Mindfulness-based Embodied Tangible Interactions for Stroke Rehabilitation at Home

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ABSTRACT

Current approaches to designing technologies for stroke rehabilitation at home show great promise using either mindfulness-based interventions or embodied tangible interactions. However, there is an untapped potential in integrating these approaches and a lack of understanding of how to embody aspects of mindfulness in tangible interactions for stroke rehabilitation. We report the first explicit effort to explore this dimension by conducting semi-structured interviews and co-design sessions involving four physiotherapists and four mindfulness experts. The major themes 'Awareness – The essence of mindfulness' and 'Tactile sensations – A pathway to mindfulness' point us towards new ways to embody mindfulness in tangible interactions to address stroke rehabilitation challenges. This work introduces a novel approach to designing technology called 'Mindfulness-based Embodied Tangible Interactions' (MBETI). We present five key design principles such as 'Design to support mindful awareness' and 'Design for Comfort' while discussing the future research opportunities of assistive technologies for stroke rehabilitation.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design theory, concepts and paradigms.

KEYWORDS

Accessibility, Embodied Interaction, Health – Wellbeing, Tangibles

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1 INTRODUCTION

Stroke is one of the leading causes of disability in the world [17, 53]. With rising numbers of stroke cases and difficulty in managing the rising costs of clinical rehabilitation, home-based stroke rehabilitation is getting popular [47]. Home-based rehabilitation exercises can get monotonous in the long run and might be demotivating to the survivors who are also adapting to a life of newly acquired disability [1, 40]. In addition to affordability, the availability of physiotherapists in the area and the lack of support at home [40] are also added challenges. In such cases, assistive technologies can be of immense support to assist stroke survivors in independently carrying out rehabilitation tasks [48].

The use of tangibles (physical objects that can be interacted with through touch [33, 39]) in designing rehabilitation technology for stroke has gained prominence in recent times [28, 41, 42, 48]. These tangibles could include specialized tools, objects, or wearable devices designed to facilitate specific exercises or activities [51]. The field of tangible and embodied interactions has grown to be integral to the field of Human-Computer Interaction (HCI), and Interaction Design comprises various aspects related to the role of our bodies while examining how we interact with and perceive objects through tactile sensations [33]. Tangibles also allow for the embodiment of other aspects such as mixed reality [2], particularly in health and wellbeing applications [4, 51, 60] due to the adaptive nature of tangible objects, showcasing the diverse potential of tangibles research, where health emerges as a significant facet [4, 33].

Mindfulness-based interventions have also shown promise in stroke recovery, with positive effects observed in both physical and psychological aspects [73]. Integrating mindfulness into stroke rehabilitation programs has offered a valuable avenue for enhancing recovery outcomes and well-being for stroke survivors [27]. Moreover, the adaptability of mindfulness practices makes them well-suited for home-based rehabilitation [17, 19], providing stroke survivors with accessible and convenient support for their recovery journey in familiar settings.

While rehabilitation through mindfulness-based approaches as well as embodied tangibles has shown benefits independently, fewer efforts have been undertaken to harness the power of both, let alone for stroke rehabilitation. While some studies have shown potential in combining these approaches, their purpose does not focus on stroke rehabilitation. We hypothesize that by incorporating awareness of tactile sensations as an integral element of tangible rehabilitation devices, we can leverage the benefits of both mindfulness and tactile sensory experiences. Throughout the study, we identified methods to achieve this integration seamlessly into the design of tangible technology. The research aimed to answer the following questions:

- What roles do mindfulness and tactile sensations play in addressing stroke rehabilitation challenges at home?
- How can we combine mindfulness and tactile sensations in designing an embodied tangible technology for home-based stroke rehabilitation?

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We utilized a two-phased study approach, conducting semi-structured interviews and co-design sessions involving two distinct groups of participants: four clinicians with expertise in home-based stroke rehabilitation and four mindfulness experts with extensive experience as mindfulness meditators, therapists, or researchers. During the interviews, we understood the intricacies of the rehabilitation process and mindfulness-based therapy practices through their narratives. During co-design, each participant received bespoke design probes tailored to their knowledge domain, built on the insights obtained from interviews. The participants then ideated multiple design ideas to address the study goals. Through qualitative interviews and co-design data analysis, we uncovered interesting insights that led to the emergence of interconnected themes. The themes encompassed the unique nature of the challenges of stroke rehabilitation, the interplay of mindfulness and tactile sensations, and the experiential significance of awareness in embodying mindfulness in tangibles.

The main contribution of this study culminated in the development of a series of design principles for Mindfulness-based Embodied Tangible Interactions (MBETI). The resulting design principles emphasize user comfort, motivation, practice, and support for mindful awareness, fostering a holistic approach to stroke rehabilitation. The proposed term "Mindfulness-based Embodied Tangible Interactions (MBETI)" represents a new paradigm of technology that enhances stroke recovery by incorporating mindfulness principles into tangible design.

2 BACKGROUND AND RELATED WORK

2.1 Technologies for Home-based Stroke Rehabilitation

In response to the growing needs of stroke survivors, researchers have explored home-based rehabilitation as a viable option for extended care [1, 24, 40]. A study by Dworzynski *et al.* highlights the primary advantages of home-based rehabilitation as: patient autonomy, the psychological benefits of being close to family, and the reduced risks associated with inpatient care [22]. In their study, Van Der Veen *et al.* found that everyday living experiences in the home environment can facilitate meaningful task-specific training consistently throughout the day [68]. They also stressed the importance of context-dependent training to make home-based rehabilitation more intensive compared to institutional rehabilitation.

However, long-term home-based rehabilitation comes with its own set of challenges, such as affordability, access to skilled rehabilitation professionals, and repetitive exercises [3, 23]. To address these challenges, technology-assisted therapy approaches such as Interactive neuro-rehabilitation (INR) systems have gained popularity [4]. The utilization of Virtual Reality (VR), Augmented Reality (AR), and modular objects [39] are critical components of INR systems that provide tangible and customizable tools for interactive therapy at home [40, 45]. Examples of INR systems include music-based interventions and exoskeletons, which also offer a unique and enjoyable way to motivate hand movement rehabilitation [23, 80]. The use of tangibles and gamification of rehabilitation exercises have also emerged as major trends in the design of interactive rehabilitation technologies [6, 41]. Sun *et al.* in their paper give a comprehensive summary of home-based stroke rehabilitation technologies depending on the purpose, which ranges from exoskeletons and serious games to computer vision techniques and sensing technologies [63].

While INR systems, AR, and VR show promise in rehabilitation, their limitations are evident. Despite demonstrating improvements in upper limb recovery, these systems are still in the early stages of progression [45, 56], which presents challenges — for example, Phan *et al.* [56] note the challenges of simulator sickness induced by Head-Mounted Displays (HMD) and depth perception issues during the use of AR in stroke rehabilitation. Such challenges impede adoption in unprepared environments like homes [56]. VR also has challenges including a limited range of trackers, heavy haptic feedback equipment, high costs, and safety concerns with forces, cables, and tethers [8]. These factors make home-based adoption difficult, raising concerns about user and clinician acceptance, equipment safety and feasibility [30], compounded by uncertainties over its impact on functional aspects like gait speed and mobility [45]. The limitations of VR and AR underscore the need for further research to address the challenges associated with these technologies, especially in home-based settings, while also ensuring their effective and safe integration into stroke rehabilitation practices.

Beyond traditional approaches to stroke rehabilitation, researchers have also explored alternative approaches like yoga and meditation to evaluate their potential benefits [65]. Notably, some technologies are designed specifically to support the psychological well-being of stroke survivors, addressing a crucial aspect of their holistic recovery [49, 65]. However, despite these efforts, new solutions for stroke rehabilitation are still divided into physical and psychological approaches while fewer efforts have been made to converge these two.

2.2 Collaboration with Participants to Understand Stroke Rehabilitation

Collaborating with stroke-affected adults is challenging [18, 31] due to ethical and health-related issues [34, 58]. However, involving experts who closely interact with the vulnerable groups brings promise [32, 74] in this approach because of the valuable insights obtained by their subjective expertise [11, 61]. Magnusson *et al.* [51] and Ozgur *et al.* [28] emphasize the importance of human-centred design processes and co-design workshops in developing tangible interactive solutions for stroke survivors. Customizing co-design methods by introducing tailored design probes to match participants' expertise can prompt their meaningful involvement [34]. An asynchronous co-design method, which has proven effective in similar research contexts, can be used to overcome logistical issues [2, 16]. Our research draws inspiration from these findings and has tried incorporating them into the methodology.

2.3 Mindfulness in Stroke Rehabilitation

Mindfulness originates from Vipassana (a Buddhist meditation technique) and Yoga in India [55, 64]. It was conceptualized in the West through Jon-Kabat-Zinn's Mindfulness-Based Stress Reduction (MBSR) [37] program, which defines the core skill of mindfulness meditation as the ability to keep one's attention in the present moment [38]. Several researchers have studied the impact of mindfulness meditation training interventions on health and wellbeing

and have observed positive results like reduced pain [9, 67], reduced stress levels [9, 13, 66], and significant improvements in treating Post Traumatic Stress Disorder (PTSD) [43, 76].

Mindfulness-based interventions have demonstrated the potential to improve attention [44], sensorimotor function [82], post-stroke depression and anxiety [67], fatigue, cognition [71], and overall quality of life [72] among individuals post-stroke. Recent studies also show a growing trend of acceptance of mindfulness-based approaches [36], like Yoga and Mindfulness-Based Stress Reduction for Stroke (MBSRfS) [27] among stroke survivors. Mindfulness meditation has also shown significant improvements in neuroplasticity [46] (the brain's capacity to reorganize and form new connections [15, 50]), which is a vital element for assessing post-stroke recovery [67, 73]. These findings further suggest that mindfulness offers potential benefits in mitigating psychological stressors for stroke survivors [49, 75] and emphasize the need to incorporate mindfulness as part of existing rehabilitation approaches [52].

The inherent flexibility of mindfulness addresses the challenges associated with transferring learned skills from structured training environments to daily activities, which is a common hurdle in home-based stroke rehabilitation [68]. By embracing mindfulness within the home setting, stroke survivors benefit from continuous, context-dependent training throughout the day [68]. The adaptability and accessibility of mindfulness practices make them a powerful tool for promoting psychological well-being and cognitive recovery in the comfort of one's home during the rehabilitation journey [24, 52].

A meta-analysis of HCI research on mindfulness by Terzimehić *et. al.* [64] discusses prominent themes that emerge based on the four perspectives, which they define as role, practice, longevity, and co-aspects of mindfulness. They also define an informal role of mindfulness without a strict regimen like meditation, but instead discuss an approach of "providing new or redesigning existing technology for a more thoughtful and slower – mindful – interaction" [64]. Our work takes inspiration from the 'Informal' role of mindfulness and the theme of 'Mindfulness in interaction,' as defined in this work.

While mindfulness-based interventions have demonstrated their effectiveness in aiding stroke rehabilitation, they often operate independently, without integration into the essential component of rehabilitation, which involves physical therapy exercises. This situation prompts the need for the development of novel approaches that not only leverage the benefits of mindfulness but also seamlessly integrate it into conventional rehabilitation practices.

2.4 Tangible and Embodied Interactions in Stroke Rehabilitation

Tangible and embodied interactions (TEI) is a field of study examining how technology impacts physical object interactions, emphasizing touch and physical presence [81]. Despite efforts in the field of TEI to develop novel technologies, very few approaches have tried to explore the possibility of having tangible representations to interact with the internal states of users, including meditation, which wants them to be conscious of and notice their internal experience.

The use of tangibles and embodied interactions has emerged as a significant approach in stroke rehabilitation due to their potential to address the challenges faced by stroke survivors during the recovery process [35]. The evaluations of bimanual devices for home-based upper limb stroke rehabilitation with stroke survivors have also emphasized the importance of such tailorable form factors [41, 42]. Bu *et al.* [6], Yang *et al.* [79], Friedman *et al.* [23] and L. Dovat *et al.* [21] also present interactive prototypes and devices designed to facilitate finger grasping, hand gripping, arm reaching exercises, and hand movement recovery.

Some researchers have also investigated more modern ways of using tangibles for rehabilitation. For example, Yeong *et al.* [80] and Gonsalves *et al.* [26] introduce robotic systems which can provide intensive and repetitive training, contributing to improved motor function. Ramírez *et al.* [57] explore the potential of augmented reality (AR) exergames to facilitate engagement in independent stroke rehabilitation. While these approaches show promise in enhancing engagement, further evaluation is necessary to determine its effectiveness compared to traditional rehabilitation methods.

These TEIs offer a promising way to support active rehabilitation at home. However, there have been fewer explorations in integrating psychological approaches that can enhance or complement tangible interactions. Therefore, critical evaluation and further research are essential to fully understand the interplay of TEI-based interventions with other potential interventions like mindfulness in designing stroke rehabilitation technologies.

2.5 Embodying Mindfulness and Tactile Sensations

Mindfulness is not an abstract idea that exists only in the mind. Through awareness of tactile sensations, it becomes an embodied concept that can be part of a tangible object interaction [20]. Touch, characterized by tactile sensations, is not only a visceral sensation but also has an affective aspect because of its association with emotions [12]. The heightened awareness of bodily functions plays a crucial role in regulating overall self-awareness and is closely linked to mindfulness and self-awareness practices as it involves paying attention to the subtle cues and signals from within the body [25].

Craig's research [7, 12] highlights the distinct neural pathways tied to interoceptive awareness (the ability to perceive and understand the physiological states of one's own body that are not externally visible, such as heartbeat, breath, hunger and temperature [12]), and imply that manual therapy approaches that disregard patients' inherent awareness of the body and responses to physiological stimuli limit the potential of therapy [12]. This observation begs for a deeper exploration of the interplay between touch and interoception while inviting a critical investigation into touch-based interventions informed by practices such as mindfulness that delve deep into interoceptive awareness [25].

Psychologist Mihaly Csikszentmihalyi [14] as well as Harvard neurologists [78] discuss the concept of psychic entropy which explains that mind-wandering is the natural mode of the brain. If this engagement is regulated and does not escalate into addiction (which indicates a loss of control over our focus), the same engagement can be harnessed to practice mindfulness [14, 59]. Researchers have explored mindful interaction approaches to address the challenges

Table 1: Participants and their expertise

ID	Category	Occupation/Area of expertise
P1	Clinician	Physiotherapist
P2	Clinician	Neuro physiotherapist
P3	Clinician	Physiotherapist
P4	Clinician	Musculoskeletal physiotherapist
M1	Mindfulness expert	Mindfulness therapist
M2	Mindfulness expert	Academic researcher in mindfulness
M3	Mindfulness expert	Long time mindfulness meditator and yoga practitioner
M4	Mindfulness expert	Yoga and mindfulness therapist

associated with psychic entropy [10] where practitioners deliberately engage in gradual, continuous, and gentle bodily movements over a prolonged period. Tai Chi, for instance, employs this method to alleviate stress and enhance concentration [10].

Through literature, it has been established that the awareness of tactile sensations is essential to re-forming the neural connections that were lost during stroke [15]. Body scan meditation is a popular technique of mindfulness meditation, which is also a core component of Vipassana (the origin of mindfulness meditation) [38]. During body scan meditation, the observer has to constantly observe the physical sensations without judgment.

Few researchers have ventured into creating technologies that blend mindfulness and tactile sensations. Vianello *et al.* introduced TANGAEON [70] attempting to integrate tactile sensations as part of mindfulness meditation, to enhance the practice. In a related effort, Cheng *et al.* created PAUSE, an application embracing mindful touch for interaction [10]. Madhan *et al.* explored the impact of mindfulness meditation on the enhancement of perception of mid-air haptic stimuli, through their MindTouch study [69]. In all these cases, deeper exploration was not carried out to investigate how we can really combine mindfulness and tactile sensations as part of an embodied technology and what can be the result of such an integration for stroke rehabilitation. This exploration requires a focused primary analysis of both these approaches, while also focusing on the combined aspects that affect the outcome of such an integration, both in principle and practice.

Our research addresses this specific gap in the literature – the lack of a unified approach that blends mindfulness with tangible technology for stroke rehabilitation. Though existing studies hint at this synergy, focused and extensive research is still missing. The review of current literature provides a unique opportunity for us to not only address this gap but also propose something novel at this intersection.

3 METHODOLOGY

3.1 Study Design

This two-phase qualitative study was structured to include the same participants in both phases. The study commenced with semi-structured interviews, delving into stroke rehabilitation complexities which informed the subsequent co-design phase. The co-design session aimed to collaboratively uncover design implications for combining mindfulness and tactile sensations.

3.2 Participants

A total of eight participants (6 female and 2 male) were recruited for the study, with a mean age of 33.5 years (See Table 1). The participants were divided into two categories: clinicians with experience in home-based stroke rehabilitation and mindfulness experts. Inclusion and exclusion criteria (See Appendix A.1) were employed to evaluate participants' eligibility for study participation.

3.3 Data Collection and Ethics

To conduct the interviews and co-design sessions, Microsoft Teams was used as an online platform. Eight participants took part in the first phase of the study, but two participants (one from each category) were unable to participate in the second phase. The interview structure (See Appendix A.2) was inspired by the guidelines set by Larry E. Wood and John M. Ford [77]. During the co-design sessions, the use of design probes (See Table 2) from existing research [41, 54, 59, 79] was incorporated to visually present and explain study concepts to the participants. We used NVivo software for the data analysis. The research obtained ethical clearance from the UCLIC Ethics Committee.

3.4 Procedure

Before beginning the study, each participant was given an information sheet and a consent form to read and sign online through the REDCap survey. The study was conducted online and in separate individual sessions with each participant.

3.4.1 Phase 1: Semi-structured interviews. Semi-structured interviews with clinicians were aimed to understand the general experience of the participants working with stroke survivors through their rehabilitation including the challenges faced, factors considered when formulating rehabilitation plans, success factors, the importance of mind-body connection, and their knowledge of technologies used in rehabilitation.

Mindfulness experts were interviewed to explore their experience and knowledge of mindfulness practice, the intricacies involved in its application, its potential use in therapy, and any encounter with technologies related to mindfulness. Additionally, they were asked about their familiarity with the application of mindfulness in therapeutic settings like stroke rehabilitation, seeking to uncover their perspectives on its efficacy as a therapeutic intervention.

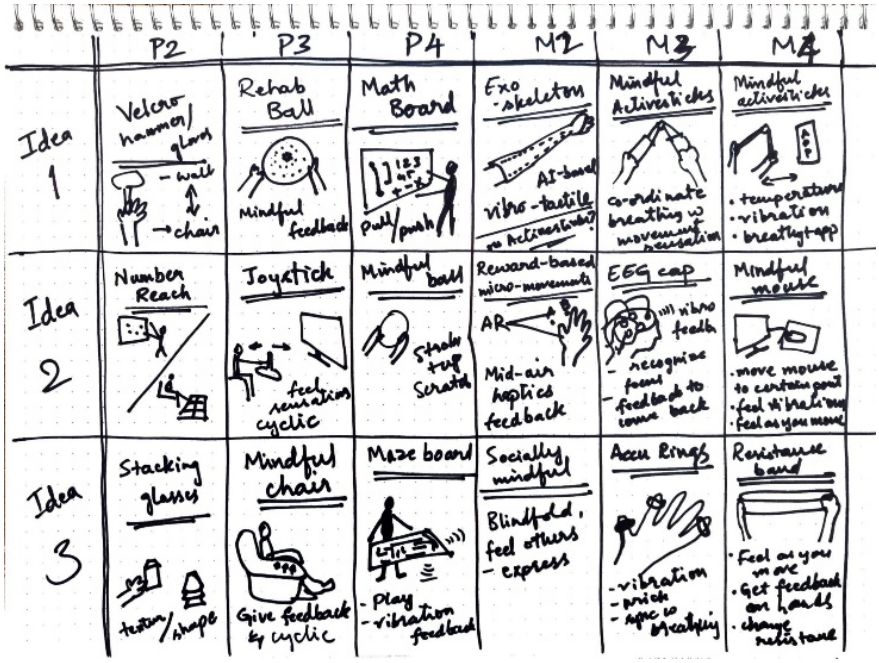


Figure 1: Participant sketches from the co-design session capturing design concepts for potential tools for stroke rehabilitation that combine mindfulness and tactile sensations.

3.4.2 Phase 2: Co-design. The co-design process followed a structured outline for both categories of participants (See Appendix A.3). Initially, participants were introduced to the project idea, accompanied by an explanation of the research questions and hypotheses followed by a brief brainstorming exercise to stimulate ideation and creativity. Subsequently, visual probes and design cues were provided with detailed explanations of each (See Table 2). For each probe, we followed the same procedure by first, introducing the goals of the reference paper and then showing the selected images along with a related explanation, followed by an explanation of the purpose of the technology shown in the images and their usage.

Following a break, participants engaged in a "crazy 8s" ideation exercise [29], generating distinct ideas that directly addressed the research question. Participants were asked to consider five critical factors: apparatus form factor, interaction technique, integration of tactile sensations, embodiment of mindfulness principles and an example scenario of its application. The subsequent step involved participants choosing and discussing their three most promising ideas from the pool of generated concepts, which generated 18 design ideas in the end (See Figure 1).

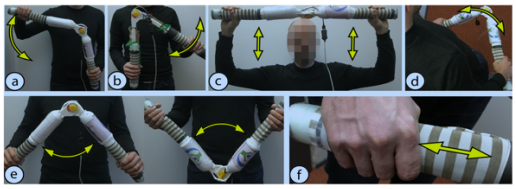
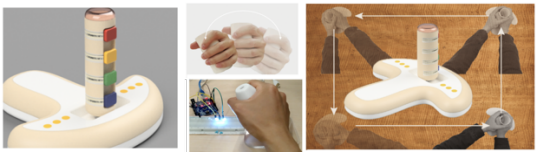
Use of design probes. We employed visual probes, drawn from research papers, to stimulate participants' thinking, provide inspiration for ideas and inform their designs (See Table 2). Each probe was carefully chosen to introduce the context progressively, covering technology design, vibrotactile feedback, gamification, and mindful interaction styles. While the same probes were used for both clinicians and mindfulness experts, the explanations varied based on their expertise.

While clinicians were skilled in stroke rehabilitation techniques, they had limited exposure to technology design and mindfulness interaction styles. The focus for them was on demonstrating how the design of stroke rehabilitation technology could incorporate tangible elements and mindfulness interactions. Mindfulness experts gained insights into the scientific aspects of stroke rehabilitation exercises and technology integration of mindfulness, aiming to bridge knowledge gaps effectively.

3.5 Data Analysis

The data analysis was carried out in a six-phase reflexive thematic analysis approach as explained by Braun and Clarke [5], examining both textual and visual data from the interview and co-design studies. We adopted a critical, constructivist approach, transitioning from an initially semantic to a more latent orientation of analysis. Interview data analysis involved analysing the transcripts and co-design data analysis involved evaluating participants' sketches representing ideas for novel tangible stroke rehabilitation technology (see Figure 1). Initially, we generated a few hundred codes and after a few rounds of re-coding, we ended up with around 120 codes. These codes were organized into nine themes to begin with, which finally ended up being five overarching themes with some of them having sub-themes. Participants' confidentiality was maintained by using identifiers and professional categories. By leveraging both qualitative data streams, the study's insights were strengthened, resulting in robust themes and design principles backed by a thorough exploration of research questions. It also reduced researcher bias, enhancing the validity of the data.

Table 2: Design probes

Probe Source	Pictures shown with explanation
Kytö, M. et. al, 2019. Using Both Hands: Tangibles for Stroke Rehabilitation in the Home. [41]	 • To show how bimanual movements can be supported through rehabilitation technology at home by gripping V-shaped device to perform hand, shoulder and wrist abduction, adduction, flexion and extension movements. Components used: a school compass, Styrofoam, and pressure-sensitive fabric. • For physiotherapists, this introduced how rehabilitation technology can be designed. • For mindfulness experts, this introduced types of rehabilitation exercises.
Yang, Z. et. al, 2018. Tangible Interactive Upper Limb Training Device. [79]	 • To show an example of rehabilitation technology that supports Upper Limb (UL) range of motion exercises through turning the joystick to practice wrist rotation, gripping, adduction, and abduction movements. • The design also incorporates visual (LED lights) and vibrotactile feedback.
Ozgur, A.G, et. al, 2018. Iterative Design of an Upper Limb Rehabilitation Game with Tangible Robots. [54]	 • To show an example of rehabilitation technology that gamifies the experience of exercising while also retaining the key elements of physiotherapy. • Users play a Pacman game by physically holding and moving the miniature robots through the maze board while collecting points along the way. The progress is indicated through LED indicators and vibrotactile feedback from the robots.
Vincent van Rheden and Bart Hengeveld. 2016. Engagement Through Embodiment: A Case For Mindful Interaction. [59]	 • To show example of a technology designed to support mindful interaction style through the tactile sensations that users feel on their palm/fingers. • The single button press style of interaction on a regular hand blender is replaced with multiple ways (using a thread, using a small stick or a spring action), so users can only turn the blender on upon applying a certain amount of pressure (which they are unaware of) on the thread or the stick or the spring (turn, push or pull actions).

4 RESULTS

In this section, we delve into the findings derived from this study, organized into five overarching themes (see Figure 2). Main themes are indicated in bold text and sub-themes in regular text. A strong link between themes is marked in bold lines and a weak link is marked in dotted lines. The sub-themes are linked to the main themes through thin lines.

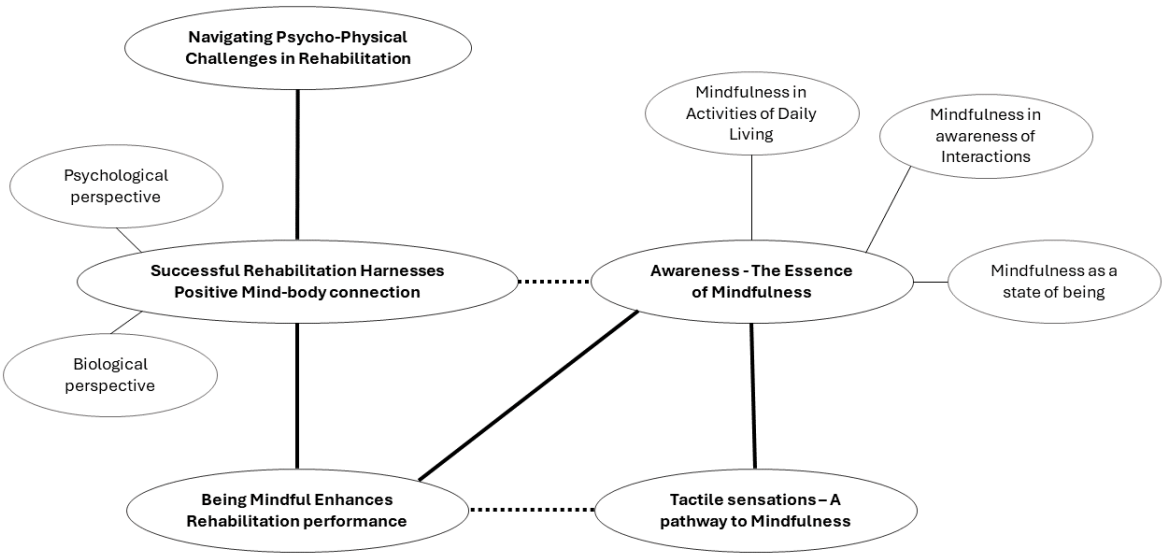


Figure 2: Thematic diagram showing the relationship between themes

4.1 Navigating Psycho-physical Challenges in Rehabilitation

In this theme, we can see the fusion of psychological and physical aspects of stroke rehabilitation that participants grapple with in their experience. Through participant accounts, we gain a deeper understanding of the multifaceted nature of rehabilitation while also exploring the interaction between mental as well as physical hurdles, shedding light on how they collectively impact the rehabilitation journey. The stories illuminate challenges arising from physical pain, motivation lapses, distractions, boredom, the extended rehabilitation journey, and the weight of slow progress in an extended home-based setting for stroke rehabilitation. Together, these factors underscore how psychological hurdles significantly affect rehabilitation.

"Most times the pain is physical, but many times it is also in the mind. There is soreness and extreme pain in the affected limbs." (M4)

"Mentally they are all very demotivated because they will still be in shock that this (stroke) happened to them. The exercises are very repetitive, and they get easily bored" (P2)

4.2 Successful Rehabilitation Harnesses Positive Mind-body Connection

This overarching theme highlights the role of synchronized mental and physical elements in leading to positive effects for rehabilitation. Participants consistently emphasize that a positive mind-body connection is not just an excellent idea but a practical asset in recovery. This theme is not limited to individual stories—it's a collective insight woven throughout.

"If you are not mentally ready to work towards recovery, then your body will not cooperate." (P4)

4.2.1 Biological perspective of mind-body connection. This subtheme specifically tries to uncover the physical perspective to look at factors affecting recovery and how they can be harnessed. The phenomenon of the reflex arc and the importance of enhancing both the sensory and motor abilities of stroke survivors was discussed.

"In medical terms, we call it reflex arc, which is like a cycle where patients perceive the touch, and the brain gets that signal and responds back. This connection is what we aim to enhance in treatment" (P4)

4.2.2 Psychological perspective of mind-body connection. This subtheme offers the psychological perspective of participants about mind-body connection through concepts like self-compassion, acceptance, and emotional support which contribute directly to physical improvement. It highlights the mind's capacity to fuel determination and perseverance, ultimately shaping the body's response to the rehabilitation process.

"Self-acceptance is really important. Also self-compassion. These are especially critical." (M1)

"Stay positive, I say during every session. I tell them inspiration stories and show them videos of other patients who are in a good recovery." (P2)

Participants also mentioned the impact of external factors such as knowledge of the rehabilitation process, familial support and motivation in nurturing the positive mind-body connection.

"One of my patients, had a very supportive wife. She would push him and support him so much that she would use any means to help him" (P3)

"Once patients understand what is happening in each exercise, this knowledge made a lot of difference" (P2)

4.3 Being Mindful Enhances Rehabilitation Performance

This theme highlights participants' discussions about the impact of mindfulness in stroke recovery, drawing from their personal experiences and expertise. While mindfulness experts consistently showed confidence in the role of mindfulness meditation and its impact on enhancing rehab performance, clinicians also recounted instances where stroke survivors showed improved performance after starting mindfulness meditation practices or simply being more attentive and mindful during exercises. They also mentioned how focusing on sensory triggers positively affected rehab performance. Through these participant narratives, this theme sheds light on the profound link between mindfulness and enhanced rehabilitation outcomes. It underscores the significance of integrating mindfulness practices to improve the rehabilitation process after a stroke.

"Now (through daily meditation) it made a big change in his rehab. [. . .]. It really made a lot of progress" (M1)

"When they do mindfulness meditation, and when they do rehab exercises, their reflex arc improves. That is the core of rehab process. There is a clear direct effect on the rehab." (P1)

4.4 Awareness – The Essence of Mindfulness

Emphasis on awareness emerges as the highlight in every discussion around the concept of mindfulness with our participants. The crux of mindfulness, as understood in this context, revolves significantly around the concept of heightened awareness. In essence, this theme encapsulates the fundamental principle of mindfulness as a heightened and conscious state of being aware.

"Mindfulness is being aware of the present moment [. . .], so not just the present moment, but in terms of more awareness towards the experience." (M1)

4.4.1 Mindfulness in Activities of Daily Living. Within this subtheme, participants shed light on the integration of mindfulness into activities of daily living, which enhances the rehabilitation process. They provide numerous real-life examples illustrating how mindful awareness can be seamlessly incorporated into tasks such as eating, drinking, and interacting with everyday objects. Participants emphasized the importance of comfort provided by a home-based setting for rehabilitation, as crucial for fostering mindful awareness in daily activities. They also highlighted the potential of awareness to become mindful by stressing the fact that mindfulness need not be restricted to a meditative session but can be part of all activities that we do.

"You are eating, you are drinking, you are cooking, whatever you might be doing, you can still be fully aware in all of that. Mindfulness need not be a separate thing like meditation, different from your actual real life" (M3)

"He used to find and do physio exercises using objects just lying around at home. For example, once he showed how he can now open an umbrella [. . .] Another time he showed me he could push a chair [. . .]" (P4)

4.4.2 Mindfulness in Awareness of Interactions. Participants highlighted that we could practice being mindful through interaction with our surroundings. Specifically, they emphasize being fully aware of sensory experience while doing any interaction with intention, no matter how subtle it is. They talk about paying attention while touching, tasting, watching, or talking allowing oneself to be more mindful.

"When you eat, try paying attention to the subtle flavours, the dryness or wetness of food or even the temperature, see what difference it makes. Now that is mindfulness" (M4)

Mindfulness is also in interacting with people and nature. When we listen closely and respond thoughtfully, it changes usual conversations into something deeper. We can see nature's patterns—rustling leaves, sunlight's dance—and feel connected.

"When you talk to people, some people are just looking somewhere else, but some are actually paying attention to what you say, looking into your eyes? It all makes a difference. This is also how one can be mindful" (M3)

"[. . .] to go outside and feel the weather or touch the grass or whatever or attach themselves with nature stuff. Nature has a strong power on us people." (M2)

4.4.3 Mindfulness as a State of Being. This sub-theme offers a unique perspective on mindfulness, which is different from other sub-themes discussed above. Here, mindfulness is seen as a way of being rather than doing. It is about having a certain mindset. This mindset includes elements like being aware without judgment, accepting oneself, and being aware of the present moment. Mindfulness, for them, can be like a way of living.

"I realised not only cognitively, but feeling it, that I'm much bigger than thinking, feeling and physical sensation. It (mindfulness) becomes the way I am" (M2)

4.5 Tactile Sensations – A Pathway to Mindfulness

This theme digs into how what we think in our thoughts and what we feel through touch blend in mindfulness. At the core, this theme bridges the gap between thoughts and tactile sensations. Participants' experiences show that focusing on what we feel through touch is a doorway to experiencing our inner thoughts. This back-and-forth interplay is a pathway to practicing mindfulness.

"When I observed my thoughts, it was so distracting. I couldn't. Then eventually when I started to observe my sensations, I could observe them more easily [. . .] In some time,

I realized experientially that my bodily sensations are nothing but my thoughts [. . .] When pain on my neck disappeared, some other thought which was constantly bothering me had just vanished. [. . .]" (M3)

"It is all underpinned by the sensory experience, like everything is connected to each other all are connected to the sensory modalities. So and without the sensory modalities, there are no input to the brain at all." (M2)

"Everything in this world is vibrating. Even sensations are also vibrations. What are thoughts? They also are just manifestations of those vibrations" (M4)

The connection between thoughts and sensations is a foundation of mindfulness. It urges users to explore the fusion of inner thoughts and outer sensations, opening doors to heightened awareness and understanding. This theme highlights the unity of these aspects and their potential in discussing the implications of our research.

5 KEY DESIGN PRINCIPLES OF 'MBETI' FOR STROKE REHABILITATION

The contribution of this research lies in the pioneering concept of Mindfulness-based Embodied Tangible Interactions (MBETI) for stroke rehabilitation. Rooted in the comprehensive findings of this study, MBETI represents a ground-breaking approach that blends mindfulness practices and embodied tangible technology. The design principles explained within this section emanate directly from the empirical insights gathered, ensuring that they are firmly grounded in the real-world experiences and perspectives of clinicians and mindfulness experts.

5.1 Design for Comfort

The design of technology for stroke rehabilitation should prioritize the comfort of users as a fundamental aspect. This principle holds particular significance within the context of designing MBETI because our empirical findings in the theme 'Navigating Psycho-physical challenges in rehabilitation' highlight the multifaceted challenges encountered during the rehabilitation process. This observation directly implied the necessity and importance of comfort — from both physical and psychological perspectives — while designing MBETI for stroke rehabilitation and gave way to this design principle where designing for user comfort serves as a foundational consideration.

Moreover, when it comes to home-based stroke rehabilitation, ensuring comfort becomes even more crucial. The primary advantage of conducting rehabilitation at home lies in the comfort that the home environment affords. Therefore, in the development of MBETI technologies tailored for home-based stroke rehabilitation, the principle of prioritizing user comfort takes precedence.

Embrace Familiarity. An essential design strategy to build comfort is incorporating elements of familiarity in the form factor of the technology. Integrating shapes, forms, and gestures of everyday life can resonate deeply with the user's existing experiences. Our research underscores participants' recurrent references to utilizing familiar objects like umbrellas and chairs in the rehabilitation process. This trend is further echoed in the concepts they developed during co-design sessions using objects like balls, rings, joystick and sofa.

Offer Customization. Customization plays a pivotal role in enhancing user comfort. Adapting exercises and interactions to personal preferences comforts users, easing apprehensions and granting control. Such customization aligns with our findings, as clinicians and mindfulness experts stress the use of personalized rehabilitation plans for patient-specific needs.

5.2 Design to Promote Practice and Motivation

The significance of this design principle is amplified in MBETI's design due to the challenges of sustained engagement in both physical exercises and mindfulness practice. Particularly in home-based rehabilitation, the challenge of maintaining motivation for consistent practice over the prolonged rehabilitation period was a recurring theme in our study. Participants often highlighted the obstacle of demotivation, stressing the importance of practice for the success of both mindfulness and rehabilitation exercises.

The theme 'Navigating psycho-physical challenges in rehabilitation' underscored the significance of providing effective strategies to overcome the hurdles encountered during the rehabilitation journey. Additionally, the theme 'Successful rehabilitation harnesses positive mind-body connection' highlighted the critical role of motivation in achieving success in rehabilitation exercises. These key insights from our study directly informed the formulation of this design principle focusing on promoting practice and motivation in MBETI's design.

Foster Consistent Practice. To encourage practice, aligning the rehabilitation journey with user-specific goals is vital, necessitating a user-centred approach. Our findings as proposed by participants during the co-design session suggest that utilizing rewards achievable through repetitive performance or visual cues of goal progress can be used as methods to foster practice.

Infuse Motivational Elements. Given the repetitive nature of rehab exercise and mindfulness practice, demotivation is a common challenge. Therefore, integrating motivational elements into the design becomes not only beneficial but imperative. Game-like features and integration of wearables or interactive components tap into users' inherent desire for achievement and progress, making rehabilitation exercises more interactive and enjoyable.

5.3 Design to Support Mindful Awareness

The essence of awareness is a shared element in both mindfulness and tactile sensations, underscored through this principle. When crafting MBETI for stroke rehabilitation, the design should facilitate users' mindful awareness during interactions by integrating elements that support users to be mindfully aware while performing rehabilitation tasks.

The theme 'Being Mindful enhances rehab performance' highlighted how mindfulness positively influences rehabilitation, and the theme 'Awareness-The Essence of mindfulness' emphasizes the central role of awareness in mindfulness practices. These themes

directly inspiring the creation of this design principle. When designing MBETI for stroke rehabilitation, it is crucial to integrate mindful awareness as a fundamental aspect, ensuring that users experience thoughtful and awareness-enhancing interactions during rehabilitation tasks.

Incorporate Sensory Feedback. A well-designed feedback loop confirms the technology's functionality while guiding users to become mindful by focusing on their sensations, leading to heightened awareness. Our findings consistently highlight the significance of tactile feedback in mindfulness and rehabilitation, evident in participants' design ideas during co-design sessions (See Figure 1). Examples include a math board requiring users to manipulate strings to perform calculations with feedback in the form of pressure on the hands felt through strings, or gloves emitting subtle vibrations with each finger movement, serving as confirmation prompts.

Implement Supportive Cues. As part of the feedback, cues act like embedded support systems that are integrated into the design of the technology. They encompass tactile, visual, or auditory elements, tailored to specific contexts. Participants highlighted cues supporting breathing exercises or finger and hand movements (See Figure 1). For instance, a participant mentioned an app featuring visual cues to assist in breathing, accompanied by a tangible device emitting subtle vibrations to signal incomplete breathing.

5.4 Design to Highlight the Interplay of Thoughts and Sensations

An essential aspect of MBETI design involves emphasizing the connection between thoughts and sensations. This integration is crucial for users' rehabilitation journey, requiring a design approach that highlights this relationship. The significant link between mind and body in stroke rehabilitation is supported by our study findings and requires a thorough understanding of how thoughts influence bodily sensations and vice versa.

The themes 'Awareness-The Essence of mindfulness' and 'Tactile sensations-A Pathway to mindfulness' directly shaped the formulation of this design principle. Serving as the backbone of our research, these themes establish a unique connection between the awareness of tactile sensations and mindfulness, which is the distinguishing feature of MBETI. Therefore, this design principle underscores the need to harness and emphasize the interplay between thoughts and sensations by recognizing and leveraging the interconnected nature of thoughts and sensations throughout the design process.

Visualise the unity of thoughts and touch. The design's focus should be on creating interactions that vividly portray the relationship between thoughts and tactile sensations. Users develop a heightened awareness of how their mental focus affects their bodily feelings through exercises and activities that illustrate this correlation. Visual depictions, such as interactive graphics or animations, can illustrate the interdependence of thoughts and touch. Understanding the impact of exercises on rehabilitation has been indicated by our participants as a success factor.

Explore multisensory engagement. Design should incorporate multisensory engagement to enhance the connection between thoughts and sensations. By adding auditory or visual elements that complement tactile sensations, a mindful experience is created, deepening the connection between mental awareness and physical sensations. Integrating multiple senses offers a richer interaction, encouraging users to engage more profoundly in their exercises.

5.5 Design to Foster Progress Tracking

The MBETI design should include mechanisms for users to monitor their rehabilitation advancements. By offering a comprehensive view of progress, the design empowers users to track their growth and remain motivated throughout their journey.

The themes 'Successful rehabilitation harnesses positive mind-body connection' and 'Navigating psycho-physical challenges in rehabilitation' directly influenced shaping this design principle. Emphasizing the importance of various motivational factors, these themes highlighted progress tracking as a key element. In designing MBETI for stroke rehabilitation, this principle emphasizes the critical role of progress tracking as a direct strategy for user motivation, empowering them to monitor advancements throughout their journey.

Integrate Progress Monitoring. The design should integrate a system for monitoring both physical and mindful progress. A dashboard or interface can display data related to both dimensions, allowing users to visualize improvements. Participants' design ideas (See Figure 1) underscore the importance of progress monitoring, such as colour-changing rings indicating exercise stages or apps displaying hand movement progress through data obtained from embedded sensors.

Imbibe Personalised Milestones. Enabling users to set personalized milestones is essential. The design should permit users to establish achievable goals for exercises and mindfulness. These tailored milestones celebrate small victories, fostering accomplishment and motivation.

6 DISCUSSION

Our findings suggest a promising integration of tactile sensations and mindfulness, offering a potentially beneficial approach to support stroke survivors. These findings contribute to the growing body of knowledge in the field and provide insights into the potential benefits of this innovative approach.

6.1 Mindfulness has Different Facets and each can be Harnessed in Designing MBETI

From this study, a clear lesson which emerges is that mindfulness is multifaceted. This corroborates with existing literature [64] that defines mindfulness from diverse angles. Additionally, our research reveals that these viewpoints present distinct opportunities to integrate mindfulness into technology design. While our study focuses on mindfulness as an interaction style, it also validates other aspects such as mindfulness as a mindset and philosophy. Empirical data reinforces these dimensions, expanding the understanding of mindfulness's applicability in design.

6.2 Embodying Mindfulness and Tactile Sensations Through Awareness

Our main research question was about how mindfulness and tactile sensations can be combined, stemming from our knowledge and understanding of existing literature. Through this research, we discovered the importance of awareness which is a common denominator to both mindfulness and tactile sensations. Literature often treats mindfulness and tactile sensations separately, aiming to enhance either one by using the other. However, our research uncovers a distinctive insight that awareness can serve as a unifying factor. The emerging themes from our findings strongly emphasize this discovery.

While in literature, awareness is explained through concepts like interoception [12] and mental awareness [25] none of them delve into looking at awareness as a medium to combine mindfulness and tactile sensations. This is unique because this effort bridges the mental and physical aspects of embodied technology which is relatively unexplored. The design ideas by participants clearly underscore this while the empirical data supports this unique role of awareness.

6.3 Are Thoughts and Sensations Really Connected?

This is the most important finding of this research where the empirical evidence supports the argument that our physical sensations on the body are nothing but the manifestations of our internal thoughts. While this notion may appear beyond the scope of empirical science, our experienced participants in mindfulness have expressed confidence in this idea, forming a foundation for our design implications. Though there is tangential literary evidence, as seen in the interoceptive awareness [25], further exploration and validation are necessary before making generalized claims due to the study's nature and constraints.

6.4 Design Implications

We envision our findings as the start of a foundation for a nascent field of technology, which we call Mindfulness-based Embodied Tangible Interactions (MBETI), which emerged from the empirical evidence and design principles rooted in this paper. Our findings converge into a meta-abstraction i.e. focusing on the key aspects of a new class of technologies for the creation of tangible and accessible rehabilitation tools that seamlessly embody mindfulness and tactile sensations into the design of stroke rehabilitation technology. These 'meta-abstractions' were first defined by Sas *et al.* [62] and should normally build on a larger set of data than we possess. However, as a foundation for these meta-abstractions, we propose the first instantiation for this area. In doing so we explain the design implications by envisioning design concepts as instantiations which provide further insight into how we can use the findings from this study to inform future designs.

Using this approach, we can imagine examples of potential instantiations for MBETI-based technologies for stroke rehabilitation, inspired by the participant ideas from the co-design session (Figure 1) such as 'Mindful Rehabilitation Ball', 'Tactile Game board' and 'Mindful Rehabilitation glove'. Envisioned as conceptual devices, their design could feature various familiar shapes like a ball, a game board, and a glove respectively. These devices could be equipped to emit vibrotactile sensations and have embedded sensors to measure movements, specifically tailored for bimanual upper limb rehabilitation. By virtue of design, these concepts show great potential to imagine various targeted physiotherapy exercises while also promoting mindful interaction styles. Users could engage with them in controlled movements, potentially synchronizing breath awareness along with physiotherapy exercises, aligning with the envisioned principles of MBETI. The feedback mechanisms could provide users with cues on their movements, varying based on the intensity and duration of vibrotactile sensations. The feedback could also be complemented by visual or audio-visual elements like scores, charts, or colours, enhancing the rehabilitation exercise experience.

These concepts are based on the MBETI principles of 'Design to support mindful awareness' and 'Design to Promote Practice and Motivation' while drawing inspiration from the themes 'Mindfulness in Awareness of Interactions' and 'Tactile Sensations, a Pathway to Mindfulness'. The familiar shapes such as the ball, the board and the glove could contribute to potential user comfort, echoing the theoretical principle of 'Design for Comfort.' The adaptable and home-friendly conceptual devices could seamlessly integrate into daily activities, theoretically aligning with the sub-theme 'Mindfulness in Activities of Daily Living.' Incorporating speculative gamification elements, and leveraging the imagined playful nature of the shapes, they might have the potential to enhance motivation. A gamified feedback mechanism, if implemented, could theoretically promote consistent practice and progress tracking, embodying mindfulness as an essential part of the technology.

The provided examples serve as a guide for future designs embodying MBETI design principles. Future work can involve ideating further along these lines and following a systematic design process to build practical rehabilitation technologies that align with the principles of MBETI for stroke rehabilitation.

6.5 Limitations and Future Directions

While our study has yielded intriguing insights, it was not without its share of challenges. Initially structured in three phases, the study aimed to include feedback from stroke survivors in the final phase. However, ethical constraints compelled us to limit the study to the first two phases, leading to the truncation of the third phase. Conducting asynchronous and individual online co-design was challenging, limiting participant interactions, and potentially impacting the richness of ideas generated. With a restricted participant pool of eight individuals engaged in two intensive sessions each, generalizability remains an aspect for further exploration.

In future stages, the concept of MBETI could be solidified through a progressive approach, aligning with the initial project plan. The next phase could realize the final phase of this project, by conducting a comprehensive user study involving individuals undergoing home-based stroke rehabilitation to obtain a deeper understanding of user needs, while validating the perceived benefits of MBETI-inspired technologies. Building on these insights, the project could advance to the conceptual design phase, where a stroke rehabilitation device would be ideated and prototyped in several design

iterations in accordance with the design principles articulated in this paper.

The developed prototype, designed based on MBETI principles, could undergo iterative refinements in collaboration with mindfulness experts, physiotherapists, and stroke survivors. The involvement of clinical experts and physiotherapists would ensure a thorough evaluation, to obtain necessary clearance before approaching the assessment phase. The conclusive phase could involve evaluating the prototype with stroke survivors, guided by physiotherapists and mindfulness experts to assess its impact on stroke rehabilitation progress. This systematic approach not only aims to validate the MBETI concept through quantitative evidence but also substantively contributes to the evolution of MBETI, offering a meaningful culmination to the endeavours of this project.

7 CONCLUSION

In the context of stroke rehabilitation, we have explored the potential of combining mindfulness and tactile sensations. Our research aimed to understand how these elements can address rehabilitation challenges and be integrated into embodied tangible technology. The emerging themes revealed the connection between psychological and physical aspects, the unity of mind and body, and the role of awareness in combining mindfulness and tactile engagement. These insights led to practical design principles such as prioritizing user comfort, encouraging regular practice, infusing motivation, and emphasizing the interaction between thoughts and sensations in design. The study culminated in developing the concept of Mindfulness-based Embodied Tangible Interactions (MBETI) that could reshape stroke rehabilitation. The next step involves developing a tangible prototype to validate the potential of MBETI. In conclusion, the convergence of mindfulness and tactile sensations within MBETI holds the promise of a future where rehabilitation transcends obstacles of current approaches and empowers stroke survivors worldwide.

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A APPENDICES

A.1 Participant Recruitment flyer

Title of Study: Mindfulness-based Embodied Tangible Interfaces for Stroke Rehabilitation at Home

We are recruiting 3 categories of participants based on the following criteria:

Category 1: Clinicians with experience in Stroke rehabilitation
Inclusion criteria:

- Age over 18
- Someone who has experience working with stroke patients through their rehabilitation
- A physician, rehabilitation therapist, physiotherapist, occupational therapist, neuropsychologist or nurse.
- No particular expectation of number of years.

Category 2 : Experts in mindfulness

- Age over 18
- A long-time mindfulness (at least one year) meditator or yoga practitioner or a researcher or expert in the field of mindfulness.

Common exclusion criteria for all categories:

- The participant should not have any chronic cognitive impairment such as Alzhimers that can hinder the person's ability to understand the research and provide informed consent.

Interested participants are please requested to contact the following contact details:

A.2 Interview outline

Outline for semi-structured interviews for

Mindfulness-based embodied tangible interfaces for stroke rehabilitation at home
Type: Individual interview (semi-structured)
Location: Online
General Disclaimer: These interviews are aimed to be semi-structured. Therefore, the questions mentioned below define the rough structure and idea of the interview. During the interview, the idea is to have flexibility to change the order of these questions or add or change some questions based on the responses from participants.

For interview with Clinicians (Physiotherapists, rehabilitation specialists, neurologists, etc)
Introduction

- Welcome
- Introduction to the idea of the project
- Introduction from participant about their relevant background and experience
- The consent form, FAQ

Rehab process at home

- How much time would it usually take to complete rehab, as per your knowledge, for survivors who undergo rehabilitation at home?

Types of treatments

- What factors do you consider while prescribing a treatment plan to a stroke patient for home-based rehabilitation?
- In your experience have any particular treatments/exercises worked better over others?
- If so, why do you think might be the reasons for their success?
- How is the progress monitored or measured?
- How important do you consider the mind-body connection in your provision/practice?

Discussion

- What are the major problems you have observed in stroke patients undergoing home-based rehabilitation?
- In your experience, has the use of any particular technologies/devices proven effective in home-based stroke rehabilitation?
- How important do you think is the role of tactile sensations for a stroke rehabilitation device?

For interview with Mindfulness experts (Mindfulness meditators, yoga therapists, academics in mindfulness research, etc)
Introduction

- Welcome
- Introduction to the idea of the project
- Introduction from participant about their relevant background and experience
- The consent form, FAQ

Mindfulness and therapy

- What is your idea of mindfulness?
- In your knowledge and experience being a mindfulness practitioner, what changes/benefits have you observed in yourself or others in practicing mindfulness?
- Have you come across any therapy or rehabilitation programs that are based on mindfulness?

- Do you consider the mind-body connection in your provision/practice?

Mindfulness and technology

- Have you encountered any technologies that incorporate mindfulness?
- What do you think about the relationship between mindfulness and tactile sensations?

Discussion

- What do you think are some of the major challenges in doing mindfulness meditation?
- What are some of the major challenges in teaching/delivering mindfulness based therapies/programs?

A.3 Co-design outline

Outline for a co-design workshop on

Mindfulness-based embodied tangible interfaces for stroke rehabilitation at home

Type: Co-design workshop

Location: Online

General Disclaimer: These sessions are aimed to be semi-structured. Therefore, the questions mentioned below define the rough structure and plan of the co-design. During the session, the idea is to have flexibility to change the order of these questions or add or change some questions based on the responses from participants.

Primary research question:

- "How might we design a novel technology for home-based stroke rehabilitation that combines the principles of mindfulness and tactile sensations?"
- "What are the design implications of embodying principles of mindfulness in a tangible stroke rehabilitation technology in enriching the rehabilitation experience?"

Principles:

- Participatory design, speculative design.

Participants:

- 4 x clinicians with experience in stroke rehabilitation
- 4 x mindfulness experts

Structure (Separate individual sessions with each participant):

Section	Description
Introductions & Ice Breaker	• Brief overview of why we are here • Reiterate consent rights and recordings • Run a short ice breaker exercise to ease up participants (in case of group workshop)
Defining Contexts	• Define the key concepts of the project – Mindfulness, Tangible interfaces (tactile sensations) and stroke rehabilitation • Explain the interplay between these concepts • Explain the goals of the study • Explain the research questions
Design Inspirations	• Explain some of the existing technologies in research that is closely related to the topic: • ActiveSticks • T-shape device • Robot-Pacman game • Mindful blender • • Prompt participants to identify: • Apparatus form factor • Interactions • Mindfulness • Tactile sensations • Scenario
Break	• 10 min
Rapid ideation and brainstorming	• Reiterating the research question and goals • Participants will play a 'Crazy 8s' rapid ideation session in which each participant has to come up with 8 distinct design ideas/scenarios in 8 minutes. • Researcher shall facilitate the time and explain the rules • Participants can ask questions before starting the session
Sharing Ideas	• Each participant shares 3 of their best ideas
Discussion & Conclusion	• Offer space for Q&A, further questions, feedback on both the ideas and experience.
END	