The Influence of Music on Player Performance in Exergames for Parkinson's Patients

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Abstract. Music therapy and music and rhythm in general can support standard physiotherapy for people suffering from Parkinson's disease to improve the motion performance and quality, sometimes even helping to overcome motion blocks. With the availability of cheap motion-tracking devices, exergames have become an interesting option to complement traditional physiotherapy. However, the role of music and rhythm in the context of games for this special audience is still largely unexplored. Based on a prototype exergame we developed, a user study was conducted to compare the effects of different auditory clues and their absence in exergames for this target group. The results show significant performance differences with music versus without music, but surprisingly no differences were found between music synchronized with the interaction and unsynchronized background music.

Keywords: exergames, auditory cues, kinect, Parkinson's disease.

1 Introduction

The most common occurring symptoms of Parkinson's disease (PD) are reduced movement in amplitude and speed, problems in initiating movement, freezing, postural control difficulties, resting tremor or rigidity [1]. Physical therapy (PT) can slow down the progression of PD [2], but due to its repetitive nature, it can quickly bore and tire patients [3].

Music therapy (MT) can greatly enrich traditional PT and help to improve the precision, range, speed and quality of upper body movement [4]. By instructing PD patients to step to the beat of music, significant improvements for stride symmetry, length, gait velocity and cadence were achieved [5].

Exertion games (exergames) can motivate and immerse patients to facilitate repetitions [6] which are crucial in order to rebuild functional abilities [7].

To utilize the advantages of auditory cues and exergames, we developed a prototype which blends both approaches into one system. We hypothesize that the auditory cues will have a performance enhancing effect in this game-like environment. To validate this hypothesis we contrast the performance of three groups of patients with PD. In the first group, the music's rhythm is directly connected to the timing of the movement. In the second, the music does not correlate with the movement. In the third, no music is used during gameplay.

M. Herrlich, R. Malaka, and M. Masuch (Eds.): ICEC 2012, LNCS 7522, pp. 433–436, 2012.

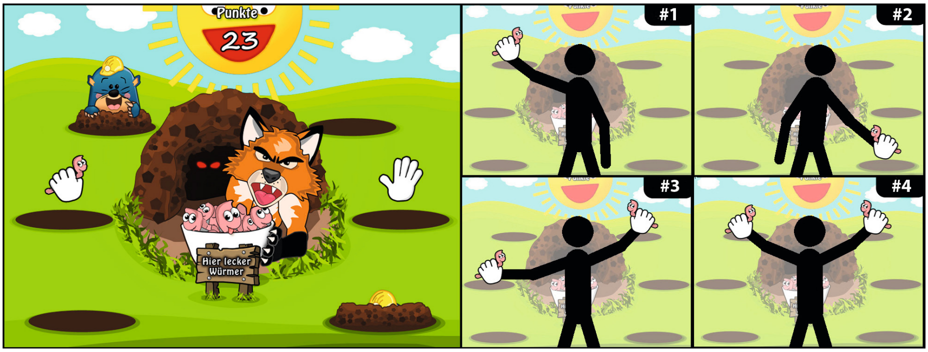

Fig. 1. Gameplay screen and an extract of movements for the mole game

Our results indicate that music can, in fact, have a performance enhancing effect when used in a game-like environment. In our particular setup it did not matter whether the music had a clear, easily followed beat or a more fluid, calming tempo.

2 Related Work

Assad et al. developed a collection of mini-games specifically for PD patients in order to train memory as well as upper and lower extremities. Within this collection the game “Cinderella” makes use of auditory cues in order to motivate and guide the patient’s pace of movement [8]. However, these auditory cues are not directly connected to the timing of the motion. A system for PD patients by Yu et al. lets the user interact with the system by wearing a motion suit and also makes use of auditory cues in order to help the patients to pace their movements [3]. However, the timing of these movements is not directly synchronized with the beat of music. Contrary to both systems, ours strongly connects the beat of the music with the timing of the movement in the attempt to help train its temporal precision as well as to reduce motion blocks.

3 The Mole Game Prototype

While standing in front of the camera, the player’s hands are tracked by the camera and represented as cartoon hands on the gameplay screen (cf. left side of figure 1). The game’s goal is to grab a worm and feed the moles appearing from the holes repetitively. The earlier the player hits the appearing moles the higher the score, ranging from 100% to 0%. Visual cues, small helmets peaking out of the holes, act as a hint for the player where the next mole will appear.

4 Evaluation

We conducted nine meetings over the duration of three months at three places where Parkinson's disease patients meet for physiotherapy or socializing. Every meeting lasted for approximately 1 to 2,5 hours.

4.1 Procedure

We tested for differences between the groups' performances by logging their scores. Additionally, we videotaped the motion of the participants. They were randomly assigned by us into one of three groups. The participants played a training round which had no music, followed by three gameplay rounds with the same movement patterns and with the specific background song settings for their group. Each round lasted one minute and 14 seconds. The choreography for all three rounds was the same and consisted of simple one and two-handed reaching tasks (cf. right side of fig. 1). Group one's beat of the music exactly matched the timing when a mole appeared and should therefore have helped with the temporal precision of the movement. We did not, however, explicitly instruct the participants in both music groups to use the auditory cues to pace their motion.

4.2 Results

A total of 24 participants with a mean age of 70.4±6.9 took part in the evaluation. 62,5% were males and 37,5% were females. All three groups had the same proportion of males (5) to females (3).

We conducted Kruskal-Wallis tests in order to reveal significant differences in the performances among the groups. In round one (H(2) = 2,885, p=0,236) as well as round three (H(2) = 4,56 p=0,102) no significant differences among the groups could be found, whereas the test revealed significant differences among the groups in round two (H(2) = 6,5 p=0,039). In this round, the participants of group one achieved an average score of 77,59%±22,84. Slightly lower was the score of the participants of group two with a mean score of 76,72%±10,92. Lastly, by nearly 20% less compared to the previous groups, the control group achieved a mean score of 57,18%±20,50.

Afterwards, we conducted pairwise Mann-Whitney U post-hoc tests in order to evaluate which pairs of groups had significant differences in round two. The difference between group one and the control group was significant (Mann-Whitney U=10,0, n1=n2=8, p=0,021 two-tailed). By analyzing the differences between group two and the control group, we found a tendency (Mann-Whitney U=14,0, n1=n2=8, p=0,059 two-tailed) for group two to score higher than the control group. Lastly, the differences in scores between the two groups with music were not significant.

Exclusively based on the observations, we could not identify any participants from group one rocking themselves or noticeably nodding their heads to the beat of the music.

5 Discussion

Our results show that music indeed effects player performance positively, even if the players are not explicitly instructed to regard the auditory clues. In contrast to our assumptions, the participants did not follow the specific beat in group one. We conclude that explicitly instructing players about the synchronization of the beat and the interaction might further increase performance.

6 Conclusion and Future Work

We have presented first experimental findings that music can improve the performance of PD patients in a game-like environment. For a follow up study we particularly recommend to explore if PD patients would time their movements with the help of auditory cues when explicitly instructed to do so. Further research could also discover the other attributes of music that could have positively affected performance in gameplay and why.

Acknowledgements. We thank the “Deutsche Parkinson Vereinigung”, particularly the physiotherapists Katharina von Sauken, Rieke Tischkewitz, Brigitte Kloker, Marlis Böger and Renate Stöver. We further want to thank all the participants who patiently and with great effort took part in this study.

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