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Data-driven User Profiling and Personalization in Tiimo: Towards Characterizing Time Management Behaviors of Neurodivergent Users of a Scheduling Application

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Abstract. Deficits with time management and other cognitive functions can stem from multiple causes and be found across different diagnostic conditions. At the same time, cognitive function can differ within diagnostic classes, which calls for adaptable and personalized assistance. A great deal of literature on cognitive assistive technology (CAT) focus on diagnostic populations rather than cognitive impairments across different conditions. This study reports the initial steps towards a data-driven approach to map out the characteristics and behavior of users of a time management app, Tiimo, originally targeting children with ADHD. Based on results from a questionnaire and analysis of user activity data, findings indicate a tendency of attracting a more heterogeneous user population compared to the originally intended target group, thus supporting the need for a more complex and data-driven 'design for all' approach to CAT rather than delimitations based on diagnostic groups. Preliminary findings from the analysis of activity data across user groups and diagnoses show that users generally schedule fewer than five daily activities and most often in the morning, suggesting a potential emphasis on support particularly during morning routines. However, the analysis also highlights the need for more data points to enable assessment of progress, motivation, and effectiveness of the technology. Next steps include a more detailed analysis of user activity that takes different types of behavior and other relevant factors into account by applying NLP to further develop data-driven approaches to user profiling and personalization in time management apps for neurodivergent users.

Keywords: Cognitive Assistive Technology, Time Management, Task Completion, Design for All, Data-Driven User Profiling and Personalization.

1 Introduction

Time management is a higher-level cognitive function that involves the ordering of events in a chronological sequence and the allocation of time to events and activities

[1], which is an essential function for perceived control of time, job satisfaction, and health [2]. The International Classification of Functioning, Disability and Health (ICF) defines higher-level cognitive functions as mental functions especially dependent on the frontal lobes of the brain, which include a broad range of goal-directed behaviors such as time management as well as organization and planning functions [1]. Impairment in higher-level cognitive functions is often seen in people with cognitive disabilities, and the functional capabilities and consequences of impairment can differ substantially within and across different diagnostic populations. Applications of assistive technology for cognition (ATC) or cognitive assistive technology (CAT) can help compensate for cognitive impairments and alleviate barriers to daily life participation. However, ATC/CAT are often conceptualized in accordance with diagnostic classes (e.g., dementia), which can be problematic because similar cognitive deficits can be found across different clinical populations [3]. O'Neill & Gillespie [3] propose an alternative framework based on the specific cognitive functions being assisted, e.g., higher-level cognitive functions, thus encouraging a shift towards 'design for all', which constitutes the underlying conceptualization of this paper.

Applications supporting time management include prompting systems informing the user that an action should be taken through visual, verbal, or auditory cues, and time management technologies aiding the planning, prioritizing, and execution of daily and time-dependent tasks [4]. Tiimo is a research-based combined task management and prompting system designed in close collaboration with families and experts as a tool to support children with attention deficit hyperactivity disorder (ADHD) navigate daily challenges through structure and predictability [5]. The smartwatch application utilizes a visual timeline, persuasive visual reminders, checklists, and icons among other behavioral design elements to support executive function and motivate the user to build and stick to daily routines. Since its launch in 2018, the application has gained a large userbase representing 65 different countries. Apart from a need for support in managing time, little is known about the users, as the system does not automatically collect personal information regarding age, health, or potential diagnosis. However, raw data on activities, checklists and routines, their time slots as well as the users' progress is stored – an extensive data collection constituting a potentially valuable source of insight into the behaviors of neurodivergent users with time management support needs. This paper reports the preliminary findings from a two-step approach to map out the characteristics and behavior of users of an assistive technology originally targeting children with ADHD and their families. The initial data collection is based on an online questionnaire and user activity data from the app. The two-step approach intends to generate insights into 1) who the users are and motivating factors to start using the technology, and 2) what characterizes their actual behavior when interacting with the app, for the purpose of investigating if and how these insights might potentially contribute to improvements and accommodation of their needs.

2 Related work

In recent years, ATC/CAT have been developed and investigated as compensation for difficulties related to higher-level cognitive functions with the aim of helping different target groups cope with daily life demands. Since the point of departure in the current research is focused on mobile high-tech intervention, the following section will present related work centered around mobile technologies supporting relevant higher-level cognitive functions.

Time management functions have previously been supported through different mobile technologies, including an iPod Touch personal digital assistant (PDA) targeting adults with ASD in a work context [6], a smartphone application supporting children with attention deficit disorder (ADD) in both private and school context' [7], and location-specific tangible objects connected to a web-based interface supporting children with ADHD during morning routines [8][9]. Assistive features included to-do lists, video-based task-sequencing prompts [6], real-time monitoring and progress tracking [8][9][7], and task reminders [6][7]. The support of task management though PDAs have been investigated for adults with acquired brain injury (ABI) in a cognitive rehabilitation setting [10], high school students with autism spectrum disorder (ASD) in everyday life tasks [11], and middle school students with ASD in the completion of novel tasks and transition within and between tasks [12]. PDA features included reminder, to-do-list, address book and predefined scripts [11][10], and combined auditory and visual prompt levels [12].

Aside from time and task management, other functions have been of focus in the described studies, e.g., organization and planning functions supported by to-do-lists and automatic planning features and memory functions supported by PDA reminders [8] [9][10][6]. Research approaches and methods included a delayed randomized control trial [6], system design and pilot testing [7], initial stages of a user-centered design process [8] and evaluation [9], randomized parallel-group study [10], quasi-experimental study [11], and multiple probe experimental design [12].

As it appears from the research above, mobile ACT/CAT are often developed and investigated as aids for specific diagnostic populations and supporting different cognitive functions, either separately or combined with others. However, the needs and characteristics of people within specific diagnostic groups can differ substantially, while specific cognitive impairments can be found across a variety of diagnoses, and correspondingly, interventions and research targeting a single diagnostic group may be beneficial to another [3]. A systematic review of ICT-based assistive technology for impaired cognition found that mobile prompting systems can improve task execution for different diagnostic groups with shared activity limitations [13], while another systematic review of cognitive function and ATC found that reminder and micro-prompting systems are effective in supporting organization and planning functions for most clinical populations targeted [14]. Thus, similar outcomes are often detected across diagnostic classes, which underlines the importance of addressing neurodivergence according to the type of impairment or need rather than a specific diagnosis alone. The current study will contribute with an examination of an implemented ATC/CAT developed for a

specific target group (children with ADHD) but addressing general difficulties with time management, and a data-driven approach to analyzing the extensive collection of user activity data across cognitive conditions or diagnoses. By mapping out user characteristics and behaviors, the aim is to generate insights into the potential of data-driven user profiling and personalization to further inform and improve the Tiimo app specifically, as well as mobile ATC/CAT in general.

3 Data collection and methodology

The initial data collection is based on a two-step approach to map out general user characteristics and behavior using a self-completion questionnaire and user activity data. The questionnaire was administered to newly registered users of Tiimo in welcoming emails from October 2021 to January 2022 via Google Forms. The purpose of the questionnaire was to generate insights into the characteristics and motivation of newly registered users through a three-part structure. The first part focused on the motivation, onboarding experience and general usage of the app through close-ended questions, while the second part collected information regarding the users' cognitive and health-related condition. The third part collected personal information through close-ended questions related to age, gender, occupation, and country of residence, as well as open-ended questions welcoming general feedback based on their initial experiences from using the application.

Subsequently, activity data from a subset of Tiimo users from approximately the same time period as the questionnaire was analyzed to characterize user behavior based on their actual interaction with the technology. This is accomplished by looking at basic descriptive statistics concerning users along various dimensions regarding, for example, how frequently they schedule activities, what activities they find important to schedule, or what time of the day these activities occur. The analysis is based on fully anonymized data collected from 70,018 current Tiimo user profiles during the period from 2021-01-01 to 2021-11-30. Table 1 shows an anonymized sample of data and relevant headings for a typical Tiimo user profile.

Table 1. Anonymized sample of activity data and relevant headings for a typical user profile.

ProfileId	Title	Starttime	Endtime	Created
anony-mizedUserProfileID	Eat dinner	2021-10-02 19:00:00	2021-10-02 20:00:00	2021-09-21 08:42:17

The 'ProfileId' field in Table 1 indicates the unique user ID provided by Tiimo for each of their users' profiles. The 'Title' field indicates the shortened description of the scheduled activity that may be created by the user or Tiimo while the 'StartTime' and 'EndTime' fields indicate the starting and ending time of that scheduled activity, respectively.

4 Preliminary findings and discussion

4.1 User characteristics

A total of 50 respondents completed the survey between October 2021 and January 2022. The results show a high dispersion in age, ranging from 16 to 71 (median=33), geographical setting, and occupation type. The vast majority (n=48) reported themselves as the primary user of Tiimo, while one reported their partner/spouse, and one reported their child(ren). Furthermore, the respondents were asked if the primary user of Tiimo was either diagnosed or self-diagnosed with any cognitive disabilities. The majority (n=33) identified with ADHD, out of which nearly half reported comorbid disorders such as dyslexia, generalized anxiety, and intellectual disability. A large portion identified with ASD (n=20), out of which only four reported no comorbid disorders. Furthermore, several respondents reported the primary user as neurotypical (n=6) or "not sure" (n=7). These findings indicate a great diversity and interest from a heterogeneous group of users compared to Tiimo's original target group. This emphasizes the problem of delimiting ATC/CAT according to a single diagnostic and age specific group, as the technology appears to attract other groups of neurodivergent users, including self-diagnosed groups and neurotypical users. A common goal for the respondents was to create structure throughout the day (n=48) as well as to build and stick to routines (n=43). From the open-ended questions inviting general feedback, several respondents expressed an overall preliminary satisfaction with the technology, while others emphasized barriers in meeting their needs, such as an insufficient amount of initial training and confusion in differentiating between activities and routines. Some respondents also emphasized the potential of built-in suggestions for how to e.g., break down the day and come up with activities and routines, since, as one respondent noted "I often find it easier when solutions to problems are presented in this way, as I can struggle to think of them myself". However, developing suggestions that meet the needs of a diverse group of neurodivergent users is a difficult task, as there is no 'one-size-fits-all' solution. Thus, future potential may include efforts to tailor suggestions based on the users' needs, preferences, and past behavior. While findings from this initial questionnaire reflect only local patterns of user characteristics based on a small sample of novice users and thus do not provide conclusions on usage and the actual effectiveness of the technology, initial steps towards realizing this potential are taken by creating an overview of user characteristics and behavior. The next steps towards a more comprehensive mapping of user characteristics include a follow-up questionnaire that inquire into the following usage and experience of the same users, as they have moved from novice to more experienced users.

4.2 Descriptive statistics of activity data

In our preliminary analysis of activity data, basic descriptive statistics will be applied in the analysis of 'typical' Tiimo user profiles, e.g., in terms of what and how many activities they schedule each day and where in the day these activities occur. Figure 1 shows the frequency of Tiimo user profiles' median number of daily (repeated or not)

scheduled activities and the relative frequency of all such daily activities (morning, afternoon, and evening).

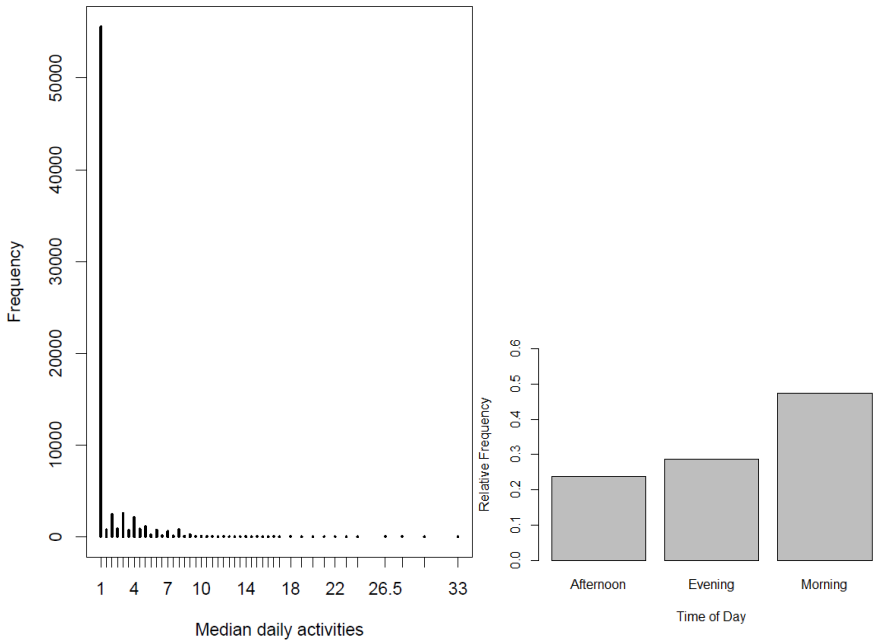

Fig. 1. Frequency of user profiles' median number of daily scheduled activities (left) and the relative frequency of all daily activities according to the time of day (right).

One will note that the vast majority of Tiimo user profiles have scheduled fewer than 5 median daily activities while in the graph shown at right, nearly 50 percent of all daily scheduled activities occur in the morning. The next steps towards characterizing user behavior include a more detailed analysis that explores the potential of clustering activities, e.g., by applying NLP to analyze factors such as titles and whether the activities are divided into sub activities, as well as when the activities are created and the actual progress of completing activities. Finally, it will be relevant to investigate whether the users are motivated to continue using the technology and the potential usefulness in enabling users to self-monitor, self-regulate and set goals based on their own activity data.

5 Conclusion and Future Work

This paper presented preliminary findings from of a two-step data-driven approach to identifying characteristics and behaviors of users of the Tiimo time management and prompting system. Although the technology was originally developed to support children with ADHD, findings from the questionnaire indicate that the app attracts a more heterogeneous population of mostly neurodivergent users, who share a goal of building

routines and creating structure throughout the day. The diversity and complexity of users emphasize the problem of delimiting ATC/CAT in accordance with just one diagnostic and age specific group and demonstrates the value in a data-driven and 'design for all' approach to conceptualizing the technology supporting time management as a higher-level cognitive function. The preliminary analysis of activity data generated insights into how a data-driven approach enables the exploration of user behavior without prior knowledge or bias regarding potential diagnoses. However, the analysis also highlights the need for more data points to enable assessment of progress, motivation and effectiveness of the technology. The initial findings from the descriptive analysis indicate that the current users generally schedule fewer than five daily activities, most frequently scheduled in the morning, suggesting a need across user groups for more structure-support particularly during morning routines. Next steps towards characterizing user behavior include a more detailed analysis of user activity data, that takes different types of behavior into account by applying NLP to factors such as activity titles, sub activities, and progress of users, including those with more experience. Furthermore, a connection with other types of data such as mood-tracking might support the user's own assessment of the quality of scheduled activities, self-regulation and goal setting as well as data-driven approaches to user profiling and personalization in time management and scheduling applications for neurodivergent users in general.

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