Oh Snap!: A Game of Focus, Calm & Collaboration

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Abstract
Previous studies have shown that self-regulation of heart rate variability (HRV) and other forms of biofeedback can help children positively manage stress, increase focus, and improve performance on standardized tests. This paper explores the use of Heart Rate Variability as an input in a tangible user interface game we call *Oh Snap!* The game uses an HRV sensor as well as motors, force sensors, and hand held joysticks to move a bucket around a three-dimensional game board. The tension and movement of the game piece is based on the players' combined level of HRV to encourage collaboration and social awareness of emotions. The game offers a potential tool for classrooms and after-school programs to help students learn stress management and concentration skills within a collaborative environment important for social development and learning.

Keywords
Biofeedback, physiological computing, games, assessment, behavioral assessment, collaborative learning.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces—prototyping.

General Terms

Educational games, biofeedback games, stress reduction, tangible user interfaces, mindfulness in education.

Introduction

There have been numerous studies showing the potential benefits of biofeedback and mindfulness on positive educational outcomes especially with children with ADHD and ADD [2]. This is particularly relevant since 7% of American children between the ages of 3 and 17 are diagnosed with Attention Deficit Disorder [4]. Additionally, studies within California classrooms have show significant learning improvements after students were taught HRV self-regulation techniques. These techniques include attention on breathing, focus on heart beats, and positive visualization and associations [5].

One peer-reviewed study found that students who practiced self-regulation techniques had 21% increase in English Language Arts and 11% improvement in Math for students trained in self-regulation techniques [5]. Yet much of the previous research does not adequately address how biofeedback can effectively be integrated into an environment appropriate for children's social development.

While there has been extensive research on the benefits of collaborative learning experiences there is no known research on the integration of biofeedback into a collaborative tangible user interface specifically for children. Tangible interactions on the playground offer a social and physical environment with which the majority of children are already familiar that can incorporated into the game design.

This paper explores the use of biofeedback self-regulation using heart rate variability (HRV) as an input into a collaborative game prototype *Oh Snap!*

Previous Work

Our design is informed by previous work on biofeedback gaming although there are few games specifically designed for children in a collaborative setting.

While there has been some research on biofeedback games within a social context this has been within a competitive instead of a collaborative framework. One example is the game "Relax to Win," a racing game where two players competed against each other to see who could relax for a higher amount of time [16] however not surprisingly this element if competition was shown to create greater stress that the gamers had to overcome.

A multi-player approach is also present in the prototype game "Water Game" out of the Helsinki Institute for Information Technology. This game as a First Person Shooter (FPS) has a theme that does not fit well into an educational environment or a game for children. The game is played using mobile phones as the individual devices and a big screen that all of the players can view offering an intriguing look at the potential use of mobile devices for collaborative gaming [17].

The game "HeartBall" developed at the MIT Media Laboratory offers an example of a tangible biofeedback game. Players' EKG and heart rate were recorded using biosensors and the game goal was for players to lower their heart rate to a prescribed rate within 20 seconds. While this game presents interesting example of

drawing on existing sports as a mode for bio-focus, the game again utilizes a competitive instead of a cooperative or collaborative model [14].

Theoretical Background

An emphasis on collaborative interactions for childhood learning and development has been a highly covered topic in scholarship. Honebein stresses the importance of creating a "social experience" as exemplified by collaboration within the classroom [6]. More generally this social experience in learning might consist of peers sharing information, sharing methods of learning, or encouraging each other towards better performance [9]. Peer assessment can additionally offer helpful skills that allow students to problem solve and come to solutions within a group environment [10]. Games offer an environment where social interaction can be encouraged in a collaborative manner in which peers can help each other achieve a goal.

Another aspect of learning theory incorporated into our game is formative assessment in which the student is given feedback on performance within the context of the learning experience itself and is another important constructivist technique [7]. This type formative assessment is integrated into the design of *Oh Snap!* as players are given immediate feedback on their own individual HRV as well as that of the group.

Design Research

While learning theories were helpful in the design process we also utilized participant observation of playground spaces in the design and development the physical mechanisms of *Oh Snap!* Aspects of the game were also based on team building exercises.

Two public playgrounds in Berkeley, CA were observed to gain a better understanding of how children collaborate and interact socially within a play environment [Figure 1]. Several key themes emerged from these observations and these were incorporated into the game design of *Oh Snap!*

figure 1. One of the two playgrounds observed.

Exploration: Children enjoyed exploring the playground space and trying new postures and physical gestures. This included upside-down hanging on the rings and using the playground equipment in interesting ways. In response to this observation we wanted our game to allow children to explore the game space in novel ways that were not always structured.

Mimicry: Several of the older children would experiment with different ways of standing on, hopping off or holding on to equipment like rings, bars and ladders. Other children would follow the way they used the equipment attempting to mimic their gestures and

use in similar ways. In our game the collaborative movement of the game piece allowed children to mimic other children's movements.

Explanatory Dialogue: Children would often explain the motions they were performing to the other children playing as a running narrative. In one example a young boy perhaps five years old shouted "We're doing my daily exercises … Try that" showing other kids how to perform similar motion on the rings. Similarly, at another time a child noted "that really scared me," sharing and explaining his emotions in response to his friend's jumping off a tall bar in the play area. Monitoring other children's performance is an intrinsic part of our game play, and allows children to coach each other in ways to reach the optimal level of HRV similar to how they might provide feedback to each other in a playground environment. These coaching methods of "leaders" and "guides" in a collaborative game environment are also well supported in previous research [1].

Our game was additionally informed by the team building exercise "Toxic Waste." In this team building game each individual is given the end of a rope attached to a bucket and the object of the game is to move the toxic waste from the bucket into a safe or neutral space (often another bucket). Balls, sand, or water can be used in the bucket to represent the "toxic waste" and because there are numerous players holding a rope attached to the bucket they must work together to maneuver it without spilling its contents.

Combining our observations of playground spaces with aspects of the team building game allowed us to integrate children's natural methods of play with more collaborative and structured game environments.

Game Description & Prototype

Oh Snap! is a collaborative game in which three players work together to move a bucket around a prescribed game area. The tension and weight of the bucket is based on the players combined HRV levels. The more stressed the players are the harder it is to move the bucket.

The design of the game originally replicated a sandbox or a playground space (Figure 2). A metaphor of tension is used throughout the design with the tension of the strings holding the bucket representative of the stress or tension of the game's players. In this early design the game was highly influenced by the team building exercise "Toxic Waste" with the similar goal of getting the contents from one bucket to another bucket (marked "start" and "end" in Figure 2). Additionally, the red balls were to be reminiscent of "stress balls" allowing players to squeeze them to tighten the tension of their individual string attached to the bucket.

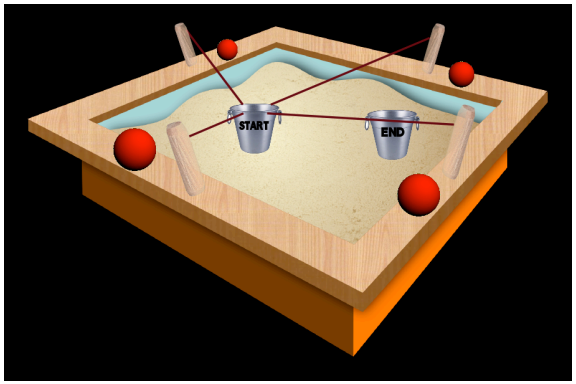

figure 2. An early design mock-up of the game.

After an early prototype was tested we found that the physical mechanisms to scoop and pick up either sand or balls would simply be to challenging for 3-4 players to accomplish. Since this was not the sole object of the game and this physical motion of the bucket needed to balanced with the players' ability to successfully self-regulate their HRV, the concept of moving contents from one bucket to another was replaced with the concept of moving a bucket around a path of various colored squares on the game board. These colored squares were based on the players combined levels of HRV.

In Figure 3 a prototype of the game is shown in which the players combined HRV is used to turn an LED display red, blue or green respective of whether the players are stressed (red) or focused and relaxed (green). The object of the game is to move the bucket to the various colored squares based on the players' ability to self-regulate HRV. Therefore to reach a blue square each player can reach an intermediate level of HRV (blue) or one player can have a red (stressed) HRV and another green (focused).

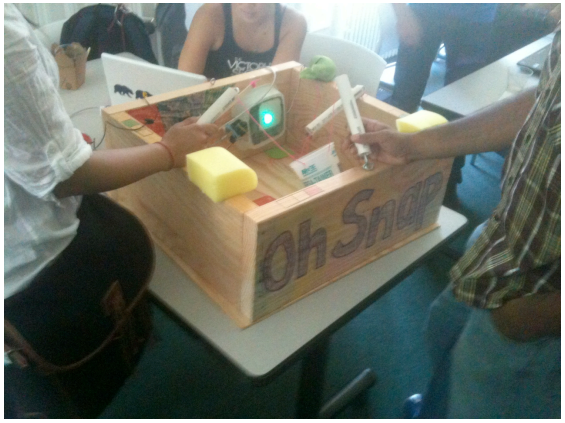

figure 3. Players moving a bucket during a game of *Oh Snap!*

These aspects of strategy and awareness allow players' to monitor not only their individual HRV (which is shown on a small display) but also of the combined group's HRV (on a larger display) and are meant to encourage a sense of emotional awareness of both one's own level of attention and focus as well as that of other players.

Training children to play the game can be done in under five minutes by an adult or educator and includes techniques of breathing at a slowed pace, attention on heart beat by placing one's hands on one's chest, and visualizing a place of personal relaxation and comfort. The collaborative design of the game encourages that players with greater experience in the game share their knowledge with more novice players. This technique of sharing gestures and behavior was observed in

playground observations and also confirmed with early trials with students.

While the fundamental goal of the game is quite simple, allowing children to work together to more a bucket around a game space, there are several mechanisms used to change the position, tensions, and perceived weight of the bucket along the x and y axis [Table 1].

Input	Collaborative	Bucket Position
Hand controlled joysticks	Yes	Multi-directional
HRV	Yes	"Stressed" HRV restricts tension of the string at bucket bottom (restricting movement up and down)
Stress balls	No	Each player's stress ball controls tension of the bucket forward and backwards

Table 1. Control mechanisms and inputs for bucket position.

A commercially available ear sensor and clip from HeartMath was used to gather data the input data on the player's HRV in the design prototype. Optimal HRV shows a more regular sinusoidal wave pattern and "green" or optimal HRV was calculated to be within .1 Hz of a sine wave. This input was connected to an Arduino program, circuit board and servo motors to produce the tension on the bucket. An additional servo motor and a force sensor was used in the stress ball mechanism to allow players to control forward and backward tension of the bucket using their own stress ball.

Further Work and Recommendations

There is much we would like to do to improve the design and implementation of the game including further user testing and evaluation as well as several changes to the mechanics and display of the game.

Instead of using the HRV ear sensor we would like to integrate the measure of HRV directly into the joysticks to make the experience less invasive for the players and a more intuitive part of the tangible user interface. Additionally, since the prototype only utilized the HRV of one player we feel it is important to display both the individual HRV of each player as well as the combined HRV score.

There are currently no game play instructions on the prototype and based on preliminary user evaluation we feel it would be beneficial to include several instructional cards that explain the fundamental game goals as well as methods of reaching optimal or non-optimal HRV levels (e.g. taking deep breaths for optimal HRV and jumping around for non-optimal HRV).

We would like to also conduct further user testing with children within a classroom environment during recess, or in an after-school program. While various aspects of the game design were based on natural play interactions further testing would help us modify and

enhance the usability of the game to ensure that these interactions make sense to children in the context of their play environment.

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