FOQUS : A (Wrist) Wearable Application for Individuals with ADHD and Mental Health Challenges

Abstract
Recent studies have shown that attention deficit hyperactivity disorder (ADHD) affects not only kids but adolescents and older demographics. 3.5% of all working adults struggle with ADHD and it is projected that various forms of ADHD is associated with 143.8 million lost days of productivity each year [3]. The affected group of people primarily have challenges with concentrating on tasks which leads to high levels of anxiety and stress. In this paper we explore the design of FOQUS, an app running on a wearable smart watch device which addresses mental health problems like ADHD through two main routes – tools to improve focus abilities and tools to reduce internal anxiety/stress levels. Using a user-centric design approach, we have implemented features which aim to leverage the benefits of wearable devices by implementing several salient functions: a tool for guided meditation, a flexible implementation of the Pomodoro time management technique, robust progress analytics and text-based priming.

Author Keywords
Wearables, Smart watch, Mental Health, Wellness, Attention Deficit Disorder, User-centered design, Habit formation, Stress.

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Introduction

In the emerging era of wearables and the quantified self, new opportunities arise for the application of computing technology in the area of health and wellness. Whilst much work has been done regarding physical fitness tracking, a less addressed area of inquiry is the application of wearables to mental health and wellness issues. Mental health issues such as ADHD, which materialize in the form of obstacles to sustained task focus and constantly elevated levels of anxiety, can be a debilitating challenge to many patients with such conditions [1]. ADHD is a commonly diagnosed neurobehavioral condition in which patients have are unable to pay attention or concentrate on tasks for extended periods of time. Such individuals exhibit developmentally inappropriate levels of inattention and/or hyperactivity and impulsivity [1]. Unfortunately, the impact of such mental health issues on the quality of life, are less likely to be observed by the general public, and not given appropriate attention. In some cases when patients are eventually diagnosed, there are few tools that can help them adopt behavioral change approaches to improving their condition. For such people, their pain is acute and what they need is support, above everything else. There is a critical need for more work towards providing help and support to this less-understood demographic of people.

Wearables as a class of computing devices worn on a bearer’s body (on the skin, below the skin, wrists, head, upper arm, ankle etc) have received considerable attention as a means of addressing health and physical activity related problems. Of the group of wearable devices in use today, programmable wrist-worn wearables have received the most attention especially with the rise of smart watches. In our work, we developed a working prototype of a wearable application running on the Samsung Gear 2 smart watch which provides tools to help individuals improve their ability to focus on extensive tasks and to lower their levels of anxiety.

Theoretical Background

Traditionally, ADHD has been viewed as a childhood disorder which youngsters outgrow as they get older. Childhood ADHD is estimated to affect 5-7% of school aged children in the world, and about 6.4 million children in the USA alone [2]. However, recent studies have highlighted ADHD diagnosis even within adolescents [1] and older demographics [3]. For older demographics, their condition have serious implications for their work life. Attention deficit problems in the workplace can cause an individual to exhibit symptoms such as anxiety, depression and low self-esteem [4]. They appear to be flighty, edgy, late, disorganized [4], constantly unable to meet deadlines, prioritize appropriately, fidget and daydream. The work of de Graaf et al (2008) [3] shows that 3.5% of all working adults (age 18 – 44years, n = 7075) across 10 countries met the standard (DSM IV) diagnosis criteria for ADHD. These results suggest that a significant percentage of ADHD cases persist into adulthood, and only a small amount of them receive appropriate treatment. Their findings also highlight the impact of ADHD on job role performance for workers (employed and self-employed). Specifically, workers with ADHD had an excess of 8.4 more sickness absence days per year and even greater annualized average excess

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**ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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number of workdays associated with diminished work quantity (21.7 days) and quality (13.6 days). Taken together, it is projected that various forms of ADHD is associated with 143.8 million lost days of productivity each year [3].

Designing a Solution

As a neurobehavioral phenomenon, there are different methods of addressing focus and attention deficit issues – counselling, behavioral management techniques (BMT), and medication. In this work, we follow the behavioral management approach and explore the design of technology tools that implement BMT approaches to ADHD treatment. BMT covers a range of cognitive behavioral approaches such as cognitive training, and social skills training. It has been identified to be particularly helpful when patients are unresponsive to medication [5], intolerant to medication, when symptoms are mild or where there are strong ethical or moral objections to medication [6].

From the technology artifact design perspective, work has been done in this regard. [7] Proposed a video game that gets harder when a player's brainwaves indicate waning attention. [8] Design a tool that provides in situ cues for ADHD parenting using mobile and sensing tools. They use a skin conductance sensor connected to a mobile phone and a peripheral screen to estimate parental stress levels and proffer positive priming messages to encourage positive behavior. Such approaches also succeed because they measure, curate and display objective physiological data (e.g. activity, stress, focus) of the user's state, in addition to user-reported data. However, one drawback of existing solutions has to do with ubiquity limitations. Existing systems are not well suited to mobile lifestyles and use in the workplace.

On the other hand, wearable devices, especially smart watches, hold fashion implications and are already deeply entrenched in the daily life of individuals. They are also sensor rich, capable of measuring important bio-information such as electroencephalogram (EEG), heart rate, ambient conditions (light, pressure, UV) and proximity. These qualities inspire an important question - how can we leverage these characteristics of wearables in designing more effective BMT tools?

To build our solution, we followed a user-centric design approach which began with user surveys, interviews, secondary user data review, persona development, brainstorming, cognitive walkthroughs, prototyping and usability tests.

Survey

To guide our initial foray into the development of smart watch wearable apps, we did the following:

i. Conducted a survey of college staff/students (n=27, age 16 - 40) to access their adoption of wearables and what aspects of wearables are important to their adoption decision.

ii. Reviewed secondary data from online repositories which documents the experience of ADHD patients (See Fig 1 and 2). We also reviewed approaches used within mobile apps recommended for ADHD patients.

iii. Conducted interviews with 5 participants, 3 of whom mentioned that they had constantly high levels of anxiety related to their inabilitys to focus and complete tasks.

From this initial study, we learned a few things.

i. Individuals exhibited a generally high interest in wearable devices and wearable apps.

ii. Indicated that interface design and functionality of the wearable app is more important compared to the price when making the decision to adopt a wearable device.

iii. Most respondents felt that wearable apps had greater potential to help them realize health related benefits compared to mobile or desktop based apps.

iv. Individuals who felt that they were overwhelmed with daily work expressed more interest in the value of digital productivity tools compared to people who felt they were in control of their schedule.

v. Adults who indicated various attention deficit problems were most affected by inabilities to complete extended tasks, and their high levels of anxiety/stress.

**Initial Design**

With the learnings from the initial data collected, we were able to define 3 personas of our target user (See Fig 3). We have chosen to design our solution as a wearable app for two main reasons. First their embedded sensors provide proxies to objectively observe conditions like stress, and secondly these devices are highly ubiquitous, and better positioned to encourage habit formation. Our app features are:

- **Pomodoro**: The pomodoro time management technique (see [http://pomodorotechnique.com/](http://pomodorotechnique.com/)) invented by Francesco Cirillo, in which tasks are broken down into 25 minutes of uninterrupted work sessions followed by 5 minute breaks. Each session is called a pomodoro. This technique has been acknowledged to help reduce procrastination, avoid distraction as well as engender flow and focus. In our implementation we abide by the tenets of the pomodoro technique but allow for a more flexible control of pomodoro and rest durations to accommodate users with diverse time schedule granularity. We also use vibrations to notify users of focus milestones and end of sessions. (Fig 7)

- **Mindful Meditation**: Research results from the UMass Medical Center identifies mindful meditation as a solution to stress, anxiety, depression and other mental health issues. FOQUS provides timed visual and vibration (mild) cues which guide users on regulating their breathing pattern as the meditation session progresses. Users can also customize their meditation experience e.g select longer inhale/exhale cycle for deeper meditation.

- **Analytics**: This feature allows users visualize their progress regarding pomodoro/meditation sessions per day (total time or total sessions). Another important feature is that FOQUS displays information on the user’s heart rate at the beginning and end of each meditation session. This provides instant feedback on the benefit/quality of the completed meditation session. This feature is informed by research results which highlight the important effect of progress visualization on motivation and effort [10].

- **Message Based Priming**: Extant research indicate the value of positive message priming in encouraging behavior[9]. Priming is implemented in two ways throughout FOQUS. First, positive messages (e.g Awesome job!) are displayed on successful completion of a pomodoro or meditation session. Secondly, there is a dedicated Health Tips screen that provides mental health tips (adapted from the mental health foundation²) to users.

- **Fine Grained Control**: Given that the level of

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² [http://www.mentalhealth.org.uk/](http://www.mentalhealth.org.uk/)
customization or control which a user has over a technology tool will affect their adoption and continuous use (habit), we strove to build in fine grained control into FOQUS. Users can modify vibration settings, duration of sessions, meditation breathing cycle, and units of visualization.

**Evaluation - Low Fidelity Prototype Testing**

Low fidelity prototypes helped us to review the clarity of our design, structure out the different aspects of each functionality, test the effectiveness of our interface and identify potential mismatch between user expectations and our interface. Results of a verbal protocol tested with 3 users are summarized below:

i. Some users indicated they would like to visualize their completed sessions in terms of total time spent while others indicated number of sessions completed.

ii. Users were excited and felt happy about the ability to visualize the amount of time they had successfully spent working or meditating.

At the end of this round, we began to consider important tradeoffs that needed to be made in order to keep the app simple and useable. One way in which we accomplished this was by removing two initial features which appeared to be of less value and difficult to use. This was a to-do list/reminder function which would require text input, and a feature that played sounds (white noise) via Bluetooth to aid concentration. We also found out that users who had never used a smart watch before our tests could not fully understand the range of expected interactions or how the device worked. This inspired us to invest in the actual development of a working prototype for a more accurate test of our interaction model.

**High Fidelity Prototype**

In this phase we developed a working prototype of our app deployed on a Samsung Gear 2 smart watch. To inspect the usability of our prototype (Fig 6,7), we conducted a cognitive walkthrough to ascertain functional completeness and then usability tests with 3 participants (Fig 8). We asked each participant to perform multiple focusing and meditation tasks over a 7 day period and surveyed their levels of reported and measured stress (changes in heart rate).

i. Context was an important factor for users in conceptualizing the value of functions. For example, a user mentioned they would be delighted to wear only a smart watch (rather than carry a smartphone) when in yoga and meditation classes.

ii. While there were minor concerns regarding the accuracy of the smart watch heart rate readings, users were excited about the instant feedback on the effect of their meditation session. A reduced heart rate value helped them believe they were less stressed and less anxious. They also reported reduced levels of anxiety.

iii. Users also made less mistakes on the interfaces where functions were disaggregated into multiple screens. E.g rather than adding 4 buttons on the screen, a horizontal scroll menu with 4 distinct screens produced better results.

iv. Users were excited about the opportunity to visualize real-time changes in their levels of anxiety before and after meditation sessions.

**Conclusion**

In this work, we have designed, prototyped and tested a wearable app that helps users improve their ability to focus on tasks (via a flexible implementation of the Pomodoro time management technique), reduce their
anxiety via mindful meditation and improve their overall mental health via positive message priming. While there were doubts regarding the accuracy of the wearable heart rate sensor, the sheer instant feedback where users could "see" changes in their stress level drew very high levels of engagement and repeat usage behavior. We also observed that users were excited about various contexts in which a smart watch was perceived to be more convenient compared to a smartphone. In conclusion, we believe our choice of the wearable platform is timely, given recent investments in smart watch development from large technology companies like Google, Microsoft, Samsung, Asus as well as fashion and consumer electronics companies like Withings and Montblanc. As these firms push the envelope regarding the array of sensor embedded within smart watches, our design direction becomes even more relevant.

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