Contextual Assesments and Biomarker in Agitation Prediction for ADHD Patients

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ABSTRACT

ADHD has an estimated worldwide prevalence of 2-3 % and is one of the most frequent neurodevelopmental disorders. The disease starts in childhood and persists in up to 50 % into adulthood. Many problems in an ADHD-patient's life arise from the lack of self-management abilities. Technologies may be able to support adolescents and adults with ADHD by strengthening self-awareness of their symptoms, monitoring treatment and helping to develop responsibility, emotional self-regulation and self-management. In our work, we develop a modular on-body system which supports self-management of psychological disorders for young adults unobtrusively in everyday life. We present insights into the future concept of an assessment system based on contextual experience sampling and biomarkers, to predict agitated situations and enable patients to reflect on their own behaviors.

KEYWORDS

ADHD, Biomarker, Experience Sampling, Machine Learning

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1 BACKGROUND

One of the most common diagnosed psychiatric disorders for children as well as adolescents is ADHD (Attention-deficit-hyperactivity disorder). The prevalence of ADHD in adults is around 2-3 % [3]. In recent years an increase in diagnosis as well as medication can be found in multiple sources (e.g., [2, 12]). Core symptoms of the disorder are inattention, hyperactivity and impulsivity, however patients suffering from various combinations of these and further symptoms. Before the disorder can be clinically diagnosed, screenings are performed to evaluate a person's risk of ADHD. More commonly used are self-reporting scales (such as ADHD Rating Scale-IV [7]), which are assessing behavioral patterns that are considered ADHD risk factors.

The use of self-reporting questionnaires is often criticized, due to the lack of a missing specific situational context. Patients need to imagine and predict their own behaviour for situations described within these assessments. Because of a missing self-awareness of their own reaction, patients may have difficulties in evaluating oneself objectively, or may differ in their ability for introspection. Previous works have suggested that additional behavioral data could allow for more objective measures. Technologies may be able to support adolescents and adults with ADHD by strengthening self-awareness of their symptoms, monitoring treatment and helping to develop responsibility, emotional self-regulation and self-management.

In this paper, we propose an additional approach to an objective prediction of agitated situations and symptoms for ADHD. Based on the desing framework presented by Sonne et al. [10], we aim to mainly support two technological dimensions (1) automatically executing services based on in-situ analysis of context information (AES) and (2) capturing contextual data for later retrieval (CCD). As the proposed system will be designed to aggregate data and predict agitated behaviors, we do not support reflection directly in the first step. However, we aim to use the presented system to foster reflection, self-awareness and support in later development steps.

Our concept includes a modular on-body system which supports self-management of psychological disorders for young adults unobtrusively in everyday life (see Figure 1). Sensing modules will detect symptoms that are relevant for this disorder by using unobtrusive sensors, that continuously collect data about a person's movements [8, 11], heart-rate variability [4, 9], eye-movements [5], contextual parameters e.g., body temperature [1] and in-situ experience sampling [6]. Current moods and self-evaluations are queried through a mobile device in appropriate moments. Further, to design and

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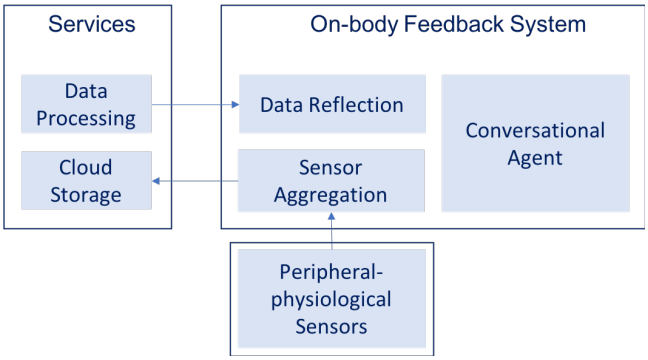

Figure 1: Structure of the proposed system including server-side processing, and user-side data acquisition and reflection.

evaluate suitable and unobtrusive feedback mechanisms, that help patients to self-reflect and increase awareness about their own state of mind.

With our work, we aim to contribute to the following research questions.

(1) Sensor assessments and evaluation for the prediction of agitated situations and symptoms for ADHD.
(2) A modular on-body system which supports self-management of psychological disorders.

2 PERSONAS

Following we will document some of the challenges, that ADHD patients face in their day-to-day life. We describe three personas, that reflect some of the challenges and wishes for patients. These insights are based on existing literature, in-depth interviews with experts and a design workshop with a patient. As ADHD is a very heterogeneous disorder, these challenges can only reflect some of the experiences that patients face. However, our insights show some requirements, that where repeatedly mentioned. These requirements for a digital assistance are:

- assisting in day-to-day organization
- strategies to handle overwhelming situations
- positive feedback for achievements
- dividing larger tasks into short-term actions
- strong need to be heard and to have a trusted communication partner

Dani Daydream Dani is a 21-year old woman that works as a developer in a medium-sized company. She has a hold back character and does not socialize very much. Often she finds herself daydreaming and replaying experiences from her life in her mind. By her colleges she is perceived as a shy and silent. When she spends time with close friends - that know about her disorder, she acts open and talks about her problems and the things that are going through her mind.

Compared with others, Dani is overly structured. She never misses a chance to reorganize things around her or make sure everything is in order. However, she often misses appointments because her mind gets distracted easily. When it comes to chores in her everyday life, she often postpones them and is not at all motivated to finish them on time.

When Dani gets stressed, because she missed a task or she feels too much pressure on her shoulders, she acts very emotional. These emotional reactions or often the reason, that she gets into a fight with her friends or other family members. Although she does not like the way she reacts, it is hard for her to control her own feelings and moods. Especially when it comes to criticism that may be based on her disorder, she has a hard time to accept it and work on herself. Only a few very close persons are able to talk with her about her problems.

Aaron Active Aaron is 18 years old and lives with his parents together. He studies fashion design at a small university. Aaron often feels a strong need for physical activity, and tries to do some activity like sport on each day. Because he feels agitated regularly, he has a hard time to focus on tasks and keep on working for extended times. He often is late for his lectures and finishes assignments on the last call. He often postpones work and other things in his life grab his attention more easily.

Other students from his courses do not takes his problems serious and assume he is just too lazy to finish the tasks that he is facing. However, Aaron can not make himself do something, even if he really wanted to. He feels much better during his day-to-day life when he can do short breaks and is able to get a good amount of physical activity from sports.

Hannah Helpless Hannah is 22 years old and works as a trainer for professional athletes. She moved into her own flat six months ago and starts building her own life, independent of her parents. Although she is willing to live on her own, she has problems to structure her life and keep up with the necessary tasks. Because of that she often has phases where she feels overwhelmed and experiences slightly depressive episodes.

Hannah often is awake for extends periods of time and tends to over-think experiences that happened in her day-to-day life. She has a good amount of social contacts, but need time to get to know a new person and does not open up easily. To keep going with a long-term task, she needs acknowledgement and compliments from co-workers and other people around her.

To distract herself, Hannah loves to play online video-games. She plays for long times and starts to forget things surrounding her. She calls this state hyperfocus and likes it, because she feels like being able to work on something without being distracted. Video-games also give her a feeling of acknowledgment and rewards to keep her going.

3 PERIPHERAL-PHYSIOLOGICAL BIOMARKERS FOR ADHD

Biological marker (biomarker), refers to a measurable indicator of a biological state or condition. Biomarkers are often measured to examine biological processes, pathogenic processes, or responses to a therapeutic intervention. Based on existing studies using biomarkers and follow-up discussions with medical professionals, we describe promising on-body sensing units and questionnaires for ADHD assessments in Table 1. These units measure or assess one

Measuring units	Biomarker	Study design	Author
EDA sensors Acceleration sensors Body temperature	Electrodermal activity (8Hz)	EDA-supported recognition of stress situation for parents (n=10) of children affected by ADHD 4 hours recording time/day 7-day stress management without EDA /7 days with	Pina et al., 2014
Acceleration sensors	Real-time ADHD off-task lower body; Excessive motoric behaviors	Children with ADHD (n=11 of whom 8 were medicated) and without (n=9) wore the sensors in everyday school life.	Sonne, Obel & Gronbaek, 2015
Eye tracker (1kHZ sampling rate)	Saccade movements	Children: ADHD (n=35), healthy (n=88); significantly longer response times to saccadic eye movements in ADHD patients	Matsuo et al., 2015
Eye tracker (500 Hz sampling rate)	Oculomotor marker	Adults: ADHD (n=22), controls (n=22); Go/NoGo task; microsaccades and blink rate was higher at ADHD; pupil diameter decreased over timenon medication	Fried et al., 2014
Sleep diary Actigraphy (motion sensors) Body temperature	Sleep / temperature monitoring	Adults: ADHD(n=12), controls (n=12); Irregular sleep/wake phases associated with delays and dysregulations of core and skin temperature	Bijlenga et al., 2013
ASRS questionnaire for the determination of ADHD traits GSQ questionnaire to measure sensory sensitivity	-	Online survey of 234 healthy subjects between 18 - 69 years;High positive correlation between number of ADHD characteristics and reported problems of sensory processes	Panagiotidi, Overton & Stafford, 2018
ECG	HRV parameters time domain: e.g. heart rate, mean values of NN intervals, SDs of NN intervals (SDNN). HRV parameters frequency domain: e.g. total power, HF (0.15 - 0.4 Hz), LF (0.04-0.15 Hz)	HRV comparison between 10 ADHD children between 7 and 12 years and 10 controls; HRV differences (especially lower HRV with reduced sympathovagal imbalance) with different parameters in both time and frequency domain.	Rukmani et al., 2016

Table 1: Biomarkers and sensor-systems used in previous works related to ADHD-symptoms

specific biomarker each, which might be insufficient to cover the diverse range of symptoms, that patients face. Therefore, we propose the use of a sensor network, containing sensing units e.g. heart-rate variability, contextual information e.g. activities and questionnaire to gain a more holistic view of a patients conditions.

4 CONTEXTUAL ASSESMENTS

Besides the use of peripheral-physiological biomarkers for analysis and prediction, we aim to utilize contextual information to enable labeling of agitated situations (see Figure 2). Contextual assessments will include information about a patients current activities (e.g. tasks, sports activities), social interactions (e.g. shared activities, communications), environmental context (e.g. location, loudness, weather). Further, we will asses the patients current perceived stress-level as well as affective dimensions of valence and arousal. Contextual assessments will be used as labels for physiological biomarkers to be used as training and validation data set.

Contextual assessments will be taken on a regular basis, including:

(1) **Morning-assessment** Questions regarding sleep-quality and sleep-length

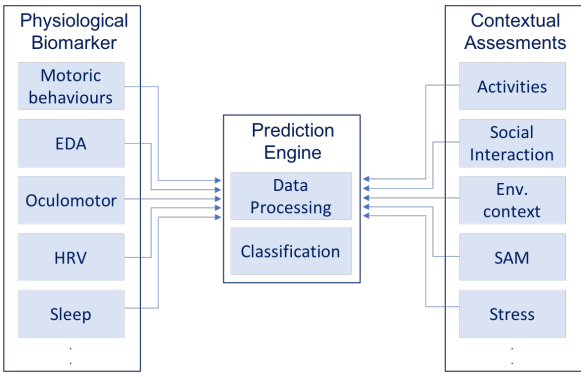

Figure 2: Overview of data collection for training and classification of marker.

(2) **Daily In-Situ** Questions throughout the day collecting contextual parameter and affective states of patients
(3) **Evening Reflection** Reflections on the daily experiences. Questions regarding ADHD-symptomatology.

Daily in-situ assessments will be taken either on a regular basis e.g. every other hour or when measured biomarkers exceed a certain

threshold of a personalized baseline. As an example, a users heart rate might increase above the common mean for a longer period of time. As an response to this, the systems queries an additional in-situ assessment, to be able to identify reasons for the changes in physiological measurements.

5 FEEDBACK

Feedback for patients will be provided in two separate ways. One goal is to provide long-term behavioral and contextual data that help a patient to reflect on her own disease. Therefore, we will provide data visualizations that enable users to gain insights from overviews or detailed information on specific measurements. Patients will have the option to create individual reports of data collected by the systems and provide it to their doctor or therapist to support and individualize therapy. The intention is to understand the situations in which ADHD related symptoms are most prominent, which would allow us to individualize therapy based on the objective behavioral parameters. This allows for more precise and therapy plans than before.

In a second step, feedback related to patients behaviors and predictions of agitated phases will be provided by a conversational agent (see Figure 1). The agent will provide information, carry out questionnaires through conversations and provide material for psycho-education of patients.

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