# SpanAbility Design Brief

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**Problem Statement/Research Question and Background**

Stroke is the fifth leading cause of death in the United States, and every year, more than 795,000 people in the United States have a stroke ("Stroke Facts", 2020). A stroke occurs when there is insufficient blood flow to the brain, either through a blocked blood vessel (ischemic stroke) or trauma that causes bleeding in the brain (hemorrhagic stroke). The most common type of stroke is an ischemic stroke of the middle cerebral artery (MCA) (Navarro-Orozco & Sanchez-Manso, 2019). The MCA supplies the parietal lobe of the brain, which is involved in integration of sensory information. When a stroke affects the parietal lobe, spatial neglect can occur in about 50% of stroke patients acutely (Vallar & Calzolari, 2018). The resulting hemispatial (or unilateral) neglect is when a person does not attend to sensory information in one half of their visual field.

Unfortunately, hemispatial neglect is indicative of poorer rehabilitation outcomes (Oh-Park, Hung, Chen, & Barrett, 2014). However, recent research has investigated the efficacy of virtual reality (VR) in stroke rehabilitation for hemispatial neglect. VR is a computer simulated experience that mimics the real or imaginative world. A person can be completely immersed in an environment and navigate through the system by moving their body. Currently, the literature suggests that there is potential for VR to have an impact on rehabilitation outcomes for patients with hemispatial neglect (Lloréns, Noé, Colomer, & Alcañiz, 2015). VR is a useful resource for assessment and treatment purposes and is often beneficial when a real-life context/environment is unsafe or inaccessible (such as during a hospital stay). Although some studies have produced mixed results, a large limitation of these studies is due to the lack of similarity/generalization to real-life contexts. The VR games in these studies are fairly rudimentary and bulky, boring, and irrelevant to daily life activities. This suggests that, in order to fully evaluate the effectiveness of VR in stroke rehabilitation, the games need to be improved significantly (Ogourtsova, Silva, Archambault, & Lamontagne, 2017; Tsirlin et al., 2009). Therefore, SpanAbility is seeking to address these limitations by creating VR games that can be used in rehabilitation which are realistic, motivating, relevant, and engaging for patients. Our goal is to improve a patient's functional independence in daily life activities, quality of life, and safety during rehabilitation. Additionally, we want to expand on our product by creating toolboxes for different diagnoses such as PTSD, anxiety, autism, and chronic pain.

**Methods/Approach/Solutions Considered**

After initial brainstorming and filtering through our ideas, we chose the best three ideas to explore in further depth. These three design ideas were scanning glasses, virtual reality, and augmented reality.

Our idea for scanning glasses was to design glasses that could be worn by hemispatial neglect patients to ensure their safety in public spaces. The desired outcome of the scanning glasses is increased safety for users as they go about their daily routines. Our design utilized sound and light sensors to detect objects or people in close proximity to the user, particularly in

the neglected space of the user (most commonly the left side). After detection of the stimulus, the sensors would deliver a signal to the user indicating the presence of an entity in their neglected side of space through a combination of haptic and sound feedback. For our design, we intended to use Arduino parts to attach sensors to glasses and connect them to a feedback system. However, this approach requires a high level of expertise in electronics as well as a thorough understanding of sensory feedback. Due to the high complexity of such an approach combined with little clinical research to indicate the effectiveness of such a design, our team decided to pursue an alternative design that suited our strengths better.

The next two approaches we considered are Virtual Reality (VR) and Augmented Reality (AR). Using either VR or AR, our design centered on a game that keeps the patient engaged while requiring the patient to interact with their neglected side of space through actions in the game. We initially began brainstorming games with both technologies. However, AR requires a physical external environment to be set up in addition to designing a virtual game. On the other hand, VR only requires a virtual game to be designed. VR appeared as the best choice because it is the least complicated to set up for use, which promotes the flexibility of our rehabilitation game to be administered in a variety of settings.

Once our team decided on a VR-centered rehabilitation game as our solution, we brainstormed potential designs for the game. After considering the demographic of stroke patients and literature on virtual-reality based rehabilitation, our team decided on creating a game with different scenarios that simulated every-day actions. This was based on data indicating that in general, hemispatial neglect patients found games that were too far removed from reality to be mundane and seemingly pointless at times (Tobler-Ammann, Surer, Knols, Borghese, & Bruin, 2017). We found that this approach fulfilled our objectives for inexpensive and effective rehabilitation while improving upon the flaws of previous VR-based rehabilitation games.

**Description of Final Approach and Design**

With virtual reality (VR) as our primary method for rehabilitation, we focused on addressing the problems that plagued previous attempts at developing VR-focused rehabilitation methods, such as shallow or elementary gameplay. Our games will provide motivation and incentive through engaging gameplay, difficulty progression, and an immediate feedback system that will reward patients for improvements in their neglect while indicating areas for improvement. We aim to develop a rehabilitation program that is appealing to a diverse demographic with a primary focus on prolonged interest and engagement. In short, the rehabilitation games should not *feel* like rehabilitation.

With this in mind, we have developed rich environments that mimic the real world. For example, we have created a kitchen environment with various cooking tools and machines that the patient can interact with, just as if it was a real kitchen. One assessment game we have in this scenario is a chopping game where the patient grabs a knife and does their best to split a vegetable, such as a cucumber, in half. The patient has the flexibility to choose whichever knife or vegetable they want to cut, which makes the game less monotonous and repetitive. Additionally, depending on how close the patient was to cutting the vegetable in half, a quantitative score will be calculated to give feedback as well as incentivize the patient to try

harder. In the future, we plan on implementing a difficulty system that increases the complexity of the games and a time requirement, such as cooking entire recipes in 30 minutes in the previously mentioned kitchen scenario.


**Outcome**

Currently, SpanAbility is further developing the game to include a more comprehensive user experience with feedback to inform the player of their progress. The overall goal is to have an assessment room where players can participate in traditional assessment techniques in the virtual environment. Players will have access to their individual accounts, which can save the scores, and have the option to return and redo the assessment to check their progress. In the rehabilitation rooms, players can participate in rehabilitation games that have real world applications such as shopping at a grocery store, crossing the street, or cooking a meal. The SpanAbility team has discussed the next steps we plan to take to further the product. First, we plan to conduct a user feedback trial with people that have recovered from strokes. The individuals will be able to provide feedback based on their previous experiences with rehabilitation. Additionally, we plan to recruit occupational and physical therapists to use the software and virtual reality system and obtain their feedback on the usability and effectiveness.

After these user feedback trials, we will further the game development, make connections with hospitals/ clinics for preliminary trials, and recruit a professional to serve as a principal investigator. Next, we will conduct a pilot study. The results of this study will be published to use for marketing our virtual reality product to hospitals and clinics around the St. Louis area. We envision this timeline to end in 2024. After St. Louis, we will move to other large cities in the Midwest.

**Cost**

SpanAbility targets stroke rehabilitation including inpatient/outpatient rehabilitations centers, telemedicine companies, and patients (for in-home VR experiences). For this analysis, inpatient/outpatient rehabilitation centers will be the primary target. The cost to run the business including salary for five employees, R&D costs, material, office space, and other administrative costs is $460,600 per year. 25% of the cost is devoted to purchasing and assembling the computer and headset while the remaining 75% is for research, development, and deployment of the games and subscription platform. We estimate that the development of a new game will take 13.25 weeks resulting in 10 new games each year with three developers. To calculate our breakeven cost, we assumed 30 new clients each year, 10 returning clients needing new equipment, and 50 monthly subscribers to our VR game toolboxes. The cost for the unit is $5,000, and the monthly subscription price is $480. Any additional clients or subscribers will be profit for SpanAbility. To justify this pricing, we approximated the cost of rehabilitation based on previous studies. If we assume that a patient in outpatient rehabilitation is prescribed 20 one-hour sessions, the cost for the rehabilitation is ~$2,000 which includes the cost of occupational therapist in the US (~$40/hour) and transportation to and from the center (~$60) (Lloréns, Noé, Colomer, & Alcañiz, 2015). The cost of our VR device and yearly subscription is paid off within 5.38 patients. For inpatient rehabilitation, the cost of room, board, and rehabilitation is $1600 per day, and rehabilitation is responsible for 47% of this cost (Mayer, Pelensky, Whyte, & Fidler-Sheppard, 2003). The cost of our VR device and yearly subscription is paid off within 14.3 days of inpatient rehabilitation.

**Significance**

One of the problems with current stroke rehabilitation methods is the lack of patient engagement, which lowers efficiency and treatment success. Our games aim to create a completely immersive experience in which patients are able to interact with objects and environments that may otherwise be unsafe or inaccessible in the hospital or clinic. Researchers' previous attempts at developing VR rehabilitation software have fallen short in several ways: environments were unrealistic, games were boring or elementary, and games were unable to be adapted to an individual's needs (Tobler-Ammann, Surer, Knols, Borghese, & Bruin, 2017). Because of this, they did not serve as a particularly strong therapeutic tool. With these past design issues in mind, SpanAbility aims to deliver a high-quality product that can be easily implemented and enjoyed by users. Not only do our games allow for fun, leisure exploration, but they also provide access to environments for individuals to engage in activities necessary for daily life.

While SpanAbility has started as a team designing games for use in rehabilitation of stroke with hemispatial neglect, we see high future potential in our products. In the future, we plan to create toolboxes of games targeted towards rehabilitation of PTSD, anxiety, autism, and more. We also envision that within each toolbox are games that serve as tools for both assessment and treatment. The games will be capable of collecting data to measure progress and sending feedback to a patient's care team. We aim to create products that can be implemented anywhere within the continuum of care, whether it be in acute rehabilitation, home health, schools, outpatient rehabilitation, or within a skilled nursing facility. We intend for our products to be usable and accessible to children, adults, and older adults as well as those with diverse physical and cognitive abilities.

~SpanAbility, providing patients new possibilities~

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