Development of a music-based video game for upper limb rehabilitation therapy in children with cerebral palsy

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Introduction

- Cerebral palsy (CP) is the most common physical disability in children. In children with hemiplegic CP, motor control is affected in one arm/hand. Deficits are largely managed through therapy.
- A sufficient therapy dose is difficult to achieve in the clinic, given children's busy home/school schedules. Home-based therapies can offer flexible opportunities for guided practice.
- To motivate practice and encourage adherence at home, we can draw from children's interests to design interventions. Music and video games are two of the top interests of children with CP.

Objective

We are developing a home-based therapy video game to target arm/hand movement in children with hemiplegic CP through music-making.

Step 1: Initial Design

- With input from music therapists and occupational therapists, we have developed a suite of four mini-games, described below.
- The mini-games use the Microsoft Kinect, a commercially-available device that tracks players' movements as inputs. By moving their arms and hands, players affect their virtual in-game environment.
- The mini-games use music to provide extrinsic feedback (knowledge of performance/results) and are situated in a self-determination theory framework to support sustained motivation.

Step 2: Preliminary Acceptance Testing

- It is important for us to understand if children like and would use music-based therapy games at home.
- Preliminary acceptance testing of two mini-games has been conducted with members of Holland Bloorview Kids Rehabilitation Hospital's Children's Advisory Council.
- Children aged 5-14 responded to the statements shown in the table below.
- Children also supplied open-ended feedback: possible changes to create suitable challenges, and features to make the mini-games more appealing, and thoughts on the inclusion of music in the games.

	"I really like playing this game"	"I would play this game at home"	"Learning to play this game was easy."
MusicMaster	10/11 agree	7/11 agree	9/11 agree
Bootle Band	8/12 agree	10/12 agree	10/12 agree

- Children enjoyed the games, and their feedback suggested that home-based video game therapies which incorporate music may be appealing.
- Children liked the music in the games. Many children wanted the games to be more challenging to sustain interest. To address this, game modes of greater complexity are currently being developed.
- Further testing will determine if children consider these changes sufficient for sustained home use.

Step 3: Home-based Feasbility Study

- To understand if music-based therapy games motivate practice and encourage adherence, and if they lead to changes in body structure/function/activity, we have planned a feasibility study for Sept, 2017.
- **Participants:** 15 children with mild to moderate hemiplegic CP (GMFCS Levels I-II, MACS Levels I-II)
- **Intervention:** 30 minutes of music-based therapy games/day, 5 days/week, for 12 weeks (total = 30h)
- **Outcome Measures:**
  - **Primary:** Feasibility of intervention design. *Motivation* (Intrinsic Motivation Inventory - IMI). *Adherence* (computer-logged duration of play).
  - **Secondary:** Motor outcomes within the International Classification of Functioning, Disability and Health. *Body structure* (active range of motion, grip strength). *Function* (Quality of Upper Extremity Skills Test - QUEST, Bruininks-Oseretsky Test of Motor Proficiency - BOTMP). *Activity* (Canadian Occupational Performance Measure - COPM).
  - **Semi-structured Interview:** To collect participants' and parents' perspectives on the intervention.

Week	Timeline	Measures
Week 0	baseline	QUEST/BOTMP, active range of motion, grip strength
Week 2	pre-intervention	QUEST/BOTMP, active range of motion, grip strength, COPM, IMI
Week 2-13	intervention	computer-logged duration of play
Week 13	post-intervention	QUEST/BOTMP, active range of motion, grip strength, COPM, IMI, interview
Week 15	follow-up	QUEST/BOTMP, active range of motion, grip strength

- This research may demonstrate the feasibility of music-based video games as an approach for home-based arm and hand rehabilitation in children with mild to moderate hemiplegic CP.

Research with Impact

- Findings from the home-based feasibility study will be used to adjust the design of the intervention (e.g. game design, use of music, suitability of dose) and the battery of outcome measures to be included in a future randomized controlled trial.
- Low-cost, home-based therapy options that are appealing to children with CP may increase access to care and lead to measurable improvements in function that translate to improved quality of life.
- If successful, music-based therapy video games may have potential for other populations including acquired brain injury and adult stroke.

References

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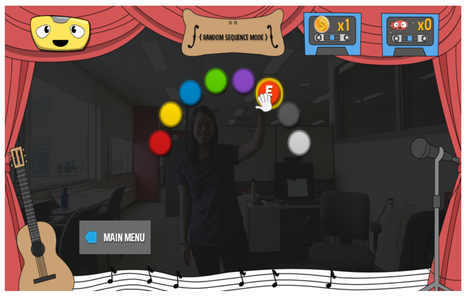
Mini-games

MusicMaster

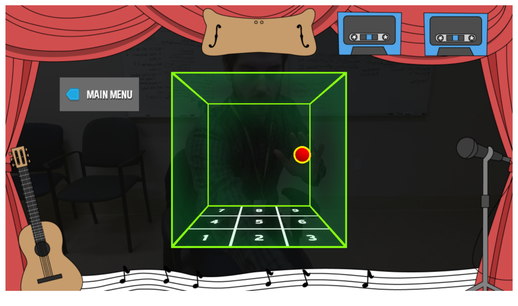


- Therapy goals: reach, cross-body reach
- Musical tones are mapped to an arc of 8 targets. The player learns to play songs by touching the targets.
- Based on music-supported therapy [1].

Conductor

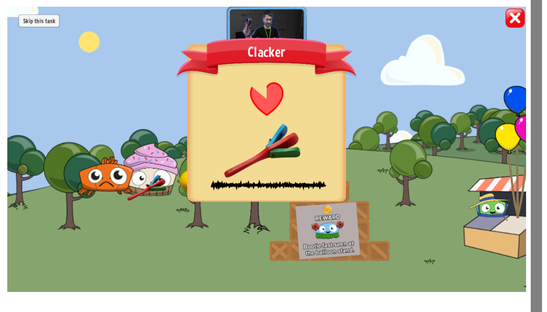
- Therapy goal: Timed reach
- The player must hit four targets to the beat of the music. The placement of the targets can be customized.
- Based on rhythmic auditory stimulation [2].

Composer



- Therapy goal: Smoothness of arm/hand movement
- Movements along the x, y, and z axes of the cube's frame adjust the music's timbre, tone, and volume.
- Based on sonified movement therapy [3].

Bootle Band



- Therapy goals: arm/hand strength, grip.
- This mixed-reality game tracks the sounds of real musical instruments (e.g. tambourine, castanets, bells).
- The player must play their instrument when prompted.