Tabletop Computer Game Mechanics for Group Rehabilitation of Individuals with Brain Injury

Jonathan Duckworth[1], Jessica D. Bayliss[2], Patrick R. Thomas[3], David Shum[4], Nick Mumford[5], and Peter H. Wilson[5]

[1] School of Media and Communication, RMIT University, Melbourne, Australia
jonathan.duckworth@rmit.edu.au
[2] School of Interactive Games and Media, Rochester Institute of Technology, Rochester, USA
jdbics@rit.edu
[3] School of Education and Professional Studies, Griffith University, Brisbane, Australia
p.thomas@griffith.edu.au
[4] Behavioural Basis of Health, Griffith Health Institute and School of Applied Psychology, Griffith University, Brisbane, Australia
d.shum@griffith.edu.au
[5] School of Psychology, Faculty of Arts and Sciences, Australian Catholic University, Melbourne, Australia
{nimumford,peterh.wilson}@acu.edu.au

Abstract. In this paper we provide a rationale for using tabletop displays for the upper-limb movement rehabilitation of individuals with brain injury. We consider how computer game mechanics may leverage this technology to increase patient engagement and social interaction, and subsequently enhance prescribed training. In recent years there has been a growing interest among health professionals in the use of computer games and interactive technology for rehabilitation. Research indicates that games have the potential to stimulate a high level of interest and enjoyment in patients; enhance learning; provide safe task conditions; complement conventional therapy; and become intrinsically motivating. We explore how game mechanics that include reward structures, game challenges and augmented audiovisual feedback may enhance a goal-orientated rehabilitation learning space for individuals with brain injury. We pay particular attention to game design elements that support multiple players and show how these might be designed for interactive tabletop display systems in group rehabilitation.

Keywords: Computer Game Mechanics, Game Design, Group Interaction, Tabletop Display, Movement Rehabilitation, Acquired Brain Injury.

1 Introduction

Acquired brain injury, particularly from stroke and traumatic brain injury, causes a broad range of cognitive and physical problems for patients. One of the major impediments to recovery is a patient's reduced ability to engage in therapy and to persist with it [1]. For example, movement performance in brain injured patients is

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2014, Part II, LNCS 8514, pp. 501–512, 2014.

constrained by a number of physiological and biomechanical factors including the increase in muscle tone that occurs as a result of spasticity, reduced muscle strength, and limited coordination of body movement [2]. Physical and cognitive impairments often lead to a significant incidence of depression and low self-esteem among people with physical and intellectual disabilities, which presents a psychological barrier to engaging in rehabilitation and daily living [3]. Designing therapeutic tasks and environments that can be presented in a meaningful and stimulating way is one of the key challenges facing therapists. Rehabilitation orientated games may offer a viable adjunct to traditional therapy, offering patients highly engaging environments and playful activities.

A number of rehabilitation systems using computer games to present activity to a diverse range of users have emerged in recent years. One example, which shows the flexibility needed for rehabilitation, is the Makoto Arena [4]. The concept of the Makoto Arena is simple and requires the player to listen for a tone, watch for a light, and then hit the column and area that lit up quickly. This type of game is commonly called a *toy* in academic literature due to the open-ended and flexible nature of how the physical device may be used.

Another example of a game used for rehabilitation is the game Lazy Eye Shooter [5]. This game is a first-person shooter used for the treatment of Amblyopia and has a traditional game structure (see Figure 1). Lazy Eye Shooter is a bit different from the Makoto Arena as the former only lasts for 40 hours but the latter could be considered a long-term exercising game. In addition the Lazy Eye Shooter uses an adaptive training regime so that people with different types of amblyopia may still use the same training.

Fig. 1. Lazy Eye Shooter, an example of a traditional first-person shooter game that has been reworked into a successful game treatment for amblyopia.

Our previous rehabilitation application called Elements shows how tabletop displays support upper-limb interaction as the main form of user input and enable an embodied, first-person view of performance [6] [7]. The Elements system provides goal directed and exploratory game-like tasks of varying complexity geared toward reaching, grasping, lifting, moving and placing tangible user interfaces on a tabletop display (Figure 2). We also discussed the key advantage of tabletop displays that support co-located face-to-face social interactions and facilitate multimodal forms of communication between co-located users in the context of rehabilitation [8]. This has important implications for rehabilitation game design that supports social play as studies indicate co-located play evokes stronger social engagement and increased levels of enjoyment [9]. Co-located game orientated rehabilitation may provide patients with a more comprehensive social experience that is visual, tactile, auditory and enriched.

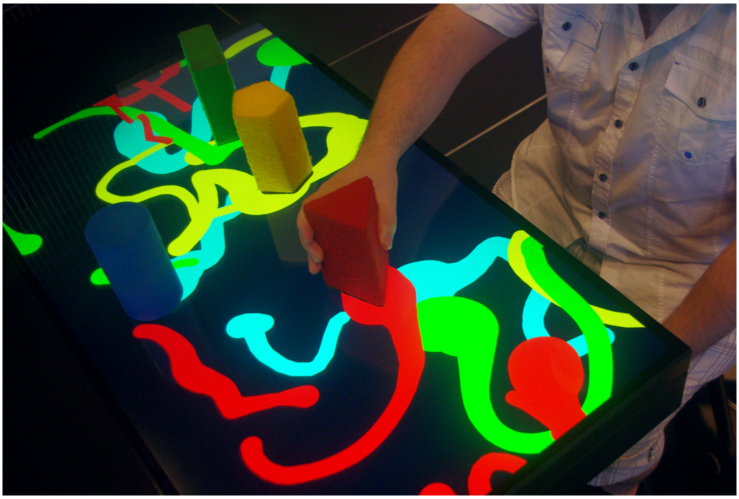

Fig. 2. An individual using the Elements system explores the functions of several soft graspable tangible user interfaces to draw and paint digitally

When considering game design for rehabilitation, it is important to consider the time needed for treatment. It is likely that short treatments such as Lazy Eye Shooter may be more successful using traditional game techniques, but longer-term treatments such as Elements may need to be more ‘toy-like’, embodied and tangible in their approach to sustain patient motivation beyond the initial ‘novelty’ of the technology [7].

In general, existing commercial game systems often lack appropriate game mechanics, design, and user interfaces for movement rehabilitation, which presents a barrier for patients engaging in therapy [10] [11]. Within the game design field, more research is needed to inform developers who are designing games for health about the circumstances under which specific game mechanics might be most effective [12]. However motor and cognitive impairments can present a broad range of significant problems for patients using existing commercial game systems and adapted solutions for movement rehabilitation [13]. The developers of rehabilitation systems could significantly benefit from analysing the principles of game design to engage and motivate patients [14].

2 Game Design for Brain Injury Rehabilitation

A wide variety of mechanics are used in game media to deliver game play experiences that motivate and engage players. According to Johan Huizinga [15], the first rule of play is that play must be voluntary and with this the central element of all design must be the player(s). The other elements of game design include objectives, procedures, rules, resources, conflict, boundaries, and outcome [16]. Feedback is inherent and necessary in these elements and game mechanics are commonly a combination of procedures and rules. Reward structures map to objectives and the game outcome. Game challenges include objectives, resources, and conflict. Boundaries may be the edge of a game map or emotional as in social play.

The integration of game design, social play and rehabilitation does not have a strong presence in current therapy. To develop rehabilitation tabletop games, developers and designers need to be aware of the patient's particular needs, deficits, the characteristics of group social interactions and how these relate game mechanics particular to tabletop interfaces. Recent findings suggest the principles of game design relevant to acquired brain injury rehabilitation include meaningful play that translates into learning outcomes; handling the level of failure in game play so as to maintain patient engagement; setting adaptable challenges, rules and goals appropriate to the abilities of the individual user; and the setting of game reward structures to assist in motivation and tracking the progress of the patient over time [17]. Furthermore, the social aspects of gaming such as shared user interfaces may provide patients with additional important avenues for learning [18]. We consider how these game design elements might be used for brain injury rehabilitation in a co-located group context using tabletop display interfaces.

2.1 Feedback

Audiovisual feedback is a central mechanic of most games that is provided to the player in response to some action. Typically, this involves the player performing an action that in turn causes some effect within the game. The player receives feedback on their action that informs how they perform the next action to progress in the game. In movement rehabilitation contexts, audiovisual feedback provides the patient with additional functions that revolve around understanding the nature of their movement. Feedback provides patients with additional knowledge of the outcomes of their actions to aid in future movement planning. The audiovisual feedback can also direct the patient to focus their attention on the external effects of their movement, rather than the internal biomechanics of the movement itself.

Intrinsic feedback (i.e., sensory information from the body) is often compromised as a result of brain injury. Extrinsic feedback, an external focus of attention to the effects of action, has been shown to be more effective in enhancing motor learning as opposed to internally focused attention [19] [20]. In motor learning theory feedback is provided to the learner about their movement patterns or knowledge of performance (KP), as well as feedback about the outcome of the movement or knowledge of results (KR). For example, a therapist's corrective feedback provided to a learner during an improper movement pattern is a form of KP.

The use of KP and KR in game design can provide task related information about the skill being learned. However, there is limited evidence to support the amount and frequency schedule of feedback for optimal results in rehabilitation [21]. While modern digital games give consistent and frequent feedback, this may be detrimental for rehabilitation games.

Frequent presentation of feedback may have several detrimental impacts on learning a task. For example, a learner may become too reliant on feedback to detect errors, thus unable to perform independently when the feedback is withdrawn. In addition, frequent feedback may result in the learner making too many corrections that interfere with the stability of their overall performance. Several researchers have indicated that feedback ‘faded’ over time compared with a continuous schedule may be more beneficial to longer-term retention and learning [22] [23]. However, more research is required to establish how the frequency and intensity of feedback in games can best be utilised to enhance real-world outcomes.

Our initial discussion with therapists suggests that complete therapist control over the presentation of KP, KR and augmented audiovisual feedback variables is desirable. As such, in Elements all forms of feedback are switched off by default with control options that enable the augmented feedback, performance and results to be selected and presented at the discretion of the therapist (Figure 3). In this way, the therapist can adapt the frequency of the feedback and task variables to the appropriate level to suit the client and their progress. As the game Lazy Eye Shooter shows [5], it is also possible to use dynamic difficulty adjustment with the therapist setting the initial difficulty and feedback structure.

Fig. 3. A therapist manually touch-selects a range of augmented feedback options using the Elements rehabilitation system

2.2 Reward Structures

Reward structures in games are designed to intrinsically motivate engagement in game challenges and increase expenditure of effort [24]. Intrinsic motivation is defined as a person’s free will of doing an activity for its inherent satisfaction rather than for some separable consequence [25]. Game rewards can take many different forms depending on the game, including score systems, experience points, resources, item unlocks, achievements, and feedback messages [24]. These incentives might lead to increased enjoyment that in turn motivates the player to complete a particular task and reach certain goals.

In movement rehabilitation contexts reward structures may be linked to performance accomplishments, for example, a range of movements or time engaged in play may be rewarded using a scoring mechanism. Rewards might occur on multiple levels, from moment to moment during task performance to cumulative rewards based on overall performance. The purpose of rewards may allow the players to experience challenge as well as demonstrate mastery and are understood to be extrinsically motivating. Games rewards such as scoring may assist the individual assess his or her capability to perform a certain task, and be used to foster individual feelings of autonomy and self-efficacy [17]. Extrinsic rewards provide tools for self-assessment and comparison that satisfy the innate needs for competence and self-determination.

Strategies that focus primarily on extrinsic rewards to control behavior may undermine rather than promote intrinsic motivation [26]. Findings indicate that the primary negative effect of rewards (particularly tangible rewards such as money) tend to forestall self-regulation, or in other words people taking responsibility for motivating or regulating themselves [26].

In a recent study, operant conditioning (a schedule of reinforcements, rewards and punishments to change behavior) in a rehabilitation game targeting hand and wrist movement was found to increase participants' motivation to play longer [27]. A combination of parameters including reward scores, activity bonuses, and aversive stimuli that reset the game to the beginning was shown to increase the level of enjoyment and player motivation. However, further study is required to evaluate whether operant conditioning in games can translate into longer-term acquisition of motor skills. Short-term rehabilitation rewards may need to be different from those meant for longer-term rehabilitation.

Furthermore, the effects of extrinsic game rewards such as player achievements, trophies and badges warrant research for game-orientated rehabilitation. Prior motivational research indicates that these rewards may reduce intrinsic motivation [26]. Interestingly enough, rewards given semi-randomly may actually enhance motivation. Extrinsic forms of reward may convey negative feedback as they may impose values on behavior and status, may not be understood, and are not universally appreciated [28].

Other than operant conditioning rewards, verbal persuasion that provides encouragement or information about performance may be of benefit. For example, in Elements we provide short positive messages as a form of reward at the end of each task. These messages are generally encouraging, humorous in tone and we are careful not to introduce value judgments. In the case of severe brain injury it may be desirable to reward all engagement with success in the initial stages of game play. By doing so, failure is dealt with in a positive way rather than highlighting the player's impaired capabilities.

2.3 Game Challenges

The level of challenge in games is a primary mechanism to increase player engagement with the game. In general, the level of difficulty in a game is designed to gradually increase as the game progresses to maintain a level of challenge for the player. In motor rehabilitation it is unlikely that designers will know the skills and capabilities of players in advance. A range of movement tasks may seem trivial for some patients whilst challenging (and often painful) for many others. For optimal player engagement, games should present an ideal level of challenge for each individual player that is neither too difficult that it becomes frustrating, nor too easy that the player loses interest [29]. Dynamic difficulty adjustments are of particular importance in games for rehabilitation.

Games for rehabilitation should be designed so that the therapist can always set the level of difficulty according to their assessment of the patient's capabilities. Typically, video games use levels to structure difficulty. For example, new game levels are made available to the player on completion of the previous ones. As the game progresses each successive level builds upon the skills and knowledge acquired by the player, requiring the acquisition of new skills or fine-tuning of existing skills as the difficulty increases with each new level. Challenges used in this example allow the player to progress only after once they understand enough of the game play.

There are many different types of challenges in games. Chris Crawford provides a list including cerebellar, sensorimotor, spatial reasoning, pattern recognition, sequential reasoning, numerical reasoning, resource management, and social reasoning [30]. Within rehabilitation game design the preferred challenges are based on sensorimotor skills, which are the skills used to throw a balled up piece of paper into a waste paper basket. The Makoto Arena discussed earlier is a good example of this type of challenge. These skills may be mixed with other types of challenges such as spatial reasoning and pattern recognition.

Spatial reasoning is commonly used in puzzles such as Tetris and when combined with sensorimotor learning can create a variety of potential rehabilitation games. It is possible to create puzzles that can enhance sensorimotor learning. Pattern recognition is useful for boss fights, an enemy-based challenge usually at the end of a video game level. In order to overcome the boss, game players may need to learn its attack patterns in terms of both attack frequency as well as movement. This may be useful in rehabilitation contexts where a specific movement may need to be learned repeatedly.

2.4 Social Play

Social play can be categorized into collaborative, cooperative, and competitive play [31]. In rehabilitation games, competitive play is a poor design choice as the existence of competition means that there are winners and losers. Losers may experience reduced motivation to continue with therapy, which is undesirable.

In contrast, in both collaborative and cooperative game play individuals play a game together to achieve a desired outcome. In collaborative game play, individuals form a team that obtains the game's objective. In cooperative game play, individuals may choose to form a team, but each will receive their own benefits from their cooperation. Group play in general is seen as beneficial and may facilitate vicarious learning when individuals can observe and imitate each other's behavior. Observing others' success in accomplishing certain tasks provides a sense of self-efficacy to the observer that they might also have the ability to accomplish the task.

One of the guiding factors in encouraging true collaborative play is to encourage selfless decisions by bestowing different abilities or responsibilities upon the players [31]. In rehabilitation games this is beneficial since different individuals will likely have different strengths and weaknesses. This also reduces the tension involved in a group setting where individuals may see each other's abilities and compare themselves to the other participants.

Tabletop media offer unique instances of how feedback can be presented to the patient, particularly in a group setting. Feedback may be targeted to an individual, the group or both. For example, private feedback in a shared environment context can be provided in a user's local space directly in front them. Depending on the size of the tabletop display a local space may not be easy for other users to see or reach. Morris et al. report that in a shared learning environment private feedback assisted in reducing potential embarrassment over incorrect actions by not highlighting them to the entire group [32]. This can be used to highlight the different roles for users in a shared game environment.

Activities on tabletop displays are generally designed for shared activities. Individual feedback that others can see as well as feedback on the group performance on a shared task could be made to facilitate awareness of others' actions [33] [34]. In this way, participants might learn by observing and imitating others' performance and feedback in manipulating objects and environments, consequently directing higher levels of attention and focus in users.

Rewards in a group setting add social dimensions that may motivate game play, foster social relationships and encourage social interactions between players. Many games require players to work together cooperatively to complete a goal such as collecting resources. Rewards that show group achievement can enhance feeling of belonging and team building. In the case of rehabilitation, team rewards may add a social component that enables the player to feel strongly committed to remain in the game and work together with other players to develop strategies to maximise the reward. The social aspects of game rewards may enable players with severe impairments to find new ways to increase communication and social support related to their health issues. Indeed, recent surveys with stroke patients indicate that the opportunity for social interaction as part of rehabilitation is a key motivation to participate in therapy [35].

Most co-located video games direct players to focus attention on a common wall-mounted screen but not on other players. This configuration hinders social interaction and reduces opportunity for more complex interpersonal communication. Tabletop display interfaces offer several advantages in this regard by offering a shared workspace where users can clearly observe the actions of others face-to-face, communicate in a collaborative setting, and coordinate activities between each other. Furthermore, studies indicate that co-located face-to-face play provides additional fun, challenge, and perceived competence in games [36]. Studies indicate that co-located play increases player enjoyment through shared attention, increased motivation, higher arousal and performance contingent on the social context of the game setting [37].

The ability to give players different roles in a shared game environment also enhances the ability for players to play the game many times. By changing roles players can experience the same game but from a different perspective incorporating unique challenges and rewards specific to the character. This is partially what makes role-playing fantasy games playable over long periods of time.

3 Summary and Future Work

We have discussed four key game design parameters that can be used in the development of multi-user rehabilitation games for tabletop displays. We maintain that tabletop rehabilitation activities that incorporate game design challenges, judicious rewards, meaningful feedback, and co-located social play afford a powerful therapeutic tool to engage individuals with brain injury socially in rehabilitation and motivate them to persist in therapy. A critical predictor of success in therapy is time on task, together with high levels of user engagement and investment in the activity [39]. For designers, the critical task is to find a balance between these key ingredients.

This paper has discussed some of the design principles developers may consider and how they might be applied to create cooperative and collaborative games in a group therapeutic setting. With respect to feedback (both real time and summary), the challenge for the designer is to consider carefully how, when, and in what form feedback is supplied to the performer, and reduce potential cognitive overload. Indeed, the take-home message is "more is not always better". A good example of this is the use of Nintendo Wii Fit games in rehabilitation where the effects of repeated failure are made apparent in the game avatar combined with discouraging comments [39]. Related to this point is embedding appropriate reward structures into the game environment. It is important that both extrinsic and intrinsic forms of reward be considered, and how these are integrated over different time scales—short-term and longer term. Short-term rewards may promote persistence in the game and enable users to learn basic game rules. But this does not necessarily translate to persistence over extended time, from session to session and month to month. Research shows that users must be fully engaged in the activity, which presupposes some discretion or independence in selecting game attributes and the level of challenge.

To facilitate user engagement, designers and therapists should consult clients during the research and development phase to ensure that game elements, rewards and challenges are presented in an appropriate format or in a way that is motivationally significant. Bridging all the above is the social element of the game environment, specifically the use of co-located systems. For example, rewards that are shared in a group context, even vicariously, can enhance levels of participation (i.e., on task behavior plus engagement), which predicts longer-term persistence and therapeutic gains [40]. Added to this are (i) the positive effects of social engagement in a therapeutic context and its flow on effect for psychosocial adjustment and well-being, and (ii) the opportunities social activity affords for observational learning. The game design principles discussed in this paper are a starting point toward understanding how to build co-located games for movement rehabilitation that are social, motivating, engaging and are effective.

Acknowledgements. This work is supported by an Australian Research Council (ARC) Linkage Grant LP110200802, and Synapse Grant awarded by the Australia Council for the Arts.

References

1. Murphy, T.H., Corbett, D.: Plasticity during stroke recovery. Nature Rev. Neurosci. 10, 861–872 (2009)
2. McCrea, P.H., Eng, J.J., Hodgson, A.J.: Biomechanics of reaching: clinical implications for individuals with acquired brain injury. Disability and Rehabilitation 24(5), 780–791 (2002)
3. Esbensen, A.J., Rojahn, J., Aman, M.G., Ruedich, S.: The reliability and validity of an assessment instrument for anxiety, depression and mood among individuals with mental retardation. J. Autism and Devel Disorders 33, 617–629 (2003)
4. Hilton, C.L., Cumpata, K., Klohr, C., Gaetke, S., Artner, A., Johnson, H.: Dobbs, Effects of Exergaming on Executive Function and Motor Skills in Children with Autism Spectrum Disorder: a Pilot Study. American Journal of Occupational Therapy 68(1), 57–65 (2014)
5. Bayliss, J.D., Vedamurthy, I., Nahum, M., Levi, D., Bavelier, D.: Lazy eye shooter: making a game therapy for visual recovery in adult amblyopia usable. In: Marcus, A. (ed.) DUXU 2013, Part II. LNCS, vol. 8013, pp. 352–360. Springer, Heidelberg (2013)
6. Duckworth, J., Wilson, P.H.: Embodiment and play in designing an interactive art system for movement rehabilitation. Second Nature 2(1), 120–137 (2010)
7. Mumford, N., Duckworth, J., Thomas, P.R., Shum, P., Williams, G., Wilson, P.H.: Upper-limb virtual rehabilitation for traumatic brain injury: A preliminary within-group evaluation of the elements system. Brain Injury 26(2), 166–176 (2012)
8. Duckworth, J., Thomas, P.R., Shum, D., Wilson, P.H.: Designing Co-located Tabletop Interaction for Rehabilitation of Brain Injury. In: Marcus, A. (ed.) DUXU 2013, Part II. LNCS, vol. 8013, pp. 391–400. Springer, Heidelberg (2013)
9. Gajadhar, B., de Kort, Y.A.W., Ijsselsteijn, W.A.: Rules of Engagement: Influence of Co-player Presence on Player Involvement in Digital Games. International Journal of Gaming and Computer-Mediated Simulations 1(3), 14–27 (2009)
10. Flynn, S.M., Lange, B.S.: Games for rehabilitation: the voice of the players. In: Proc. 8th Intl. Conf. on Disability, Virtual Reality and Assoc. Technologies, Viña del Mar/Valparaíso, Chile, pp. 185–194 (2010)
11. Rand, D., Kizony, R., Weiss, P.L.: Virtual reality rehabilitation for all: Vivid GX versus Sony PlayStation II EyeToy. In: Fifth International Conference on Disability, Virtual Reality and Associated Technologies, Oxford, UK, September 20 -22, pp. 87–94 (2004)
12. Baranowski, T., Lieberman, D., Buday, R., Peng, W., Zimmerli, L., Widerhold, B., Kato, P.M.: Videogame Mechanics in Games for Health. Games for Health Journal 2(4), 194–204 (2013)

13. Flores, E., Tobon, G., Cavallaro, E., Cavallaro, F.L., Perry, J.C., Keller, T.: Improving Patient Motivation in Game Development for Motor Deficit Rehabilitation. ACM Advances in Computer Entertainment Technology 352, 381–384 (2008)
14. Rizzo, A.A.: A SWOT Analysis of the Field of VR Rehabilitation and Therapy. Presence 14, 119–146 (2005)
15. Huizinga, J.: Homo Ludens: a Study of the Play Element in Culture. Beacon Press, Boston (1955)
16. Fullerton, T.: Game Design Workshop: a Playcentric Approach to Creating Innovative Games, pp. 28–33. Morgan Kaufmann, Boston (2008)
17. Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H., McDonough, S.M.: Optimising engagement for stroke rehabilitation using serious games. The Visual Computer 25(12), 1085–1099 (2009)
18. Xu, Y., Barba, E., Radu, L., Gandy, M., Macintyre, B.: Chores Are Fun: Understanding Social Play in Board Games for Digital Tabletop Game Design. In: Proc. of Think Design Play: The Fifth International Conference of DiGRA (2011)
19. Wulf, G., Prinz, W.: Directing attention to movement effects enhances learning: A review. Psychonomic Bulletin & Review 8(4), 648–660 (2001)
20. van Vliet, P.M., Wulf, G.: Extrinsic feedback for motor learning after stroke: what is the evidence? Disability and Rehabilitation 28(13-14), 831–840 (2006)
21. Subramanian, S., Massie, K., Malcolm, C.L., Levin, M.P., Does, M.F.: the provision of Extrinsic Feedback Result in Improved Motor Learning in the Upper Limb Poststroke? A systematic review of the evidence. Neurorahbilitation and Neural Repair 24(2), 113–124 (2010)
22. Winstein, C.J., Schmidt, R.A.: Reduced Frequency of Knowledge of Results Enhances Motor Skills Learning. Journal of Experimental Psychology: Learning, Memory, and Cognition 16(4), 677–691 (1990)
23. Hemayattablab, R., Rostami, L.R.: The effects of feedback on the learning of motor skills in individuals with cerebral palsy. Research in Developmental Disabilities 31(2010), 212–217 (2010)
24. Wang, H., Sun, C.: Game Reward Systems: Gaming Experiences and Social Meaning. Proceedings of DiGRA 2011 Conference: Think Design Play (2011)
25. Przybylski, A.K., Scott Rigby, C., Ryan, R.M.: A motivational Model of Video Game Engagement. Review of General Psychology 14(2), 154–166 (2010)
26. Deci, E.L., Koestner, R., Ryan, R.M.: A Meta-Analytic Review of Experiments Examining the Effects of Extrinsic Rewards on Intrinsic Motivation. Psychological Bulletin 125(6), 627–668 (1999)
27. Shah, N., Basteris, A., Amirabdollahian, F.: Design Parameters in Multimodal Game for Rehabilitation. Games for Health Journal 3(1) (2014)
28. Antin, J., Churchill, E.F.: Badges in Social Media: A Social Psychological Perspective. In: ACM CHI 2011, Vancouver, BC, Canada, May 7-12 (2011)
29. Salen, K., Zimmerman, E.: Rules of Play: Game Design Fundamentals. MIT Press, Cambridge (2003)
30. Crawford, C.: Chris Crawford on Game Design, pp. 35–53. New Riders, Indianapolis (2003)
31. Zagal, J., Rick, J., Hsi, I.: Collabortive Games: Lessons Learned from Board Games. Simulation & Gaming 37(1), 24–40 (2006)
32. Morris, M.R., Cassanego, A., Paepcke, A., Winograd, T., Piper, A.M., Huang, A.: Mediating Group Dynamics through Tabletop Interface Design. IEEE Computer Graphics and Applications 26(5), 65–73 (2006)

33. Rick, J., Marshall, P., Yuill, N.: Beyond one-size-fits-all: How interactive tabletops support collaborative learning. In: IDC 2011, Ann Arbor, USA, June 20-23 (2011)
34. Nacenta, M.A., Pinelle, D., Gutwin, C., Mandryk, R.: Individual and group support in tabletop interaction techniques. In: Müller-Tomfelde, C. (ed.) Tabletops – Horizontal Interactive Displays, pp. 303–333. Springer, London (2010)
35. Lewis, G., Rosie, J.A.: Virtual reality games for movement rehabilitation in neurological conditions: how do we meet the needs and expectations of the users? Disability and Rehabilitation 34(22), 1880–1886 (2012)
36. Kruger, R., Carpendale, S., Scott, S.D., Greenberg, S.: How People Use Orientation on Tables: Comprehension, Coordination and Communication. In: Proceedings of GROUP 2003, pp. 369–378. ACM Press (2003)
37. Gajadhar, B.J., de Kort, Y.A.W., IJsselsteijn, W.A.: Shared Fun Is Doubled Fun: Player Enjoyment as a Function of Social Setting. In: Markopoulos, P., de Ruyter, B., IJsselsteijn, W.A., Rowland, D. (eds.) Fun and Games 2008. LNCS, vol. 5294, pp. 106–117. Springer, Heidelberg (2008)
38. Almqvist, L., Hellnas, P., Stefansson, M., Granlund, M.: 'I can play!' Young children's perception of health. Pediatric Rehabilitation 9(3), 275–284 (2006)
39. de Kort, Y.A.W., IJsselstein, W.A., Gajadhar, B.J.: People, Places, and Play: A research framework for digital game experience in a socio-spatial context. In: DiGRA 2007 Proceedings "Situated Play", pp. 823–830 (2007)
40. Lange, B., Koenig, S., Chang, C., McConnell, E., Suma, E., Bolas, M., Rizzo, A.: Designing informed game-based rehabilitation tasks leveraging advances in virtual reality. Disability and Rehabilitation 34(22), 1863–1870 (2012)