of the task/s, their variability and progression for a BCI intervention. These characteristics took into account ideal brain activation, the acceptability from the patients and possible transference of the benefits of the intervention to the patient's daily life.

3.4.1. Subtheme 1.1. Characteristics of tasks

Regarding to the characteristics of the tasks, the participants debated several aspects that may optimize the occurrence of brain plasticity that are relevant for the rehabilitation. The "simplicity of task and environment" might contribute to patients' focus and system calibration. The preference for "activities of daily living" may increase patient motivation for its relevance for independency. The "familiarity of the task to the patient" might lead to an ease in illicit a motor imagery. The benefits of "unilateral and asymmetric tasks" are related to a more directed and rehabilitation-specific brain activity.

Simplicity of task and environment

For BCI interventions the participants highlighted the importance of considering simple tasks and virtual environments, which means settings with lower number of task subcomponents and lower amount of stimuli in the virtual environment. The importance of simplicity was highlighted, regardless of the clinical traits and specially in the beginning of the training programme.

From their perspective, this simplicity may help with the motor imagery and decrease the risk of provoking confusion for the patient. Adding complexity may be an appropriate way to achieve task progression with potential benefits. Thus, the participants recommend selecting simple tasks and environments in the beginning of the intervention.

> *"Whether the patient has more or less disability, even for normal people, the task should be as simples as possible; simple in regard to motor imagery"* (Expert 10, Physiotherapist, Workshop 2)
>
> *"With more complexity, supposedly, more activation. And there you go! It is like this progression of "ok, here I see an empty water jug and a glass", then I will see the jug with some water, just a little water and then a lot of water"* (Expert 1, Physiotherapist, Workshop *1.1)*
>
> *"There is an aspect that I think you will have to choose really well, which is the type of feedback you will give, right? Because when there are three* concurrent feedback *signals it may confound the patient. You want to give visual, auditory, and tactile, right? I would opt for just one or two feedbacks"* (Expert 6, Occupational therapist, Workshop 1.2)

Activities of daily living

Choosing tasks that are similar or replicating activities of daily living might, according with the participants, improve the patient's understanding of the task, brain activation and adaptation to the VR setting (immersion). These benefits could be related to an ease to evoke the motor planning of mundane tasks, an increased motivation to practise tasks that are involved in functionality and independency and an improved transference from these BCI+VR training to conventional training. The participants recommend including in the intervention activities of daily living or closely resembling tasks.

The most common movements of the upper limb are asymmetric, goal oriented, and initiated by vision. The inclusion of tasks that involve using the hand to interact with (virtual) objects in the BCI+VR training, was considered to possibly activate more relevant neural pathways and lead to a more productive intervention, as opposed to more repetitive movements like cycling, rowing, or climbing a ladder.

> *"There are motor goals, and concerning the hand we have three major motor goals, which are reaching, grabbing and manipulation. These involve the entire upper limb. I believe the tasks should incorporate the entire upper limb, instead of focusing only on the hand. Because when focusing only on the hand we activate predominately the (brain) circuit of grasping and hand representation.* (Expert 6, Occupational therapist, Workshop 1.2)

> *"I always prefer to practice things that make sense for me, in my daily life (…), things that are really practical, that are useful."* (Patient 6, Workshop 3)

> *"On an initial phase it would be, undoubtably, discrete tasks, with determined start-finish in which the less affected limb would have mostly a supporting role for the activity of the other limb."* (Expert 6, Occupational therapist, Workshop 1.2)

Familiarity of the task to the patient

Familiarity refers to how well the task is known by the patient, allowing the engagement of memories to aid in the motor imagery process. From the participants' perspective, the task will be more meaningful to the patient if it is familiar, which could lead to increased brain activation. However, some participants also reported that the lack of novelty might lead to tediousness.

Taking into account that familiarity varies considerably from person to person, this was identified as a good opportunity to include some of the patient's specific interests or hobbies, with added benefits for engagement and acceptability. Considering the stated benefits, the participants recommend choosing tasks that are familiar to the patients.

> *"I think that initially there should be familiar tasks to begin with, and as the (brain) activation improves, eventually, as a matter of motivation, of novelty and of stimulating the cortical representation, there should be a shift for new tasks"* (Expert 5, Physiotherapist, Workshop 1.2)

“(What movements do you suggest should be trained on the virtual reality?) - Pick up the cat, pet it.” (Patient 6, Workshop 3)

“Shaking hands with a famous person could be positive… but even if there was an increased motivation, I would prefer a mundane context, because it’s more relatable, it is more meaningful. However, an exception could be made if the patient says that he/she enjoys immersing into a fantastic world.” (Expert 1, Physiotherapist, Workshop 1.1)

Unilateral and asymmetric tasks

According to the participants’ perspectives, performing motor imagery exclusively of the hemiplegic UL will lead to more specific brain activation. In other words, unilateral training focuses the effort on the most affected UL and reduces the risk of the least affected side taking over the activity.

Taking into account the characteristics of upper limb movements, the participants considered the asymmetric and unilateral tasks to be preferential for the use in this intervention, for better inter-hemispheric coordination and greater cortical activation, respectively. Additionally, asymmetric tasks are more prevalent in functional movements, hence represent a more relevant training set-up. An exception was considered for patients with very severe lesions, where a bilateral task may be easier to perform, in the beginning of an intervention programme.

“I believe that the start should be unilateral” (other participants nodded) (Expert 5, Physiotherapist, Workshop 1.2)

“Start with asymmetric, because we perform asymmetric tasks. If the severity (of the motor disability) is extensive, I would not be shocked if we start with symmetric activities.” (Expert 1, Physiotherapist, Workshop 1.1)

“To make so that there is less competition between the brain hemispheres, I would say that (the task) could be unilateral. However, we know that bilateral tasks promote active movement and recovery. (…) I think that I would ask to perform a unilateral task and, in most cases I would also try to inhibit the opposite side.” (Expert 2, Physiotherapist, Workshop 1.1)

In short, the participants recommend selecting unilateral tasks using the most affected UL or asymmetric tasks in which the least affected UL has a more supportive role. Additionally, bilateral symmetric tasks should be considered for the introduction of patients with severe motor impairments.

3.4.2. Subtheme 1.2. Variability of tasks

From the participants' viewpoint, variability is a constant component of functional movement, and for that reason it is essential that stroke patients are able to adapt to nuances in tasks, for example, in the shape and size of objects, or the same object placed in different locations in space.

Although the importance of repetition for motor learning was mentioned by the participants, they also highlighted the importance to balance repetition with the performance of the movement with small variations. Training with variation is more demanding, however, it is also more closely related to real life scenarios.

The participants' opinions about task variability were divided into the "degree of variety" and its "contribution for engagement".

Degree of variability

While excessive variability was perceived by the participants as a possible obstacle for motor learning, the lack of variability might lead to training experience that feels artificial and less relevant for the execution of functional tasks. Variability was agreed by the participants as an important feature of the training to increase transference of the intervention to daily life. Additionally, variability allows for the execution of repetitions without leading to repetitiveness, which in turn could prevent the patient getting jaded throughout the training sessions.

The participants stated that two tasks can be reasonably similar, or they can be very distinctive, particularly if they imply additional movement components, the use of more range of motion, or different hand and digits configurations. It was pointed out that tasks that vary only slightly, for example in the colour, texture, or size of the object, could present a variability small enough to not require system calibration to capture the MI.

On the other hand, some variability can appear small while affecting the motor parameters of the task significantly, for instance the positioning of the object in relation to the patient, or the function to be performed (for example, reaching a glass of water to place it on the table or to take a sip). This could represent task progression or a variation of similar demand.

In regard to the context or background of the task, the participants did not show a clear viewpoint in how much it contributes to the degree of variability. Leaning towards less variability in the cases where the movement and object is exactly the same (reaching for an apple on a tree, supermarket shelf or home refrigerator shelf) and for more variability in the cases where the movement and object while similar require some adaptations (introducing a key inside a house door lock, a car door lock or mailbox).

> *"The goal is to transfer these gains for the day to day, I would probably say variability instead of variety"* (Expert 4, Physiotherapist, Workshop 1.1)

> *"You could have several doors, the door for a house or the door for a shop, or the... in which the movement is always the same, this is repetition without repetitiveness. Because it varies the context, although the task is really the same."* (Expert 2, Physiotherapist, Workshop 1.1)

> *"Even though repetition is effective for brain activation and motor learning, if the image is repetitive, the patient could easily get demotivated. On the other hand, showing different images thorough out the sessions might dilute the salience, which is highly important for the performance of the task. The truth is that, depending on the image, it can also slightly alter the task components, and that can be viewed as a form of progression."* (Expert 1, Physiotherapist, Workshop 1.1)

In summary, the participants recommend training programmes to take into account the need for moderation in the degree of variability in order to be a positive addition. Variability should be included, as soon as the patient can tolerate it, and in gradual manner, both in the number of factors that add to the variability as well as to the degree of variability. The participants recommended the first factors of variability should be visual components, for example the colour of the object or environment.

Contribution of variety for engagement

Although some patients have high intrinsic motivation to achieve the rehabilitation goals, planning a less tedious intervention was perceived by participants as important in promoting the engagement of the stroke patients. The identified contributors to engagement were variability, gamification, and extraordinary environments.

However, the participants showed concern that focusing excessively on the motivational elements might decrease the impact of task components mentioned previously such as task and context familiarity, mundane context, and simplicity.

"While games represent an environment that doesn't relate to reality, we know that they also improve cortical representation, increase brain activity… Improve all biomarkers, increase motor function, even while being in a different setting" (Expert 6, Occupational therapist, Workshop 1.2)

"If it (the task) is ludic, it removes some of the tedious aspect of the repetition, in other words, if you are repeating for the purpose of repeating, maybe you get tired and lose motivation, right? If you turn that activity into a playful activity with goals et cetera, naturally it's one of the advantages of virtual reality, right?" (Patient 4 on Workshop 3)

"An extraordinary environment can be more motivating, right? However, we want to make that person as functional as possible in the mundane context, right? In the real context, therefore, is a matter of asking the individual and conceivably once per week make things more extraordinary, right?" (Expert 6, Occupational therapist, Workshop 1.2)

The participants' recommendation is that variability can be an effective form of increasing patient engagement. However, it should not take precedence over familiarity, simplicity, and mundane context.

3.4.3. Subtheme 1.3. Principles to task progressions

Considering that BCI+VR interventions focus on motor imagery instead of performing movement, the participants debated how to include progressions into the training programme. This debate included the "components of the task to progress" and "timing and approach for applying progressions".

Components of the task to progression

The participants mentioned several options to achieve task progression. Adding variations to the task was considered a valid and flexible form of progression, as mentioned in the topic "Degree of variability", in the case of the variations that substantially change the task.

The task variations can be as simple as increasing the speed and range of the movement (for example by changing the position of the object or the goal), changing the object used in the task (for example by requiring adaptation of the position of the hand and digits) or the goal associated with the same object.

Increasing the complexity of the task was also considered a relevant progression by expanding the number subcomponents of the task or the number of stimuli (of the same or different type – visual, vibration, sound) in the virtual environment. The participants stated that adding complexity, besides providing a progression to the task, also resemble real-life scenarios, that naturally include complexity.

Task fragmentation was pointed as a means to specifically train a subcomponent of the task, allowing to focus on that subcomponent, to later re-integrate it into the task.

> *"Doing this de-fragmentation (of the task), while keeping the focus clearly on the goal and on the (entire) activity, even when working on only a small portion, allows to take the full advantage of the motor imagery activation and then related to the movement (...)"* (Expert 8, Occupational therapist, Workshop 1.2)

> *"Complete paresis, pain, and improper postural activity, in many cases have a common element. (…) These symptoms could benefit from motor imagery, if we adapt the speed of movement and the range of movement in the task."* (Expert 7, Physiotherapist, Workshop 2)

The participants clarified the distinction between task variability and task progression, stating that task progression is an essential component of any training programme. Being clear what are the components that can be considered for task progression is important for designing BCI training programmes, in short: adding variations (speed, range, position, object, function), increasing stimuli, adding complexity and using task fragmentation.

Timing and approach for applying progressions

The participants agreed that both variability and progression should be added as soon as possible and as frequently as possible. It was implied from the participants that variety can be safely introduced earlier than progression, since that by definition will not increase the difficulty to the task (for example by changing only the visual aspect of the task).

One point the participants agreed on was that, analogous to conventional rehabilitation, the progressions should be added slowly and gradually, even if the optimal progression process could vary widely from patient to patient.

The participants recommend that progression should be gradual and as frequent as possible, starting with increasing range or speed of movement, changing the task to a variation of the initial task and finally by adding complexity, either by increasing sensory stimuli or task subcomponents.

"Each passing day, it is possible to increase the difficulty of the goal... Therefore, a person gets to a certain point, and is able to achieve even a small portion of what was proposed. Therefore, there has to be another goal set immediately after that." (Patient 1, Workshop 3)

"Variability can be introduced gradually, or it can even be integrated in the same virtual environment in which the person travels between different scenarios, opens the front door using a key, closes the front door, goes to the car, opens the car, gets in, closes the car door, turns the ignition, arrives at the workplace, opens the door again, closes the door. The progression can be through multiple environments." (Expert 6, Occupational therapist, Workshop 1.2)

3.5. Theme 2. User related considerations

The participants agreed on the importance of respecting the variety in the patient experience. Stroke patients have a range of different dependency, lesion location, rehabilitation experiences, on top of personal differences unrelated to the stroke (including age, education, previous motor experience, laterality, hobbies, and interests).

Thus, it was agreed that this difference must be respected and taken into account to achieve the optimal intervention, which will require patient assessment and personalization of the intervention. The more relevant topics involved in accommodating this multitude of stroke patients were divided into the following subthemes: initial patient assessment, set-up considerations and features of personalization.

3.5.1. Subtheme 2.1. Initial patient assessment

The participants acknowledged the considerable variation of stroke patients' clinical presentations, rehabilitation experiences and personal preferences, leading to the importance of the initial patient evaluation. This initial evaluation will be essential both to support the decision-making about patient inclusion in the intervention, and to measure the intervention outcomes. Additionally, it was also perceived as an important step to support the personalization of the intervention. This subtheme's insights were organized in "objective evaluation of the patient" and "patient inclusivity".

Objective evaluation of the patient

Participants stated the importance of assessing sensory processing dysfunction (in particular hypersensitivity), changes in postural control, visual scanning deficits, body awareness dysfunction, spatial awareness deficits, motor activity of the upper limb (using the Fugl-Meyer Assessment Scale) and the patient's ability to imagine movement.

In order to guarantee the personalization of the intervention, participants considered that it to be relevant to enquiry about the severity of impairment, laterality, communication dysfunction, previous experiences with rehabilitation, hobbies, and personal preferences.

> *"There are questionnaires that assess the ability to imagine movement and that have robust psychometric proprieties. Hm, and that is as important as having or not having sensory deficits or postural control deficits, which is to know if the patient has, to start with, the capacity to imagine movement. And I think it should be taken into account for patient inclusion."* (Expert 5, Physiotherapist, Workshop 2)

> *"(regarding the application of vibratory stimulation) and what if there is hyper sensibility? Then it will be very complicated (…) Of course if the vibration can be turned off it won't be a problem."* (Expert 3, Occupational therapist, Workshop 1.1)

> *"(…) either in regard to spatial organization, or to the ability for visual scanning, or spatial perception, and body awareness… There are a series of conditions that seem to me to be more of a cognitive origin than specifically from a motor origin, because we are in fact discussing motor imagery (…)"* (Expert 2, Physiotherapist, Workshop 2)

Patient inclusivity

From the participants' viewpoint, it is important to consider which patients may benefit the most from BCI+VR interventions and which patients may get merely minimal benefit. Another important viewpoint stated by the participants is the opportunity to include a broad range of patients that are routinely excluded from investigation.

The participants debated the interplay between inclusivity and optimizing intervention results. Some participants highlighted that patients with severe communication deficits or inability to produce motor imagery wouldn't be able to participate in BCI+VR intervention due to inability to understand the instructions and to trigger the software, respectively.

Apart from the patients totally unable to participate in a BCI+VR intervention, the participants stated that other situations that hinder the patients' ability to fully participate should, as much as possible, be accommodated. While discussing the strategies to accommodate these patients (mentioned on subtheme 2.2), the participants also agreed that there is not a clear decision which patients would not benefit from the intervention.

However, the participants stated that since there is no clear-cut line for patient exclusion, ethically the decision should lean towards inclusion. This statement was followed by the analogy that in conventional therapy virtually no patients are excluded and that there is added value in research mimicking the population characteristics it aims to target.

In short, the participants clearly stated that the intervention should offer adaptations, whenever possible, in order to include a broad range of patients and avoid patients' exclusion.

> *"There is so little ability (in experimental interventions) to include some subgroups of patients that we are discussing that maybe the development of something for that fringe of patients (would be) highly relevant"* (Expert 1, Physiotherapist, Workshop 1.1)

> *"Patients with global aphasia won't even be able to comprehend what is being said to them by the research team" (Expert 3, Occupational therapist, Workshop 1.1)*

> *"Motor imaginary should be assessed, even though it's hard since the basis for that assessment always ends up in some form of questionnaire (which can be impossible for some patient with communication deficits)"* (Expert 10, Physiotherapist, Workshop 2)

3.5.2. Subtheme 2.2. Set-up considerations

With the aim of optimizing this intervention, the participants talked about some factors that should be taken into account when planning the intervention, that could influence the relevant cortical activity or minimize possible distracting factors.

This subtheme is focused on considerations independent from the task, including: “enhancing instructions with video”, “physical position of the patient” and “considerations for visual representation”.

Enhancing instructions with video

The participants considered that the task instructions should include a video demonstration, both to support patients with deficits in communication and boost brain activation, since motor observation on its own creates relevant brain activity.

The perceived benefits of adding video demonstration before BCI training were to aid in understanding the task, increasing motor memory recall, priming the motor planning, and keeping in mind the entire task when practising a subset of the whole movement.

> *“To ensure that the task is recognized, not only the context but also the goal, having an example of a person reproducing the movement would be important. Further, it causes cortical representation, which would lead to improved feedforward.”* (Expert 2, Physiotherapist, Workshop 1.1)

> *“The progress could be in means of what is first, pick up the (water) jug, and then after grabbing the jug, then the water gets poured into the glass. I would exemplify the task beforehand, as a whole. Since this way it will be easier to recognize (the task) and retrieve the (motor) memory.”* (Expert 2, Physiotherapist, Workshop 1.1)

Physical position of the patient

In conventional rehabilitation the starting position and postural activity influences the performance of the movement, either positively or negatively. The participants argued if this effect is present in motor imagery training, concluding it is expected to be present, even if to a lesser extent.

Considering the uncertainty, the participants debated the importance of recommending to perform some form of postural activation prior to the motor imagery training, ultimately agreeing that the benefit would be too small to justify the time investment. Additionally, this could be difficult to perform on patients with more severe motor limitations.

Another recommendation reached from the workshops, was the importance of matching the position of the virtual hand and real hand, in some point of the intervention, to increase immersion.

> *"To me it makes sense that the person is comfortable, right? In a comfortable position and that there won't be confounding variables around while he is doing this, right? (for example) The person being unbalanced and trying to manage what is the real body with the virtual body (would be confusing or distracting)."* (Expert 10, Physiotherapist, Workshop 2)

> *"And how should be the support of the upper limb? A cut-out table for the patient to fit in? I don't know, I am trying to visualize if there will be elbow support or not, and if that support is in the chair, how will the hand be supported?"* (Expert 1, Physiotherapist, Workshop 2)

> *"In virtual reality it could be easier to achieve that immersion, right? If the real hand is placed on top of the table and we can see the real hand and the virtual hand is also on top of that table"* (Expert 7, Physiotherapist, Workshop 1.2)

In summary, the participants recommended that the patient should be sitting in a comfortable upright position with supported back. Additionally, the patient's elbow and forearm should be supported on the table or chair's armrest, reducing the risk the limb slides of the support surface.

Considerations for visual representation

Considering the change in body schema stroke patients frequently present with, either directly from the brain lesion or from the prolonged unuse, recommendation for having both hands present in the visual field whenever possible was provided by participants. From their perspective, this recommendation may contribute to a positive change in the body perception and possibly benefit the active component of the intervention.

> *"It is related to the body schema, therefore, the inclusion of both hands should be present (in the field of vision)"* (Expert 8, Occupational therapist, Workshop 1.2)

Moreover, it may be expected the need of some rest periods between bouts of practise. Concerning what should be visible during those periods of no mental practise, some participants mentioned preferring a pleasant nature landscape, while others showed preference for keeping the visual representation on the training task scenario, to help keep the focus when the pause ends. Perceiving the disparity of personal preferences during the workshop with patients, participants came to the recommendation of having the possibility of choice according to each patient's preference.

> *"A pretty landscape (yes), the screen staying black… no, no, no, that won't do! At least a pretty landscape, I think we all agree"* (Patient 8, Workshop 3)

> *"(What if during the rest period the visual field stays the same as it was during the training except there is no movement performed?) That one sounds good to me too."* (Patient 8, Workshop 3)

3.5.3. Subtheme 2.3. Features of personalization

As mentioned previously, the participants considered highly important to tailor the intervention to each patient, not only to allow the inclusion of a broader range of patients but also to increase the potential benefits for all patients. Involving the patient in decisions was also considered important to promote motivation. These decisions could be based on the patients' clinical features and the patients' personal interests.

Clinical traits of each patient

Taking into account the high variety of symptoms of stroke patients, adapting the intervention to the clinical features could improve the effectiveness of the BCI training. The participants mentioned some of the key factors that are relevant to consider in the decision making of the plan of a rehabilitation intervention. Stroke lesion location (left or right hemisphere; cortical, sub-cortical or both), laterality (patient is more affected on the dominant or non-dominant side), visual and special perception, and motor capacity (particularly if the motor impairments are present in the proximal and/or distal component of the UL) were some of the mentioned factors.

Patients with deficits of visual perception and spatial awareness would appreciate additional cues so they are able to still benefit from this intervention, keeping in mind that each patient is a unique individual and might require different strategies. The participants suggested that, previously to the training, there could be added a visual stimulation focused on the affected visual side and that could reduce its impact on the BCI training. Additionally, during the BCI task training there could be added visual cues to help the patient focus on the object or the task goal, when the task involves the affected visual side.

> *"In this situation, it is likely that for lesions on the right (hemisphere), they probably will need of slightly different cues, an increase of information, to find themselves in space and the body part in space."* (Expert 4, Physiotherapist, Workshop 1.1)

> *"Wandering about an activity that requires a scan of the image, or a call of attention to the left side so that afterwards you can develop the task (by) thinking and imagining the movement with the left arm."* (Expert 2, Physiotherapist, Workshop 1.1)

> *"Studies say that it doesn't matter that much (…) the type of feedback we give, it matters more the time-consistency in which we give the feedback. That is, regardless of whether the stimulation is given in the arm, finger, or hand, as long as it is compatible (in time) with the motor action executed."* (Expert 10, Physiotherapist, Workshop 2)

Meaningfulness for the patient

The task being meaningful to the patient was perceived by the participants as having benefits for the ease of accessing motor memory, for maintaining the focus and for the engagement in the training. Furthermore, taking into account the tasks and contexts the patients appreciate would lead to additional phyco-emotional benefits and might increase the time needed to reach fatigue.

The participants mentioned the notion of patient inclusion in the decisions of the training plan leads to increased transference from the training to functional gains.

> *"We all have mental maps (…) and (the ideal would be) having several tasks that have meaning and the individual can select one of them.* (Expert 4, Physiotherapist, Workshop 1.1)

> *"The decision could really depend on the preference of the patient and the (rehabilitation) goal, and it's also between the team, between therapist and patient, hm… Because maybe there are patients that if we put them in a rhythmic task, the attention might decrease throughout the task and then we lose our focus".* (Expert 2, Physiotherapist, Workshop 1.1)

> *“We know that also in terms of functional gains, they are bigger when the patient is involved in the decision of the treatment, right?”* (Expert 6, Occupational therapist, Workshop 1.2)

In summary the participants considered crucial that the BCI training supports the selection of a task and of an environment that is meaningful to the patient, and that selection should include the patient itself whenever possible.

4. Discussion

This study aimed to produce a set of recommendations for future interventions using BCI and VR, that takes into account the neurophysiologic effects of training in an individual with a unilateral brain lesion.

Looking at the recommendations given by the participants concerning task and environment simplicity, it is in agreement with another author that declared that the simplicity might be beneficial for BCI intervention with stroke patients, since it enhances their ability to control the device (Nojima et al., 2022). The simplicity of the environment was pointed out as relevant for decreasing the cognitive load, by decreasing the need to filter the relevant sensory elements. The participants also pointed out that the simplicity of the task will facilitate the system calibration, while the simplicity of the environment might reduce additional cortical activity that could interfere with the detection of the motor plan of the relevant task.

The participants advice the tasks to be unilateral using the most affected UL, or, when including both ULs, the least affected UL has a more supportive role, in a very asymmetric manner. This recommendation included an exception for patients with severe motor deficits, who might benefit from bilateral symmetric task to start the training programme.

Both training regiments appear to have different benefits, with bilateral tasks having been indicated as a priming intervention before unilateral training (Renner et al., 2020). Bilateral training might assist in improving interhemispheric coordination, that appears to differ with the location of the stroke (cortical or subcortical) (Renner et al., 2020). On the other hand, unilateral training might reduce inhibition from the least affected side (Renner et al., 2020). In chronic stroke patients, unilateral training was more effective than bimanual movement using mirror training (Selles et al., 2014). There is evidence, in patients with severe paresis following subcortical stroke, of greater improvement after bilateral training over unilateral training, while patients with cortical involvement on their stroke revealed no advantage of bilateral training over unilateral training (Renner et al., 2020).

The participants highlighted the diversity in stroke patients' presentations, making it impossible to give recommendations that apply to all patients, as made clear by the difference in cortical and subcortical stroke for deciding between unilateral and bilateral training. The participants also alerted to relevant differences between strokes associated with different artery affectation, and between right and left hemisphere. Despite the deep theoretical and practival knowledge from the experts, the complexity of the interaction between this features, made it difficult to make clear recommendations. Grouping the patients appear to be essential to predict neural response and achieve more effective interventions (Grefkes et al., 2020), and understanding the underlying mechanisms will support those decisions (Reinkensmeyer et al., 2016). Additionally, this process of understanding the principles and identifying patient groups might be aided by computational models (Reinkensmeyer et al., 2016).

Concerning including activities of daily living in the BCI intervention, the participants recommendation is to include those tasks, which is aligned with one of the principles to increase neuroplasticity (Maier, Ballester, et al., 2019). Stroke rehabilitation guidelines also recommend the inclusion of activities of daily living training (Teasell et al., 2020). The participants considered the familiarity of the tasks and relevancy for rehabilitation goals to be relevant factors for preferring ADL tasks, even though this tasks include movements that might not be simple. Executing ADL tasks involve higher levels of motor-cognitive and perceptual processes, while simple motor tasks are less susceptible to interference (Liao et al., 2020), however the participants considered that familiar tasks are easier to understand and elicit the motor plan.

When considering familiarity to the patient, the participants also mentioned the importance of the context of the task, the details of the objects and the environment. To practise movements as close as possible to normative movement, with attention on the practise and its repetition, was also recommended (da Rosa Pinheiro et al., 2021).

Looking at the recommendation to prefer familiar tasks (considering personal interests and hobbies), directly relates to another recommendation to personalize the intervention to each patient. The participants suggest that the intervention settings should be possible to be regulated by the therapist according to the patients' evaluation as well as the response during the session. Personalizing BCI intervention to each patient was also previously recommended (Nojima et al., 2022).

The participants recommend future interventions to conduct careful evaluation of each patient, concerning the severity of impairment, laterality, communication dysfunction, previous experiences with rehabilitation, hobbies, and personal preferences. This would help to effectively personalize the intervention to each patient. One of the limitations to applying BCI in a larger scale was reflective motivation, referring to the therapists' ability to understand the patients' abilities and goals to set the tasks demands and contexts (Jervis-Rademeyer et al., 2022) although this study used BCI with FES and not VR, it has similar limitations of set-up and portability of the equipment.

It was recommended that the intervention should offer adaptations, whenever possible, to increasing inclusivity of patients. This highlights an important ethical concern, which is commonly not considered in research. For the need of clarity in results, experimental studies exclude patients with complex clinical features, including having multiple strokes or other concurrent diseases. However, considering that the design of the intervention should take into account this features, research using exclusively the simpler cases of stroke might not be informative for more complex clinical cases. For example, neglect is clinical feature of stroke patients that is an exclusion criteria for some studies, however it was found that the features of the VR could lead to effective rehabilitation, regardless of embodiment (Salatino et al., 2023). Considering that ethically the patients with complex clinical features have equal rights to have access to effective interventions, they should also have the opportunity to participate in the scientific process.

Choosing a task and environment that is meaningful to the patient was another recommendation from the participants. Meaningfulness of the task was one of the mentioned relevant neuroplasticity principles (Page & Peters, 2014). This could also contribute to patients' attention, since intense attention was found to be necessary to use BCI technologies (Yadav et al., 2020).

In regard to including the patient in training programme decisions, the participants recommend to do it whenever possible. Evidence has shown that when a patient can make a decision, can be as small as choosing the colour of the object, can improve task learning (Lewthwaite et al., 2015). This further supports the benefits and need of allowing personalization to each patient.

The participants recommended that task instructions should include a video demonstration, both to support patients with deficits in communication and boost brain activation. This would mimic the frequent behaviour performed by therapists in conventional therapy of demonstrating a movement to the patient to increase clarity of instructions before the patient starts the task training. The relevance of task visualization is supported by the evidence of meaningful cortical activation on the observation of movement, even without motor imagination (Brighina et al., 2000), however, using motor observation as a priming strategy as not been proven to have a significant effect for task-oriented training (da Silva et al., 2020).

The participants recommended that the training should have variability, early and frequent. A virtual scenario that is not fixed across all sessions has been hypothesized to increase motivation (Carpinella et al., 2020). Variability allows for a simple task to maintain the patients' engagement without adding difficulty. The participants recommended, that when adding variability to avoid sacrificing familiarity, simplicity, and the mundane context. It has been mentioned that training in lifelike scenarios may optimize the assimilation of the motor skills from the training to the day-to-day life (Ambrosini et al., 2021), this was also observed in a VR intervention (Oña et al., 2019).

After the beginning of the training, the participants recommended to incorporate some progression in the programme, which could avoid the diminishing effect of BCI training. Previous studies reported a plateau after the first six sessions on a BCI-robotic system (Frisoli et al., 2022) and the same was found on action observation training meta-analysis (Zhang et al., 2019). Thus,on a BCI-VR system it is expected a similar effect, however it may be more easily addressed in BCI+VR, through the addition of variability and progression.

Looking at the participants recommendation for components for task progression, they listed the following: adding variations (speed, range, position, object, function), increasing stimuli, adding complexity, and using task fragmentation. The participants also recommend the progression should be gradual and as frequent as possible, starting with increasing range or speed, task variation and adding complexity, either by increasing sensory stimuli or task subcomponents. It was also advised that VR training in enrich environments might increase skill acquisition (Bermúdez i Badia et al., 2016), while the participants recommend simplicity for tasks and environments at the start of the training programme, adding complexity should include the sensory stimulation.

Starting the progression by increasing the amount of movement, can be associated with the advice from one author that patients with severe motor impairment should start by training low numbers of degree of freedom and gradually increased (Lee et al., 2020). Complexity in training has been used previously to add variety for the patient and provide incremental intensity (Crema et al., 2021). This mention of adding sensory stimuli is in concordance with the already mentioned recommendation to prefer VR training in enrich environments to increase skill acquisition (Bermúdez i Badia et al., 2016).

Considering the lack of clear evidence of the effect of postural activity for the effectiveness of BCI interventions, the participants recommend the patients should be seated in a comfortable upright position with supported back. The elbow and forearm should be supported. The stability of the sitting position and of the UL might be important to reduce noise for the reading from the BCI system, as noted by one of the participants.

Seeing the BCI meta-analysis recommended taking a pause after 15-20 minutes to avoid fatigue or discomfort symptoms (Bai et al., 2020; Nojima et al., 2022), the participants recommend that, during these pauses, the visual representation should be chosen taking into consideration patient preferences (for example a nature landscape).

4.1. Study limitations

Despite having produced a number of recommendations, this study has limitations, since this is a topic too deep to fully address in the scope of a study of this scale. The number of participants and/or of sessions could have allowed for further insights, either in additional topics or deeper discussion. Some relevant topics were not discussed and should be considered for future research:

- the preference between attempting to move and only imagining the movement, with some data showing more brain activation for the intending to move group (Mansour et al., 2022);
- focusing on the distal arm function, for its essential role in ADL's and low probability of recovering functional with conventional therapy (Ranzani et al., 2020) or focusing on whole limb motion since it provokes an increase motor evoked potential (J. H. Park, 2020)
- relevant differences for patients with left or right hemisphere stroke, cortical or subcortical stroke, hemiparesis in the dominant side

Additionally, in topics in which there were recommendations, it was not possible to explore how to finalize those recommendations in specific situations. Some participants commented that some of the topics are not clear cut, and depend on different clinical features, without specifying.

The dept of knowledge of the experts could have been more effectively explored in asynchronous workshop or forum, in combination with the held synchronous sessions, possibly allowing to explore the underlying reasoning behind the participants' opinions. The patient selection might have been biased towards highly intrinsically motivated individuals and limited the richness of strategies used to boast adherence and motivation in unmotivated patients. Additionally, the patient selection included patients with limited or inexistence experience with VR, having patients with deep experience with VR might lead to richer opinions. Some of the participants in the study showed some interest in using technology in rehabilitation, yet if they had been selected with this interest in mind, it might have led to a more focused and deeper discussion.

All the participants were invited to make additional comments after the sessions, however only a few added comments to the workshop's discussion and these were not in detail comments.

Finally, this study's results were limited by the experience of the main author in designing and moderating workshops, by the allotted resources and could have benefited from additional methodology that would invite more thoughtful contributions from the experts, for example planned asynchronous activities.

5. Conclusion

This study brings attention to the importance of careful consideration of the different neurophysiological principles that support rehabilitation after stroke, that allows some patients to recover function even after years post-stroke (Ingwersen et al., 2021). A qualitative study can be an effective tool to record the tacit knowledge from clinical experts, as well as their inferences from one type of interventions to possible similar effects in others, as a way to guide future quantitative research.

Some recommendations can be drawn from this study. The task and environment should be simple, include ADL and familiar tasks to the patient. The BCI intervention should prefer unilateral tasks, with the most affected UL. The training programme should include variability and progression as soon as possible. The progression should start with increasing amount of movement (range or speed) and later include task variation, adding stimuli, adding complexity and task fragmentation.

The patient evaluation should include the severity of impairment, laterality, communication dysfunction, previous experiences with rehabilitation, hobbies, and personal preferences. The intervention should offer adaptations to patients' deficits to avoid patient exclusion, for example by adding additional visual cues (before and/or during the training) to accommodate deficits of visual perception and spatial awareness.

The task and environment selected should be meaningful for the patient, that is included in clinical decisions whenever possible. The interventions instructions should include video demonstrations of the tasks and keep both hands visible on the virtual environment, whenever possible. The patient should be sitting in a comfortable upright position with supported back, elbow and forearm.

Future research should address the factors not discussed in this study and aim to produce specific questions for future experimental interventions.

6. Dissemination

This study will be submitted to the 13th World Congress for Neurorehabilitation of the World Federation for neurorehabilitation to take place in May 2024. The abstract submission deadline for this congress is on 30th of November.

7. Bibliography

Abdullahi, A., Wong, T. W. L., & Ng, S. S. M. (2023). Variation in the rate of recovery in motor function between the upper and lower limbs in patients with stroke: some proposed hypotheses and their implications for research and practice. *Frontiers in Neurology*, *14*. https://doi.org/10.3389/fneur.2023.1225924

Allison, R., Shenton, L., Bamforth, K., Kilbride, C., & Richards, D. (2016). Incidence, Time Course and Predictors of Impairments Relating to Caring for the Profoundly Affected arm After Stroke: A Systematic Review. *Physiotherapy Research International*, *21*(4), 210–227. https://doi.org/10.1002/pri.1634

Al-Whaibi, R. M., Al-Jadid, M. S., ElSerougy, H. R., & Badawy, W. M. (2022). Effectiveness of virtual reality-based rehabilitation versus conventional therapy on upper limb motor function of chronic stroke patients: a systematic review and meta-analysis of randomized controlled trials. In *Physiotherapy Theory and Practice* (Vol. 38, Issue 13, pp. 2402–2416). Taylor and Francis Ltd. https://doi.org/10.1080/09593985.2021.1941458

Ambrosini, E., Gasperini, G., Zajc, J., Immick, N., Augsten, A., Rossini, M., Ballarati, R., Russold, M., Ferrante, S., Ferrigno, G., Bulgheroni, M., Baccinelli, W., Schauer, T., Wiesener, C., Gfoehler, M., Puchinger, M., Weber, M., Weber, S., Pedrocchi, A., … Krakow, K. (2021). A Robotic System with EMG-Triggered Functional Eletrical Stimulation for Restoring Arm Functions in Stroke Survivors. *Neurorehabilitation and Neural Repair*, *35*(4), 334–345. https://doi.org/10.1177/1545968321997769

Aminov, A., Rogers, J. M., Middleton, S., Caeyenberghs, K., & Wilson, P. H. (2018). What do randomized controlled trials say about virtual rehabilitation in stroke? A systematic literature review and meta-analysis of upper-limb and cognitive outcomes. In *Journal of NeuroEngineering and Rehabilitation* (Vol. 15, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s12984-018-0370-2

Aprigio, D., Bittencourt, J., Ramim, M., Marinho, V., Brauns, I., Fernandes, I., Ribeiro, P., Velasques, B., & Alves E Silva, A. (2022). Can mental practice adjunct in the recovery of motor function in the upper limbs after stroke? A systematic review and meta-analysis. *Brain Circulation*, *8*(3), 146. https://doi.org/10.4103/bc.bc_28_22

Ayre, J., & McCaffery, K. J. (2022). Research Note: Thematic analysis in qualitative research. In *Journal of Physiotherapy* (Vol. 68, Issue 1, pp. 76–79). Australian Physiotherapy Association. https://doi.org/10.1016/j.jphys.2021.11.002

Bai, Z., Fong, K. N. K., Zhang, J. J., Chan, J., & Ting, K. H. (2020). Immediate and long-term effects of BCI-based rehabilitation of the upper extremity after stroke: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation*, *17*(1). https://doi.org/10.1186/s12984-020-00686-2

Ballester, B. R., Maier, M., Duff, A., Cameirão, M., Bermúdez, S., Duarte, E., Cuxart, A., Rodríguez, S., María San Segundo Mozo, R., M J Verschure, P. F., & Segundo Mozo, S. R. (2019). A critical time window for recovery extends beyond one-year post-stroke. *J Neurophysiol*, *122*, 350–357. https://doi.org/10.1152/jn.00762.2018.-The

Barclay, R. E., Stevenson, T. J., Poluha, W., Semenko, B., & Schubert, J. (2020). Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. In *Cochrane Database of Systematic Reviews* (Vol. 2020, Issue 5). John Wiley and Sons Ltd. https://doi.org/10.1002/14651858.CD005950.pub5

Batista, D., Caetano, G., Fleury, M., Figueiredo, P., & Vourvopoulos, A. (2023). Effect of head-mounted virtual reality and vibrotactile feedback in ERD during motor imagery Brain–computer interface training. *Brain-Computer Interfaces*, 1–10. https://doi.org/10.1080/2326263X.2023.2264000

Bermúdez i Badia, S., Fluet, G. G., Llorens, R., & Deutsch, J. E. (2016). Virtual reality for sensorimotor rehabilitation post stroke: Design principles and evidence. In *Neurorehabilitation Technology, Second Edition* (pp. 573–603). Springer International Publishing. https://doi.org/10.1007/978-3-319-28603-7_28

Bernhardt, J., Hayward, K. S., Kwakkel, G., Ward, N. S., Wolf, S. L., Borschmann, K., Krakauer, J. W., Boyd, L. A., Carmichael, S. T., Corbett, D., & Cramer, S.

C. (2017). Agreed definitions and a shared vision for new standards in stroke recovery research: The Stroke Recovery and Rehabilitation Roundtable taskforce. *International Journal of Stroke*, *12*(5), 444–450. https://doi.org/10.1177/1747493017711816

Bo Nielsen, J., Willerslev-Olsen, M., Christiansen, L., Lundbye-Jensen, J., & Lorentzen, J. (2015). Science-based neurorehabilitation: Recommendations for neurorehabilitation from basic science. In *Journal of Motor Behavior* (Vol. 47, Issue 1, pp. 7–17). Routledge. https://doi.org/10.1080/00222895.2014.931273

Braun, R. G., & Wittenberg, G. F. (2021). Motor Recovery: How Rehabilitation Techniques and Technologies Can Enhance Recovery and Neuroplasticity. *Seminars in Neurology*, *41*(2), 167–176. https://doi.org/10.1055/s-0041-1725138

Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, *18*(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Brighina, F., La Bua, A., Oliveri, M., Piazza, A., & Fierro, B. (2000). Magnetic stimulation study during observation of motor tasks. *Journal of the Neurological Sciences*, *174*(2), 122–126. https://doi.org/10.1016/S0022-510X(00)00271-9

Carpinella, I., Lencioni, T., Bowman, T., Bertoni, R., Turolla, A., Ferrarin, M., & Jonsdottir, J. (2020). Effects of robot therapy on upper body kinematics and arm function in persons post stroke: a pilot randomized controlled trial. *Journal of NeuroEngineering and Rehabilitation*, *17*(1). https://doi.org/10.1186/s12984-020-0646-1

Charlton, J. M., Eng, J. J., Li, L. C., & Hunt, M. A. (2021). Learning Gait Modifications for Musculoskeletal Rehabilitation: Applying Motor Learning Principles to Improve Research and Clinical Implementation. *Physical Therapy*, *101*(2). https://doi.org/10.1093/PTJ/PZAA207

Chen, J., Or, C. K., & Chen, T. (2022a). Effectiveness of Using Virtual Reality–Supported Exercise Therapy for Upper Extremity Motor Rehabilitation in Patients With Stroke: Systematic Review and Meta-analysis of Randomized

Controlled Trials. *Journal of Medical Internet Research*, *24*(6). https://doi.org/10.2196/24111

Chen, J., Or, C. K., & Chen, T. (2022b). Effectiveness of Using Virtual Reality–Supported Exercise Therapy for Upper Extremity Motor Rehabilitation in Patients With Stroke: Systematic Review and Meta-analysis of Randomized Controlled Trials. *Journal of Medical Internet Research*, *24*(6), e24111. https://doi.org/10.2196/24111

Clery, A., Bhalla, A., Rudd, A. G., Wolfe, C. D. A., & Wang, Y. (2020). Trends in prevalence of acute stroke impairments: A population-based cohort study using the South London stroke register. *PLoS Medicine*, *17*(10). https://doi.org/10.1371/journal.pmed.1003366

Cortés-pérez, I., Zagalaz-anula, N., Montoro-cárdenas, D., Lomas-vega, R., Obrero-gaitán, E., & Osuna-pérez, M. C. (2021). Leap motion controller video game-based therapy for upper extremity motor recovery in patients with central nervous system diseases. A systematic review with meta-analysis. In *Sensors* (Vol. 21, Issue 6, pp. 1–22). MDPI AG. https://doi.org/10.3390/s21062065

Cramer, S. C., Sur, M., Dobkin, B. H., O'Brien, C., Sanger, T. D., Trojanowski, J. Q., Rumsey, J. M., Hicks, R., Cameron, J., Chen, D., Chen, W. G., Cohen, L. G., Decharms, C., Duffy, C. J., Eden, G. F., Fetz, E. E., Filart, R., Freund, M., Grant, S. J., … Vinogradov, S. (2011). Harnessing neuroplasticity for clinical applications. In *Brain* (Vol. 134, Issue 6, pp. 1591–1609). https://doi.org/10.1093/brain/awr039

Crema, A., Furfaro, I., Raschellà, F., Rossini, M., Zajc, J., Wiesener, C., Baccinelli, W., Proserpio, D., Augsten, A., Immick, N., Becker, S., Weber, M., Schauer, T., Krakow, K., Gasperini, G., Molteni, F., Russold, M. F., Bulgheroni, M., & Micera, S. (2021). Reactive exercises with interactive objects: Interim analysis of a randomized trial on task-driven NMES grasp rehabilitation for subacute and early chronic stroke patients. *Sensors*, *21*(20). https://doi.org/10.3390/s21206739 da Rosa Pinheiro, D. R., Cabeleira, M. E. P., da Campo, L. A., Gattino, L. A. F., de Souza, K. S., dos Santos Burg, L., Gamarra Blauth, A. H. E., Corrêa, P. S., & Cechetti, F. (2021). Upper limbs cycle ergometer increases muscle strength, trunk control and independence of acute stroke subjects: A randomized clinical trial. *NeuroRehabilitation*, *48*(4), 533–542. https://doi.org/10.3233/NRE-210022

da Silva, E. S. M., Ocamoto, G. N., Santos-Maia, G. L. dos, de Fátima Carreira Moreira Padovez, R., Trevisan, C., de Noronha, M. A., Pereira, N. D., Borstad, A., & Russo, T. L. (2020). The Effect of Priming on Outcomes of Task-Oriented Training for the Upper Extremity in Chronic Stroke: A Systematic Review and Meta-analysis. In *Neurorehabilitation and Neural Repair* (Vol. 34, Issue 6, pp. 479–504). SAGE Publications Inc. https://doi.org/10.1177/1545968320912760

Daly, J. J., Cheng, R., Rogers, J., Litinas, K., Hrovat, K., & Dohring, M. (2009). Feasibility of a new application of noninvasive brain computer interface (BCI): A case study of training for recovery of volitional motor control after stroke. *Journal of Neurologic Physical Therapy*, *33*(4), 203–211. https://doi.org/10.1097/NPT.0b013e3181c1fc0b

Dawson, J., Engineer, N. D., Prudente, C. N., Pierce, D., Francisco, G., Yozbatiran, N., Tarver, W. B., Casavant, R., Kline, D. K., Cramer, S. C., van de Winckel, A., & Kimberley, T. J. (2020). Vagus Nerve Stimulation Paired With Upper-Limb Rehabilitation After Stroke: One-Year Follow-up. *Neurorehabilitation and Neural Repair*, *34*(7), 609–615. https://doi.org/10.1177/1545968320924361

Dobkin, B. H. (2004). Strategies for stroke rehabilitation. In *Lancet Neurology* (Vol. 3, Issue 9, pp. 528–536). https://doi.org/10.1016/S1474-4422(04)00851-8

Domínguez-Téllez, P., Moral-Muñoz, J. A., Salazar, A., Casado-Fernández, E., & Lucena-Antón, D. (2020). Game-Based Virtual Reality Interventions to Improve Upper Limb Motor Function and Quality of Life after Stroke: Systematic Review and Meta-analysis. In *Games for Health Journal* (Vol. 9, Issue 1, pp. 1–10). Mary Ann Liebert Inc. https://doi.org/10.1089/g4h.2019.0043

Douiri, A., Grace, J., Sarker, S. J., Tilling, K., McKevitt, C., Wolfe, C. D. A., & Rudd, A. G. (2017). Patient-specific prediction of functional recovery after stroke.

International Journal of Stroke, *12*(5), 539–548. https://doi.org/10.1177/1747493017706241

Edwards, L. L., King, E. M., Buetefisch, C. M., & Borich, M. R. (2019). Putting the “sensory” into sensorimotor control: The role of sensorimotor integration in goal-directed hand movements after stroke. In *Frontiers in Integrative Neuroscience* (Vol. 13). Frontiers Media S.A. https://doi.org/10.3389/fnint.2019.00016

Ericsson, K., & Crutcher, R. (1990). The nature of exceptional performance. In *books.google.com*.

Feigin, V. L., Brainin, M., Norrving, B., Martins, S., Sacco, R. L., Hacke, W., Fisher, M., Pandian, J., & Lindsay, P. (2022). World Stroke Organization (WSO): Global Stroke Fact Sheet 2022. *International Journal of Stroke*, *17*(1), 18–29. https://doi.org/10.1177/17474930211065917/ASSET/IMAGES/LARGE/10.1177_17474930211065917-FIG2.JPEG

Frisoli, A., Barsotti, M., Sotgiu, E., Lamola, G., Procopio, C., & Chisari, C. (2022). A randomized clinical control study on the efficacy of three-dimensional upper limb robotic exoskeleton training in chronic stroke. *Journal of NeuroEngineering and Rehabilitation*, *19*(1). https://doi.org/10.1186/s12984-022-00991-y

GBD 2016 Lifetime Risk of Stroke Collaborators, Feigin VL, Nguyen G, Cercy K, Johnson CO, Alam T, Parmar PG, Abajobir AA, Abate KH, Abd-Allah F, Abejie AN, Abyu GY, Ademi Z, Agarwal G, Ahmed MB, Akinyemi RO, Al-Raddadi R, Aminde LN, Amlie-Lefond C, … Roth GA. (2018). Global, Regional, and Country-Specific Lifetime Risks of Stroke, 1990 and 2016. *New England Journal of Medicine*, *379*(25), 2429–2437. https://doi.org/10.1056/NEJMoa1804492

Grefkes, C., Grefkes, C., Fink, G. R., & Fink, G. R. (2020). Recovery from stroke: Current concepts and future perspectives. In *Neurological Research and Practice* (Vol. 2, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s42466-020-00060-6

Grosse-Wentrup, M., Mattia, D., & Oweiss, K. (2011). Using brain-computer interfaces to induce neural plasticity and restore function. *Journal of Neural Engineering*, *8*(2). https://doi.org/10.1088/1741-2560/8/2/025004

Hao, J., He, Z., Yu, X., & Remis, A. (2023). Comparison of immersive and non-immersive virtual reality for upper extremity functional recovery in patients with stroke: a systematic review and network meta-analysis. *Neurological Sciences*, *44*(8), 2679–2697. https://doi.org/10.1007/S10072-023-06742-8/TABLES/4

Herranz-Gómez, A., Gaudiosi, C., Angulo-Díaz-Parreño, S., Suso-Martí, L., La Touche, R., & Cuenca-Martínez, F. (2020). Effectiveness of motor imagery and action observation on functional variables: An umbrella and mapping review with meta-meta-analysis. *Neuroscience and Biobehavioral Reviews*, *118*, 828–845. https://doi.org/10.1016/J.NEUBIOREV.2020.09.009

Ingwersen, T., Wolf, S., Birke, G., Schlemm, E., Bartling, C., Bender, G., Meyer, A., Nolte, A., Ottes, K., Pade, O., Peller, M., Steinmetz, J., Gerloff, C., & Thomalla, G. (2021). Long-term recovery of upper limb motor function and self-reported health: results from a multicenter observational study 1 year after discharge from rehabilitation. *Neurological Research and Practice*, *3*(1). https://doi.org/10.1186/s42466-021-00164-7

Iruthayarajah, J., McIntyre, A., Cotoi, A., Macaluso, S., & Teasell, R. (2017). The use of virtual reality for balance among individuals with chronic stroke: A systematic review and meta-analysis. In *Topics in Stroke Rehabilitation* (Vol. 24, Issue 1, pp. 68–79). Taylor and Francis Ltd. https://doi.org/10.1080/10749357.2016.1192361

Jervis-Rademeyer, H., Ong, K., Djuric, A., Munce, S., Musselman, K. E., & Marquez-Chin, C. (2022). Therapists' perspectives on using brain-computer interface-triggered functional electrical stimulation therapy for individuals living with upper extremity paralysis: a qualitative case series study. *Journal of NeuroEngineering and Rehabilitation*, *19*(1). https://doi.org/10.1186/s12984-022-01107-2

Jin, M., Pei, J., Bai, Z., Zhang, J., He, T., Xu, X., Zhu, F., Yu, D., & Zhang, Z. (2021). Effects of virtual reality in improving upper extremity function after stroke: A systematic review and meta-analysis of randomized controlled trials. *Https://Doi.Org/10.1177/02692155211066534*, *36*(5), 573–596. https://doi.org/10.1177/02692155211066534

Kilteni, K., Groten, R., & Slater, M. (2012). The Sense of Embodiment in virtual reality. In *Presence: Teleoperators and Virtual Environments* (Vol. 21, Issue 4, pp. 373–387). MIT Press Journals. https://doi.org/10.1162/PRES_a_00124

Kleim, J. A., & Jones, T. A. (2008). Principles of Experience-Dependent Neural Plasticity: Implications for Rehabilitation After Brain Damage. *Journal of Speech, Language, and Hearing Research*, *51*(1). https://doi.org/10.1044/1092-4388(2008/018)

Kokkinara, E., Kilteni, K., Blom, K. J., & Slater, M. (2016). First Person Perspective of Seated Participants over a Walking Virtual Body Leads to Illusory Agency over the Walking. In *Scientific Reports* (Vol. 6). Nature Publishing Group. https://doi.org/10.1038/srep28879

Kong, K. H., Chua, K. S. G., & Lee, J. (2011). Recovery of upper limb dexterity in patients more than 1 year after stroke: Frequency, clinical correlates and predictors. *NeuroRehabilitation*, *28*(2), 105–111. https://doi.org/10.3233/NRE-2011-0639

Kruse, A., Suica, Z., Taeymans, J., & Schuster-Amft, C. (2020). Effect of brain-computer interface training based on non-invasive electroencephalography using motor imagery on functional recovery after stroke - a systematic review and meta-analysis. *BMC Neurology*, *20*(1). https://doi.org/10.1186/s12883-020-01960-5

Laver, K. E., Lange, B., George, S., Deutsch, J. E., Saposnik, G., & Crotty, M. (2017). Virtual reality for stroke rehabilitation. In *Cochrane Database of Systematic Reviews* (Vol. 2017, Issue 11). John Wiley and Sons Ltd. https://doi.org/10.1002/14651858.CD008349.pub4

Le Wang, Jean-Lon Chen, Alice M.K. Wong, Kuei-Chia Liang, & Kevin C. Tseng. (2022). Game-Based Virtual Reality System for Upper Limb Rehabilitation After Stroke in a Clinical Environment: Systematic Review and Meta-Analysis.

Games for Health Journal, *11*(5), 277–297. https://pubmed.ncbi.nlm.nih.gov/36252097/

Lee, H., Honeycutt, C., & Perreault, E. (2022). Influence of task complexity on movement planning and release after stroke: insights from startReact. *Experimental Brain Research*, *240*(6), 1765–1774. https://doi.org/10.1007/s00221-022-06368-w

Lee, S. H., Park, G., Cho, D. Y., Kim, H. Y., Lee, J. Y., Kim, S., Park, S. B., & Shin, J. H. (2020). Comparisons between end-effector and exoskeleton rehabilitation robots regarding upper extremity function among chronic stroke patients with moderate-to-severe upper limb impairment. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-58630-2

Levin, M. F., & Demers, M. (2021). Motor learning in neurological rehabilitation. In *Disability and Rehabilitation* (Vol. 43, Issue 24, pp. 3445–3453). Taylor and Francis Ltd. https://doi.org/10.1080/09638288.2020.1752317

Lewthwaite, R., Chiviacowsky, S., Drews, R., & Wulf, G. (2015). Choose to move: The motivational impact of autonomy support on motor learning. *Psychonomic Bulletin & Review*, *22*(5), 1383–1388. https://doi.org/10.3758/S13423-015-0814-7

Liao, W. W., Chiang, W. C., Lin, K. C., Wu, C. Y., Liu, C. T., Hsieh, Y. W., Lin, Y. C., & Chen, C. L. (2020). Timing-dependent effects of transcranial direct current stimulation with mirror therapy on daily function and motor control in chronic stroke: A randomized controlled pilot study. *Journal of NeuroEngineering and Rehabilitation*, *17*(1). https://doi.org/10.1186/s12984-020-00722-1

Lucas-Noll, J., Clua-Espuny, J. L., Lleixà-Fortuño, M., Gavaldà-Espelta, E., Queralt-Tomas, L., Panisello-Tafalla, A., & Carles-Lavila, M. (2023). The costs associated with stroke care continuum: a systematic review. In *Health Economics Review* (Vol. 13, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13561-023-00439-6

Luengo-Fernandez, R., Violato, M., Candio, P., & Leal, J. (2020). Economic burden of stroke across Europe: A population-based cost analysis. *European Stroke Journal*, *5*(1), 17–25. https://doi.org/10.1177/2396987319883160

Maier, M., Ballester, B. R., & Verschure, P. F. M. J. (2019). Principles of Neurorehabilitation After Stroke Based on Motor Learning and Brain Plasticity Mechanisms. In *Frontiers in Systems Neuroscience* (Vol. 13). Frontiers Media S.A. https://doi.org/10.3389/fnsys.2019.00074

Maier, M., Rubio Ballester, B., Duff, A., Duarte Oller, E., & Verschure, P. F. M. J. (2019). Effect of Specific Over Nonspecific VR-Based Rehabilitation on Poststroke Motor Recovery: A Systematic Meta-analysis. In *Neurorehabilitation and Neural Repair* (Vol. 33, Issue 2, pp. 112–129). SAGE Publications Inc. https://doi.org/10.1177/1545968318820169

Mansour, S., Ang, K. K., Nair, K. P. S., Phua, K. S., & Arvaneh, M. (2022). Efficacy of Brain–Computer Interface and the Impact of Its Design Characteristics on Poststroke Upper-limb Rehabilitation: A Systematic Review and Meta-analysis of Randomized Controlled Trials. In *Clinical EEG and Neuroscience* (Vol. 53, Issue 1, pp. 79–90). SAGE Publications Inc. https://doi.org/10.1177/15500594211009065

Marques, N., Gerlier, L., Ramos, M., Pereira, H., Rocha, S., Fonseca, A. C., André, A., Melo, R., & Sidelnikov, E. (2021). Patient and caregiver productivity loss and indirect costs associated with cardiovascular events in Portugal. *Revista Portuguesa de Cardiologia*, *40*(2), 109–115. https://doi.org/10.1016/j.repc.2020.05.019

Marquez-Chin, C., Kapadia-Desai, N., & Kalsi-Ryan, S. (2021). *Brain-Computer Interfaces Neurorehabilitation of Voluntary Movement after Stroke and Spinal Cord Injury*.

Matamala-Gomez, M., Slater, M., & Sanchez-Vives, M. V. (2022). Impact of virtual embodiment and exercises on functional ability and range of motion in orthopedic rehabilitation. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-08917-3

Monteiro, K. B., Cardoso, M. dos S., Cabral, V. R. da C., Santos, A. O. B. dos, Silva, P. S. da, Castro, J. B. P. de, & Vale, R. G. de S. (2021). Effects of Motor Imagery as a Complementary Resource on the Rehabilitation of Stroke Patients: A Meta-Analysis of Randomized Trials. In *Journal of Stroke and Cerebrovascular Diseases* (Vol. 30, Issue 8). W.B. Saunders. https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.105876

Moser, A., & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. In *European Journal of General Practice* (Vol. 24, Issue 1, pp. 9–18). Taylor and Francis Ltd. https://doi.org/10.1080/13814788.2017.1375091

Murphy, M. A., Resteghini, C., Feys, P., & Lamers, I. (2015). An overview of systematic reviews on upper extremity outcome measures after stroke. *BMC Neurology*, *15*(1). https://doi.org/10.1186/s12883-015-0292-6

Nojima, I., Sugata, H., Takeuchi, H., & Mima, T. (2022). Brain–Computer Interface Training Based on Brain Activity Can Induce Motor Recovery in Patients With Stroke: A Meta-Analysis. In *Neurorehabilitation and Neural Repair* (Vol. 36, Issue 2, pp. 83–96). SAGE Publications Inc. https://doi.org/10.1177/15459683211062895

O'Cathain, A., Croot, L., Duncan, E., Rousseau, N., Sworn, K., Turner, K. M., Yardley, L., & Hoddinott, P. (2019). Guidance on how to develop complex interventions to improve health and healthcare. *BMJ Open*, *9*(8). https://doi.org/10.1136/bmjopen-2019-029954

Oña, E. D., Garcia-Haro, J. M., Jardón, A., & Balaguer, C. (2019). Robotics in health care: Perspectives of robot-aided interventions in clinical practice for rehabilitation of upper limbs. In *Applied Sciences (Switzerland)* (Vol. 9, Issue 13). MDPI AG. https://doi.org/10.3390/app9132586

Owolabi, M. O., Thrift, A. G., Mahal, A., Ishida, M., Martins, S., Johnson, W. D., Pandian, J., Abd-Allah, F., Yaria, J., Phan, H. T., Roth, G., Gall, S. L., Beare, R., Phan, T. G., Mikulik, R., Akinyemi, R. O., Norrving, B., Brainin, M., Feigin, V. L., … Zhang, P. (2022). Primary stroke prevention worldwide: translating evidence into action. In *The Lancet Public Health* (Vol. 7, Issue 1, pp. e74–e85). Elsevier Ltd. https://doi.org/10.1016/S2468-2667(21)00230-9

Ozkaynak, M., Sircar, C. M., Frye, O., & Valdez, R. S. (2021). A systematic review of design workshops for health information technologies. *Informatics*, *8*(2). https://doi.org/10.3390/informatics8020034

Page, S. J., & Peters, H. (2014). Mental practice: Applying motor PRACTICE and neuroplasticity principles to increase upper extremity function. In *Stroke* (Vol. 45, Issue 11, pp. 3454–3460). Lippincott Williams and Wilkins. https://doi.org/10.1161/STROKEAHA.114.004313

Park, J. H. (2020). Effects of mental imagery training combined electromyogram-triggered neuromuscular electrical stimulation on upper limb function and activities of daily living in patients with chronic stroke: a randomized controlled trial. *Disability and Rehabilitation*, *42*(20), 2876–2881. https://doi.org/10.1080/09638288.2019.1577502

Park, S. W., Kim, J. H., & Yang, Y. J. (2018). Mental practice for upper limb rehabilitation after stroke: A systematic review and meta-analysis. In *International Journal of Rehabilitation Research* (Vol. 41, Issue 3, pp. 197–203). Lippincott Williams and Wilkins. https://doi.org/10.1097/MRR.0000000000000298

Pohl, J., Held, J. P. O., Verheyden, G., Alt Murphy, M., Engelter, S., Flöel, A., Keller, T., Kwakkel, G., Nef, T., Ward, N., Luft, A. R., & Veerbeek, J. M. (2020). Consensus-Based Core Set of Outcome Measures for Clinical Motor Rehabilitation After Stroke—A Delphi Study. *Frontiers in Neurology*, *11*. https://doi.org/10.3389/fneur.2020.00875

Prabhakaran, S., Zarahn, E., Riley, C., Speizer, A., Chong, J. Y., Lazar, R. M., Marshall, R. S., & Krakauer, J. W. (2008). Inter-individual variability in the capacity for motor recovery after ischemic stroke. *Neurorehabilitation and Neural Repair*, *22*(1), 64–71. https://doi.org/10.1177/1545968307305302

Published by OECD. (2019). *Portugal: Country Health Profile 2019*. OECD. https://doi.org/10.1787/85ed94fc-en

Ranzani, R., Lambercy, O., Metzger, J. C., Califfi, A., Regazzi, S., Dinacci, D., Petrillo, C., Rossi, P., Conti, F. M., & Gassert, R. (2020). Neurocognitive robot-assisted rehabilitation of hand function: A randomized control trial on motor recovery in subacute stroke. *Journal of NeuroEngineering and Rehabilitation*, *17*(1). https://doi.org/10.1186/s12984-020-00746-7

Reinkensmeyer, D. J., Burdet, E., Casadio, M., Krakauer, J. W., Kwakkel, G., Lang, C. E., Swinnen, S. P., Ward, N. S., & Schweighofer, N. (2016). Computational neurorehabilitation: Modeling plasticity and learning to predict recovery. In *Journal of NeuroEngineering and Rehabilitation* (Vol. 13, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s12984-016-0148-3

Reisner, S. L., Randazzo, R. K., White Hughto, J. M., Peitzmeier, S., DuBois, L. Z., Pardee, D. J., Marrow, E., McLean, S., & Potter, J. (2018). Sensitive Health Topics With Underserved Patient Populations: Methodological Considerations for Online Focus Group Discussions. In *Qualitative Health Research* (Vol. 28, Issue 10, pp. 1658–1673). SAGE Publications Inc. https://doi.org/10.1177/1049732317705355

Renner, C. I. E., Brendel, C., & Hummelsheim, H. (2020). Bilateral Arm Training vs Unilateral Arm Training for Severely Affected Patients With Stroke: Exploratory Single-Blinded Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*, *101*(7), 1120–1130. https://doi.org/10.1016/j.apmr.2020.02.007

Richard, B., Sivo, S. A., Orlowski, M., Ford, R. C., Murphy, J., Boote, D. N., & Witta, E. L. (2021). Qualitative Research via Focus Groups: Will Going Online Affect the Diversity of Your Findings? *Cornell Hospitality Quarterly*, *62*(1), 32–45. https://doi.org/10.1177/1938965520967769/FORMAT/EPUB

Saha, S., Mamun, K. A., Ahmed, K., Mostafa, R., Naik, G. R., Darvishi, S., Khandoker, A. H., & Baumert, M. (2021). Progress in Brain Computer Interface: Challenges and Opportunities. In *Frontiers in Systems Neuroscience* (Vol. 15). Frontiers Media S.A. https://doi.org/10.3389/fnsys.2021.578875

Salatino, A., Zavattaro, C., Gammeri, R., Cirillo, E., Piatti, M. L., Pyasik, M., Serra, H., Pia, L., Geminiani, G., & Ricci, R. (2023). Virtual reality rehabilitation for unilateral spatial neglect: A systematic review of immersive, semi-immersive and non-immersive techniques. In *Neuroscience and Biobehavioral Reviews* (Vol. 152). Elsevier Ltd. https://doi.org/10.1016/j.neubiorev.2023.105248

Selles, R. W., Michielsen, M. E., Bussmann, J. B. J., Stam, H. J., Hurkmans, H. L., Heijnen, I., De Groot, D., & Ribbers, G. M. (2014). Effects of a mirror-induced visual illusion on a reaching task in stroke patients: Implications for mirror therapy training. *Neurorehabilitation and Neural Repair*, *28*(7), 652–659. https://doi.org/10.1177/1545968314521005

Shou, Y. Z., Wang, X. H., & Yang, G. F. (2023). Verum versus Sham brain-computer interface on upper limb function recovery after stroke: A systematic review and meta-analysis of randomized controlled trials. *Medicine (United States)*, *102*(26), E34148. https://doi.org/10.1097/MD.0000000000034148

Sigrist, R., Rauter, G., Riener, R., & Wolf, P. (2013). Augmented visual, auditory, haptic, and multimodal feedback in motor learning: A review. In *Psychonomic Bulletin and Review* (Vol. 20, Issue 1, pp. 21–53). Springer Science and Business Media, LLC. https://doi.org/10.3758/s13423-012-0333-8

Simpson, L. A., Hayward, K. S., McPeake, M., Field, T. S., & Eng, J. J. (2021). Challenges of Estimating Accurate Prevalence of Arm Weakness Early After Stroke. *Neurorehabilitation and Neural Repair*, *35*(10), 871–879. https://doi.org/10.1177/15459683211028240

Song, K., Wang, L., & Wu, W. (2019). Mental practice for upper limb motor restoration after stroke: an updated meta-analysis of randomized controlled trials. *Topics in Stroke Rehabilitation*, *26*(2), 87–93. https://doi.org/10.1080/10749357.2018.1550613

Stinear, C. M. (2017). Prediction of motor recovery after stroke: advances in biomarkers. In *The Lancet Neurology* (Vol. 16, Issue 10, pp. 826–836). Lancet Publishing Group. https://doi.org/10.1016/S1474-4422(17)30283-1

Stinear, C. M., Byblow, W. D., Ackerley, S. J., Smith, M. C., Borges, V. M., & Barber, P. A. (2017). Proportional Motor Recovery after Stroke: Implications for Trial Design. *Stroke*, *48*(3), 795–798. https://doi.org/10.1161/STROKEAHA.116.016020

Subramanian, S. K., Massie, C. L., Malcolm, M. P., & Levin, M. F. (2010). Does provision of extrinsic feedback result in improved motor learning in the upper limb poststroke? a systematic review of the evidence. In *Neurorehabilitation and Neural Repair* (Vol. 24, Issue 2, pp. 113–124). https://doi.org/10.1177/1545968309349941

Sullivan, J. E., Crowner, B. E., Kluding, P. M., Nichols, D., Rose, D. K., Yoshida, R., & Pinto Zipp, G. (2013). *Outcome Measures for Individuals With Stroke: Process and Recommendations From the American Physical Therapy Association Neurology Section Task Force*. https://academic.oup.com/ptj/article/93/10/1383/2735565

Sun, Y., Ledwell, N. M. H., Boyd, L. A., & Zehr, E. P. (2018). Unilateral wrist extension training after stroke improves strength and neural plasticity in both arms. *Experimental Brain Research*, *236*(7), 2009–2021. https://doi.org/10.1007/s00221-018-5275-6

Teasell, R., Mbbs, N. H., & Foley Msc, N. (2018). *EBRSR [Evidence-Based Review of Stroke Rehabilitation] 4 Managing the Stroke Rehabilitation Triage Process*. www.ebrsr.com

Teasell, R., Salbach, N. M., Foley, N., Mountain, A., Cameron, J. I., Jong, A. de, Acerra, N. E., Bastasi, D., Carter, S. L., Fung, J., Halabi, M. Lou, Iruthayarajah, J., Harris, J., Kim, E., Noland, A., Pooyania, S., Rochette, A., Stack, B. D., Symcox, E., … Lindsay, M. P. (2020). Canadian Stroke Best Practice Recommendations: Rehabilitation, Recovery, and Community Participation following Stroke. Part One: Rehabilitation and Recovery Following Stroke; 6th Edition Update 2019. *International Journal of Stroke*, *15*(7), 763–788. https://doi.org/10.1177/1747493019897843

Timmermans, A. A. A., Spooren, A. I. F., Kingma, H., & Seelen, H. A. M. (2010). Influence of task-oriented training content on skilled arm-hand performance in stroke: a systematic review. *Neurorehabilitation and Neural Repair*, *24*(9), 858–870. https://doi.org/10.1177/1545968310368963

Vourvopoulos, A., Jorge, C., Abreu, R., Figueiredo, P., Fernandes, J. C., & Bermúdez i Badia, S. (2019). Efficacy and brain imaging correlates of an immersive motor imagery BCI-driven VR system for upper limb motor rehabilitation: A clinical case report. *Frontiers in Human Neuroscience*, *13*. https://doi.org/10.3389/fnhum.2019.00244

Ward, N. S., Brander, F., & Kelly, K. (2019). Intensive upper limb neurorehabilitation in chronic stroke: Outcomes from the Queen Square programme. *Journal of Neurology, Neurosurgery and Psychiatry*, *90*(5), 498–506. https://doi.org/10.1136/jnnp-2018-319954

Wilkins, E., Wilson, L., Wickramasinghe, K., Bhatnagar, P., Leal, J., Luego-Fernandez, R., Burns, R., Rayner, M., & Townsend, N. (2017). *European Cardiovascular Disease Statistics 2017 edition*. www.ehnheart.org

Winters, C., Van Wegen, E. E. H., Daffertshofer, A., & Kwakkel, G. (2015). Generalizability of the Proportional Recovery Model for the Upper Extremity After an Ischemic Stroke. *Neurorehabilitation and Neural Repair*, *29*(7), 614–622. https://doi.org/10.1177/1545968314562115

Wu, J., Zeng, A., Chen, Z., Wei, Y., Huang, K., Chen, J., & Ren, Z. (2021). Effects of Virtual Reality Training on Upper Limb Function and Balance in Stroke Patients: Systematic Review and Meta-Meta-Analysis. *J Med Internet Res 2021;23(10):E31051 Https://Www.Jmir.Org/2021/10/E31051*, *23*(10), e31051. https://doi.org/10.2196/31051

Yadav, D., Yadav, S., & Veer, K. (2020). A comprehensive assessment of Brain Computer Interfaces: Recent trends and challenges. In *Journal of Neuroscience Methods* (Vol. 346). Elsevier B.V. https://doi.org/10.1016/j.jneumeth.2020.108918

Yang, Y., Shi, Y. Z., Zhang, N., Wang, S., Ungvari, G. S., Ng, C. H., Wang, Y. L., Zhao, X. Q., Wang, Y. J., Wang, C. X., & Xiang, Y. T. (2016). The disability rate of 5-year post-stroke and its correlation factors: A national survey in China. *PLoS ONE*, *11*(11). https://doi.org/10.1371/journal.pone.0165341

Zhang, B., Kan, L., Dong, A., Zhang, J., Bai, Z., Xie, Y., Liu, Q., & Peng, Y. (2019). The effects of action observation training on improving upper limb motor functions in people with stroke: A systematic review and meta-analysis. *PLoS ONE*, *14*(8). https://doi.org/10.1371/journal.pone.0221166

Appendix 1 – Review of outcome measures for the upper limb

A search of meta-analysis was made on the Pubmed database for articles using the MeSH terms "modalities, physical therapy", "stroke" and "upper extremity". This search was filtered for literature reviews with meta-analysis, to obtain outcome measures used in several studies. This search was conducted on June of 2022 and produced 39 meta-analysis, each was scanned for the outcome measures analysed.

Some of the registered outcome measures were mentioned in only one meta-analysis, while 24 outcome measures were mentioned in two or more meta-analysis. Eight outcome measures were mentioned in ten or more meta-analysis, representing a clear difference in prevalence in the literature.

Appendix 2 – Review of meta-analyses of mental practise interventions

A search of meta-analysis was made on the Pubmed database for articles using the search terms "Mental Practise" (MP) or "Motor Imagery". The search included tittle or abstract for the search term and filtered the results to show only meta-analysis published in the last 5 years. This review was carried out in October 2022 and updated in August 2023.

The results of this search were analyzed through their tittle, for mentions of stroke rehabilitation, and a total of six articles were considered. Four found a significant beneficial effect of adding MP to conventional treatment and two found a beneficial effect, however not statistically significant for upper limb function. MP used in isolation showed a smaller or non-existing effect.

The effect of MP in ADL was not clear, and outcomes of muscle power, range or motion and quality of life didn't have enough evidence to reach a conclusion. Table 7 shows the main findings of each article, including the weighted mean difference or standardized mean difference, confidence interval and some of the authors conclusions.

Table 7 Description of main findings of mental practise meta-analysis, published in the last five years

Article	Meta-analysis	WMD or SMD
	Arm function	4,43 (2,72;6,14)

Park et al., 2018	(MP + Conventional vs. Conventional)	
	Arm function (MP + mCMIT vs. mCIMT)	4,00 (2,60; 5,40)
	Arm function (MP guided NMES vs. NMES)	6,11 (23,43; 8,79)
	Arm function (MP guided RAT vs. RAT)	-1,42 (-11,91;9,07)
	Arm function (Overall)	4,49 (3,39; 5,39)
	MP showed a significant effect when added to an intervention, except for Robot Assisted Therapy. The authors highlighted that the methodology of MP intervention would benefit from standardization. Additionally, they found that the patient with highest levels of UL function at baseline had the smallest benefit from the intervention.	
Song et al., 2018	Fugl-Meyer Scale (Experimental vs. control)	2,07 (1,24; 2,91)
	Arm Research Test (Experimental vs. control)	4,09 (3,22; 4,97)
	These authors found a large effect size (an effect size is considered large when it's for SMD values equal or larger than 0,8) for both outcome measure, concluding there is a significant benefit to adding MP to stroke rehabilitations.	
Herranz-Gómez et al., 2020	Arm function (Experimental vs. control)	1,05 (0,5; 1,6)
	Arm performance on activities of daily living (Experimental vs. control)	1,76 (1,1; 2,43)
	These authors found a statistically significant large effect size for both outcome measure. These authors concluded that both MP and action observation lead to neuroplasticity similar to active interventions, even when the patient was not able to produce active movement (this includes stroke and musculoskeletal disorders patients). The authors cautioned that there is insufficient information about the protocol to apply, including frequency, duration of the session and duration of the total intervention. These authors highlighted the importance of establishing the ideal method for applying these techniques to optimize the results.	
Barclay et al., 2020	<u>Upper extremity activity</u> - Observed (ARAT, WMFT, Arm functional test)	0,61 (0,28; 0,94)

- Self- Perceived (MAL-QOM)	0,89 (0,41; 1,38)
- Total	0,66 (0,39; 0,94)
- Upper extremity impairment	0,59 (0,30; 0,87)
- Activities of daily living	0,08 (-0,24; 0,39)
Time post stroke subgroup:	
Upper extremity activity	
- Greater than or equal to 6 months post stroke	0,75 (0,44; 1,06)
- Less than 6 months post stroke	0,48 (-0,04; 0,99)
- Total	0,63 (0,34; 0,92)
Time post stroke subgroup:	
Upper extremity impairment	
- Greater than or equal to 6 months post stroke	0,60 (0,16; 1,05)
- Less than 6 months post stroke	0,53 (0,13; 0,94)
- Total	0,56 (0,27; 0,85)
Dosage of MP subgroup:	
Upper extremity activity	
- Greater than 360 minutes MP	0,59 (0,09; 1,09)
- Less than or equal to 360 minutes MP	0,72 (0,42; 1,03)
- Total	0,66 (0,39; 0,94)
Dosage of MP subgroup:	
Upper extremity impairment	
- Greater than 360 minutes MP	0,62 (0,24; 1,00)
- Less than or equal to 360 minutes MP	0,56 (0,08; 1,04)
- Total	0,59 (0,30; 0,87)
Comparison type subgroup:	
Upper extremity activity	
- MP + Conventional vs. Conventional + Placebo	0,71 (0,06; 1,35)
- MP + Conventional vs. Conventional only	0,69 (0,40; 0,98)
- Total	0,66 (0,39; 0,94)
Comparison type subgroup:	
Upper extremity impairment	
- MP + Conventional vs. Conventional + Placebo	0,28 (-0,17; 0,62)
- MP + Conventional vs. Conventional only	0,70 (0,32; 1,07)
- Total	0,59 (0,30; 0,87)
Upper extremity impairment	
- MP vs. Conventional	0,34 (-0,33; 1,00)

	Note The control intervention considered conventional both with and without placebo MP, except when clearly stated The authors found moderate-quality evidence showing MP to have a beneficial effect in upper extremity activity and upper extremity impairment when added to other treatments. Subgroup analysis found no difference in time post stroke, dosage, or type of comparison. The authors advise to consider the patients ability to image movement and to consider the preparation for the intervention. Low-quality evidence suggested that adding MP to other treatments might not be beneficial for ADLs. The authors advise future studies to include outcomes of ADL, health-related quality of life and economic costs.	
Monteiro et al., 2021	Fugl-Meyer Assessment (Experimental vs. control)	2,32 (-1,19, 5,83)
	The authors found a large, but not statistically significant effect of MP for upper limb function. These authors described the reviewed studies has having extensive variation of motor imagery protocols and also extensive variation of the interventions that the MP was combined with. The wide variety was also observed in the duration of training sessions, frequency, and intervention duration. The authors declared the inclusion of ADL task practise to be important, however they cautioned that this is limited by the patients' habits. This meta-analysis also pointed out that none of the included RCT's monitored the patients training with parameters such as heart and breath rate.	
Aprigio et al., 2022	Fugl-Meyer Assessment (Experimental vs. control)	0,22 (-0,17; 0,62)
	Arm Research Test (Experimental vs. control)	0,62 (0,14; 1,11)
	Overall	0,38 (0,08; 0,69)
	This meta-analysis found a statistically relevant moderate effect for arm research test, a small statically insignificant effect for FMA and a small statistically significant effect for the combined data. The authors reported an extremely varied protocol of MP, and unclear mechanism when MP was used in isolation This meta-analysis concluded that the technique might not have any benefit in subacute patients with cognitive deficits and severe muscle weakness. There was a larger effect with the increase of sessions and duration in minutes, although not statistically significant. The authors hypothesized that these results were associated with the lack of standardization of MP methods in stage of stroke, duration and frequency of intervention, modality of imagery (visual or kinesthetic) as well as type of input provided (video, audio or photo).	

The authors also mentioned the results could be improved with monitoring the MP with measurement of the participants heart and respiratory rates.

They conclude that future trials should clearly state the reasoning of the choice of parameters, with an attempt of optimization. Future studies should include follow-up and be task specific.

ADL - activities of daily living; FMA - Fugl-Meyer Assessment; MAL-QOM - Motor Activity Log-Quality of Movement; mCIMT - modified constraint-induced movement therapy; MP - mental practice; RAT - robot-assisted therapy; SMD - Standardized mean difference; UL - Upper limb; WMD - Weighted mean difference; WMFT - Wolf Motor Function Test

Appendix 3 – Review of meta-analyses for BCI interventions

A search of meta-analysis was made on the Pubmed database for articles using the search terms “Brain Computer Interface”” on tittle or abstract, combined with the search term “stroke” used as a MeSH term, with the modifier AND between this two research terms.

These results provided 170 results, after being filtered for meta-analysis, provided 5 results. This review was updated in August 2023.

Table 8 Description of main findings of BCI meta-analysis, published in the last five years

Article	Meta-analysis	WMD or SMD
Kruse et al., 2020	Upper extremity motor function	0,39 (0,17; 0,62)
	Brain recovery index	1,11 (0,64; 1,59)
	These authors found a statistically significant large effect size for brain pattern of activation and a statistically significant medium effect size for upper extremity motor function. These authors recommend that future studies to consider assessing cognition, attention, concentration, and ability to motor imagine. Additionally, future studies should include follow ups at 24-32 weeks. BCI interventions have shown to have diminishing returns, with the majority the of the results being focused on the initial sessions. To decrease this phenomenon these authors, suggested to increase the intensity (over three sessions per week).	
Bai et al., 2020	Upper extremity motor function	0,42 (0,18; 0,66)
	Comparison type subgroup: Upper extremity function - Motor imagery based BCI - Movement attempt based BCI - Action observation based BCI - Overall	 0,16 (-0,13; 0,45) 0,69 (0,16; 1,22) 1,25 (0,05; 2,45) 0,46 (0,13; 0,80)
	Comparison type subgroup: Upper extremity function - BCI – robot - BCI – FES - BCI – visual feedback - Overall	 0,04 (-0,30; 0,38) 1,04 (0,47; 1,62) 0,46 (-0,03; 0,95) 0,46 (0,13; 0,80)
	Upper extremity motor function on follow up	0,12 (-0,28; 0,52)
	These authors found a statistically significant moderate effect size for upper extremity motor function overall, although the subgroup analysis shows a diverse even though large effect for action	

	observation, a diverse moderate effect size for movement attempt and a statistically not significant effect for motor imagery. The motor imagery subgroup analysis had 8 studies and a total of 204 participants, allowing to have some confidence in that data. The other two subgroup analysis mentioned had two studies each, and 59 and 50 total participants considered, not grating so much confidence in the data. These authors performed another subgroup analysis according to the type of BCI feedback, finding a statistically insignificant effect for robot assisted BCI. For the visual feedback subgroup, a statistically insignificant effect was found, (even though on this subgroup the effect was found to be quite close to statistical significance). On the other hand, the FES subgroup showed a statistically significant large effect. The authors hypostatised that this variation in effects according to BCI feedback system, appear to be related to the difference in underlaying neural mechanisms. These authors also noted an improvement in the brain pattern of activation of the experimental groups, pointing to some studies having evidenced an increase of the ipsilesional motor system activation. However, the authors noted no clear evidence of interhemispheric rebalance playing a role in the patient's recovery. These authors preformed another meta-analysis on the pooled studies, focused on the upper extremity function at follow-up, with only 5 studies having provided follow-up data, and with a wide variation in follow-up timing. This meta-analysis showed a statistically insignificant effect size, leading the authors to conclude that the long-term effects of BCI interventions are not evident. The authors of this review also pointed out that the majority of the results from BCI interventions were obtain from the initial sessions, with reduced added benefit from the following sessions. They advance a possible reason for these diminishing returns of BCI interventions, and that was stated as the initial greater effort required by the participants to activate the system, when compared with the relative ease on later sessions.	
Mansour et al., 2022	Comparison type subgroup: Upper-limb motor function - Assessed immediately after finishing the intervention	0,73 (0,21; 1,24)
	- Assessed at weeks long follow-up	0,33 (0,01; 0,64)
	Comparison type subgroup: Upper-limb motor function	

	- Chronic phase	0,41 (-0,13; 0,95)
	- Sub-acute phase	1,45 (0,38; 2,52)
	Comparison type subgroup: Upper-limb motor function - Intention of movement - Motor imagery	 1,21 (0,62; 1,80) 0,55 (-0,08; 1,19)
	Comparison type subgroup: Upper-limb motor function - FES - Robot - Virtual hand - Visual feedback	 1,20 (0,50; 1,89) 0,48 (-0,31; 1,26) 0,86 (0,11; 1,61) 1,07 (0,17; 1,97)
	In similarity with the authors (Bai et al., 2020), these authors analysed the effect of BCI interventions after the intervention and at follow up. In this meta-analysis the effect on both timings was considered statistically significant, however the effect size for upper-limb motor function assessed immediately after the intervention was large while the effect size measured at weeks follow-up was found to have a moderate effect size. In regard to the subgroup analysis of stroke phases, the chronic stroke patients showed a statistically insignificant for the BCI interventions while the sub-acute stroke patients showed a statistically significant large effect size. The subgroup analysis for the type of training showed a statistically significant large effect for intention of movement and a statistically not significant moderate effect for motor imagery. This subgroup analysis had 9 studies in the motor imagery and 3 in the intention of movement, leading to some data confidence in the motor imagery subgroup. These authors also performed a subgroup analysis on the type of BCI feedback used, with the functional electrical stimulation showing a statistically significant large effect size with 3 studies contributing for that data. As for the robot assisted interventions, there were 7 studies taken into account and showed a statistically insignificant effect. As for the virtual hand and virtual feedback subgroups they both found a statistically significant large effect size, and each had 1 study in each group. These authors suggest that future interventions should last six weeks and include three training sessions per week.	
Nojima et al., 2022	Comparison type subgroup: Upper extremity function - Passive movement - NMES	 0,15 (-0,21; 0,51) 1,01 (-0,03; 2,04)

	- Perceptual stimulus	0,66 (-0,05; 1,37)
	- Overall	0,48 (0,16; 0,80)
	These authors found an improvement in upper extremity function statistically significant small effect size for the combined analysis of the different feedback systems. On the subgroup analysis the authors showed that none of the subgroups considered – passive movement, NMES and perceptual stimulus – had a statistically significant effect, meaning that there cannot be concluded that any subgroup of BCI interventions is effective for the rehabilitation of stroke patients. In regard to the overall analysis of the studies in this review, the authors pointed out that in 8 of the 14 studies reviewed the improvement of UL motor function measured through the Fugl-Meyer Assessment (FMA) exceeded the minimal clinically important difference. This represents the results achieved with BCI intervention exceeded the statistically relevant benchmark and were also considered large enough to impact the patient's clinical situation. The evidence of increased activity in the ipsilateral cortex was also highlighted by these authors, however cautioning that the mechanisms and factors that support and influence the recovery associated with BCI interventions are not yet clear. The authors also stated that this understanding of underlying processes is essential for the design of future interventions due to the complexity implicated in stroke rehabilitation.	
Shou et al., 2023	- FMA for Upper Extremity	3,33 (-0,17; 6,84)
	- FMA for Upper Extremity – subgroup analysis	4,78 (1,90; 7,65)
	Modified Barthel Index	7,37 (1,89; 12,84)
	- Motor activity log	-0,70 (-3,17; 1,77)
	- Motor activity log – subgroup analysis	0,81 (-3,59; 5,22)
	Action Research Arm Test	3,05 (-8,33; 14,44)
	Wolf Motor Function Test	4,23 (-0,55; 9,01)
	This review focus exclusively on BCI interventions in which the control group had sham BCI interventions. These authors found an improvement in upper extremity function measured through FMA that was statistically significant for subgroup analysis however it was not statistically significant for overall analysis. On the modified Barthel index, these authors found a statistically significant effect, and four studies were considered. For the motor activity log, both the overall and subgroup analysis showed a statistically insignificant effect for the BCI interventions, having considered three studies.	

Similarly, a statistically insignificant effect was calculated for the action research arm test and wolf motor function test, although further data may point to a different result since these analyses had only two and one study included, respectively.

These authors pointed out the lack of long-term follow-up data.

BCI - Brain Computer Interface; FES - Functional Electric Stimulation; FMA - Fugl-Meyer Assessment; NMES - Neuro-muscular Electric Stimulation; SMD - Standardized mean difference; UL - Upper limb; WMD - Weighted mean difference

Appendix 4 – Review of neuroplasticity and motor learning principles

A search was conducted on Pubmed database for articles that included three different components.

1 – on tittle/abstract – Principles, Factors or mechanisms

2 – on tittle/abstract – Neuroplasticity, “brain plasticity”, “motor learning”, “skill learning”, “skill acquisition”, “task training”, “task acquisition”

3 – MeSH major topic – Stroke, rehabilitation

On each of this three topics the modifier OR was used between each word or phrasing. These topics were combined with the modifier AND, netting a total of 719 results. These results were filtered for the studies published in the last 10 years to 494, and then furthered filtered according to article type (review, systematic review and meta-analysis) leading to 194 results.

Additionally, during other searches, whenever an author mentioned specific principles related to the aforementioned topics those references were looked up and added to this review. That pool of studies were selected through their tittle and abstract and the most relevant results are shown below.

Table 9 Summary of rehabilitation principles according to different authors

Article	Rehabilitation principles
(Kleim & Jones, 2008)	Use it or lose it, use it and improve it, specificity, repetition matters, intensity matters, time matters, salience matters, age matters, transference, interference
(Page & Peters, 2014)	Part-whole practice should be used, Repetitive and goal focused, Activities should be meaningful to the client, Client driven, Train in a practical way, Impairments should be addressed, Challenge regularly and appropriately, Emphasize accomplishments

(R. G. Braun & Wittenberg, 2021)	Structured feedback, knowledge of results, knowledge of performance, practise schedules, high repetition
(Timmermans et al., 2010)	Clear functional goal, Frequent repetition, Context-specific environment, Within task-exercise variety, Feedback, Random practice, Distributed practice
(Bo Nielsen et al., 2015)	Active Patient Participation Is Necessary, Physical Aids Should Only Be Given When Really Necessary, Provide Challenges That Can Support Learning, Training Should Be the Responsibility of the Patient, Train Every Day for as Long as Possible, Ensure Motivation and Reward, Structure Practice to Optimize Acquisition and Retention, Improved Function Requires Optimal Consolidation, Focus on the Paresis less on Spasticity, Individualization Is Necessary,
(Maier, Ballester, et al., 2019)	Massed practice/repetitive practice, Spaced practice, Dosage/duration, Task-specific practice, Variable practice, Increasing difficulty, Multisensory stimulation, Explicit feedback/knowledge of results, Implicit feedback/knowledge of performance, Modulate effector selection, Action observation/embodied, Goal-oriented practice, Rhythmic cueing, Motor imagery/mental practice, Social interaction
(Maier, Rubio Ballester, et al., 2019)	Massed practice (training that is repetitive), dosage (training that is intensive), structured practice (training that is spaced in time), task-specific practice (skill training that is relevant for activities of daily living),variable practice (training that is randomized and variable), multisensory stimulation (training that provides not only visual feedback),increasing difficulty (training that is individualized), explicit feedback (training that provides knowledge about results), implicit feedback (training that delivers

	implicit task-relevant cues), avatar representation (training that is embodied and immersive) and promoting the use of the paretic limb (training that counteracts compensation and learned nonuse).
(Charlton et al., 2021)	Factors known to affect motor learning: expectancy, autonomy, and attention; Random practice improves motor learning despite poorer performance during practice
(Bermúdez i Badia et al., 2016)	When considering VR training the crucial aspects to consider for skill acquisition are enriched environments, augmented feedback, practice dosing, adaptation, motivation, and task-oriented experiences
(Levin & Demers, 2021)	High intensity (dose, frequency, and duration of training), Training specificity, Training progression and motivation, Type of task practise, Type of feedback and delivery, Virtual reality interventions to promote motor learning

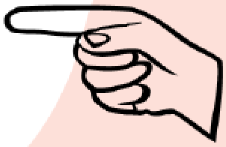
Appendix 5 – Pre-workshop briefing pamphlet

Page 1/2

Page 2/2

EVIDÊNCIA RELEVANTE PARA:

BCI + Realidade Virtual

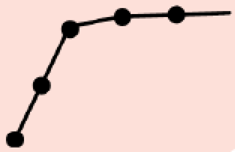


1 CASO CLÍNICO - AVC

Após 3 semanas de intervenção um utente recuperou a extensão isolada e controlada de um dedo (Daly et al., 2009)

2 RELAÇÃO NÃO-LINEAR ENTRE DOSE E EFEITO

Observou-se uma melhoria significativa até à sexta sessão, seguindo-se um plateau com melhorias adicionais ligeiras (Frisoli et al., 2022)



3 META-ANÁLISES

Foi demonstrado um efeito moderado a elevado para intervenções utilizando **tentativa de movimento**, e um efeito demonstrado efeito moderado mas sem significância estatística para intervenções com **imaginação motora** (ou prática mental)

A eficácia verificou-se tanto em utentes agudos como crónicos (Bai et al., 2020; Mansour et al., 2022)

4 OBSERVAÇÃO DE AÇÃO

O recrutamento neuronal é maior na observação de movimento do que na prática mental isolada, sendo ainda maior quando combinados.

A excitabilidade cortical parece ser maior para tarefas mais exigentes (Herranz-Gómez et al., 2020)

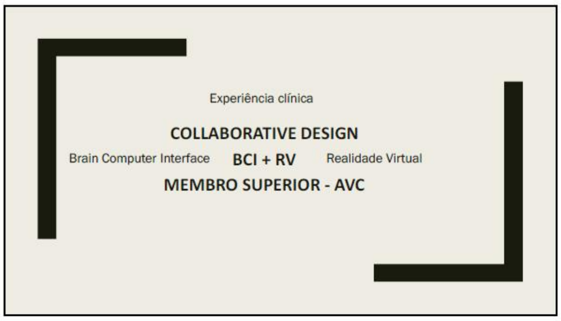
5 ESTÍMULO VIBRATÓRIO

A adição de vibração (na mão) parece levar a maior plasticidade, ao diminuir o delay do feedback e aumentar a área sensorimotora ativada (Grosse-Wentrup et al., 2011)

- Bai et al., (2020). Immediate and long-term effects of BCI-based rehabilitation of the upper extremity after stroke: A systematic review and meta-analysis. Journal of NeuroEngineering and Rehabilitation
- Daly et al., (2009). Feasibility of a new application of noninvasive brain computer interface (BCI): A case study of training for recovery of volitional motor control after stroke. Journal of Neurologic Physical Therapy
- Frisoli et al., (2022). A randomized clinical control study on the efficacy of three-dimensional upper limb robotic exoskeleton training in chronic stroke. Journal of NeuroEngineering and Rehabilitation
- Grosse-Wentrup et al., (2011). Using brain-computer interfaces to induce neural plasticity and restore function. Journal of Neural Engineering
- Herranz-Gómez et al., (2020). Effectiveness of motor imagery and action observation on functional variables: An umbrella and mapping review with meta-meta-analysis. Neuroscience and Biobehavioral Reviews
- Mansour et al., (2022). Efficacy of Brain–Computer Interface and the Impact of Its Design Characteristics on Poststroke Upper-limb Rehabilitation: A Systematic Review and Meta-analysis of Randomized Controlled Trials. In Clinical EEG and Neuroscience

Appendix 6 – Workshop visual aids

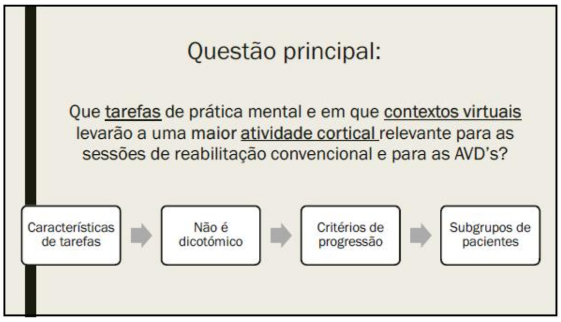
Workshop 1



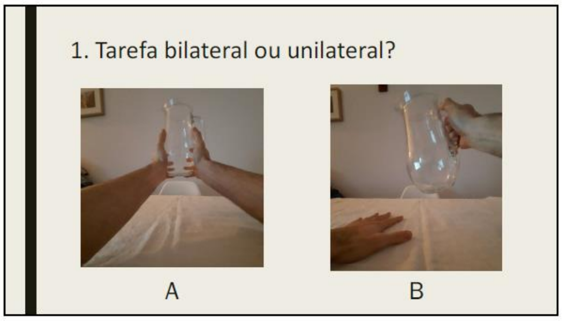
1

2

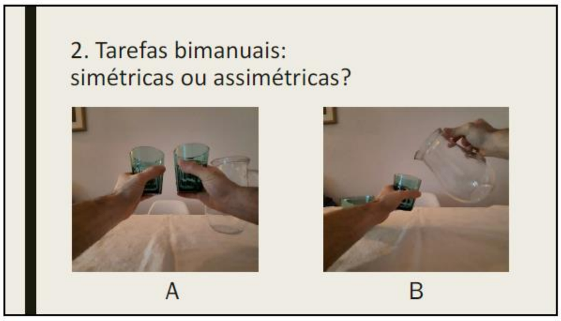
3



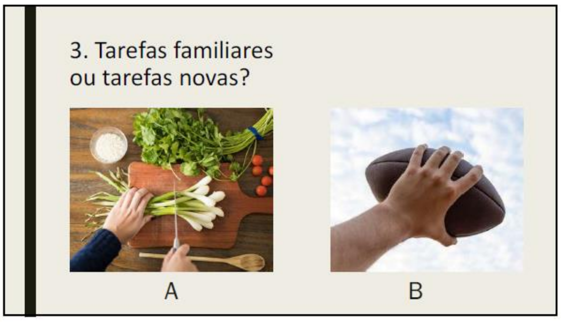
4



5



6



7

8

5. Tarefa rítmica ou com início e fim?

A B

9

6. Repetição do gesto:
no mesmo contexto ou com variedade?

A B

10

7. Contexto mundano ou extraordinário?

A B

11

8. Focar na mão ou
em todo o membro inteiro?

A B

12

Questão adicional:

Considerando a experiência na reabilitação de indivíduos após AVC, existem outros princípios importantes na intervenção do membro superior?

13

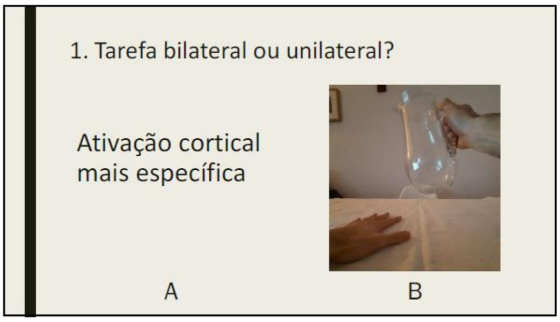
OBRIGADO
AGENDAMENTO 2ª SESSÃO
FORMULÁRIO AVALIAÇÃO

14

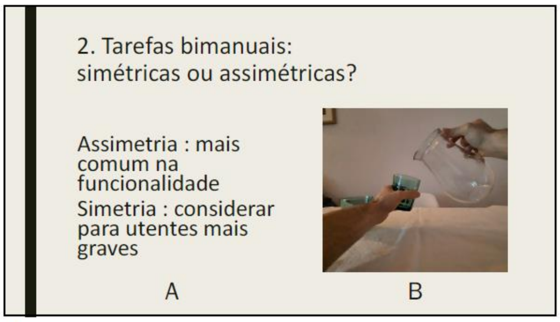
Workshop 2

1

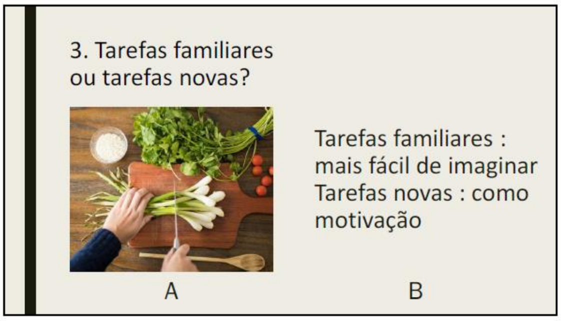
2



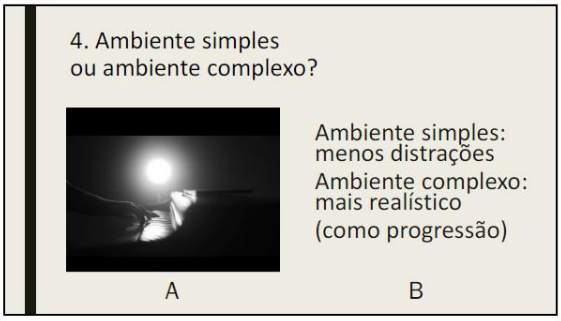
3



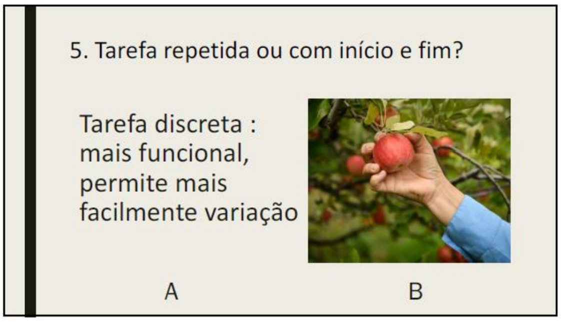
4



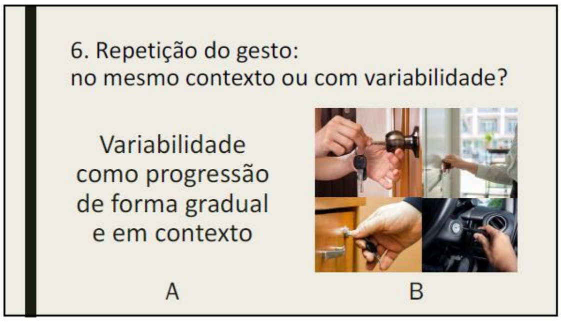
5



6



7



8

7. Contexto mundano ou extraordinário?

Contexto real: mais relevante e fácil de imaginar

Extraordinário: motivação pontual

A B

9

8. Focar na mão ou em todo o membro inteiro?

Incluir a globalidade do membro superior: mais funcional

A B

10

Outros pontos referidos:

Oportunidade de incluir franjas	Cognição, comunicação, negligência...	Setting postural	Adaptar ao utente
Apresentação clínica, preferências	Dar opções ao terapeuta	Progressões e variabilidade	Segmentação da tarefa

11

ADAPTAR AO INDIVÍDUO

12

Características clínicas

Ausência de movimento	Dor	Atividade postural indevida
Orientação espacial indevida	Défice cognitivo	Outro?

13

Característica clínica

Adaptação da intervenção
- ...
- ...
- ...

Exemplos de tarefas
- ...
- ...
- ...

14

Avaliação objetiva:

- Quais os outcomes ideais para medir a efetividade desta intervenção em estudos experimentais?

Barthel, MIF	Action Research Arm Test	Fugl-Meyer Motor Assessment
Motor Evaluation Scale for Arm in Stroke	Box and Block Test	Motor Activity Log (amount of use/ quality of movement)
Active range of motion	Finger motor sequences	Outros?

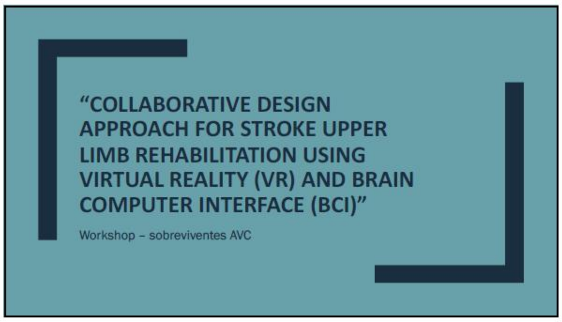
15

Fim da sessão

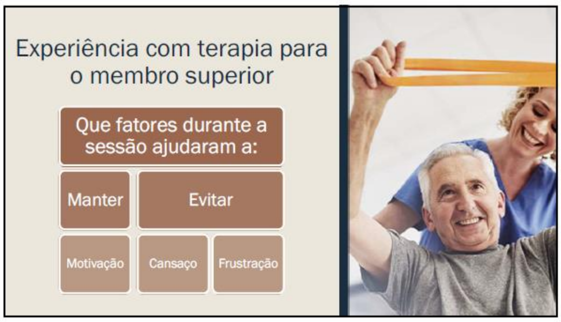
Muito obrigado

16

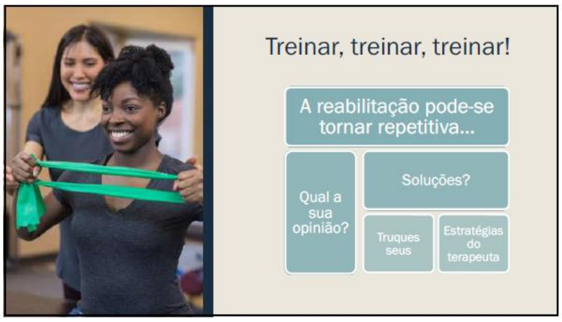
Workshop 3



1



2

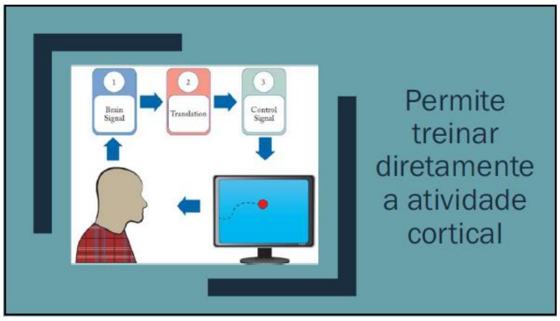


3

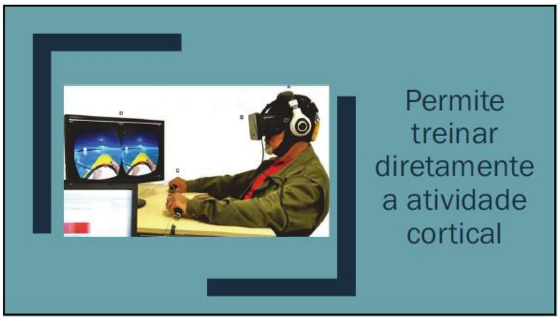
4

5

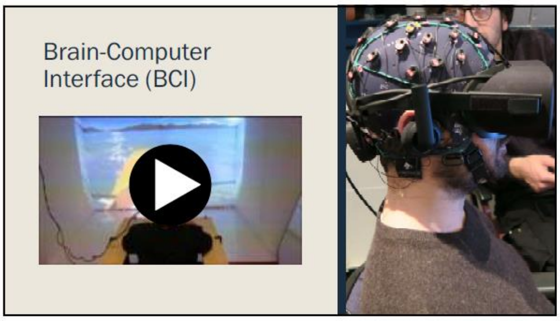
6



7



8



9

10

11

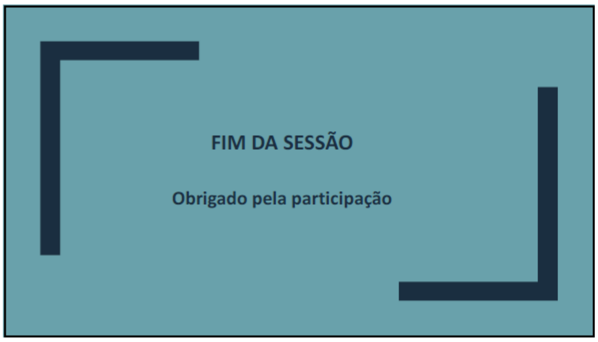
12

13

14

15

16



17

Appendix 7 – Invitation letter – Experts

IPS Instituto Politécnico de Setúbal
Escola Superior de Saúde

Carta Explicativa

O Projeto "Collaborative design approach for stroke upper limb rehabilitation using virtual reality and brain computer interface", pretende criar um conjunto de princípios orientadores de futuras intervenções que utilizem esta tecnologia como adjuvantes à reabilitação do membro superior de pessoas com AVC.

Este projeto está a ser desenvolvido no contexto do Mestrado em Prática Avançada de Fisioterapia em Neurologia da Escola Superior de Saúde do Instituto Politécnico de Setúbal (ESS/IPS) Este estudo foi aprovado pela comissão de ética do Instituto Politécnico de Setúbal.

Relevância da sua participação

Convidamo-lo/a a participar neste estudo, na capacidade de perito clínico, visto que a sua experiência na reabilitação de utentes será crucial para o desenvolvimento deste estudo. Antes de tomar qualquer decisão, é importante que compreenda as razões pelas quais este estudo está a ser conduzido e o nível de envolvimento que lhe é pedido. Por favor, utilize o tempo que necessitar para ler a informação que se segue. Poderá falar com outras pessoas sobre este estudo, se o desejar e solicitar esclarecimentos junto do investigador principal ou membros da equipa de orientação. O seu contributo através da experiência clínica e conhecimento científico, irá permitir o estabelecimento de critérios orientadores para futuras intervenções.

Relevância deste estudo

Cerca de 60% das pessoas 6 meses após AVC reporta que a sua mão não é funcional para as atividades de vida diária, representando o sintoma mais comum nesta população. Intervenções de prática mental (ou imaginação motora) com utilização de interface computador-cérebro e realidade virtual já mostraram ser uma intervenção adjuvante eficaz para a reabilitação destes utentes, no entanto, o desenho destas intervenções não teve em consideração os vários princípios relevantes para a reabilitação após lesão neurológica.

Consideramos que este estudo será de elevada relevância para contribuir para o aumento da efetividade destas intervenções, o que poderá contribuir para uma redução da incapacidade desta população. Cada participante terá de assinar um formulário de consentimento informado em que autoriza a utilização dos seus dados pessoais.

Colaboração dos participantes

O desenho colaborativo incluindo peritos clínicos, utentes com AVC e engenheiros informáticos/biomédicos pretende-se que contribua para o desenvolvimento de programas de intervenção com maior aceitabilidade e eficácia. O estudo irá incluir 3 fases distintas:

1) workshop (dividido em duas sessões) realizado com peritos em reabilitação do membro superior em utentes com AVC, com o objetivo de delinear linhas orientadoras para intervenções de interface cérebro-computador com realidade virtual, focando na seleção dos movimentos e ambientes virtuais;

2) workshop com utentes com AVC, com o objetivo de definir aspetos que tornem futuras intervenções mais convidativas e cativantes, recorrendo à sua experiência nomeadamente em lidar com a sua incapacidade e participação em diversas situações para a sua reabilitação.

3) workshop com peritos, utentes e engenheiros digitais/biomédicos para informar sobre a construção de futuros protótipos de intervenção. Na fase 1 prevê-se a realização de dois workshops com um grupo de 6 a 10 peritos, em formato online (via Zoom).

Para suportar o debate e processo colaborativo eficiente será disponibilizado um briefing com alguns conceitos relevantes, bem como um sumário da evidência mais relevante e recente em relação a intervenções na área.

Para além da participação nos workshops, será solicitado o preenchimento de dois questionários (em formato digital), sendo o primeiro de avaliação do próprio workshop (estimativa de preenchimento de 2 minutos), e o segundo, após a leitura do resumo da sessão realizada, de esclarecimento (estimativa de preenchimento de 2 minutos). Prevê-se que cada workshop tenha a duração máxima 90 minutos.

Cessação da participação

Qualquer participante poderá retirar a sua participação do estudo a qualquer momento, devendo para esse efeito contactar o investigador principal por correio eletrónico (miguel.russo@gmail.com). Nesse momento pode também decidir se quererá que os seus dados e comentários já registados sejam excluídos do estudo. A remoção da sua participação no estudo não terá nenhuma consequência ou penalização.

Riscos e benefícios

Consideramos que a participação neste estudo não contempla qualquer risco, nem levará a benefício direto para os participantes. A identidade de todos os participantes será protegida utilizando um sistema de codificação para se referir a cada participante na transcrição do workshop durante a análise dos dados, bem como na publicação do estudo.

Proteção e utilização de dados pessoais

O workshop será gravado para permitir uma melhor análise do conteúdo da discussão. Sendo o objetivo deste estudo o desenho colaborativo, irão usar-se ferramentas como o brainstorming, mind-map e personas. Para potenciar a assiduidade e pontualidade dos participantes serão enviados dois lembretes na aproximação da sessão.

Toda a informação recolhida no decorrer deste estudo será armazenada num dispositivo de armazenamento de dados, com proteção de password e acedidos apenas pela equipa de investigação, sendo a sua identidade mantida preservada em todos os momentos, após a análise da gravação da sessão, sendo a sua transcrição realizada com um sistema de codificação para identificar cada participante. Os dados serão destruídos após 3 anos ou após a publicação.

Para garantir a tranquilidade e sigilo da sessão online, haverá uma sala de espera e só serão admitidos na sessão os participantes, não havendo risco de entrarem indivíduos estranhos ao projeto. O link de acesso à sessão online será enviado apenas no dia anterior à sessão, para facilitar o seu acesso e reduzir o risco de disseminação indevida.

Agendamento

O agendamento da 1ª sessão será feito de acordo com a disponibilidade dos vários participantes, na terceira semana de Janeiro de 2023. A marcação da 2ª sessão será realizada no final da 1ª sessão, cerca de uma semana após a 1ª sessão. O agendamento da fase 3, será realizado posteriormente, receberá posteriormente o convite para participar nessa fase.

Contatos para esclarecimento ou reclamação

Caso tenha alguma preocupação ou dúvida sobre algum aspeto do estudo poderá contactar o membro da equipa de investigação responsável: Miguel Russo, através do email: miguel.russo@gmail.com ou a orientadora científica: Carla Pereira: carla.pereira@ess.ips.pt. Caso pretenda fazer uma reclamação, poderá fazê-lo através de correio eletrónico para a Comissão de Ética (CE) do IPS, através do endereço eletrónico: comissao.etica@ips.pt

Plano de disseminação

Assim que o estudo esteja finalizado, será produzido um relatório/ tese. Caso queira receber este relatório, poderá solicitá-lo através do email: carla.pereira@ess.ips.pt. Os resultados serão também apresentados no seminário Neuro Research Talk Series IV 2023 na ESS/IPS e podem ser publicados em congressos/revistas da especialidade ou outras formas de divulgação. No relatório e outros documentos com apresentação dos resultados do estudo, não será apresentada informação individual dos participantes. Os resultados serão, sempre, divulgados de forma agregada, não possibilitando a sua identificação.

Com os melhores cumprimentos, e disponível para qualquer questão,

A equipa de investigação,

Miguel Russo (Investigador principal)	miguel.russo@gmail.com
Carla Mendes Pereira (Orientadora)	carla.pereira@ess.ips.pt
Ana Isabel Almeida (Co-orientadora)	isabel.almeida@ess.ips.pt
Athanasios Vourvopoulos (Co-orientador)	athanasios.vourvopoulos@tecnico.ulisboa.pt

Appendix 8 – Invitation letter – Stroke patients

IPS Instituto Politécnico de Setúbal Escola Superior de Saúde

Carta Explicativa

O Projeto "Collaborative design approach for stroke upper limb rehabilitation using virtual reality and brain computer interface", pretende criar um conjunto de princípios orientadores de futuras intervenções que utilizem esta tecnologia como adjuvantes à reabilitação do membro superior de pessoas com AVC.

Este projeto está a ser desenvolvido no contexto do Mestrado em Prática Avançada de Fisioterapia em Neurologia da Escola Superior de Saúde do Instituto Politécnico de Setúbal (ESS/IPS) pelo estudante Miguel Russo sobre a orientação da professora doutora Carla Mendes Pereira (ESS/IPS), e co-orientação da professora Ana Isabel Almeida (ESS/IPS) e professor doutor Athanasios Vourvopoulos (IST-Instituto Superior Técnico). Este estudo foi aprovado pela comissão de ética do Instituto Politécnico de Setúbal.

Cerca de 60% das pessoas 6 meses após AVC reporta que a sua mão não é funcional para as atividades de vida diária, representando o sintoma mais comum nesta população. Intervenções de prática mental (ou imaginação motora) com utilização de interface computador-cérebro e realidade virtual já mostraram ser uma intervenção adjuvante eficaz para a reabilitação destes utentes, no entanto, o desenho destas intervenções não teve em consideração os vários princípios relevantes para a reabilitação após lesão neurológica.

O desenho colaborativo incluindo peritos clínicos, utentes com AVC e engenheiros informáticos/biomédicos poderá contribuir para o desenvolvimento de programas de intervenção com maior aceitabilidade e eficácia. O estudo irá incluir 3 fases distintas:

1) workshops realizados com peritos de reabilitação do membro superior de utentes com AVC, com o objetivo de delinear linhas orientadoras para intervenções de interface cérebro-computador com realidade virtual, focando na seleção dos movimentos e ambientes virtuais;

2) workshop com utentes com AVC, com o objetivo de definir aspetos que tornem futuras intervenções mais convidativas e cativantes, recorrendo à sua experiência nomeadamente em lida com a sua incapacidade e participação em diversas situações para a sua reabilitação.

3) workshop com peritos, utentes e engenheiros digitais/biomédicos para informar sobre a construção de futuros protótipos de intervenção.

Assim, convidamo-lo/a a participar neste estudo, na capacidade de perito clínico, visto que a sua experiência na reabilitação de utentes será crucial para o desenvolvimento deste estudo. Antes de tomar qualquer decisão, é importante que compreenda as razões pelas quais este estudo está a ser conduzido e o nível de envolvimento que lhe é pedido. Por favor, utilize o tempo que necessitar para ler a informação que se segue. Poderá falar com outras pessoas sobre este estudo, se o desejar e solicitar esclarecimentos junto do investigador principal ou membros da equipa de orientação.

O seu contributo através da experiência clínica e conhecimento científico, irá permitir o estabelecimento de critérios orientadores para futuras intervenções. Na fase 1 prevê-se a realização de dois workshops com um grupo de 6 a 10 peritos, em formato online (via Zoom).

Para suportar o debate e processo colaborativo eficiente será disponibilizado um briefing com alguns conceitos relevantes, bem como um sumário da evidência mais relevante e recente em relação a intervenções na área.

Para além da participação nos workshops, será solicitado o preenchimento de dois questionários (em formato digital), sendo o primeiro de avaliação do próprio workshop (estimativa de preenchimento de 2 minutos), e o segundo, após a leitura do resumo da sessão realizada, de esclarecimento (estimativa de preenchimento de 2 minutos). Prevê-se que cada sessão tenha a duração máxima 90 minutos.

Consideramos que a participação neste estudo não contempla qualquer risco, nem levará a benefício direto para os participantes. Qualquer participante poderá retirar a sua participação do estudo a qualquer momento, devendo para esse efeito contactar o investigador principal por correio eletrónico (miguel.russo@gmail.com).

Nesse momento pode também decidir se quererá que os seus dados e comentários já registados sejam excluídos do estudo. A remoção da sua participação no estudo não terá nenhuma consequência ou penalização.

A identidade de todos os participantes será protegida utilizando um sistema de codificação para se referir a cada participante na transcrição do workshop durante a análise dos dados, bem como na publicação do estudo.

Consideramos que este estudo será de elevada relevância para contribuir para o aumento da efetividade destas intervenções, o que poderá contribuir para uma redução da incapacidade desta população. Cada participante terá de assinar um formulário de consentimento informado em que autoriza a utilização dos seus dados pessoais.

O workshop será gravado para permitir uma melhor análise do conteúdo da discussão. Sendo o objetivo deste estudo o desenho colaborativo, irão usar-se ferramentas como o brainstorming, mind-map e personas. Para potenciar a assiduidade e pontualidade dos participantes serão enviados dois lembretes na aproximação da sessão.

Toda a informação recolhida no decorrer deste estudo será armazenada num dispositivo de armazenamento de dados, com proteção de password e acedidos apenas pela equipa de investigação, sendo a sua identidade mantida preservada em todos os momentos, após a análise da gravação da sessão, sendo a sua transcrição realizada com um sistema de codificação para identificar cada participante. Uma vez apresentados os resultados, os dados serão destruídos após 3 anos.

Para garantir a tranquilidade e sigilo da sessão online, haverá uma sala de espera e só serão admitidos na sessão os participantes, não havendo risco de entrarem indivíduos estranhos ao projeto. O link de acesso à sessão online será enviado apenas no dia anterior à sessão, para facilitar o seu acesso e reduzir o risco de disseminação indevida.

O agendamento da 1ª sessão será feito de acordo com a disponibilidade dos vários participantes. A marcação da 2ª sessão será realizada no final da 1ª sessão. O agendamento da fase 3, será realizado posteriormente.

Caso tenha alguma preocupação ou dúvida sobre algum aspeto do estudo poderá contactar o membro da equipa de investigação responsável: Miguel Russo, através do email: miguel.russo@gmail.com ou a orientadora científica: Carla Pereira: carla.pereira@ess.ips.pt. Caso pretenda fazer uma reclamação, poderá fazê-lo através de correio eletrónico para a Comissão de Ética (CE) do IPS, através do endereço eletrónico: comissao.etica@ips.pt

Assim que o estudo esteja finalizado, será produzido um relatório/ tese. Caso queira receber este relatório, poderá solicitá-lo através do email: carla.pereira@ess.ips.pt. Os resultados serão também apresentados no seminário Neuro Research Talk Series IV 2023 na ESS/IPS e podem ser publicados em congressos/revistas da especialidade ou outras formas de divulgação. No relatório e outros documentos com apresentação dos resultados do estudo, não será apresentada informação individual dos participantes. Os resultados serão, sempre, divulgados de forma agregada, não possibilitando a sua identificação.

Com os melhores cumprimentos, e disponível para qualquer questão,

A equipa de investigação,

Miguel Russo (Investigador principal)	miguel.russo@gmail.com
Carla Mendes Pereira (Orientadora)	carla.pereira@ess.ips.pt
Ana Isabel Almeida (Co-orientadora)	ai.almeida@sapo.pt isabel.almeida@ess.ips.pt
Athanasios Vourvopoulos (Co-orientador)	athanasios.vourvopoulos@tecnico.ulisboa.pt

Appendix 9 – Consent form

Formulário de Consentimento Informado

IPS Instituto Politécnico de Setúbal Escola Superior de Saúde

No âmbito do projeto "Collaborative design approach for stroke upper limb rehabilitation using virtual reality and brain computer interface" aprovado pela comissão de ética do Instituto Politécnico de Setúbal, foi-me proposta a participação num workshop para design colaborativo para criar linhas orientadoras para o desenvolvimento de futuras intervenções de Interface Computador Cérebro com realidade virtual imersiva para o membro superior.

Este projeto está inserido na tese realizada por Miguel Russo com orientação da professora doutora Carla Mendes Pereira, e co-orientação da professora Ana Isabel Almeida e do professor doutor Athanasios Vourvopoulos, no contexto to mestrado em "Práticas Avançadas em Fisioterapia Neurológica".

□ Declaro que li e compreendi a informação disponibilizada na carta informativa. Foram-me explicados o objetivo e procedimentos envolvidos na participação deste estudo e as minhas dúvidas foram esclarecidas de forma satisfatória pela equipa de investigação.

□ Autorizo a utilização dos dados pessoais que irei fornecer para análise pela equipa de investigação, com objetivo de contribuição para o projeto, e utilização unicamente académica a profissional. Declaro que compreendo a confidencialidade e sigilo com que serão tratados os dados recolhidos, sem possibilidade de serem consultados por terceiros.

□ Autorizo a captação de vídeo e gravação da minha voz para posterior análise da informação, tendo garantia da total proteção dos meus dados. Compreendi que os dados serão armazenados de forma segura.

□ Compreendi o tempo estimado para a minha participação no estudo.

□ Reconheço o meu direito de não participar ou interromper a minha participação no presente projeto a qualquer momento, sem quaisquer consequências e necessidade de justificação da minha decisão, bastando comunicá-la a um membro da equipa.

□ Fui também informado/a quanto à ausência de quaisquer riscos potenciais, do ponto de vista social, legal e financeiro.

Aceito participar neste projeto.

Nome:

______________________________________ Data:_________________

Assinatura:

__________________________________ Data: 10/01/2022

Assinatura do investigador:

Miguel Marques Russo

Contactos:

Miguel Russo (Investigador principal) miguel.russo@gmail.com
Carla Mendes Pereira (Orientadora) carla.pereira@ess.ips.pt
Ana Isabel Almeida (Co-orientadora) isabel.almeida@ess.ips.pt
Athanasios Vourvopoulos (Co-orientador) athanasios.vourvopoulos@tecnico.ulisboa.pt

Appendix 10 –Summary invitation image

Appendix 11 – Feedback form

The online questionnaire for participants' feedback was identical for workshop 1.1, 1.2 and 3 (version A), however for workshop 2 a few open questions were added (version B). The closed questions were the same for both versions.

Closed questions of online questionnaire

Questões fechadas						
Como avalia a experiência de ter participado neste workshop?						
Negativa	1	2	3	4	5	Positiva
Considera que a execução do workshop foi congruente com os objetivos do estudo em que se insere?						
Nada produtiva	1	2	3	4	5	Bastante produtiva
Como avalia a moderação deste workshop? (condução da sessão)						
Nada adequada	1	2	3	4	5	Bastante adequada
Como avalia a organização deste workshop? (a nível de preparação prévia)						
Nada adequada	1	2	3	4	5	Bastante adequada
Considera que participar neste workshop foi uma utilização útil do seu tempo pessoal?						
Nada valiosa	1	2	3	4	5	Bastante valiosa

Open questions - version A

Perguntas abertas
Qual foi, na sua opinião, o tópico mais importante que foi discutido?
Surgem-lhe, neste momento, tópicos relevantes que não foram abordados?

Em que aspetos poderá ser melhorado este workshop?
Outros comentários

Open questions - version B

Perguntas abertas
Qual foi, na sua opinião, o tópico mais importante que foi discutido?
Na sua opinião que sub-grupos devem ser considerados na elaboração de recomendações específicas que permitam a sua inclusão
Discutiu-se que utentes com défice cognitivo ou de comunicação severos serão incapazes de participar por incapacidade de compreender as instruções, no entanto os défices moderados a leves poderão participar com cuidados adicionais para comunicação simples e clara. Deseja acrescentar algum comentário? Como se poderá estabelecer de forma objetiva este fator de exclusão?
Um dos participantes indicou que para manter a qualidade dos dados biométricos recolhidos pelo EEG será importante selecionar uma tarefa simples, como por exemplo alcançar. Pode dar algum exemplo específico de uma tarefa simples que seja ideal para a maioria dos utentes? Que objeto se colocará no ambiente virtual para o utente alcançar?
Surgem-lhe, neste momento, tópicos relevantes que não foram abordados?
Em que aspetos poderá ser melhorado este workshop?
Outros comentários

Appendix 12 – Thematic Codebook

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Characteristics of tasks	Simplicity of task and environment	(W2P10)	Independentemente seja um utente com mais capacidades, menos capacidades, mesmo para normais, **a tarefa deve ser o mais simples possível,** mais simples de em termos de imagética	A tarefa selecionada deve ser o mais simples possível
		(W1.1P3)	(ambiente simples ou rico?) Eu aqui acho que é **mais simples,** porque o enriquecido depois estimula outras áreas que nós não queremos também.	Preferir ambiente simples, progredir com ambiente rico
		(W1.2.P5)	(...) o rico não, não é sinónimo de complexidade(...) ri**cos, são chamados aqueles ambientes que têm os estímulos adequados para estimular neuroplasticidade** (...) com interação social, com estímulos agradáveis para o utente que é	Ambientes ricos são os que mais estimulam a neuroplasticidade, mas neste contexto trata-se de um
		(W1.2.P6)	Há um aspecto que eu acho que vão ter que escolher muito bem, que é o tipo de feedback que vão dar, não é? Porque quando **são 3 feedback de concorrentes pode confundir o doente**. Quer dar o visual, o auditivo e o tátil não é?(...) Eu	A quantidade de diferentes estímulos pode confundir o utente, considerar começar com apenas um ou 2
		(W1.1P4)	[tarefa simétrica ou assimétrica] Não diria nem uma, nem outra . Provavelmente uma progressão no membro, uma função mais de estabilidade, outro mais de movimento (...)	Movimento bilateral assimétrico, implica um lado com função de estabilidade e outro de movimento
		(W1.1P1)	(...) **quanto mais complexas supostamente maior ativação**. E lá está! E tal como esta graduação, (...) é "ok. Aí aqui vejo uma jarra sem água no copo", depois vou ver a jarra com a água... pouca água, depois com muita água, (...)	A ativação cortical é maior quanto maior for a complexidade da tarefa. A graduação pode ser por características naturais da
	Activities of daily living	(W3U6)	**eu prefiro sempre treinos de coisas** que façam sentido para mim na minha vida do dia a dia, (...) coisas sempre **que sejam realmente práticas**, que tenham alguma utilidade.	Preferência por treino de tarefas funcionais
		(W3U3)	*(Que movimentos sugerem treinar em realidade virtual?)* **Todos aqueles que têm a ver com o dia a dia**, o o o comer, o cortar a carne, o o levar (imperceptível) à boca?	Preferência por treino de tarefas funcionais
		(W3U3)	Portanto eu acho que os movimentos, que **a gente usa no dia a dia são os melhores**, porque são aqueles que mesmo a nível muscular, se há alguma **recordação muscula**r, ela está lá escondida nalgum lado, não é? Mas a gente pode-a despertar.	Movimentos da rotina poderão desencadear memória muscular para a reabilitação
		(W3U7)	Ah, condução. A natação	Preferência por treino de tarefas funcionais
		(W3U3)	Portanto, esses movimentos, digamos que era **aqueles movimentos fáceis e que a gente nem sequer pensava**, não é? **Acho que são os melhores mesmo,** porque é assim, a a, é como quando a gente começou a andar! A gente já lembra-se lá que tem que, que tem que, a, a, apertar as nádegas e tem que não sei quê... não se lembra! E depois quando começamos a andar depois do AVC, é uma das coisas que a gente tem que se lembrar de fazer.	Preferir movimentos automáticos pela sua simplicidade e importância funcional
		(W1.1P1)	(contexto mundano ou extraordinário) Eu acho que optaria mais **mais pelo contexto mundano** (...)	Preferir tarefas em contexto mundano
		(W1.1P1)	Estou a cumprimentar um líder qualquer, se bem que eu acho que r**emetia sempre mais para o mundano**, porque é mais o que é familiar para mim, é o que tem mais significado, mas também acho lá está se a pessoa me disser assim, wow viajo neste mundo e gosto.(...)	Preferir tarefas em contexto mundano por familiaridade, mas permitindo ao utente escolher o extraordinário
		(W1.2.P6)	(...) na questão do cozinhar de u**ma forma de dar reforço positivo, poderíamos pôr a cozinhar a pessoa com Ramsey ou com outro chef conhecido** pronto, teria a sua piada, não é? Aaa, e eventualmente se a pessoa gosta muito, hm... podemos escolher algumas personagens, do tal ambiente rico	Reforço positivo, motivação, poderia ser dado ao utente, por uma personagem que lhe seja relevante (p.ex. chef famoso)
		(W1.2.P6)	São objetivos motor, e quando pensamos na mão temos três grandes objetivos motores, que é o alcançar, o agarrar e manipular. E que envolve o superior todo. E **eu acho que as atividades deveriam envolver um membro inteiro**, e não específica, porque se vamos focar só na mão, em termos de activação, vamos ativar predominantemente o circuito, claro, do agarrar, o da mão (...)	Preferir tarefas que envolvam o membro todo, para ativar os circuitos neuronais relevantes
		(W1.1P3)	(tarefa cíclica ou contida?) (...) acho que tem a ver com o que que o que é definido e o grau de dificuldades. Eu acho que no **no início, uma muito mais simples** e depois vai aumentando o grau de dificuldade.	Preferir a tarefa cíclia por ser mais simples que a tarefa contida
		(W1.1P4)	Aqui a **atividade rítmica**, ou a repetição da atividade, (...) **trás alguns benefícios, diferentes** da tarefa que inicia e tem um	Tarefa cíclica tem benefícios diferentes
		(W1.2.P6)	Mas **numa fase inicial seriam sem dúvida, tarefas discretas**. O início-fim determinado em que o membro menos afetado serviria, sobretudo de suporte para a atividade do outro membro.	Iniciar com tarefas de início e fim, com o movimento focado no membro mais afetado
		(W1.2.P7)	**(tarefa cíclica) acaba por ter pouca variabilidade** (...) **pode não ser tão enriquecedor nessa estimação** (...) acho que é uma questão de ir graduando a dificuldade ou... não digo intensidade, mas a dificuldade da mesma tarefa. E aí... Relativamente a amplitudes, direcções já na questão anterior de aumentar os efeitos diastratores ou enriquecedor do ambiente, pode ser interessante, sem dúvida	A tarefa cíclica tem menos variabilidade, podendo ser menos estimulante

Subtheme		Participant	Quote (insight highlighted)	Interpretation
			ambiente, pode ser interessante, sem dúvida	
Characteristics of tasks	Familiarity of the task to the patient	(W3U6)	*(Que movimentos sugerem treinar em realidade virtual?)* **Pegar no gato**, fazer-lhe uma festinha.	Preferência por tarefas que vão ao encontro dos gostos pessoais (p.ex gato)
		(W1.1P4)	(tarefas familiares ou novas?) Eu iria pelas **familiares desafiava com as novas**.	Preferir tarefas familiares, progredir com novas
		(W1.2P5)	"Eu acho que inicial**mente também começar por tarefas mais familiares** e à medida que a ativação vai melhorando eventualmente **por uma questão de motivação**, de novidade e de **estimular mais a representação cortical**, vamos passar para tarefas novas (...)"	Iniciar por tarefas familiares, progredindo para tarefas novas
	Unilateral and asymmetric tasks	(W1.1P2)	É para para fazer com que **reduzamos a concorrência em termos dos hemisférios cerebrais e eu diria que poderia ser unilateral**. No entanto, sabemos que tarefas bilaterais favorecem, por vezes esta ...ahh ahh... o movimento, o movimento ativo e a reabilitação. (...)Eu penso que convidaria a uma atividade unilateral e muito **possivelmente procuraria inibir o ladro, o lado contralesional.**	Movimento unilateral reduz a concorrência entre hemisférios, considerar inibir o lado que não está a ser ativado
		(W1.1P1)	Isso também **vai aqui organizar um bocadinho, o tipo de ação que nós queremos que o indivíduo faça**. Por exemplo, nesta tarefa específica, faz me sentido que a pessoa, a experiência motora que tenha realmente é unilateral. Não vejo muita vantagem, estar a experienciar uma atividade material bilateral com esta... tarefa em particular, por exemplo.	Selecionar uma tarefa que seja "naturalmente" unilateral em vez de modificar uma tarefa bilateral para torná-la unilateral
		(W1.1P4)	Que possam potenciar a atividade unilateral ou bilateral (...) Mas **nós pensamos no estado funcional que o indivíduo tem; e nas alterações, neuromotoras que o indivíduo tem. Se calhar para uns, poderia fazer sentido bilateral para outros**, hm, o unilateral, independente da fase em que se encontra e da disfunção.	Possivelmente a decisão entre tarefa unilateral e bilateral, irá depender da disfunção do utente
		(W1.2P5)	Eu acho que inicialmente unilateral (concordância de P6 e P7)	Início por unilateral
		(W1.1P1)	apelando à nossa realidade das atividades, (...) faz mais sentido, porque **é efetivamente uma atividade assimétrica que nós fazemos desta forma.** Mas, por exemplo, se eu tivesse uma imagem de carregar uma caixa com as duas mãos, como é uma atividade mais simétrica, também me ap**ela mais ao meu registo e à memória motora** que eu tenho da tarefa.	Considerar a forma mais comum de realizar a tarefa, prefirindo escolher outra atividade a realizar modificações "pouco naturais"
		(W1.1P1)	(Começar) pelo assimétrico, porque nós desempenhamos tarefas assimétricas. (...) se a severidade é imensa, também não me choca ter atividades primeiro simétricas	Iniciar por tarefas assimétricas, por serem mais frequentes. A excepção será em casos muito severos
		(W1.2.P5)	Tendo em conta que a **maioria das tarefas do dia a dia são assimétricas**, eu optaria pelas assimétricas. Porque **habitualmente usamos uma mão para segurar a outra virar**, uma alcançar a outra segurar, a outra para manipular...	Preferência por tarefas assimétricas
		(W1.2.P7)	"(...) acho que **deverá ser assimétrico,** queria só acrescentar r(...), que a vi**sualização das duas mãos** é mantida (...) Assim tanto uma como a outra ..."	Preferência por tarefas assimétricas mas com visualização de ambas

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Variability of tasks	Degree of variety	(W1.1P1)	Eu diria também ao trabalhar a mão, lá está, a importância da especificidade da tarefa.	Importância da especificidade da tarefa
		(W1.1P1)	(...) consoante as tarefas que vamos mostrando, por exemplo, **neste caso a pega é à direita** (...) independentemente depois do hemisfério que é lesado o imaginar que faço a **tarefa com a mão direita ou imagine mostra um secador**.(...) isso também traz implicação e diferença... e pensando **na memória motora que a pessoa tem dessa própria tarefa**... e depois a **dominância que já tinha pré lesão** da tarefa. Tudo isso são fatores que podem efetivamente, depois condicionar a ativação... o resultado.	Especificidade da tarefa é relevante (lado e tipo de pega), bem como memória motora prévia
		(W1.2.P6)	São objetivos motor, e quando pensamos na mão temos três grandes objetivos motores, que é o alcançar, o agarrar e manipular. E que envolve o superior todo. E **eu acho que as atividades deveriam envolver um membro inteiro**, e não específica, porque se vamos focar só na mão, em termos de activação, vamos ativar predominantemente o circuito, claro, do agarrar, o da mão (...)	Preferir tarefas que envolvam o membro todo, para ativar os circuitos neuronais relevantes
		(W1.1P1)	**se repetir sempre a mesma imagem** claro que para aprendizagem temos ativação, mas f**acilmente o utente pode desmotivar** e lá está esta significância, que é que é tão importante, para o desempenho da tarefa. Acho que se pode diluir. Se mostrar várias imagens ao longo das sessões. A verdade é que, também, dependendo da imagem, **pode mudar um bocadinho as componentes da tarefa**. (...). Acho que até vejo com um sentido de progressão	Repetição no mesmo contexto pode levar a desmotivação. No entanto variar o contexto vai implicar mudar alguns componentes da tarefa
		(W1.1P2)	Mas colocar várias portas, ou uma porta de casa, ou a porta de uma loja, ou em que **é sempre o mesmo movimento, isso é repetir sem repetir**. Porque varia ao contexto, mas a tarefa é realmente a mesma	Variabilidade sem alterar componentes, permite repetição com menos desmotivação
		(W1.1P4)	O objetivo é (...) **transferir esses ganhos para o dia-a-dia**, (...) Variabilidade em vez de variedade, se calhar.	Variabilidade ajuda a transferir os ganhos para o dia-a-dia
		(W1.2.P8)	Nós **conseguimos picar ou despicar** o que queríamos ativo. O ambiente rico pode ser muito imersivo, ou seja, pode, pode criar um setup de base do doente para a tarefa interessante, mas temos que nos certificar que não depois não **há componentes que vão dispersar, que podem tirar o foco.**	A opção de controlar a quantidade de estímulos poderá potenciar a imersão minimizando a perda de foco
		(W1.2.P6)	Eu acho que devemos c**omeçar por ambientes mais simples e ir acrescentando complexidade** (...) inicialmente sem sons, sem estimulação tátil e (...) com poucos estímulos visuais, com pouco movimento.	Iniciar com ambientes simples e ir aumentar cumulativamente
		(W1.1P2)	Normalmente são sempre as atividades com o membro superior, **as atividades que provocam mais fadiga**. Não te sei dizer quanto tempo é que é o mais indicado, ou na clínica como é que normalmente as pessoas começam a bocejar mais cedo do que, quando é o trabalho de controlo postural, por exemplo. Ou, ou podem dispersar mais.... A atenção. Não sei qual poderá ser o tempo ideal, a que se sujeita a pessoa a esta atividade de imagética	Vulnerabilidade à fadiga ao treinar o membro superior
	Contribution of variety for engagement	(W1.2.P6)	**O ambiente extraordinário pode ser mais motivador**, não é? **Mas nós queremos tornar a pessoa o mais funcional possível no contexto mundano**, não é? No contexto real, por isso, eventualmente é uma questão de perguntar à pessoa ou, eventualmente uma vez por semana, tornar as coisas mais extraordinárias, não é?	Ambiente extraordinário pode ser motivador, justifica-se utilização ocasional, mas o contexto mundano é mais relevante
		(W1.2.P6)	S**endo que (...) os jogos (...) são ambientes que não têm nada a ver com com a realidade**, nós sabemos que também melhoraram a representação cortical, melhoram a atividade cerebral, melhoram os biomarcadores todos, melhoram a função motora, mesmo sendo um ambiente diferente.	Jogos, com contextos não-mundanos, demonstraram melhorias clínicas em vários componentes
		(W3U4)	(...), **se for lúdico tira aquele aspecto maçador da repetição** em fazer, ou seja, você estar a repetir por o repetir, ahm, se calhar canso-me e posso desmotivar, né? A transformando essa atividade, uma atividade lúdica com objetivos et cetera naturalmente, a realidade virtual é que tem vantagens, né?	Acrescentar um aspeto lúdico à reabilitação alivia a repetitividade

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Principles to task progressions	Components of the task to progress	(W1.1P2)	a **progressão** poderia ser dentro daquilo que é **primeiro, apanha o jarro, e depois de apanhar o jarro, então é que entorna a água para o copo**. (...) Eu exemplificaria sempre inicialmente a tarefa. Como um todo. Porque a pessoa tem mais facilidade em reconhecer e ir buscar a memória.	Progressão da tarefa pode ser acrescentando passos de uma tarefa mais complexa
		(W1.2.P7)	Poderia haver aqui **uma progressão na tarefa (...) o fasear essa tarefa**, o treino da imagética, o chegar o braço à frente e depois vou abrir a mão ou agarrar... haver essa, essa progressão, não é?	Progressão da tarefa como fasear de uma atividade mais complexa
		(W1.2.P8)	(...) **fazer esta decomposição, mas mantendo um foco** em objetivo e à atividade, **mesmo que estejamos a trabalhar apenas numa pequena porção**, de maneira a manter todo o potencial de ativação da imaginação motora e a correlação depois com o movimento, mesmo que seja só o início do movimento (...)	Ao decompor uma tarefa em sub componentes motores, é importante que não se perca o contexto da atividade global
		(W1.2.P6)	Mas **numa fase inicial seriam sem dúvida, tarefas discretas**. O início-fim determinado em que o membro menos afetado serviria, sobretudo de suporte para a atividade do outro membro.	Iniciar com tarefas de início e fim, com o movimento focado no membro mais afetado
		(W2P7)	a ausência do movimento, a dor e atividade postural indevida em muitos casos, **está relacionado, pode estar aqui um fio condutor**. Estou a pensar em nível da utilização da realidade virtual usando algumas características. Desde a própria da utilização da imagética motora, a **própria velocidade do movimento, dos graus de movimento** dentro da tarefa. Poderia ser vantajoso, (...)	Alterações clínicas distintas, poderão ser afetadas pelo mesmo mecanismo terapêutico. Adaptar a amplitude e velocidade do movimento
	Timing and approach for applying progressions	(W3U1)	**a cada dia que passa ir aumentando a dificuldade do objetivo**, digamos assim. Portanto uma pessoa chega a um terminado ponto, consegue nem que seja um bocadinho daquilo que se propôs, portanto tem que, terá que ter logo outro objetivo à frente.	Colocação de objetivos com sucessivo acréscimo de dificuldade como forma de suportar a progressão
		(W1.2.P8)	(...) **sempre que possível, nós introduzimos a variabilidade** e faz-me sentido haver sempre essa possibilidade, embora claro que **numa forma faseada e gradual**, e possamos controlar também essa, o tipo de variabilidade queremos introduzir, mas na minha opinião sempre com variabilidade.	A variabilidade deve ser introduzida sempre que possível, de forma faseada e gradual
		(W1.2.P6)	(...) **pode-se ir introduzindo variabilidade ou até se pode fazer num mesmo (...) um ambiente virtual em que a pessoa vá viajando pelos vários ambientes** abre a porta de casa à chave, fecha a porta de casa, vai até ao carro, abre o carro e entra no carro, fecha o carro e põe o carro a andar, Chego ao emprego, abre novamente a porta, fecha a porta. Seja uma progressão em vários ambientes.	A variabilidade da tarefa pode ser em diferentes num mesmo ambiente com uma relação lógica entre si
		(W1.2.P6)	Se **fizerem isto tipo, jogo através do do scores**, não é? Quando atingem determinado score de ativação, não é um determinado ponto, pode passar ao próximo nível **que tem mais variabilidade.**	Progressão da tarefa em variabilidade de acordo do desempenho (score) do utente

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Initial patient assessment	Objetive evaluation of the patient	(W2P5)	Porque **há questionários que avaliam essa capacidade** e que tem algumas propriedades psicométricas que são robustas. Hm, e tão tão importante como ter ou não alterações sensitivas ou alterações do controle postural, é saber se o utente tem, à partida**, capacidade para imaginar o movimento.** Ahm, e acho que também deveria ser considerado para a inclusão dos utentes.	Será importante aplicar questionários da capacidade de imaginética, posívelmente como critério de inclusão.
		(W2P6)	Portanto, left/right discrimination nolla (?) and laterally judgement task, e pronto, mas e era só este parecer poderia ser interessante ou não fazer esta estratificação, mas para isso precisaria, **era necessário fazer-se uma avaliação cuidad**a, não é? Do tipo de neglect, que também pode ser complicado, porque depois, também em termos nomeclatu*, até as nomelcaturas às vezes são complicadas	Será importante aplicar questionários da capacidade de imaginética, e do tipo de neglet
		(W2P10)	Avaliar imagética motora, deve ser avaliada mas é difícil, mas e **a base disso é que acaba por ser sempre questionários**	A avaliação da capacidade imaginética é realizada por questionário, que afeta a sua reabilidade
		(W2P5)	(Qual o melhor instrumento de medida para medir o efeito desta intervenção?) O mais utilizado em estudos para o membro superior e, e recomendado pela APTA, e pelo Grupo de interesses em neurologia pela Associação de Fisioterapeutas em neurlogia **é a Fulgh-Meyer.**	O instrumento de medida recomendado é a Fulgh-Meyer.
		(W2P9)	Agora, como é que chegam a perceber se o doente tem ou não capacidade para? Aí é que a dúvida, não é? E para isso, só com **uma avaliação formal**, senão…	Para realmente compreender se o utente tem alterações de compreensão, será necessário uma avaliação formal
	Patient inclusivity	(W2P10)	O que acontece muitas vezes são estes critérios mínimos, ou seja, de cognitivamente bem… Não, lá está, **têm os critérios de inclusão muito superficiais**. Ahm, agora eles querem garantir que a população consegue perceber a tarefa e consegue executar a tarefa de forma… minimamente.	Estudos anteriores descrevem critérios de inclusão muito superficiais
		(W2P10)	(…) no paciente mais agudo (…) Há muita tendência de dizzyness e de vertingens e náuseas e essas coisas, portanto eles normalmente **a aplicabilidade é mais no paciente crónico (…)**	Estudos de realidade virtual são realizados em utentes de AVC crónicos têm menor incidência de sintomas vestibulares
		(W1.1P3)	(utilização do estímulo vibratório) Mas se **tiver hipersensibilidade**? já, já vai ser muito complicado…	Em utentes com hipersensibilidade, poderá ser contraproducente utilizar vibração
		(W1.1P1)	há tão pouco (em estudos) e**sta capacidade de incluir alguns subgrupos de utentes** que estamos a falar que, se calhar o desenvolver algo para essa franja de utentes (…) (iria ser) bastante relevante	Capacidade de incluir subgrupos de utentes normalmente excluidos, através de adaptações, será uma grande mais valia
		(W1.1P3)	(…) numa afasia global **as pessoas não conseguem sequer perceber** aquilo que nós estamos a dizer…	Afasia global como possível fator de exclusão

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Set-up considerations	Instructions enhanced by video	(W1.1P2)	(...) para garantir que a tarefa de alguma forma reconhecida, não só no seu contexto, como no seu objetivo, te**r um exemplo de uma pessoa a reproduzir o movimento** seria importante até porque tem representação cortical. (...) que daria um melhor feedfoward	Importância de visualização da tarefa antes do treino (feedfoward)
		(W1.1P2)	(...) Aí passarem **um filme da pessoa a executar a tarefa**, poderá ser interessante até para essas dificuldades de compreensão.	Instruções dadas em demonstração em vez de indicação verbal
		(W1.1P2)	a progressão poderia ser dentro daquilo que é primeiro, apanha o jarro, e depois de apanhar o jarro, então é que entorna a água para o copo. (...) **Eu exemplificaria sempre inicialmente a tarefa. Como um todo**. Porque a pessoa tem mais facilidade em reconhecer e ir buscar a memória.	Progressão da tarefa pode ser acrescentando passos de uma tarefa mais complexa
		(W2P2)	(pessoas com dificuldade na compreensão) E nesse caso, **a estratégia podias ser ou mostrar um filme** ou imagens para ultrapassar a barreira linguística	Estratégias para utentes com dificuldade na compreensão
		(W1.1P2)	(...) Aí passarem **um filme da pessoa a executar a tarefa**, poderá ser interessante até para essas dificuldades de compreensão.	Instruções dadas em demonstração em vez de indicação verbal
	Physical position of the patient	(W1.1P1)	acho muito importante neste tipo de terapias ah... **esta organização do contexto e desta (...) esta posição inicial do indivíduo. Esta preparação para o movimento**, independentemente de não existir um movimento, ainda, será muito importante. Lá está na preparação para, depois, a própria atividade.	Preparação prévia, contexto e posicionamento, importante para a performance
		(W2P1)	E como é que também deveria ser **o apoio do membro**? Uma mesa recortada para estar encaixado? Não sei, estou aqui a visualizar para ver se tem ou não **apoio do cotovelo**, se é na cadeira que tem o apoio do cotovelo, como é que estará à mão depois apoiada?	Garantir o apoio do membro superior mais afetado (antebraço e cotovelo)
		(W1.1P4)	na própria postura que ele vai integrar, hm. Os facilitadores que possam estar ali envolvidos para potenciar, aaa, atividades relacionadas ... **pré-requisitos relacionados com o tronco.**	Capacidade postural pode potenciar a capacidade de ativação da tarefa
		(W1.1P4)	Por isso tentaria olhar para... para **o potencial do tronco e a sua capacidade de adaptação**. Potencial das vias ipsi-laterais. Ou ipsi-lesionais. Hm... e **tomar decisões a partir daí**, se calhar.	Tomar decisões com base no potencial do utente específico
		(W1.1P2)	são aqueles robôs (...) há **uma posição do membro superior, mas... é negligenciado o set postural.** (...) Poderia ter se o cuidado de é, é de, da postura inicial, estar garantida (...)	Advertência de que intervenções róboticas até têm atenção ao posicionamento do membro superior, mas não há garantia da atividade postural
	Considerations for visual representation	(W1.2.P7)	"(...) acho que **deverá ser assimétrico,** queria só acrescentar r(...), que a vi**sualização das duas mãos** é mantida (...) Assim tanto uma como a outra ..."	Preferência por tarefas assimétricas mas com visualização de ambas
		(W1.2.P8)	Tem a ver também com o **esquema corporal**, portanto, a **incorporação das duas mãos deve estar presente.**	Incorporação das duas mãos melhora a representação do esquema corporal
		(W2P10)	Os estudos dizem em relação a isso é que não interessa tanto (...) o tipo de feedback nós damos, a interessa mais **a coerência no timing que nós damos**. Ou seja, independentemente se eu dou um estímulo no meu braço, no meu dedo ou na minha mão, se ele tem que ser concordante com a ação motora que eu fiz.	A localização do estímulo no corpo do utente parece ser pouco relevante, sendo o timing do estímulo muito relevante
		(W3U8)	(O que visualizar durante os momentos de pausa?) **Uma paisagem bonita**, ficar o ecrã preto... Não, não, não, não dá nada, pelo ao menos uma paisagem bonita. Estamos todas, na minha opinião.	Visualizar uma paisagem durante os momentos de pausa
		(W3U2)	Eu acho que para não perder o foco precisamente, o negro. Assim a gente não se distrai. Estamos sempre concentrados.	Visualizar ecrã negro durante os momentos de pausa
		(W3U8)	*(Opção de durante o momento de pausa manter a visualização do ambiente da tarefa de treino, apenas sem realizar a tarefa)* E essa também, me **parece bem.**	Visualizar o mesmo ambiente durante os momentos de pausa

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Features of personalization	Clinical traits of each patient	(W1.1P3)	Deve ser aquela premissa que o **próprio terapeuta deve escolher** e deve escolher se quer alterar a imagem ou não, ou seja, se é possível **adaptar às necessidades clínicas** de cada doente.	Dar ao terapeuta capacidade de escolher, adaptando ao utente
		(W1.1P3)	eu acho que (...) pode ser feito graduação da atividade e o próprio terapeuta é que define que tipo de atividade é que pode fazer, não é? E qual é **o grau de dificuldade** para aquele doente? Isto **depende sempre dos objetivos**, (...) E aí torna o tratamento mais personalizado	Importância da personalização para ajustar o tipo e dificuldade de tarefa ao utente e aos seus objetivos
		(W1.1P4)	É aqui provavelmente nas questões de **o lado direito, eles provavelmente vão precisar de pistas um bocadinho diferentes**, um acréscimo informação, para se localizarem no espaço e o segmento no espaço.	Lesões cerebrais direitas podem necessitar de mais pistas para orientação
		(W1.1P2)	nos casos graves de (...) membro superior a-funcional é muito comum termos **neglect** sobretudo quando temos o membro superior esquerdo (afetado). (...) **A pessoa poderá não ver o ecrã todo**	Neglet é comum em lesão graves, poderá afetar a capacidade de visualização da realidade virtual
		(W1.1P2)	Se vocês pensam em alguma atividade em que é tenha que **surgir um varrimento na imagem ou uma chamada de atenção ao lado esquerdo** para depois, então desenvolver a tarefa pensando e imaginando o movimento com com com o braço esquerdo	Estimular o campo visual esquerdo antes de realizar a tarefa com o membro superior esquerdo pode ser benéfico
		(W2P2)	(...) quer **à organização espacial, quer à capacidade de varrimento da imagem, da percepção do espaço e da noção corporal**... Há aqui uma série de coisas que me parecem mais do foro cognitivo do que necessariamente motor, porque se de facto é só a imagética, (...)	Percepção espacial e noção corporal podem limitar a capacidade de realizar imaginética
		(W3U2)	Eu acho que em primeiro lugar, temos que dar consciência de que **cada AVC é único e diferente dos outros, assim como o, cada processo de reabilitação e é único e diferente** dos outros, assim como nós pessoas somos únicos, diferentes dos outros, não é? Pronto, e de maneira que, hm, a, esta esta estratégia de de que a mera repetição vai dar frutos	Os casos de AVC não são todos iguais, logo o seu processo de reabilitação também não deve ser igual
		(W1.1P4)	Só conseguimos ver a parte do antebraço e mão..., mas as **adaptações mais proximais possam existir e favorecer o desempenho**. (...) o indivíduo ter essa base preparatória.	Referência ou apoio para o corpo do utente (tanto proximal como distal)
		(W2P2)	(cuidados preparatórios deverão ser para todos os utentes ou os mais severos apenas?) Portanto, para **criar menos ruído e para favorecer uma melhor ideia motora, penso que as pessoas devem estar numa postura**. E porque o membro superior depende muito dessa estabilidade proximal, devem ter uma postura assegurada e preparada se melhor consciencializada	Ter cuidado com a atividade postural de todos os utentes, poderá melhor o planeamento motor
		(W1.1P1)	É pensando aqui no membro superior, que pode não ter qualquer movimento também, até que ponto **pode ou não conseguir segura**r (dispositivo de vibração)	Possível necessidade de adaptação
		(W1.2.P7)	"(...) uma questão de realidade virtual pode ser mais facilmente, **ganhar essa imersão**, não é? (...) **A mão real está em cima de uma mesa** e estamos a ver a mão real, a **mão virtual também em cima dessa mesa**."	Possível aumento da imersão se a mão real estiver na mesma posição que a virtual
		(W2P10)	**para mim faz-me sentido que a pessoa esteja confortável**, não é? Numa postura confortável e que não tenha outras variáveis parasitas à volta enquanto está a fazer isto, não é? A pessoa estar desequilibrada e a **tentar gerir o que é o seu corpo real, com aquele corpo virtual**.	Colocar o utente sentado de forma confortável poderá ser sufeciente para a imaginética e evitar "desiquilíbrio" entre o corpo real e virtual

Subtheme		Participant	Quote (insight highlighted)	Interpretation
Features of personalization	Meaningfulness for the patient	(W1.1P4)	**ter um leque que o terapeuta possa selecionar**. Por exemplo, estou-me a lembrar, há pessoas que gostam muito. De jardinagem, mas há outras pessoas que não. (…)	Várias opções para seleccionar de acordo com os gostos do utente
		(W1.1P2)	Eu penso que aqui poderia poderiam colocar as duas questões, para, para, para o **terapeuta escolher**. É penso que podem colocar estas duas tarefas. Porque a rítmica do membro superior é sempre é cognitivado, né? Trabalhar nas tarefas rítmicas se eventualmente as **componentes sub corticais poderão ter alguma influência**(…) **poderá ser interessante, como um fator até de manutenção do estímulo.** A tarefa de início e fim… pois … Também, também é importante e, aliás, temos vindo sempre a discutir as atividades de início e fim, que, que para o membro superior**, se calhar são a maior parte delas, menos cíclicas, e mais de início e fim.**	Permitir o terapeuta seleccionar para o utente; tarefa ritmica ativa estruturas sub corticais; tarefa ritmica promove a manutenção de atividade durante mais tempo; as tarefas de início e fim são mais frequentes nas tarefas funcionais
		(W1.1P1)	O **significado da tarefa** vai ter muito impacto na ativação e na motivação que eu continuo a ter para, para, para fazer o, o, a atividade.	Significância da tarefa é muito importante para a ativação e motivação
		(W1.1P2)	poderia depender um pouco realmente a escolha depois e **preferência do utente e do objetivo** também é entre a equipe, entra terapeuta e utente, hum… por que se calhar há utentes que se colocarmos uma tarefa rítmica, a **atenção ao longo da tarefa pode ir diminuindo** e depois podemos perder ali o nosso foco.	Permitir o terapeuta seleccionar para o utente; na tarefa rítmica a atenção pode se ir perdendo
		(W1.1P4)	Todos temos mapas mentais, (…) em **ter várias tarefas que tenham significância, e o indivíduo selecionar uma delas**. Em cada uma delas, implementar também **esta possibilidade de variabilidade**. Isto no plano de sessão	Ter várias opções de tarefa para o utente escolher. Cada uma delas com variabilidade
		(W1.2.P6)	Porque nós sabemos que isso em termos também de **ganhos funcionais é maior quando o doente está envolvido na escolha** do tratamento. Não é?	Incluir o utente na escolha do tratamento aumenta os ganhos funcionais da intervenção