User Perspectives on Tabletop Therapy

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ABSTRACT

Technology-based activities are becoming more popular in therapy programs, and direct-touch interactive tabletops seem particularly suited to many therapy tasks. To better understand the potential benefit of interactive tabletops in rehabilitation, we examined users' attitudes as they performed rehabilitation activities on a multi-touch tabletop and a normal, non-interactive surface. This revealed the elements of multi-touch tabletops and their associated activities that contribute to their success in rehabilitation programs and identify improvements for future designs. We found that although the engaging and dynamic nature of the interactive tasks was preferred, many participants were heavily influenced by prior exposure to commercial interaction devices and expected very precise and responsive sensing. We discuss the implications of user expectations and experiences on the design of future activities and rehabilitation technologies.

1. INTRODUCTION

Most recently, multi-touch tabletop-based games have become increasingly important therapy tools. They are believed to be very useful in regaining function and motor ability in patients recovering from stroke and traumatic brain injury by encouraging lateral upper-body movement (Annett et al., 2009, Mumford et al. 2008). Recently, it was also found that the structure of the activities had more influence on participant movement than the use of technology (Anderson et al., 2012). These results emphasize that the strength of technology is in improving motivation and compliance, and demonstrate the need for effective and informed design of activities.

Interactive tabletops and other direct-interaction devices have several advantages (Hutchins et al., 1985) that make them very good candidates for new rehabilitation technologies. First, they support direct and natural interaction (Wigdor and Wixon, 2011), that is, one touches and manipulates the object or target that one wants to select, and does not select it using a proxy device, like a mouse, keyboard or joystick. This is an important advantage, as patients with cognitive disabilities may have trouble creating a mapping between the proxy object and the target, whereas no mapping needs to be created with a tabletop. Also, tabletops have the ability to support the patient's upper-body weight while performing the activity, allowing patients with a wide range of abilities to benefit from the activities. Lastly, interactive tabletops provide a large interaction space, which is needed for many patients to exercise gross motor function and fully explore their entire range of motion, which is not possible on small hand-held devices.

It has been widely recognized that client motivation and compliance with rehabilitation exercises are critical problems in physical therapy programs. One approach to address this problem has been to use video games with patients, as it is believed that patients can become as highly engaged with their therapy exercises as video game enthusiasts are with their games (Rizzo and Kim, 2005). Thus, various gaming technologies such as the Microsoft Kinect (Chang et al., 2011), PlayStation EyeToy (Rand et al., 2008), and Nintendo Wii (Saposnik et al. 2010) have become pervasive in therapy programs (Flynn and Lange, 2010).

These previous studies on tabletop-based therapy (Anderson et al., 2012; Mumford et al., 2008; Annett et al., 2009) have focused on the movements produced by users, and have not considered the equally important aspect of user engagement. In addition, there are unique challenges and opportunities that multi-touch technologies can present in a clinical setting. The usefulness of direct-touch interaction and expectations that

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patients may have due to familiarity with similar devices, such as tablets and touch screens, are both important factors that the present study investigates.

In this paper, we examine user's subjective impressions towards tabletop therapy-based activities. We conducted an experiment in which participants were exposed to two 'traditional' therapy methods, as well as two new tabletop therapy-based activities. Participants completed questionnaires and a semi-structured interview to assess their subjective views on the therapy activities. Overall, people enjoyed the technology-based activities, but many were unsatisfied with some aspects of the technology activities. We provide design recommendations to help mitigate the impact of these issues.

2. EXPERIMENT

3.1 Participants and Equipment

As patient safety is of great concern with any new treatment, this study examined healthy participants. Although the healthy and disabled populations differ, with respect to age or physical abilities, for example, we believe that many valuable inferences can be made from the healthy to the clinical population. Seven males and seven females participated in the study (18-77 years old). Each participant was right handed and had no prior experience with a multi-touch tabletop. The University of Alberta's Research Ethics Board approved the study.

The technology-based approaches used in this study were implemented using a custom-built Frustrated Total Internal Reflection (FTIR) based (Han, 2005) interactive table. The table measures 61 cm x 91 cm, with the surface 80 cm off the ground. The table consists of a projector, mirror, and infrared camera. Infrared light sources are embedded in sides of the acrylic display surface. Being FTIR based, the table is not as responsive or accurate as smaller-scale commercial devices that use capacitive sensing (e.g., iPhone, iPad), but the system is still very usable and responsive, especially for activities with large targets such as the ones used in this study. The software used in the study includes the ofxTouch modules which process the raw video stream to determine when and where a user is touching, and the custom therapy activities (more fully described in previous work by Annett et al. (2009)) were written using the Adobe Flex platform.

3.2 Task

Participants completed four tasks, two using the multi-touch tabletop (Memory and Puzzle, see Figures 1a and 1b) and two using a traditional table surface (Card Sorting and Grid of Stickers, see Figures 1c and 1d). All four tasks were similar to activities currently used by patients at a local rehabilitation hospital, and all encouraged similar movements. For instance, the Puzzle activity required participants to slide square images on the surface of the interactive table, whereas the Card Sorting activity required the same type of motions to position the cards. Similarly, both the Memory and the Grid of Stickers required participants to reach out and touch a number of square targets on the surface of the table.

Participants performed each activity for 5 minutes, with the order of activities randomized between participants. If participants finished the activity before the allotted time had elapsed, the activity was reset and the participant repeated it until 5 minutes elapsed. Similar to constraint-induced movement therapy (Kunkel et al. 1999; Taub et al., 2004), participants were restricted to use only their dominant arm to complete each task.

Once all tasks were completed, two Intrinsic Motivation Inventories (IMI) (McAuley et al., 1989) were administered, one assessing the traditional tasks (Card Sorting and Grid) and the other assessing the technology-based tasks (Memory and Puzzle). The IMI assesses the subjective opinions towards activities using Likert-type responses to statements such as "I would describe the activities as very interesting". From the participant's responses, scores for four separate dimensions are computed which represent the participant's subjective feelings of: interest and enjoyment, effort and importance, mental tension and pressure, perceived competency.

Participants were also asked about their experiences with the tasks and the multi-touch tabletop in a semi-structured exit interview. The following guiding questions were used during the interview, but the participants were encouraged to engage in an open discussion:

- Which type of activity did you prefer, and why?

- Were there any particular activities that you disliked?
- If you could change the activities, how would you improve them?
- If you were in a therapy program, which of the activities would you choose to use?

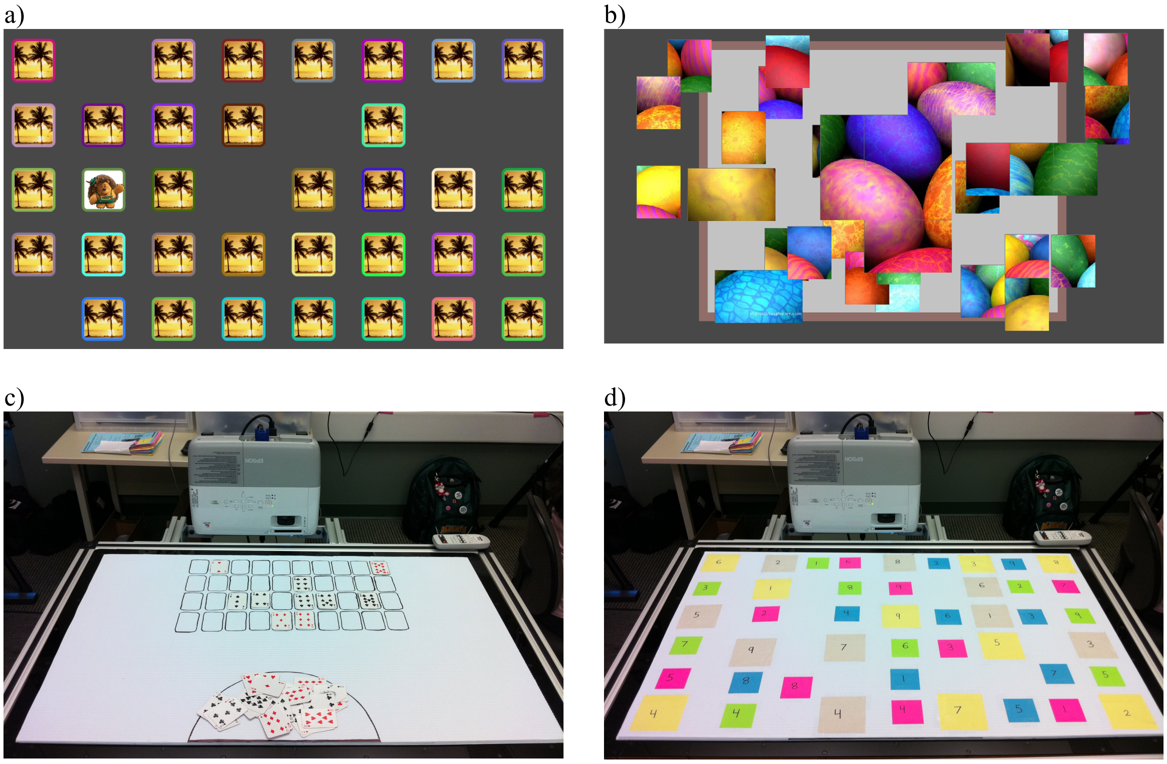

Figure 1. The four tasks used in the study. a) Memory, in which participants touched virtual tiles to 'flip them', to reveal images underneath which they must match. b) Puzzle, in which participants had to slide tiles on the screen to assemble a large picture. c) Card sorting, in which participants had to slide the physical cards into order, ascending by suit. d) Grid of tiles, in which participants had to touch the tiles in order, by colourcolour, repeatedly.

3. RESULTS AND DISCUSSION

The Intrinsic Motivation Inventory responses (Figure 2) were analyzed using Bonferroni-adjusted, Wilcoxon signed-rank comparisons. Participants rated the multi-touch tasks as significantly more interesting and enjoyable than the traditional tasks ($Z=2.79$, $p=0.0052$). There were no significant differences found along the other dimensions (i.e., perceived effort and importance ($p = 0.45$), perceived competence ($p = 0.71$), and mental pressure/tension ($p = 0.68$)). The lack of a difference between the dimensions of competency, effort and tension is unsurprising, as all four of the activities were quite simple and self-paced.

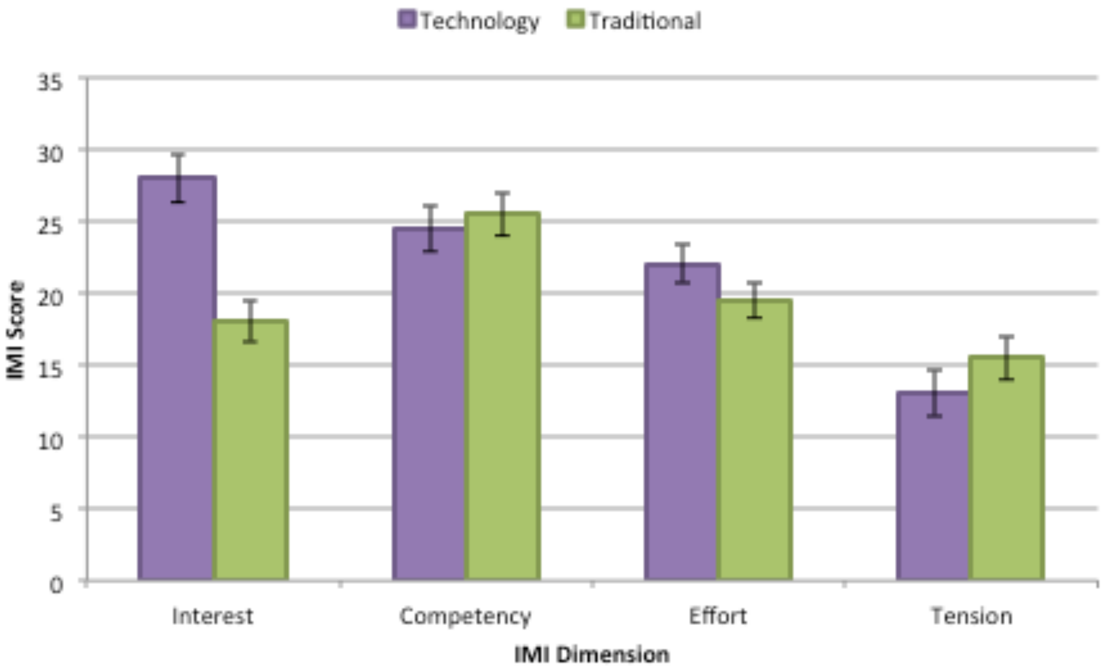

Figure 2. Median scores for each of the dimensions of the IMI. Error bars show standard error of the mean. Interest is significantly higher with the technology-based activities.

The semi-structured interviews help to explain the reasons for the increased scores of enjoyment and interest. Several participants commented that they enjoyed the technology-based tasks more because they contained dynamic elements and feedback about their progress: “hearing the puzzle click together and having the tiles disappear in front of me was super motivating” (P1). Although they completed each task individually, many participants also felt as if they were competing against themselves, “[the tech] wasn’t frustrating at all! For me it was like a competition” (P10). Additionally, the multi-touch tabletop made several participants feel as if they were accomplishing a worthwhile goal: “I like the puzzle one because you’re actually playing a game instead of just touching stickers” (P3).

These comments suggest that technology-assisted rehabilitation is more enjoyable because it can provide a meaningful challenge and real-time feedback. These comments are consistent with the belief that the dynamic gaming elements of interactive therapy lead to increased enjoyment, and ultimately more adherence to the therapy program. When designing activities for therapy, it is important to fully use the technology to provide engaging and challenging elements for participants. If these elements are ignored, a technology-based activity can become just as monotonous as many traditional activities, and they will be neglected.

It was also found that prior exposure to technology had an influence on participants’ experiences with the multi-touch tabletop. Many compared the multi-touch table and its activities to commercial multi-touch devices: “if you have an iPad you can see that it registers every motion and gesture ... the design of those games are better” (P13); “I’m just use to playing those iPhone games” (P12). Many participants expressed that they would definitely prefer to use the multi-touch tabletop in a rehabilitation setting if it was as refined as the commercial products they use everyday. These observations are particularly relevant, as the quality of commercial technology increases but budgets for therapy-driven software remain comparatively low.

The user-facing aspects of therapy software need to be improved to meet the growing expectations of patients. In the near future, many patients will be intimately familiar with software products and video games from large production studios with equally large budgets. Unfortunately, custom therapy-targeted projects will likely not have those budgets. To create engaging, high-quality games at a low cost, designers should leverage existing content where possible, use openly available video-game engines, and ensure that the rehabilitation games do not feel like ad-hoc prototype applications.

Several participants were also quick to cite the technology as the source of any errors that occurred rather

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than their own actions. As the multi-touch tabletop provides direct-touch interaction, there is a much smaller gulf of execution than with indirect-touch interfaces (Hutchins et al., 1985), causing more ambiguity about the source of errors. During our experiment, the largest source of frustration were the cases where no touch was being detected, and the user received no feedback. When this happened, many users were unsure if they were pressing hard enough, or not pressing in the right spot, leading to the participant becoming confused, or annoyed. For example, one participant was "irritated at how the tabletop wasn't too responsive" (P7). In contrast, no users complained about the mechanics of the traditional activities, and one participant commented that they "felt they could handle the physical materials more easily" (P8).

To minimize user frustration during input, tabletop activities must have responsive sensing and accurate feedback, as users will otherwise become quickly irritated and feel as if they are not in control of an activity. While the hardware is a large determinant of the responsiveness and accuracy, some steps can be taken in software to reduce the apparent effects of these parameters. For direct-touch devices with coarse sensing resolution (or noisy sensing), the targets can be made larger, so that pinpoint accuracy is not required. Feedback should also be used to indicate the exact location that the touch is registered, so users can adjust their touches to accommodate for any offsets, or input warping, this feedback would reduce any ambiguity caused by positioning errors. To mitigate latency issues, developers should ensure that the user's sensed touch is displayed as soon as possible, and not delayed by complex application-specific processing. If complex processing is required, the system should first provide the feedback on where the touch was registered before processing the application-specific response is computed.

4. CONCLUSIONS AND FUTURE WORK

Given the previous work showing that technology itself is not enough to modify the movement patterns of individuals in therapy programs, it is clear that the benefit of technology lies in its ability to provide responsive, dynamic content. To that end, we have studied user attitudes towards interactive tabletops, and found that while they do typically find them more engaging, there are some limitations that must be overcome to make them truly beneficial for patients.

There are several avenues for extending this work. The next step is to refine the activities based on the observations of the current study, and implement a long-term study with a patient population. While we expect many conclusions to generalize, studying the usage behavior of the target end users will likely produce new insights. Additional future work involves studying those aspects of tabletop-based therapy that contribute to the success and enjoyment for the end user, for instance, examining the relative importance of customization, dynamic feedback, and game content.

This study has revealed important insights into multi-touch therapy activities. While direct-touch interaction offers a number of benefits for therapy-based activities, there are a number of drawbacks that should be addressed. Following our user study, we developed a number of design recommendations for developers of multi-touch therapy activities. With these in mind, the engagement and enjoyment patients experience during therapy can be improved, leading to higher motivation and ultimately compliance with the therapeutic activities.

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5. REFERENCES

Anderson, F., Annett, M., and Bischof, W.F. Tabletops in Motion: The Kinetics and Kinematics of Interactive Surface Physical Therapy. Accepted for publication in the *Extended Abstracts of the ACM SIGCHI Conference on Human Factors in Computing Systems,* 2012, 2351-2356.

Annett, M., Anderson, F., Goertzen, D., Halton, J., Ranson, Q., Bischof, W.F., and Boulanger, P. Using a Multi-touch Tabletop for Upper-Extremity Motor Rehabilitation. In *Proceedings of the Australian Computer-Human Interaction Special Interest Group,* 2009, 261-264.

Chang, Y., Chen, S., and Huang, J. A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities. *Research in Developmental Disabilities,* 32(6), 2011, 2566-2570.

Han, J. Y. Low-cost multi-touch sensing through frustrated total internal reflection, *In Proceedings of UIST* 2005, pp. 115-118.

Hutchins, E., Hollan, J., and Norman, D. Direct manipulation interfaces. *Journal of Human-Computer Interaction,* 1(4), 1985, 311-338.

Kunkel, A., Kopp, B., Müller, G., Villringer, K., Villringer, A., Taub, E., and Flor, H. Constraint- induced movement therapy for motor recovery in chronic stroke patients. *Archives of Physical Medicine and Rehabilitation,* 80(6), 1999, 624-628.

Flynn, S.M. and Lange, B.M. Games for Rehabilitation, the voice of players. *In Proceedings of the 8th International Conference on Disability, Virtual Reality & Associated Technologies,* 2010, 185-194.

McAuley, E., Duncan, T., and Tammen, V.V. Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport,* 60(1), 1989, 48-58.

Mumford, N., Duckworth, J., Eldridge, R., Guglielmetti, M., Thomas, P., Shum, D., Rudolph, H., Williams, G., and Wilson, P.H. A virtual tabletop workspace for upper-limb rehabilitation in Traumatic Brain Injury (TBI): A multiple case study evaluation. In *Proceedings of Virtual Rehabilitation,* 2008, 175-180.

Rizzo, A. and Kim, G.K. A SWOT analysis of the field of virtual reality rehabilitation and therapy. *Presence,* 14, 2005, 119-146.

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe, K.E., Cohen, L.G., and Bayley, M. Effectiveness of Virtual Reality Using Wii Gaming Technology in Stroke Rehabilitation. *Stroke,* 41(7), 2010, 1477-1484.

Taub, E., Ramey, S.L., DeLuca, S., and Echols, K. Efficacy of constraint-induced movement therapy for children with cerebral palsy with asymmetric motor impairment. *Journal of Pediatrics,* 113(2), 2004, 305-312.

Wigdor, D. and Wixon, D. A Brave NUI World. *Morgan Kaufmann*, 2011.

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