Hands, Tables, and Groups Make Rehabilitation Awesome!

Michelle ANNETT[1], Fraser ANDERSON, Walter F. BISCHOF
Department of Computing Science, University of Alberta

Abstract. Technology has helped improve rehabilitation programs by providing patients with engaging alternatives to otherwise monotonous and repetitive exercises. In recent years, therapists have looked towards multi-touch technologies to further enhance patient rehabilitation programs. So far, the focus has mainly been on single-user interaction, largely ignoring many of the benefits patients receive from socially interacting with therapists, caregivers, and their peers. To make use of these valuable interactions, we have developed a suite of multi-touch activities for motor and cognitive rehabilitation. These applications can easily be adjusted to meet the needs of individual patients and enable therapists to quantitatively measure patient behaviour and performance. We also reflect on design-related discussions we had with practicing occupational therapists and provide a set of design considerations to guide future rehabilitation activities.

Keywords. Multi-touch tabletop, occupational therapy, group rehabilitation, collaboration

Introduction

Over the last decade, interest and excitement surrounding interactive surfaces and multi-touch tabletops has increased substantially. One of the most recent applications of tabletop technologies has been for motor and cognitive rehabilitation. Multi-touch tabletops can be great tools for therapists because they can include many dynamic animations and effects, allow for the precise measurement of patient behaviour and performance, and encourage patients to use natural actions to complete activities (e.g., reaching or dragging virtual objects). The flexibility of tabletop activities can also allow therapists to customize activities for specific patient abilities and gradually modify the difficulty of activities throughout a patient's rehabilitation program.

Although tabletops have been used in rehabilitation, they have largely neglected an important aspect of the rehabilitation process: group therapy. Group interaction in rehabilitation settings can maximize client effort, induce positive emotional changes, increase self-understanding, and provide long-term improvements in patients' quality of life [1]. It has also been demonstrated that patients are more willing to spend additional time performing rehabilitation exercises in group settings than by themselves, ultimately speeding their recovery [2].

By their very nature, traditional tabletops (e.g., coffee tables, supper tables, and meeting tables) encourage social dynamics, conversation, and interaction. The fusion of

[1] Corresponding Author: Michelle Annett, Department of Computing Science, University of Alberta, Edmonton, Alberta, Canada; Email: mkannett@cs.ualberta.ca.

tabletops and group rehabilitation has the potential to greatly improve patient confidence and to give patients the motivation to work harder and persevere through difficult activities. This combination also supports multi-user group interaction (i.e., cooperation and competition) between a patient and therapists, family members, and peers. We have extended our suite of rehabilitation-based software activities (AIR Touch [3]) to support cooperation and competition. We also discuss a number of recommendations that help to guide the development of future activities for multi-user tabletop rehabilitation.

1. Related Work

Due to the popularity of multi-user collaboration and tabletops, a number of researchers have developed guidelines and considerations [4] for designing multi-user interactions. While some guidelines are applicable to virtually all multi-user tabletop activities (e.g., "support interpersonal interaction", "support simultaneous user interactions"), many are constrained to document and media-based applications, making them unsuitable for our patient population and activities.

There has also been research investigating ways in which tabletop activities can be used to rehabilitate behavioural and communication skills. SIDES is an interactive tabletop game that has been effective in developing social skills of children with Asperger's syndrome [5]. The use of a tabletop interface provided the children with invaluable face-to-face contact, while the game setting forced the children to collaborate and work together. Similarly, the StoryTable is an interactive tabletop application that encourages users with Autism Spectrum Disorder to work together to create a narrative story [6]. The interactions that each child experienced while creating stories increased their positive social interactions and helped to decrease the occurrences of autistic behaviour. This work leads to our hypothesis that multi-user tabletop activities can be effective for motor and cognitive rehabilitation.

2. AIR Touch Design and Activities

We have created five multi-touch activities (and one AIR Touch extension) that help to induce immersion and increase perseverance. These activities enable patients to receive rehabilitative benefits by distracting them from their disabling conditions or impairments (Figure 1). Each of the activities was implemented using the AIR Touch system [3]. AIR Touch is a rear-projection, Windows XP-based, multi-touch tabletop system that uses FTIR technology to generate touch events. The AIR Touch software records a variety of behavioural and performance measurements that can be important for the identification of patient deficiencies and the tracking of patient progress.

2.1 Touch Tessellation

In Touch Tessellation, patients are presented with a number of puzzle pieces and must touch and drag each piece to complete the puzzle (Figure 1A). Touch Tessellation can test planning, decrease visual neglect, increase spatial relation skills, and challenge fine and gross motor skills. To customize the activity, a therapist can specify the size and number of puzzle pieces or modify the starting location of the puzzle pieces (e.g., to

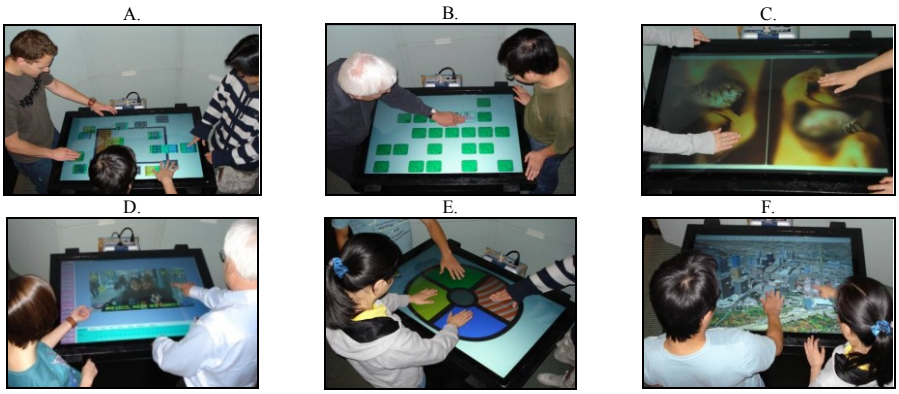

Figure 1. A) Three users assembling a Touch Tessellation puzzle, B) A user and his friend cooperatively using Match Me! to find hidden tile pairs, C) A user and family member competing to clear their Foggy Windows, D) Two users modifying a family photograph using Photo Scrapbooking, E) Three users playing Nomis Says, F) Two users exploring their hometown using Google Earth.

encourage patients to converse or perform gross motor movements). Patient photographs can be used and meaningful sounds can be played to encourage social dialog and emotional immersion.

2.2 Match Me!

Match Me! presents patients with an array of face-up or face-down touch tile pairs that need to be matched. This activity challenges gross motor movements, can increase sustained attention, and aims to improve visual neglect. To increase patient compliance and social interaction, family photos can appear on the tiles. A therapist can also choose to modify the number of touch tile pairs that are presented or change the location and pattern of the tiles. The Match Me! activity supports both cooperation and competition: a patient can work with a partner to find matching touch tiles or complete against another player to find the most touch tile pairs (Figure 1B).

2.3 Foggy Windows

In Foggy Windows, a patient is presented with a ‘foggy window’. Patients must use their fingers or hands to ‘defog the window’ and reveal the hidden picture underneath. Foggy Windows can help patients exercise their gross motor skills and challenge figure-ground discrimination. To maintain patient engagement and compliance, therapists can modify the amount of fog that each window contains, the location of each window on the tabletop, or the size and type of the hidden object that is displayed (i.e., patient photographs, emails, or documents such as news stories can all be hidden). Foggy Windows can be used cooperatively, i.e., patients work with a partner to clean a window, or competitively, i.e., a patient and his or her partner have their own ‘foggy window’ and compete to clean them the fastest (Figure 1C).

2.4 Photo Scrapbooking

In the Photo Scrapbooking activity, patients are encouraged to work cooperatively with a partner to modify personal pictures and make a scrapbook page. Patients can flip through a collection of their personal photographs to decide which one to modify and add to the scrapbook. In Photo Scrapbooking, patients can crop pictures, add stickers,

paint, annotate, or alter picture attributes such as brightness or contrast (Figure 1D). Once a picture has been modified, it can be added to a scrapbook page, which can be saved, printed, or emailed to others. Photo Scrapbooking is an ideal collaborative activity because photographs naturally encourage emotional reactions and storytelling, and activate long-term memory. The editing of photos also challenges patients to exercise their fine and gross motor skills.

2.5 Nomis Says

Nomis Says is a virtual implementation of the classic Simon™ game. In Nomis Says, a therapist can modify the number of coloured quadrants that appear, change the size and location of each coloured quadrant, or change the number of times a patient can try to repeat a light-up sequence if they have made an error. Players can take turns repeating the light-up sequences, or players can be responsible for one or two quadrants and touch them at the appropriate time (Figure 1E). Nomis Says provides many cognitive and motor challenges to patients (e.g., sequencing, divided attention, immediate recall, gross motor skills, and dexterity).

2.6 Third party application support

We have added a keyboard and mouse emulation extension to the AIR Touch system to support the use of third party applications. Interaction with Google Earth, for example, encourages patients to use their hands or fingers to navigate to places they have travelled to before or walk around their old neighbourhood (Figure 1F). Third party support also allows patients to play games with their family members, such as chess or checkers, browse the internet, or send emails using a virtual keyboard. This support allows patients to continue to stay connected to the outside world and practice skills that could be valuable once they finish their rehabilitation program.

3. Rehabilitation-Based Design Recommendations

During our iterative design and implementation cycle, we consulted with a number of practicing occupational therapists. Discussions with these experts produced a number of guidelines that have influenced the design of our rehabilitation-centric activities and should be beneficial for others working in the area.

- Including positive, salient elements in multi-user activities can help patients to become '**emotionally immersed**'. This immersion allows patients to temporarily forget the pain or cognitive deficits they may have and instead focus on the activity at hand. If a patient is working on an activity that has a picture of a loved one, they are likely motivated to put in more effort and spend more time performing the activity.
- Encouraging **communication** during multi-user activities enables patient/therapist trust to increase, encourages patients to share their feelings and difficulties with their caregivers, and creates bonds with other patients over shared life or rehabilitative experiences.
- **Cooperation** is beneficial for rehabilitation because it provides patients with motivation from others who are in similar situations (i.e., fellow patients). Using

cooperation within rehabilitation activities also encourages patients to learn from the people they are interacting with and promotes turn taking, teamwork, and patience.

- If patients can become '**competitively immersed**' in an activity, they are more likely to try harder and work at an activity longer in order to beat their competitor. Patients can also receive encouragement and motivation from onlookers who are supporting them.
- Activities should be **configurable** and have elements of **uncertainty**. Configurable activities allow therapists to tailor activities to match a patient's motor or cognitive abilities, demographic, background, or specific interests. Activities that contain surprises, uncertainty, and variability can be reused many times throughout a patient's recovery.

Conclusions and Future Work

Previous tabletop rehabilitation technologies have focused on single-user interaction, neglecting the benefits of collaboration and group rehabilitation. We have addressed this issue by working with practicing therapists to create a number of multi-user activities. These activities allow patients to gain rehabilitative benefits while working cooperatively or competitively with family members, peers, or therapists. We have also identified a number of design considerations that can be used to guide the development of rehabilitation-based multi-user tabletop activities.

The AIR Touch system is currently being used in a local rehabilitation hospital. A pilot study with therapists, patients, and family members is underway to determine the usefulness of the system. Patient interviews are being conducted to evaluate patient enjoyment and enthusiasm towards the collaborative nature of the AIR Touch system and its software.

References

[1] L. Gauthier, S. Dalziel, and S. Gauthier. The benefits of group occupational therapy for patients with Parkinson's disease. *American Journal of Occupational Therapy*, (1987), 41(6), 360-365.

[2] W. De Weerdt, G. Nuyens, H. Feys, P. Vangronsveld, A. Van de Winckel, A. Nieuwboer, J. Osaer, and C. Kiekens. Group physiotherapy improves time use by patients with stroke in rehabilitation. *Australian Journal of Physiotherapy,* (2001), 47(1), 53-61.

[3] M. Annett, F. Anderson, D. Goertzen, J. Halton, Q. Ranson, W.F. Bischof, and P. Boulanger. Using a Multi-touch Tabletop for Upper-Extremity Motor Rehabilitation. *Proc. of 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group,* (2009), 261-264.

[4] S.D. Scott, K.D. Grant, and R.L. Mandryk. System Guidelines for Co-located, Collaborative Work on a Tabletop Display. *Proc. 8th European Conference on Computer-Supported Cooperative Work 2003*, (2003), 159-178.

[5] A.M. Piper, E. O'Brien, M.R. Morris, and T. Winograd. SIDES: A Cooperative Tabletop Computer Game for Social Skills Development. *Proc. 20th Anniversary Conference on Computer Supported Cooperative Work,* (2006), 1-10.

[6] M. Zancanaro, F. Pianesi, O. Stock, P. Venuti, A. Cappelletti, G. Iandolo, M. Prete, and F. Rossi. Children in the museum: An Environment for Collaborative Storytelling. *PEACH: Intelligent Interfaces for Museum Visits*, (2007), 165-185.