CoolCraig: A Smart Watch/Phone Application Supporting Co-Regulation of Children with ADHD

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Abstract
This paper presents the design and development of CoolCraig, a mobile application supporting the co-regulation of behaviors and emotions of children with ADHD. The application works in both a smartwatch, for children, and a smartphone for their caregivers. We describe a scenario of use for how CoolCraig can support co-regulation between children and their caregivers by following a goals-rewards system and tracking emotions and behaviors.

Author Keywords
Smartwatch application; children; ADHD; self-regulation; Co-regulation.

CSS Concepts
• Human-centered computing~Human computer interaction (HCI); Human-centered computing~Ubiquitous and mobile computing

Introduction
Children with Attention Deficit Hyperactivity Disorder (ADHD) continuously struggle to manage their attention, behaviors, and emotions [1]. Finding ways to support their self-regulation is critical [13]. Self-regulation involves managing one's behavior, emotions, and thoughts in the pursuit of short- and long-term goals. This skill involves self-monitoring, goal setting,

reflective thinking, decision making, self-evaluation, and management of emotions arising as a result of behavior change [11,13]. Self-regulation is fundamental to adaptive developmental tasks at all stages of life [10]. For children who struggle with self-regulation, caregivers (e.g., parents, teachers) tend to support them using co-regulation strategies[19] (e.g., caregivers help children to initiate and sustain enthusiasm for a task and redirect child attention, or to restart the task [4]). Improving self-regulation requires a collaborative effort between caregivers and children.

Supporting co-regulation requires designing collective focused applications. Applications should create friendly environments where children feel secure and supported by their caregivers. Wearable applications have the potential to empower children to engage in their regulation activities while still depending partially on computational and human supports. Previous research in HCI has shown the importance of designing applications for families of children with disabilities [15], a finding echoed in this work.

Wearable technologies combine portable computing with ubiquitous access, providing the ability to record, simulate, communicate, and give timely feedback to users [2]. Prior research has explored how to support children and adults with intellectual disabilities [21], ADHD [12], and autism [20]. For example, wearable sensors could be used to sense problematic or risky behavior and provide real or near-time feedback to avoid inattentive episodes [14,16].

Recently, research on smartwatch has explored how to design and develop apps to display self-regulation strategies for people with neurodevelopmental disorders [20–22]. For example, in designing WELI (Wearable Life), a smartwatch application designed to assist adults with intellectual disabilities to support self-regulation in class, research indicated indicate mood regulation, reminders, checklists, surveys, and rewards as useful tools for self-regulation on the smartwatch [21,22].

These works have shown that wearable devices could be worn by people with neurodevelopmental disorders and can help them to support self-regulation strategies. However, wearable computing solutions have been used to support but, have traditionally been designed for individual users. Thus, in this work, we explicitly considered a model of intervention that involves both children and caregivers working together.

In this paper, we present the design and development of CoolCraig, a mobile application supporting the co-regulation of behaviors and emotions of children with ADHD. We present the UI and software design. We conclude by discussing scenarios of use.

Background

Wearable individual and collaborative applications should supplement existing practices of self-regulation, as it has been shown that this could ease the transition between current interventions and technology-based interventions [6]. To illustrate our approach, we briefly describe two strategies to support the self-regulation of behavior and emotion for children with ADHD.

Token-based economy

A token-based economy is based on the principles of applied behavior analysis (ABA) and emphasizes the use of positive reinforcement to target behavior change. Token-based economies help students visualize progress, accept and work for delayed reinforcement, learn to self-monitor, and learn to regulate their

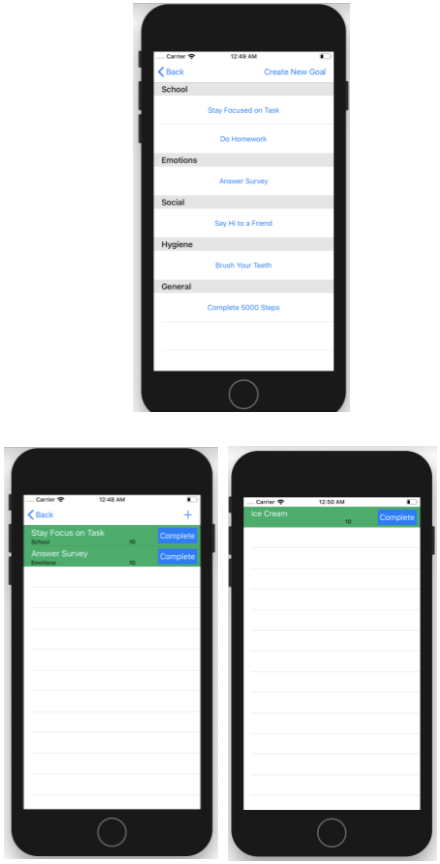

Figure 1. Screenshots of the CoolCraig smartphone app where parents can set-up goals and rewards for the children.

behaviors [9]. A token is a real or virtual reward (e.g., points) given to reinforce desired behavior. Tokens can be collected and exchanged for larger rewards.

In the Human-Computer Interaction (HCI) community, the Token-based economy has been used to support children [17] and practitioners [5,8], mainly in classroom settings showing positive results. Therefore, in this study, we incorporated this strategy as it is common and well-known to support behavior management across mainstreams and special education classrooms.

The Zones of Regulation Framework

Self-regulation is a complex but useful concept that is becoming an essential part of educational intervention – although it is not necessarily required in general curricula. The "Zones of Regulation®" [7] is a framework for teaching students to reflect on their emotions and behaviors.

Using a cognitive-behavioral approach, the framework uses four colors to help students identify how they are feeling in the moment given. Children are in the Red Zone when they feel euphoric, or experiencing anger, rage, explosive behavior. They are in the Yellow Zone when they experience stress, frustration, anxiety, excitement, or nervousness. The Green Zone is used to describe a calm state of alertness; this is happy, focused, or ready to learn. The Blue Zone is used to describe feelings such as sad, tired, sick, or bored.

This framework has been previously used in a smartwatch application supporting children with intellectual disabilities to inform their current emotions at school [21,22]. However, adapting these largely individualized self-regulation frameworks and instructional aides to a collaborative co-regulation model has yet to be tested clinically.

CoolCraig

CoolCraig is a mobile application supporting the co-regulation of behaviors and emotions of children with ADHD. CoolCraig runs in a smartwatch worn by children, and a smartphone used by their caregivers. To support the co-regulation of behaviors, CoolCraig follows a token-based economy used by children and their caregivers. To support the self-regulation of emotions, CoolCraig follows the "Zones of Regulation" framework.

The name, CoolCraig, was derived from the School program in which we conducted the qualitative study; years earlier, a staff member by the name of Craig was identified as a person that kids could emulate, due to his "cool" nature as well as his ability to remain calm and to exhibit self-control in stressful situations.

Methods

Over eight months, we conducted workshops with 24 children with ADHD and their caregivers [3]. These sessions focused on overall impressions of smartwatches, strategies for improving self-regulation, and how these strategies could be improved using a smartwatch. Finally, participants considered specific potential smartwatch features that could be useful. All discussions were transcribed and analyzed using a mix of open and axial coding. Codes and interview snippets were then grouped using affinity diagramming (for more details about the design methods and findings we refer the interested readers to [3])

Then, we followed Scrum and Kanban Software development methods to translate the qualitative

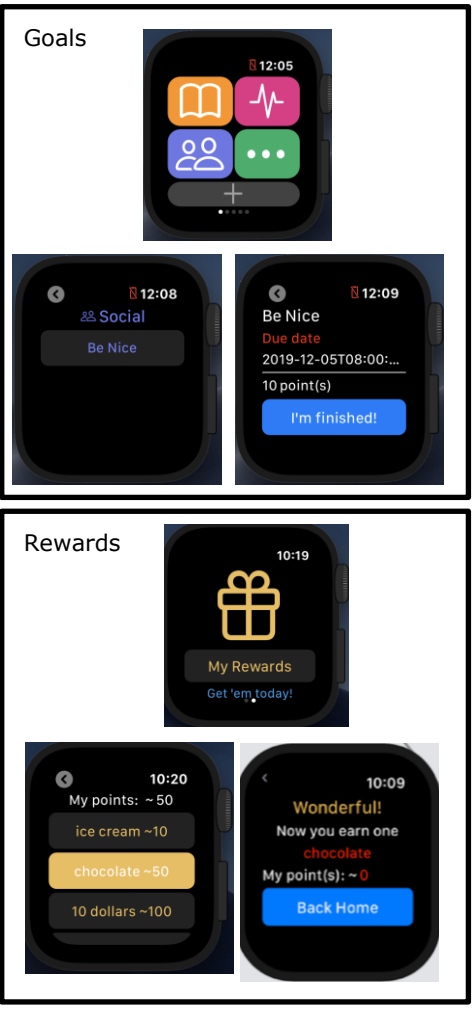

Figure 2. Screenshot of the CoolCraig smartwatch application

results into software requirements [18]. The research team had a weekly meeting to discuss the requirements and the development completed during that week. After that, we designed Personas and scenarios to discuss the developing application.

Supporting co-regulation

To support the token-based economy, CoolCraig implements a goals-reward dynamic between children and their caregivers. For security and privacy purposes, the caregivers are the owners of the application and will have an account where they pair their phone with the children's smartwatch.

On the phone, caregivers can view and set their children's goals and rewards and can assign points to each reward. CoolCraig will synchronize the information into the children's smartwatch (Figure 1).

To encourage independence, the CoolCraig application on the smartwatch also allows children to select and add a new goal for themselves. At the watch, the children can view their current goals that for the month (Figure 2).

Once children feel they have accomplished one goal, children can use the smartwatch to complete the goal. This action will send a notification to the CoolCraig phone app. Thus, caregivers then can confirm the finished goal, and the app will award points to the child. On the watch, children can visualize their earned points and an overview of rewards. These points can be redeemed for a reward identified by caregivers.

Supporting self-regulation of emotions

To support the self-regulation of emotions, CoolCraig will send a survey to the smartwatch, as a pop-up notification, where children can select rate their "Zone" from the "Zones of Regulation" framework (Figure 3). After that, CoolCraig sends a message or recommendation based on the zone the child selects. Notification timing is selected by caregivers to ensure that it fits within a child's scheduling needs. CoolCraig records data so at the end of the day children can view their regulation zones.

Overall, CoolCraig allows caregivers to see a detailed history of accomplished goals, rewards, and their children's mood throughout the day on the caregiver's phone, and in the smartwatch allows the user to see a summarized graph of last month's finished goals and to customize their notification method.

Development of CoolCraig

We developed CoolCraig to run in an Apple Watch Series 5, and a compatible iPhone. We used Xcode Version 11.1, using Swift. To store the data, we used Google Firebase Cloud Firestore.

Here, we describe the main components of the software architecture (Figure 4):

- **Fetch/Retrieve data:** When the admin (caregiver) assigns a goal to their child, the data will be stored in the Firebase Real-time Database. When the child opens the app in their Apple Watch, the data will then be loaded into their goal page and vice versa.
- **Cloud Functions:** We can retrieve data from the database using cloud functions.
- **User Authentication:** Admin users have email accounts to register their iPhone apps, meaning during registration, users can input their email

Figure 3. Screenshot of the check-in survey to support self-regulation of emotions

accounts and receive verification through emails.

- **Provide Health Data:** Research Kit is a software medical platform developed by Apple. It helps us collect health care data from the phone and the watch, as we plan future work to study the realationship between self-regulation behaviors and health care data.

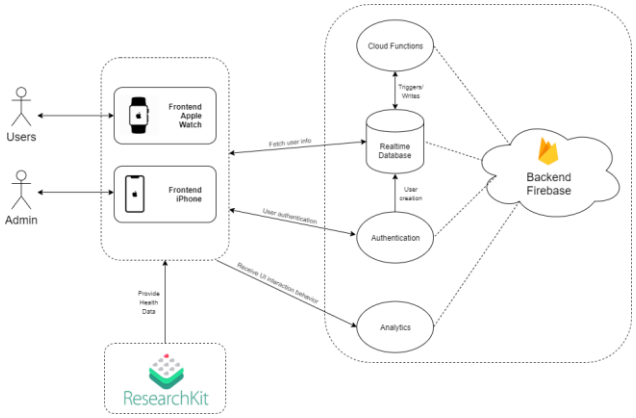

Figure 4. A scheme representing the software architecture of CoolCraig.

Personas and Scenarios of Use

To show how CoolCraig will be used we present the scenarios of three Personas, James, a child with ADHD, Chad, the father of a girl recently diagnosed with ADHD, and Sarah, a teacher at a developmental school.

James is a middle scholar at Lakeside Middle School. James has been struggling with controlling his temper. Whenever he gets nervous or anxious, he found himself acting out of anger and often presented as aggressive. His parents are worried, and they decided to give him a smartwatch with the CoolCraig app. Every day, CoolCraig sends a survey to ask James in which "Zone" of regulation he is. For example, today his answer is "angry." After he responds, CoolCraig sends a pop-up icon to remind James to "take a deep breath." James usually does not remember to do this himself when he is overwhelmed with emotion. James adds, "Do breathing exercises" goal in his watch. Now, every time he does a breathing exercise, he will receive points that later can be used to claim a reward from his caregiver, promoting a personal sense of achievement.

Chad is a 45-year-old businessman. He lives with his family in Southern California. Chad did not know his daughter had ADHD until she started middle school. Until then, he thought his daughter was just a troublesome kid who needed a little more discipline. She often interrupted or did not pay attention to him while he was talking to her. It made him felt stressed and frustrated. He wanted to do everything to help her succeed in life. As a caregiver of a daughter with ADHD, his goal is to help his daughter become independent and also understand his child's moods and behavior. The teacher of his daughter recommended using the CoolCraig app. Now with CoolCraig, he can set goals for his daughter, and she can be more motivated to accomplish her goals.

Sarah is a 36-year-old middle school teacher. Every day, Sarah wakes up, ready to lead her students on the path to success. She feels that it is her responsibility to make sure each of her students is on the right track to be successful and independent despite their disadvantages. Sarah's students are children with ADHD. Every day, Sarah struggles to help her students complete their daily schoolwork and goals. She recently started using CoolCraig to help her monitor students' moods,

behaviors, and daily goals. Sarah likes the app because it not only allows her to have access to important student data (such as their mood, accomplishments, and progress) but also each student. She has been consistently using this app to improve communication with her students.

Conclusion and Discussion

In this paper, we presented the design and development of CoolCraig, a smartwatch/phone application supporting children who struggle with self-regulation. We learned that we need to balance the token-based economy established by caregivers by allowing children to also add personal goals using a smartwatch. We created a pop-up notification system that allows children to receive reminders and to track and reflect on their emotions and behaviors. As future work, we plan to test the scenarios in a pilot clinical trial, and with the data collected, we plan to use machine learning algorithms to cluster data and make a comparison between groups as well as to study the relationship between contextual factors and behavior.

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