Adaptive Context-Aware Planning Support for Students with Autism

Robin Cromjongh*
r.cromjongh@uu.nl
Utrecht University
Utrecht, The Netherlands

ABSTRACT

Managing university life is challenging for any student, including fast-paced self-reliant learning, first experiences with independent daily living, and the social demands of student life. These struggles are even more pronounced in students with Autism Spectrum Disorder (ASD), who might face additional difficulties, including interpersonal deficits, organisational challenges, lacking self-advocacy skills and sensory overload. This thesis uses a participatory design process to research how an adaptive, context-aware system could support students with autism in planning their student life, including managing time, tasks, stress and sensory stimulation. The first interviews resulted in a focus on intelligent planning systems with a low-effort interaction design. The design process will incrementally build towards intelligent support for personalised interactive scheduling as well as in-the-moment next-action recommendations that are context-aware and adaptive to data on the user's stress level and sensory stimulation exposure.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Interaction design**; **Accessibility**; • **Social and professional topics** → **People with disabilities**; • **Information systems** → **Information systems applications**.

KEYWORDS

autism spectrum disorder (ASD), adaptive systems, planning, stress, sensory stimulation

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1 INTRODUCTION

Autism Spectrum Disorder (ASD) is a diagnosis that is increasingly recognised in society, including in higher education. ASD is characterised by deficiencies in social interaction and communication, as well as behaviours, activities and interests that are repetitive and restrictive [2]. Another attribute of ASD is its heterogeneity. There is a large diversity among people with an ASD diagnosis in terms of traits and trait severity. People with autism[1] notice its impact in many different areas of life. Of students in Dutch higher education that want support (14.3% of students), 8.8% have ASD [29]. These students require support in education, student life, and daily independent living, with challenges appearing in different combinations across either one of them [36]. According to interviews with 23 students with autism, students with autism encounter several challenges such as social demands (21/23), routine task management (20/23) and time management (20/23), the impact and management of stress (23/23), and sensory overload (19/23) [36].

Regarding potential solutions, the interviewed students emphasise the need for more personalised and comprehensive approaches in supporting them (22/23) [36]. Autism is a very diverse condition which makes it difficult to build interventions that would apply to all students with autism [1]. Currently, the most common support offered is individual counselling by psychologists or study advisors [9]. While lack of such support systems have been shown to decrease students' ability to graduate successfully [8], they are often limited due to the lacking availability of respective experts and the high cost of time-intensive individual support. Assistive technology is one way of improving the accessibility and scalability of these interventions by supporting the student in taking control of managing their individual challenges.

Based on these insights, we want to focus on building a personalised adaptive system that encompasses an integrated approach to task, time, stress, and stimulation management. The challenge of designing assistive technology for students with autism is twofold. First, many design guidelines and principles are not as suitable for users with autism [26]. Similarly, methods for co-designing and evaluating such systems cannot be translated one-to-one for co-creation with users with autism [21]. Second, due to the diversity in challenges of this user group, the technology needs to be highly adaptive. More specifically, it needs to be personalised to the user's preferences, contextualised to the environmental conditions, and adaptive to the current state of users and the suggested application content.

The research question overarching my PhD work is: ***How can adaptive interactive systems support students with autism in***

[1]Language to discuss autism and the people diagnosed with ASD is an ongoing discussion point. This document uses person-first language without any value judgement, as preferred by a majority of Dutch adults with autism [4, 7].

managing their student life? The following sections will give an overview of prior work in this area, the specific research objectives, my approach to addressing them, the initial results, and my long-term objective.

2 RELATED WORK

In this section we look at interventions for challenges experienced by students with autism. Based on our findings, we will zoom into prior research on three of these challenges, namely planning, stress, and sensory stimulation.

2.1 Interventions for Students with Autism

The most targeted areas of executive function in human interventions for students with autism were organization and time management skills (8/10) [33]. The two most recent of these interventions were a 7-week group counselling program [13] indicating improvements in time management, organizing and scheduling, as well as goal setting and coping strategies for stress and anxiety, and a 5-day mentorship summer program using a participatory design process and peer mentoring [16]. A recent review of assistive technology for adults with autism reveals a clear under-representation of this target group compared to children [38]. Of the 32 articles identified, most focused on vocational rehabilitation and communication and social skills, only one study included anxiety-related repetitive behaviours, while none addressed the organization and time management skills prominent in student interventions [38]. The biased distribution of addressed challenges might be due to a lack of focus on adults with milder cases of autism [38]. We, therefore, review existing technology for planning, stress, and sensory stimulation solutions, including approaches for neurotypical users.

2.2 Planning

Of the impairments in executive functioning (flexibility, planning, inhibition, working memory, fluency), the most prominent ones among adults with autism are planning and flexibility [41]. Adaptive systems for planning exist in different forms focusing on time management, task management, or scheduling. On the algorithmic side, work has already been done by Yorke-Smith et al. on adaptive task management for neurotypical users such as the CALO system [42] and PTIME [3]. More recently, White outlines opportunities for future intelligent task assistance, such as improving task modelling, enhancing task planning support, or improving task outcomes via human-AI cooperation [39]. On the interaction side, there has been recent work by Wiese et al. on determining the current practices, processes, and digital support of time management planning [20] and on how to design a general-purpose mobile application to support the practice of time management planning. Such solutions, however, do not always work for people with autism since they struggle to assign specific durations to tasks and to keep within the assigned timeframe while conducting a task [5]. There are some approaches to planning support for children with autism in school [18], and measurements for children and teenagers to assess time management skills [18]. A measurement aimed at teenagers, e.g. [17, 31], could be adapted to students, but generally, these solutions do not generalize to our target group.

2.3 Stress

Adults with autism have higher perceived stress and lower perceived coping abilities [14]. Many apps for stress reduction exist for neurotypical users but might not work well for students with autism, for whom the challenges of university life are enlarged and where stressor and de-stressor are sometimes reversed [12]. Work so far on users with autism has focused on detecting stress, identifying stressors, and alleviating stress. Regarding detecting stress with the use of sensors, there is work using a custom-designed wearable for people with autism to support therapy [34]. Regarding identifying stressors, there is early work on using temporal patterns (t-patterns) to derive stress factors of routine tasks [6] and very recent work on the regular use of questionnaire-based assessment with the SAM App [15], a mobile app to track stress levels over time and for different activities. Regarding actual support for alleviating stress based on this data about stress and anxiety, there is the SATORI system which provides relaxation exercises at moments of stress [10]. This system is also adaptive to the user's stress state as detected with a smartwatch [10]. However, none of these systems prevent stress before it happens, which could be done by combining these mechanisms with techniques to plan ahead.

2.4 Sensory Stimulation

People with autism are more likely to experience hypo and hypersensitivity to environmental stimuli [27, 28]. Such stimuli can be tactile, visual, auditory, olfactory, or even related to social dynamics. Due to this sensitivity to sensory stimulation, people with autism may be overwhelmed in environments with specific stimuli or become fatigued after more prolonged exposure to such environments [25]. In contrast to neurotypical students that might be invigorated or inspired by lively places, students with autism might want to avoid locations that harm their well-being [27]. There is already some work on user modelling and recommender systems focused on incorporating the environmental needs of people with autism by suggesting appropriate locations [24] or by reducing environmental exposure, e.g., with the use of an iPod in the workplace [11]. However, for students, neither the solutions for points of interest with high location variety nor the solutions for workplaces with unchanging conditions are directly applicable.

3 APPROACH ON DESIGN FOR USERS WITH AUTISM

Throughout the design of applications in the line of this research, I aim for participatory design [32] and co-creation. There is a recent effort to adapt participatory design [21] and user-initiated co-creation [37] to adults with autism. Besides using participatory design, I will make sure the resulting designs follow the guidelines on designing technologies for and with neurodiverse users by Motti [22] to create a suitable user interaction. Finally, to evaluate the separate components of our design, I will use the layered evaluation framework [23] to determine the influence of different parts of the adaptive system, and long-term studies to measure the long-term impact of the design on the lives of participants.

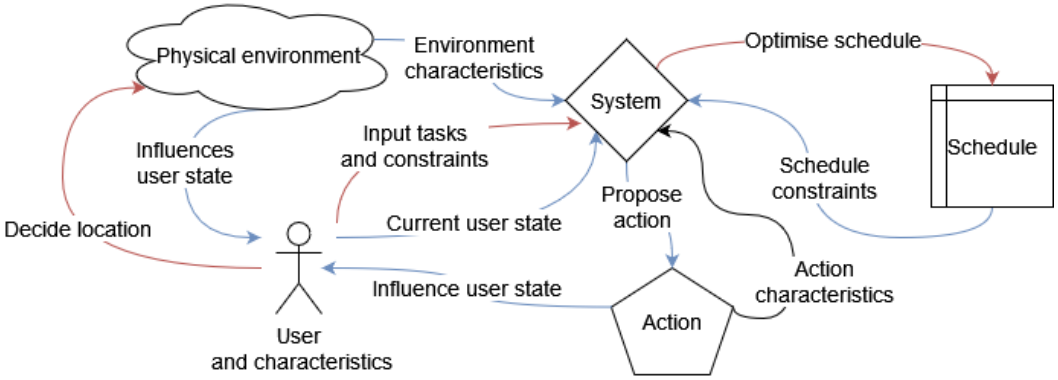

Figure 1: Diagram of the different connections of the suggested adaptive context aware planning system.

4 RESEARCH QUESTIONS

The research question overarching my PhD work is: ***How can adaptive interactive systems support students with autism in managing their student life?*** Two aspects of student life are productivity, in the form of effective planning, and mental load, in the form of stress and stimulation. Based on the related work we see that answering this question requires a holistic perspective including both planning, stress management, and context-aware stimulation management. For the planning aspect we focus both on long-term scheduling of tasks or goals and on short-term decisions for appropriate actions. The challenges of students with autism in this are difficulties with estimating durations and adapting to changes in plans. Planning in long-term and short-term contexts is investigated in research questions 1 and 2. For the mental load aspect we focus on the effects of tasks on the level of stress and sensory stimulation a person experiences. These factors are influenced by the previous and current planning, but also influencing the best future choices. Managing mental load from stress and stimulation is investigated in research questions 3 and 4. Our proposed system and the way it interacts with the user and incoming data is shown in Figure 1. In the following we will introduce our four research questions.

RQ1: How can we support students with different manifestations of autism in organizing their schedule by offering different tailored strategies for optimizing productivity? To answer this question, I first need to know what current strategies are and what adaptations are needed to make a strategy work for people with autism. Once these questions are answered, I will design different interaction strategies, such as lists, calendars, or boards, for supporting the user in optimising their schedule (the red arrows in Figure 1). Preliminary sub-questions: RQ1.1: What is the state of the art on strategies for scheduling tasks? RQ1.2: What specific challenges are student with autism facing that make these solutions inadequate? RQ1.3: How can scheduling strategies be designed for users with autism? RQ1.4: What user characteristics would those scheduling solutions need to adapt to?

RQ2: How can we support in-the-moment action decisions based on an existing schedule and the current user context? While a schedule can inform next-action decisions, situations may change in ways that force the user to reconsider what to do next. Such changes are something people with autism struggle with [2]. To support students in making in-the-moment decisions on next actions to perform, a recommender system could take into account the user's state and context. To design such a support system, I need to know which factors influence the optimal choices. Once that is complete, I will design the the workflow of recommending actions based on the context and constraints shown as the blue lines in Figure 1. Preliminary sub-questions: RQ2.1: How can an adaptive system propose adequate next actions based on user and context information and historic data of that user? RQ2.2: What are appropriate metrics for the quality of an action choice and its short and long term effects? RQ2.3: What are the relevant time frames to use in optimising the next action choice? RQ2.4: What are the long-term effects of adhering to the proposed actions?

RQ3: How can we support users in managing their stress levels throughout the day? There are many stress reduction applications and also several stress prevention techniques. Still students with autism have trouble keeping their stress in check. To design a good stress support system, we must first determine the limitations of existing approaches for students with autism. Preliminary sub-questions: RQ3.1: How do existing stress management applications work? RQ3.2: How can we design a stress management application for students with autism? RQ3.3: How do stress levels influence which scheduling decisions are optimal? RQ3.4: What is the effect on average stress level of using such a adaptive stress management system?

RQ4: How can we support prevention of sensory overload in people with autism? Some approaches already exist to manage sensory overload in-the-moment, but I want to know if we can prevent it by planning in smart ways. This will be dependent on the person, since everyone has different sensory sensitivities, which must be managed in different ways. Preliminary sub-questions: RQ4.1: How do existing sensory stimulation management applications work? RQ4.2: What characteristics should be considered in the approach to improve sensory stimulation for students with autism? RQ4.3: How can we prevent sensory overload by proactively scheduling or creating suitable environments based on a persona profile? RQ4.4: What is the effect on average sensory stimulation levels of using such an adaptive sensory stimulation management application?

5 RESULTS TO DATE

First, I reviewed the literature on autism and assistive technology for people with autism. Based on my review, I identified adults and, more specifically, students as a target group that is not yet well-researched but shows great potential to benefit from technology. The research further revealed a gap in applications that target students with autism and go beyond emotional and communication skills. In prior research on such assistive technology, many technologies are used, including robots, serious games and interactive e-learning systems. However, these do not address the problems most prominent to a population of high-functioning students with autism, such as stress and planning. To further determine the needs of students with autism, I started my research by gaining a participatory perspective on the needs of my target group and additional stakeholders. To this end, I have interviewed both psychologists and students with autism.

The motivation for the interview study with student psychologists was to get a more contextualised view of the challenges students with autism face and what support is already being offered. Two psychologists were interviewed in a semi-structured and in-depth interview [19]. The interview confirms the relevance of certain student problems mentioned in the literature. The psychologists mentioned that the classical problems with social and emotional skills in the core are not so frequent in this target group. Instead, students do struggle with navigating relationships sometimes. The problems they see most frequently are recognising and dealing with sensory stimulation or stress, planning and managing time, navigating living independently, and studying skills like preparing for exams. They also confirm that no solution works for every student, so it is necessary to personalise solutions. The psychologists offer group support consultations of 7 sessions with up to 8 participants. The topics covered are available support, time management, stress, stimulation, and fatigue, social interactions, group work, and student life. This program is comparable to the program described by Hillier et al. [13]. I plan to visit these group sessions to gain more insight into how these problems are perceived by students and addressed by the consultation.

In an ongoing study, students with autism are interviewed about their daily challenges and strategies in dealing with planning and stress. This study aims to find what concrete problems need solving and what adaptations are required for students with varying manifestations of autism. The interviews are one hour in length and transcribed from audio recordings. The interview script is semi-structured based on a set list of questions but goes in-depth with follow-up questions where necessary [19]. Results to date after one interview exposed the following themes: regularly reoccurring tasks, context and combinations of activities, and user effort for existing solutions. Regarding struggles with regularly reoccurring tasks, the participant mentions daily routines like food and self-care requiring active planning and effort. They described planning this into their day effectively to be hard and sometimes at odds with other planned activities like attending lectures because of failed planning. Regarding the importance of activity context and combinations of activities in planning, the participant mentions doing homework on campus works better when other people are also there but that getting study work done at home is difficult. The different ways that lectures are given impact their learning and their likelihood of attending at all. Combining activities, on the other hand, makes things easier, such as making sure you go to the supermarket on your way to or from university instead of making a separate trip. Regarding problems with user effort required for existing solutions, the participant mentions that many 'solutions' require additional steps that might not seem significant but take much effort for them. They gave the example that the steps of logging in with two-factor authentication to check their emails is a significant barrier for them. Applications are only worthwhile for them when the benefits outweigh the extra effort of using them.

6 NEXT STEPS AND LONG TERM GOALS

I plan to cover the research questions in incremental development steps. Currently ongoing is work in collaboration with master and bachelor students on the design of several different solutions for specific subproblems, resulting in the design and preliminary evaluation of a stress assessment app, a daily routine management app and an app for scheduling and breaking down tasks. The next steps are pilot studies on prototypes that incrementally combine more aspects to create a more detailed design, following the order of the research questions. For each new element to the design, focus groups and interviews will be held to inform design decisions.

The first step is a design that supports planning out a longer-term timeframe with adaptive support. This will be evaluated in two steps, first by 1 hour Think Aloud sessions, then by a 2 week study where participants plan out the next one or two weeks and then follow this schedule for that duration. Next, decisions on the next action will be added. Users can then plan ahead but also adapt the next action to the current situation. This design will be evaluated through a User-as-Wizard study and a study where participants use an adaptive version or rule-based version of the app for 1 day. Then I will add the mental load items, starting with stress. The stress measurement should be evaluated on reliability by comparing to a gold standard measurement and on user effort. The application will be tested in the field in a between subject study. Finally, sensory stimulation will be included. The sensory context assessment also needs to be tested on reliability and user effort. To determine how to get from the determined context to a stimulation level prediction, I will use the Ecological Momentary Assessment method [30] to gather ground truth data.

In the final year of my PhD I will do a study on the long-term effects of the full design. The goals of the design that will be evaluated are increased productivity, reduction of stress and reduction of sensory overload. The study will track participants without intervention for one period (10 weeks), followed by a full period (10 weeks) with intervention.

Following a positive evaluation of long-term impact of the design, next questions for the research field would include converting this work to different age ranges of the target group with their corresponding challenges, such as high school or transition to working life. Additionally, it would be interesting to investigate a similar approach for different conditions with similar problems, such as ADHD, where people have comparable planning problems [35].

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