Designing Exergames Combining the Use of Fine and Gross Motor Exercises to Support Self-care Activities

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ABSTRACT
Motor coordination problems are common in different developmental disorders including autism and dyspraxia. Gross and fine motor coordination skills are critical to the appropriate motor coordination development that is relevant to support individuals' independence. Exergames are a good tool to help children practice motor skills as they find them engaging. In this work, we present how FroggyBobby –an exergame designed for practicing gross motor coordination skills, can be extended to combine gross and fine motor exercises for supporting children with motor problems to practice self-care activities that require motor coordination.

Categories and Subject Descriptors
K.4.2 [**Computers and Society**]: Social Issues – *Assistive technologies for persons with disabilities*; K.8.0 [**Personal Computing**]: General – *Games.*

Keywords
Exergames; game design; children; motor coordination.

1. INTRODUCTION
Different disorders are characterized by motor coordination problems including autism [5], developmental coordination disorder or dyspraxia [8], among others. The lack of motor coordination may severely limit motor skills use and age-appropriate development [8]. Motor coordination skills are commonly used as a measure of quality of life as they are critical to help individuals to be independent [9], especially when conducting the activities of daily living like self-care (e.g., get dressed and eating).

Most exergames are appropriate to help children practicing motor skills as children find them engaging [11]. Reflecting from our experiences in designing and evaluating FroggyBobby, an exergame to promote the appropriate practicing of gross motor skills [2], in this paper, we propose a set of fine-motor exercises that could be integrated to this game to help children practice self-care activities and develop age-appropriate fine-motor skills.

2. RELATED WORK
Several projects have investigated how exergames could be used for promoting physical activity (*Astrojumper* [4]), and motor rehabilitation (*Arrow Attack* [1]) in support of different populations, e.g., children with cerebral palsy [6], and stroke patients [1]. These studies show that using exergames benefits physical activity, which may have an impact on health [11] and in motor skills rehabilitation [1]. However, exergames for children with motor problems and those focusing in the fine-motor skills development are scarce. In addition, there are projects of games using touch displays that can help children to practice fine motor coordination [3]. But, these projects set aside the combination of gross and fine motor coordination skills that can be exploited to support the practice of self-care activities of children with motor problems.

ASSETS '14, Oct 20-22 2014, Rochester, NY, USA
ACM 978-1-4503-2720-6/14/10.
http://dx.doi.org/10.1145/2661334.2661403

3. THE FROGGYBOBBY EXERGAME
We followed an iterative user-centered design methodology, to design and develop FroggyBobby, an exergame for children with motor problems where children control the tongue of a frog avatar practicing with each arm several gross motor coordination exercises [2]. The *basic gameplay* of FroggyBobby demands children to move their left or right arm up and down in a lateral or cross-lateral way. When children play FroggyBobby, they swipe their arms following a path from a start button (Figure 1a) to an end button (Figure 1b), trying to get the frog to catch as many flies as they can. FroggyBobby uses Kinect to track the user´s movements for performing the motor coordination exercises and it was implementing using C# and Microsoft Kinect SDK.

(a) (b)

Figure 1: Screenshots of the first level of FroggyBobby.

3.1 Methods
To extend FroggyBobby and uncover the fine motor coordination activities that are relevant for children with motor problems, we carried out two participatory design sessions with three psychologist-teachers that attend children with autism presenting motor coordination problems, and one HCI expert. During the design sessions, teachers expressed the importance of combining fine and gross motor exercises, and modified the dynamics for each level and their aims. Data analysis for the results of the design sessions included the use of qualitative techniques such as open coding and affinity diagramming [10].

4. SUMMARY FINDINGS
From the results of the participatory design sessions emerge that for supporting children with motor problems in the practice of self-care activities that require motor coordination, children need

to master gross motor coordination exercises. Next, they should practice fine motor coordination exercises. Finally, they should use both fine and gross exercises when conducting self-care activities. To follow this process, a set of fine motor exercises was established to support scaffolding of fine motor coordination. In addition, a set of self-care activities was designed that will promote the practicing of those newly learned motor skills.

4.1 New levels using fine motor coordination exercises

Three new levels of FroggyBobby were proposed based on the fine motor exercises that resulted from the design sessions:

- *Press*, for focusing a target: To keep the hand opened pointing towards an object and then tap it on top of the object.
- *Grip*, for preparing the fine movements: To grab objects with the open hand and then close the hand to move the objects around or catch it.
- *Fine pincer*, for performing fine pincer movements: To use the thumb and the index finger to take an object.

Three levels for each motor exercise were proposed mimicking the game dynamics already available in the original version of FroggyBobby. To prevent frustration in children, instead of catching multiple flies, children must only catch one fly. Another fly will appear after children catch the previous one.

4.2 Using coordination exercises during the practicing of self-care activities

The following informal guidelines were emerge from data analysis to support self-care activities for children with motor problems through exergames:

G1. Learn the cognitive process through gross motor exercises. The exergame should allow children solve some cognition challenges making sure they have the basic cognitive abilities to perform self-care activities (e.g., select the elements for tooth brushing). For that, children can use gross motor exercises, allowing children learn the cognitive process.

G2. Practice of self-care activities through fine motor exercises, combining tangible computing. The exergame should be combined with tangible computing [7], which allows the use of tangible objects interfaced with computers. This provides support for practicing self-care activities with real objects performing fine motor exercises.

G3. Sustained attention management. The exergame should motivate children to practice the self-care activity. Then, the exergame should allow children focus their attention on the tangible objects (e.g., show a waiting screen). Finally, the exergame should provide a strategy to link the use of tangible objects with the system.

Three mini-games were designed for FroggyBobby following these informal guidelines: tying shoelaces, tooth brushing, and selection of the appropriate serve ware for eating (Figure 2).

5. FUTURE WORK AND CONCLUSIONS

As a future work, we are planning to develop the levels for fine motor coordination exercises and one self-care mini-game. We plan to conduct a deployment of the extended version of FroggyBobby with children with motor problems and analyze if the exergame can help with the development of fine motor skills.

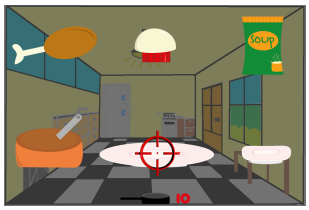

Figure 2: Screenshot of a mini-game for practicing self-care activities using gross motor exercises (informal guideline G1).

We expect FroggyBobby serves to support self-care activities of children with motor problems, supplementing current practices and therapeutic interventions of children with motor problems.

6. ACKNOWLEDGMENTS

This work is funded by the Mexican Council for Science and Technology (CONACyT) fellowship and trough Dr. Monica Tentori's Microsoft Fellowship gift.

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