TOWARDS A PERSONALISED ASSISTIVE TECHNOLOGY TO SUPPORT TASK MANAGEMENT IN UNIVERSITY STUDENTS WITH AUTISM SPECTRUM DISORDER

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Contents

List Of Abbreviations

Abbreviation	Description
ASD	Autism Spectrum Disorder
HCI	Human Computer interaction
EF	Executive Functions
OASD	Official Diagnosis of Autism
NT	Neurotypical
AT	Assistive Technology
ADHD	Attention-Deficit/Hyperactivity Disorder
UI	User Interface
TM	Task Management
UX	User Experience
IU	Intolerance of Uncertainty

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Abstract

The increasing prevalence of autism spectrum disorders (ASD) corresponds with the increasing number of university students who are identified with ASD. As well as those who self-identify with ASD traits but have not received an official diagnosis. These students face particular challenges that can affect their academic success and increase their risk of mental health problems. One notable obstacle is the lack of effective planning skills, which are essential for managing the demands of university study. Whilst there are numerous tools on the market designed to support task management, these are often inadequate, particularly for people on the autism spectrum, as they do not fully address their specific needs. Given the inadequacies of existing solutions, the development of assistive technologies to improve task management for university students is therefore imperative. In this study, a survey was conducted to understand the specific challenges faced by university students with ASD. Based on the survey results, the system requirements were formulated. Two focus groups were then organised with students from a human-computer interaction degree programme to explore possible design strategies and effective development approaches to meet the needs of this target group. Based on these results, a prototype was developed that uses ChatGPT-3.5 to extract information from course manuals and break down the tasks entered by the user into smaller, manageable steps - subtasks. These tasks and subtasks are displayed in the form of a Gantt chart. The prototype was evaluated at the beginning of the semester in a think-aloud study with a mix of neurodivergent and neurotypical students. The prototype met with a positive response, which shows that it can be a useful tool for semester planning for neurodivergent students.

1 Introduction

> *"By sharing the stories of their lives, they discovered that many of the challenges they face daily are not "symptoms" of their autism, but hardships imposed by a society that refuses to make basic accommodations for people with cognitive disabilities as it does for people with physical disabilities such as blindness and deafness."*
>
> —Steve Silberman, NeuroTribes: The Legacy of Autism and the Future of Neurodiversity

In recent decades, the prevalence of autism spectrum disorder (ASD) diagnoses among children in the Netherlands has shown an increase, reflecting trends observed

in other countries. According to reports from relevant authorities, such as the National Institute for Public Health and the Environment, the percentage of children diagnosed with ASD in the Netherlands has risen over the years. For instance, in 2020, approximately 2.8% of children in the Netherlands were diagnosed with ASD, compared to 0.7% in 2000[2]. It is important to note that this increase in diagnoses may be primarily due to improved awareness and screening practises, rather than an actual increase in the prevalence of autism. This suggests that there are still a significant number of people who need support despite not having an official diagnosis. There is also an increasing recognition of late diagnosis, particularly in women who are often less likely to receive a timely diagnosis[3].

As a result, the number of students with ASD enrolled in universities is increasing. However, the university environment is primarily tailored to neurotypical (NT) individuals, presenting challenges for students with ASD in successfully navigating university life. There are several reasons why university can be challenging for students with ASD. Firstly, the transition from school to university can be difficult as students must adapt to a new environment with minimal structure, unlike in school where schedules are predetermined. At the university level, most of the work is done independently, requiring students to manage their own time, which can be stressful and increase the need for adequate support [14].

Secondly, social challenges pose a significant issue and can contribute to the well-being of students, often leading to mental health problems such as depression and anxiety. Additionally, the academic aspect of university can also present difficulties [3]. Previous studies have found that students on the autism spectrum struggle with various aspects, including information processing speed, time management, group work, presentations, motivation to learn, following lectures, and asking questions [51].

Students with ASD may encounter challenges in completing courses if the conditions and requirements are not clearly specified. Therefore, it is beneficial for them to receive detailed and specific information about the course expectations [25]. Breaking down assignments into smaller, concrete parts can also be helpful [14, 37]. Furthermore, research indicates that students with ASD may become highly engaged in one task at the expense of others [11]. However, it is important to note that previous research on university students' experiences of ASD has primarily relied on self-report studies, highlighting the heterogeneity of their experiences. This heterogeneity may also be attributed to the diverse main impairments found in autistic individuals, which remains a significant obstacle in autism research [26].

Qualitative research suggests that students with ASD have a particular problem with planning, which significantly affects their academic performance[14]. Some of the study participants indicate that their problems with planning stem from being easily distracted and having difficulty focusing on multidimensional

tasks[14]. Managing ongoing tasks and planning are processes that require a high level of executive function (EF) as they involve several key cognitive skills. These skills include working memory, which is needed to store and process information over short periods, cognitive flexibility, which allows plans and strategies to be adapted in response to changing circumstances, and inhibitory control, which helps to maintain focus on the task at hand by suppressing irrelevant or distracting stimuli [19]. Taken together, these skills enable individuals to effectively organise, prioritise and execute complex tasks, underlining the central role of EF in planning and task management. One of the effective approaches to mitigate the impairments of EF is to support ASD students with tools specifically tailored to their needs[17].

The following study aims to explore the challenges that students with ASD face in coping effectively with tasks. It will address the specific difficulties and obstacles these students face when completing tasks in an academic setting. Through a comprehensive understanding of these challenges, the study will provide valuable insights for the development of task management tools for students with ASD. It will also explore different strategies for different areas of task management skills. In addition, the study will focus on exploring the existing tools and technologies that help students with ASD to manage tasks. It will examine the functionalities and features of these tools and analyse their effectiveness in relation to the specific needs and requirements of students with ASD.

In the final phase of the study, an assistive technology application will be developed to help university students with ASD with task management. People may have developed different strategies, use a variety of tools, and may face different challenges when it comes to task management, which will impact the nature of the need for assistive technology to support this process [27]. Especially considering the impairments of EF people with ASD, their needs for assistive devices to support task management may differ from the needs of neurotypical people. Therefore, development will focus on features that support the key challenges of students with ASD as identified through the literature review and user studies. One of the key features of the application will be the recommendation to divide tasks into smaller, more manageable subtasks, supported by the generative language model - ChatGPT. This approach aims to facilitate the effective organisation and execution of tasks.

To evaluate the implementation of the assistive technology application, a qualitative user study will be conducted. The study will evaluate user satisfaction with the application and assess its overall usefulness in supporting task management for students with ASD. The insights gained from this evaluation will help to further refine the solution and ensure that it meets the specific needs of the target group.

2 Related Work

2.1 Autism Spectrum Disorder

Autism spectrum disorder is a neurodevelopmental disorder characterised by deficits in social impairments, communication difficulties, and the presence of restricted interests and repetitive behaviours [44]. The aetiology of ASD is likely to be multifactorial, and there is no single genetic or cognitive explanation that could explain the co-occurrence of all three impairments. As a result, there is no single "cure" or intervention for ASD [26]. The severity of symptoms can vary from mild to severe, and the term *spectrum* indicates a range of differences in symptom type and severity, reflecting the unique challenges and abilities of each individual with ASD. It is also important to note that ASD can occur without an intellectual disability [4]. In addition, there is a subgroup of people with ASD who have only one dominant impairment, which makes it difficult to diagnose with currently available tools. Meeting the needs of these people on the spectrum is a major challenge [26]. Researchers believe that ASD has multiple interacting causes that disrupt the typical developmental trajectories of individuals [26]. It is crucial to recognise that each person with ASD has their own unique strengths and challenges and that there is no one-size-fits-all approach to supporting people with ASD.

People with ASD have significant problems with their time management and organisational skills. In particular, they have difficulty prioritising, coordinating, and sequencing activities, which is closely related to prospective memory [46]. Prospective memory refers to the ability to remember and carry out intended actions in the future[60]. People with ASD may have difficulty effectively retaining and retrieving future-oriented information, which directly affects their ability to plan and organise tasks[60].

These difficulties with time management and organisational skills have been identified by researchers as two key concepts that shed light on the observed poor planning skills in people with autism [9, 60, 34]. Understanding the challenges faced by people with ASD in the areas of time management and organisational skills can help to develop targeted interventions and strategies to support their specific needs in these areas.

2.1.1 Challenges of University Students

In recent years, the increasing number of students with ASD enrolling in universities has demonstrated the importance of creating an inclusive educational environment. This increase can be attributed to several factors, including improved autism awareness, earlier diagnosis, and increased efforts to promote inclusion and

accessibility in education [32]. However, it is crucial to recognise that university students with autism face particular challenges related to social communication difficulties and executive function deficits, which can contribute to higher dropout rates and mental health problems such as anxiety and depression [25]. In addition, the particular challenge of planning adds to the complexity of their academic experience and highlights the need for tailored support and adaptations to promote their success and well-being in the university environment.

It is therefore crucial that universities recognise and adapt to the needs of neurodiverse students, including those with ASD. It is important to address their particular needs and challenges while maintaining academic expectations and standards. Since research has shown that neurodiverse students are often able to learn and understand material at a similar pace as their peers [53], but that they face different challenges that may affect their academic performance.

Considerate time management, which includes managing tasks, could potentially help students with ASD avoid suffering from burnout, which has been found to be common among autistic people[58]. Burnout is defined as a chronic state of exhaustion, loss of skills and reduced tolerance to stimuli[47]. It is caused by prolonged stress without adequate support[18]. The characteristics have been described by people affected by this condition[56]. Burnout can have a serious impact on personal life, mental and physical health and even affect the ability to live independently. Autistic burnout differs from occupational burnout in the causes that trigger it in the first place, as well as in that it can exacerbate autistic traits such as increased sensitivity to sensory stimuli or difficulty with change[18].

The causes of burnout in people with autism are not well researched and there is a lack of academic or clinical literature[58]. Nevertheless, the concept of autistic burnout has been present in the autistic community for some time in the digital space, indicating the existence of a problem. It has emerged on social media platforms such as Twitter, where people with autism share their experiences, and on YouTube, where they discuss strategies for recovering from burnout[33]. This online presence suggests that those who have experienced burnout want to share their stories and connect with a community that can relate to their experiences.

As a result, it is difficult to find the right tools to support people who have experienced autistic burnout because it is not clear how it relates to occupational burnout, which has been more widely studied [58]. In the qualitative study by Raymaker et al[58], people with ASD were asked how they could prevent or recover from burnout. The solutions were divided into different areas. One of the most important areas is acceptance and social support and masking autistic traits. Another important area is reduced load, which has to do with managing energy and time. Being attuned to one's needs when taking time off and knowing when to devote oneself to the tasks at hand. The above has to do with self-awareness,

i.e. being aware of one's behaviour and patterns and reacting to early signs[58]. Strengthening self-awareness and recognising early signs of burnout are crucial elements in promoting well-being and preventing the negative effects of burnout.

2.1.2 Executive Disfunctions

Executive functions (EF) are a set of top-down control processes which are used when reliance on intuition or automatic responses would not suffice to execute the process [19]. It is generally agreed that there are three main components of EF: Inhibition, working memory, and cognitive flexibility [41]. Inhibition control is one of the core elements of EF and is responsible for controlling one's attention, behaviour, thoughts, and emotions and choosing the more appropriate response to certain stimuli. Inhibition consists of processes such as self-control/discipline, selective or focused attention, and cognitive inhibition. The second component is working memory, which is responsible for storing and processing information that is no longer perceptual. It also plays a central role in controlling attention, integrating new knowledge, and facilitating the mental processing of stored information for problem-solving and decision-making tasks [41]. The last component is cognitive flexibility, i.e. the ability to adapt one's thinking to the demands of the stimuli. This includes the ability to change perspective spatially or interpersonally and to change the way one thinks about something (thinking outside the box). Cognitive flexibility is linked to creativity [19]. Higher-order executive functions can also be distinguished, building on core elements such as relational and logical thinking, planning, and problem-solving [16].

Research suggests that impairments in executive functions (EF) are one of the key elements associated with ASD [43, 31]. In addition, deficits in EF could potentially be used to explain many autistic behaviours, including communication skills [23], time processing, and time management. These impairments in executive functions can have significant implications for individuals with ASD in various aspects of their daily lives. Communication skills may be affected, and individuals may struggle with time processing and time management. Moreover, the demands of university life, particularly in terms of work organisation, can be overwhelming for students with ASD[25].

To address these challenges, previous research has explored strategies to support individuals with ASD in overcoming executive function impairments[53]. Teaching techniques that emphasise independent task completion through prioritisation, action planning, and breaking down complex tasks into manageable steps have shown promise in supporting individuals with ASD in navigating academic and everyday tasks[53]. By providing targeted interventions and support in executive functioning, individuals with ASD can better manage their challenges and enhance their overall functioning and well-being.

2.1.3 Autistic Inertia

Expanding on the previous section describing the EF impairments observed in people with autism, the experience of autistic inertia has emerged in the digital space in recent years. This points to the relevance and necessity of investigating this phenomenon.

Autistic inertia is described as a challenge to act on one's intentions [11] and is characterised by difficulties in starting, stopping or switching between activities. In addition, other characteristics identified in the study included a feeling of lack of control over actions despite a desire to engage, problems with decision-making related to executive functions, a lack of sense of time, difficulty adapting to changing environments, indifference to the urgency of the task or the task itself, lack of motivation but the ability to maintain focus over time once engaged, and a feeling of being unable to make progress. Autistic inertia is also caused by external factors that are influenced by actions in the environment, with expectations that can be difficult for people with autism to fulfil. The difficulties described affect the person's well-being and cause stress, overload, and exhaustion, which in turn affects the person's productivity. The description of the external and internal factors that cause autistic inertia and the internal and external effects are shown in Figure 1. Sometimes autistic inertia is mistaken for an extreme avoidance of demands associated with high anxiety, but it can also be misinterpreted as a lack of motivation or laziness.

The research on autistic inertia is limited and does not investigate the causes or outcomes. The first scientific paper was published in 2021[11]. The methodology relied on qualitative studies with people with ASD, focusing on personal experiences. The difficulties in performing tasks and the impact on daily life were investigated. The main findings of the study are presented in Figure 1. In addition, most of the non-scientific articles were published in the following year 2023. Before 2021, the concept was present on digital platforms such as reddit and youtube. This indicates the lack of understanding and the large gap in research on ASD. It can be surmised that there is a lack of defined support strategies to overcome these challenges.

The aforementioned characteristics of autistic inertia appear to be universally shared experience among individuals with autism, which raises the question of how best to support them in overcoming these challenges. Consequently, this recognition emphasises the importance of further research and tailored interventions aimed at more effectively supporting people struggling with autistic inertia.

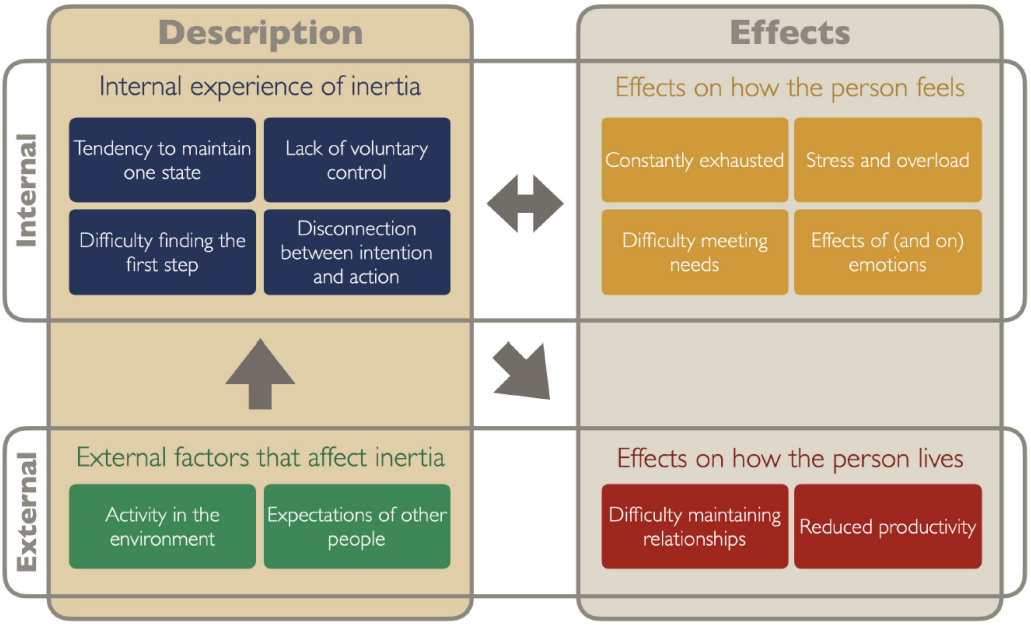

Figure 1. *Presents themes in autistic inertia (Adapted from Buckle et al 2021[11].*

2.1.4 Intolerance of Uncertainty

Effective planning often means navigating a field full of uncertainties and unexpected variables. The occurrence of unforeseen events is a common challenge that disrupts predefined schedules and requires quick adaptation. In addition, tasks may have ambiguous or inconsistent guidelines, making it difficult to identify and execute the required actions. Hence it is important to consider impact of uncertainty of planning especially among individuals with autism.

Intolerance of uncertainty (IU) is defined by Buhr Dugas [13] as "a dispositional characteristic that results from a set of negative beliefs about uncertainty and its implications and involves the tendency to react negatively on an emotional, cognitive, and behavioral level to uncertain situations and events". This means that people with IU tend to view all uncertain information as threatening and everything unexpected and all events as stressful. Two important key factors of IU are a *Desire for probability*, i.e. trying to make the future as certain as possible, and a preference for order and structure with an aversion to ambiguity and *Uncertainty paralysis*, which manifests itself in not being able to act when faced with uncertain events [6].

Several studies have shown that this plays an important role in the development of anxiety disorders in the neurotypical population [21]. The topic of IU has been investigated in the population with ASD, as several traits of autism, such

as abnormalities in sensory processing or restrictive and repetitive behaviour, suggest the relevance of this topic [66]. IU has been shown to be an important aspect in the development of anxiety in people with ASD and functions in a similar way to neurotypical people. In addition, IU appears to mediate anxiety in children/adolescents with ASD [10]. Research has shown that people with ASD have significantly higher levels of IU, resulting in higher levels of anxiety. The importance of considering IU in people with ASD is related to restricted and repetitive behaviour, which is one of the diagnostic criteria for ASD. Both concepts are based on the same factors, namely the desire for consistency and predictability. Given the results of previous research, it is hypothesised that people with ASD may benefit from interventions that focus on reducing IU.

Previous research emphasises the important role of IU in the lives of people with ASD. The tendency to perceive uncertain situations as threatening leads to higher levels of anxiety, particularly due to their desire for predictability and order. Therefore, it may be particularly beneficial for students with ASD to understand the areas that lead to uncertainty in the university environment and focus on minimising these uncertainties in order to reduce the risk of developing an anxiety disorder.

2.1.5 Assistive Technology

Assistive technology (AT) refers to any device, software program, or system that provides practical solutions for life activities. AT can be specifically designed to help people with disabilities overcome their challenges and improve their functional abilities [20]. In the case of students with autism who encounter difficulties and challenges, appropriate AT solutions can be developed to improve their quality of life.

There are various technological solutions to assist people on the autism spectrum with functional limitations. For example, virtual reality can be used to improve communication skills and prepare children for real-world situations [29]. In addition, applications can be used to train executive functions [54]. There are also serious gaming applications that facilitate learning in areas such as social skills, motor integration and sensory integration [20]. However, the main focus is often on practising the social aspect and creating AT tools that help people on the autism spectrum improve their communication skills.

Assistive technology plays an important role in supporting people with autism by providing necessary aids and adaptations without compromising or limiting expectations. This study focuses specifically on EF support, an area that is often overlooked in existing interventions and assistive technologies [50]. A literature review by Desideri et al. [17] suggests promising evidence that assistive technologies can be effective in compensating for impairments in EF.

Taking into account the multiple challenges that people with ASD may face, particularly related to EF impairments, it is evident that they could greatly benefit from assistive devices and technologies that reduce the demands on their limited executive function resources. By providing tools that support task management, these individuals can improve their ability to focus on complex tasks and effectively manage their academic responsibilities.

2.2 Personal Task Management

This chapter delves into the complex area of task management, a key component of effective time management. Task management involves the ability to maintain a comprehensive overview, reliably memorise tasks and systematically create and manage to-do lists [42]. Central to this process is the ability to juggle multiple tasks simultaneously. EF plays a crucial role in this process, for example by storing all relevant task-related information in working memory so that informed decisions can be made about prioritising tasks. As impaired EF is a characteristic trait of people with ASD [43], an understanding of task management processes is essential to address their specific needs.

To understand the concept of task management, this section explains key terms such as *time management* and *action plan* and emphasises their importance in the context of developing task management applications. The chapter then guides through the complexities and specific considerations involved in developing systems to promote task management skills, particularly for people with ASD. It also provides an in-depth analysis of various existing task management software and examines their strengths and limitations. This comprehensive overview serves as a guide for the development and improvement of task management support systems, ensuring that they are effectively tailored to the specific needs of people with ASD.

2.2.1 Time Management

Time management has been extensively researched in recent decades from various perspectives. However, there is no consensus on whether training in time management can improve work performance [15]. Nevertheless, research consistently shows that effective time management is associated with reduced stress, higher job satisfaction, and better perceived time control [49, 15].

Time management encompasses a set of processes that include achieving needs, setting priorities, and planning tasks to achieve goals [15]. Managing tasks within time involves setting priorities, effectively allocating valuable energy resources, and adapting to change. However, existing time management tools, such as calendars and schedules, often fail to fulfil these conditions. Moreover, these tools do not

adequately address the well-being aspect of time management, as their primary goal is to enhance performance. There is a plethora of time management tools on the market. However, there is insufficient scientific evidence on the effectiveness of time management apps. Despite the abundance of tools available, interviews with users show that no existing tool fully meets the needs of individual users[35]. In these circumstances, traditional methods such as using pen and paper may be less time-consuming and easier, hence preferred by individuals[28, 63].

In summary, effective time management is consistently associated with reduced stress, higher job satisfaction and better perceived time control. Although existing time management tools have their limitations, traditional methods such as pen and paper remain popular. Further research is needed to investigate the effectiveness of tools and to develop comprehensive approaches that take individual needs into account. Last but not least, based on the research of apps developed for people on the spectrum, it was found that the concept of time management was the least addressed in assistive technology [50].

2.2.2 Action Plan

To mitigate the challenges faced by students with ASD due to EF impairments, breaking tasks into smaller, more manageable segments is a recommended strategy [53]. Such segmentation is crucial in overcoming 'autistic inertia' a common barrier that makes it difficult for people with ASD to begin tasks [11]. By developing a detailed action plan that outlines the step-by-step process for completing a task, students are better able to begin tasks and complete them with greater ease. This approach, known as an action plan, is a key element of effective task management and is particularly beneficial for people with ASD as it provides a clear roadmap and reduces the cognitive load associated with initiating and completing tasks [38].

Action planning refers to the process of creating a detailed and organized plan of specific actions and steps required to complete a task [42]. It involves breaking down complex tasks into smaller, more manageable components - subtasks, determining the sequence or order of actions, setting priorities, allocating resources, and establishing deadlines or timelines. Action planning helps individuals clarify what needs to be done, how it will be done, and when it will be done.

People are more likely to complete what they have planned if they have a concrete action plan. However, creating this action plan can be a challenge. It has been studied that people are more likely to procrastinate when they are doing open-ended, abstract tasks. One can pursue less important tasks at the expense of more important ones because they are perceived as more attractive, and the process is clearer[52].

A concrete, actionable plan gives clear indications of when a break is appropriate. This prevents you from interrupting work to remind yourself of

the goal of the task. Despite the benefits of creating an action plan, people very often fail to do so. One possible explanation is that it takes time and effort, as well as proactive thinking in our schedule. And the benefits of doing so may not be enough to take that extra step. An example of a system that automates these processes is TaskGenies, a crowd-sourced task management system that helps workers create an action plan[38]. It breaks down tasks into smaller, doable parts to create automatically a concrete plan. TaskGenies has been proven to help people get more tasks done[38]. The study suggests that not requiring users to create the plan themselves can have a positive impact on productivity.

In this study, the focus is on repeatable university tasks and allows for standardisation. Therefore, it is hypothetically possible to create a series of tasks that can be broken down into smaller parts and applied to different users. This can make it easier for users to complete a series of tasks and make starting a task less overwhelming. Therefore, the automatic creation of action plans in task management software can be a valuable feature that improves organisation and planning skills

2.2.3 Analysis of Task Management Softwares

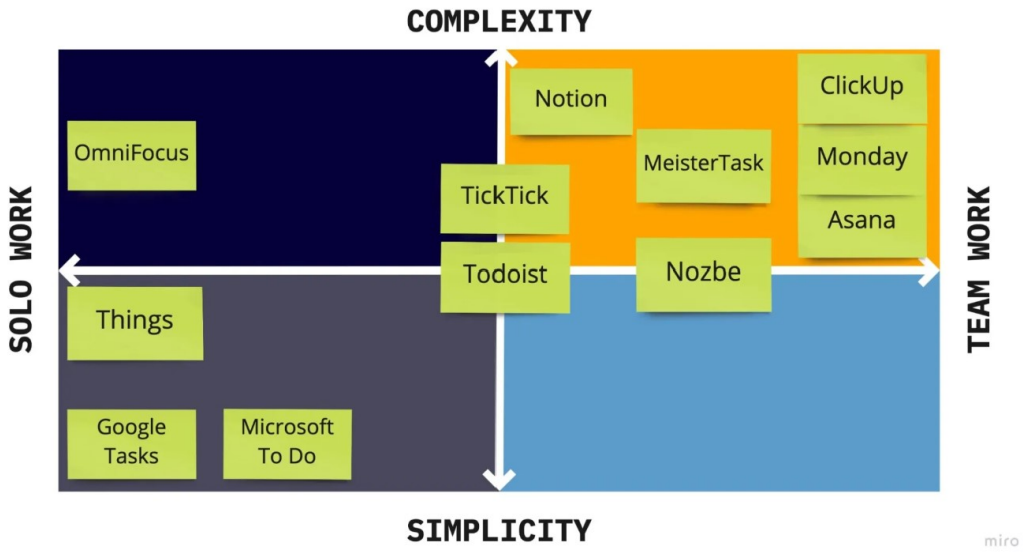

Figure 2. *Best Task Manager Apps in 2022 according to Productivity 95*

In today's digital landscape, there is a plethora of task management tools that cater to the different needs and preferences of users. These tools can be broadly divided into two categories: Project management tools for team collaboration [7],

and apps that focus on individual task lists [8]. Figure 2 shows the most popular task management tools in two-dimensional space, taking into account complexity and individual use.

One of the tools worth mentioning is Todoist, known for its straightforward yet powerful interface for creating and organising tasks. However, some users feel that Todoist lacks advanced features and customisation options compared to other task management tools[8]. Another tool for individual use is Microsoft To Do, an extension of the widely used Microsoft Office suite that integrates seamlessly with other Microsoft applications so that users can use a unified task management system on all their devices. However, the tool is limited in its functionality and may be insufficient for some users. Another example is Trello[7], a visual board-based tool where tasks are displayed as moving cards in different lists or categories. Trello is designed to facilitate collaboration between team members and uses the Kanban method, which sets it apart from other available tools. However, users who need more advanced features, such as detailed task assignments or time tracking, will find that Trello leaves much to be desired in these areas. Another tool - Omnifocus[8] - is designed exclusively for individual use with the highest level of complexity. It has robust customisation options that allow users to tailor the user interface and workflows to their specific needs, increasing flexibility and personalisation. In addition, OmniFocus enables synchronisation and access across multiple devices, so users can stay organised on the go. However, there are also some drawbacks to consider with OmniFocus. The relatively complex user interface and the steep learning curve can take time and effort to fully understand, potentially impacting initial user adoption. The summary of different task management tools and their advantages and disadvantages is depicted in Table 1

Most common task management tools lack the flexibility to accommodate the unique strategies that individuals develop for their task management. While these tools offer a wide range of features and functions designed to improve productivity and organisation, they often do not adapt to each user's preferred methods and approaches. Users' personal techniques for prioritising, scheduling and executing tasks may not fit within the predefined framework of these tools, resulting in suboptimal task management experiences. Thus, there is a gap for task management tools that offer greater customisability and allow users to tailor the tool's functions to their specific needs and strategies.

2.2.4 Enhancing Task Management

In the area of task management, the landscape is characterised by the widespread use of apps, which are powerful but often cannot be adapted to individual needs. This section looks at the limitations that these apps bring, particularly for individuals with ASD. It also explores the gaps in current task management tools

Table 1. *Comparison of the most popular dedicated digital task management tools.*

Tool	**Advantages**	**Disadvantages**
Todoist	Straightforward, powerful interface Efficient for creating and organizing tasks	Lacks advanced features Limited customization options
Microsoft To Do	Integrates with Microsoft Office suite Unified task management across devices	Limited functionality May not meet the needs of all users
Trello	Visual, board-based approach Facilitates team collaboration Uses Kanban method	Limited in advanced features like detailed task assignments and time tracking
OmniFocus	Highly customizable Tailored user interface and workflows Synchronizes across multiple devices	Complex user interface Steep learning curve, affecting initial user adoption

and highlights the need for more flexible and customisable solutions that meet the different preferences and challenges of users.

The apps supporting task management are very powerful and offer a lot of different functions. However, this aspect can be overwhelming for people on the spectrum who may need more support with their time management skills than their NT peers. On the other hand, tasks are sorted according to a small number of factors such as urgency, importance, and reminders. However, they cannot flexibly adapt to changes, context, and the user's habits and preferences [35]. This can be a barrier for people with autism as they are not very resilient to unplanned and rapid changes [66]. Therefore, they could benefit from recommendations that adapt to circumstances and suggest changes in the schedule.

When developing apps for task management, there are some limitations and challenges that need to be considered [1]. People tend to be overly optimistic about the time needed to complete a task; this phenomenon is known as the planning fallacy [12]. For example, people tend to be overly optimistic about real-world tasks such as writing an essay, whereas they tend to overestimate the time needed for laboratory work. The same study also shows that less complex tasks have a lower

prediction bias [62]. Normally, the goal of a day is to complete all scheduled tasks. Therefore, the estimate of tasks to be completed should be as accurate as possible to reduce dissatisfaction at the end of the day. In addition, task management tools should not rely solely on time planning, as this is subject to a high margin of error. The study shows that the majority of planning errors are due to inaccurate planning, and only a small part is related to external factors. It indicates that satisfaction with the completion of planned activities could benefit from accurate planning [1]. Detailed and accurate planning can reduce a planning error and contribute to creating a more realistic action plan. However, accurate planning may not be a favorable strategy for everyone due to limited flexibility and spontaneity.

People fail to take time to plan when they are busy with many things on their plates. Trying to keep everything in mind leads to overload and the inability to get things done successfully and calmly [1]. One of the studies defined four different planning strategies that differ in the frequency of planning and indicate different circumstances in which they are successful or not [1]. Multi-level planning, i.e. organizing time at different levels of granularity at the same time. Plan long-term goals monthly, but create daily lists to achieve short-term goals. This strategy is suitable for complex and lengthy tasks. However, the study shows that there is no suitable tool that supports this type of planning. In contrast, several existing tools support minimum, daily, or monthly planning [1]. This makes multi-level planning more time-consuming and in many cases not worthwhile. The above results can serve as an inspiration for developing a tool that chooses different strategies depending on the company and the variety of tasks but focuses on supporting multi-level planning.

Last but not least, an important part of a task management system is how to handle tasks in collaboration with other students. In this case, a student may be dependent on another person and the completion of an assignment may not be successful due to other people's delays. However, it will not be a focus of this study. It is assumed that a division of tasks is done in advance and all tasks are treated as individual.

Current task management apps tend to sort tasks rigidly and do not adapt to changes, user habits, and preferences. It also underscores the need for more sophisticated task management tools that support multi-level scheduling strategies to better accommodate complex tasks and individual preferences.

2.2.5 Personalisation of Task Management Software

Task management is an individual process, with individuals approaching their tasks in different ways, having varied priorities, needs, and employing diverse strategies [65]. They utilize different tools and techniques to accomplish their objectives. Consequently, prior research indicates the potential for developing more

personalised task management approaches [28]. Several studies suggest that this could enhance the effectiveness of task management tools [35]. However, further research is needed to explore personal strategies and their connection to task types [1]. Additionally, research is scarce on individual variations in task management, and the precise implementation approach remains unclear.

According to a study by Bellotti et al., [5], people have their strategies when organising and prioritising. Moreover, they prefer to apply them rather than follow imposed strategies and adapt the tool to their needs[42, 65]. They also point out that the energy people have to expend to ensure the effectiveness of their strategies is costly[5]. One of the possible personalisations was presented in a study on personal task management[28], which outlined three approaches: DIYers, Adopters, and Make-doers. The majority of people fall into the DIYers category, meaning they prefer tools that allow them to apply their strategies and meet their specific needs, such as a pen and paper or even a simple notepad[28]. DIYers use a general tool, but they adapt it to their needs. Adopters use a specific electronic tool for task management, and make-doers use a general tool but without any personalisation.

The study was repeated on a larger population[27] and the findings differed from the previous study[28]. It was discovered that individuals did not strictly fall into one specific category; rather, they could exhibit characteristics from two groups, with one category usually being more dominant. These results indicate the need to develop a tool that caters to the user's primary tendency, while also accommodating the secondary tendency if necessary [27]. Furthermore, the study examined the relationships between preferred strategies and factors such as occupation, busyness, and reliance on memory for task recall[27]. These findings suggest that these factors may play a crucial role in predicting an individual's tendencies. For instance, individuals in academic settings tend to display more tendencies towards DIYing rather than adapting, likely due to the less structured nature of tasks in an academic context[27]. People who rely less on their memory are more likely to exhibit make-doing tendencies as opposed to adapting. Given that individuals on the autism spectrum often face challenges with prospective memory[60], this implies that their reliance on memory tends to be weaker, resulting in a higher inclination towards make-doing. The last factor discussed is busyness, although it remains unclear whether the tendency influences busyness or vice versa[27].

It has been studied that individuals with ASD may experience difficulties in multitasking due to impairments in executive functions and prospective memory[57]. Consequently, the following research does not consider differences among individuals regarding their ability to engage in multiple tasks. Instead, the following study assumes that students with ASD should focus on a specific task that emphasizes a single aspect.

In the study on personal task management, the factors that consist of context were presented[35]. One of the factors is the user's internal state, including emotions, motivation, interest, and mental and physical health. For example, it may influence the decision whether a person continues writing an essay instead of switching to another scheduled task when the user is already in flow. Although various contextual factors have a significant impact on how people organise their schedules and complete tasks[35], these include the user's internal state, but this is not the focus of this study. Although capturing the user's internal state could provide valuable insights, it would require complex measurements, such as biosensors, which are beyond the scope of this study. Therefore, the primary focus is to comprehend and integrate diverse personal approaches to task execution into the tool's design, aiming for wider applicability and usability. Figure 3 illustrates the key factors that influence the context of the task management process, based on the research by Kamsin et al. [35].

Developing a task management tool that meets the diverse strategies and unique needs of individuals is a major challenge. Given the highly individual nature of task management approaches, it is crucial to develop a tool that can adapt to and accommodate personal preferences and methods.

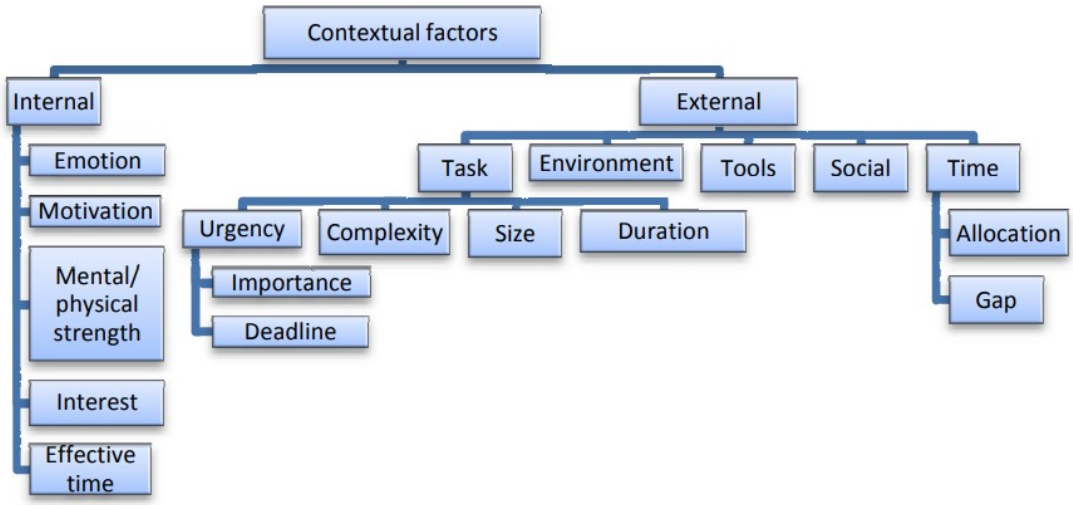

Figure 3. *Contextual factors of task management systems (Adapted from A. Kamsin et al., 2012)[35].*

2.3 Knowledge Gaps

In light of the challenges faced by students with ASD in effectively managing their study workload, the necessity for a task management tool tailored to their specific needs is evident. This tool should provide personalized features and recommendations based on the user's preferences, enabling them to adapt it to their strategies for successful task completion. However, current task management apps lack this level of personalization and the ability to accommodate individualized strategies, thus limiting their utility for individuals with ASD. The majority of research in task management has primarily focused on NT individuals, leaving a notable gap in understanding how students with ASD prioritize tasks and effectively manage their time. Moreover, insufficient attention has been given to the struggles and challenges faced by students with ASD in comparison with NT students. Consequently, further research is imperative to explore the distinct challenges, strategies and preferences in task management among students with ASD.

Given the impairments in executive functioning in individuals with ASD that impact planning and organisational skills, it is hypothesised that students with ASD require specific tools tailored to their needs. It is important to focus on the problems associated with autistic inertia, especially the difficulties in initiating tasks. The following study will examine which aspects of task management require special attention from a design perspective. It will also address the concept of personalisation of task management tools. To finally develop a prototype application that focuses primarily on the creation of a comprehensive action plan tailored to the individual needs of the user. This action plan will consist of a well-structured sequence of tasks, with complex tasks being broken down into manageable subtasks. This approach aims to alleviate the feeling of being overwhelmed and enables a step-by-step approach to task completion.

The entire process will adhere to an iterative approach, specifically following the three-step Hevner-based design research process [30]. Firstly, it involves understanding the application domain, which in this research context involves comprehending the needs of the target group, students with ASD. Secondly, it entails designing and developing the prototype, followed by user studies. Finally, the created prototype will be evaluated in real-life applications. The research aims to address the identified research questions.

3 Research Questions

RQ1. How do students with autism perceive their task management skills and how do they compare to NT students in terms of task management?

1. Are students with autism spectrum disorder less confident in their task management skills compared to neurotypical students?
2. What are the unique challenges in task management faced by students with Autism Spectrum Disorder?
3. Are there specific task management strategies preferred by students with Autism Spectrum Disorders?
4. What are the main reasons for and against the effectiveness and usability of existing task management tools for people with autism spectrum disorder?

RQ2. How can a task management tool be specifically designed to support long-term task planning for students with Autism Spectrum Disorder, considering their unique cognitive needs?

RQ3. How useful is the prototype for task management in aiding semester planning for university students?

4 Methods

This section describes the methods used to answer the previously identified research questions, following the structured approach of the Hevner-based Design Science Research Process, which comprises the Relevance Cycle, the Design Cycle and the Rigour Cycle [30]. Figure 4 visualises these steps and provides a roadmap for the research process.

The research begins with the relevance cycle, which is initiated by the formulation of a problem resulting from a comprehensive literature review. The main objective of this first phase is to identify the system requirements and potential areas of support for the proposed task management application. To achieve this, a survey method will be used, which will allow data to be collected from a large number of participants in a short period, thus increasing the generalisability of the results. In addition, the results of the survey will form the basis for the subsequent phases of the study and will significantly influence the design decisions.

In the design cycle, potential solutions for a task management system are developed. Given the wide range of requirements from the survey, a focus group

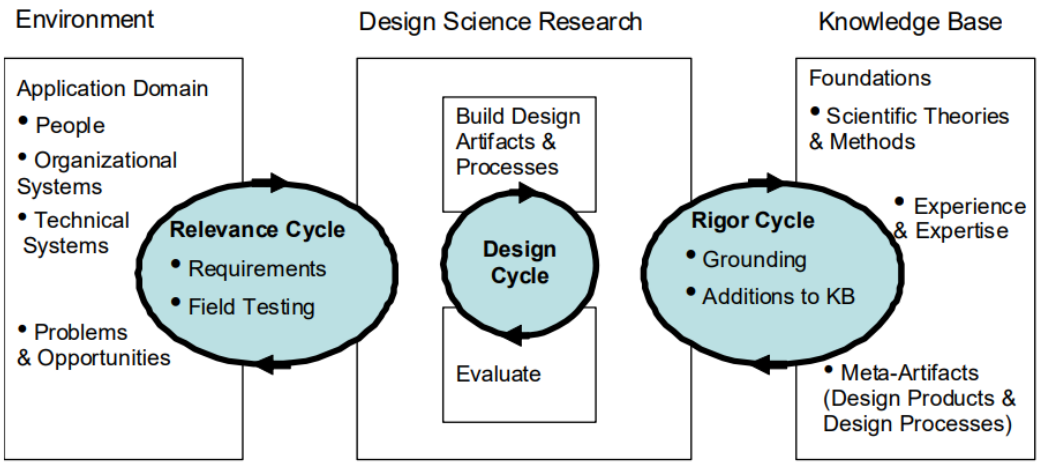

Figure 4. *Design Science Research Cycles Source: Hevner, 2007 [30]*

was conducted with HCI students. In this session, experts developed ideas for design solutions tailored to the specific needs of ASD students, focussing on the appearance and functionality of the system. A second focus group concentrated on the possible adaptation of the system, a topic that had already been discussed intensively in the first group. This group aimed to explore adaptive features and specific requirements for a semester planning system that addresses the challenges of long-term planning.

The final Rigor cycle involves the evaluation of a prototype task management app for semester planning in real-life scenarios. The effectiveness of the implemented solutions is evaluated in an experiment - a think-aloud study and feedback on the prototype is collected. This phase, conducted at the beginning of the semester, ensures the applicability of the tool and provides critical insights into the impact and user perspectives of the proposed solutions.

In addition, this section describes the participant recruitment process, including the strategies used to ensure an adequate sample. It also explains the concepts to be measured during the experiment to provide a comprehensive understanding of the data to be collected.

4.1 Online Survey

4.1.1 Survey Design

An online questionnaire, developed based on an extensive literature review, seeks to understand and compare task management patterns between individuals

with autism and NT students. A particular focus is placed on questions regarding the use of dedicated digital tools for task management, aiming to understand the reasons for their adoption or avoidance. The findings from this survey will guide the formulation of targeted questions for focus groups, which will focus on developing design strategies that address the unique needs of students with ASD. The survey questions are based on literature covering various aspects of task management [28, 35], executive functioning challenges in individuals with ASD [43, 23], and the concept of autistic inertia [11](Click here to view the preview of the survey.)

The survey is divided into three parts:

1. This section of the survey focuses on collecting participant characteristics and demographic information, including age and gender. Participants have the option to indicate whether they have an official autism diagnosis, are self-diagnosed, or describe themselves as NT. This categorisation is used to capture the participant's background. In addition, participants are asked to name specific challenges that are characteristic of the autism spectrum and to indicate the extent to which they face these challenges. Gathering this information will give you insights into participants' backgrounds, and their self-identified challenges related to the autism spectrum, and allow to explore possible relationships between these factors and their responses to the specific challenges. The questions were formulated based on articles about characteristics of people with ASD[45, 26].

2. The second part of the survey aims to assess participants' perceived task management skills and the specific challenges they face in managing tasks. A 5-point Likert scale is used for this purpose. The questions are based on the literature defining task management difficulties[25, 35] and on articles suggesting a categorisation of different strategies[27, 28]. participants will be asked the following questions::

   - Do you find it difficult to prioritise?
   - Do you think you are good at setting priorities?
   - How good are you at dealing with unexpected changes?
   - How good are you at dividing tasks into manageable subtasks?
   - How good are you at multitasking?

   For some of these questions, there will be follow-up questions to explore the participants' approach to dealing with specific situations, e.g:

   - What do you do when your schedule changes unexpectedly?

By including these questions in the survey, the research aims to gain insights into participants' self-perceived task management skills and their strategies for dealing with various task-related obstacles. This information provides valuable insights into participants' experiences and identifies possible areas for improvement or support in task management.

3. In this part of the survey, participants are asked about the online tools they use for task management and the features they find important and useful. They are also asked about their satisfaction with their current tools and how often they use them. The possible answers in this section were created based on the most popular tools on the market[7, 8].

    - What kind of software do you use for task management?
    - What features do you consider important in a task management tool?

    Gathering this information will give insights into participants' preferences in task management software and the specific features they value. This data helps to formulate possible improvements or recommendations for task management tools.

Based on the responses from the online survey, the study will analyze which aspects of task management present the greatest challenges for respondents, with a focus on any unique difficulties faced by individuals with autism. This analysis will involve examining the distribution of specific responses to discern any significant differences between the experiences of students with ASD and their NT peers. The findings from this analysis will be crucial in establishing system requirements. These requirements will inform the design direction of a prototype, ensuring it incorporates features necessary to effectively support students with ASD. The goal is to tailor the prototype's functionality to address the distinct needs and challenges identified through the survey, thereby enhancing its utility and effectiveness for the intended user group.

4.1.2 Particpants Recruitment

Participants for the survey were recruited through various methods. Snowball sampling was utilized to address the challenge of locating and reaching the target group, which consists of students with ASD. Outreach efforts included contacting study associations at Dutch universities that cater to students with autism, various research groups focusing on ASD/neurodiversity, and other Dutch associations dedicated to individuals with autism.

In addition, the survey was shared within the Reddit community , specifically on the Autism subreddit, and distributed among members of Discord channels that

serve communities diagnosed with autism. These online platforms were chosen due to their active engagement with the target demographic, providing a wider reach and potentially diverse responses from participants with varied experiences and backgrounds.

4.1.3 Analysis

The analysis phase of this research project focused on analysing the survey responses received in the initial phase. The main aim of the initial phase was to gain a comprehensive understanding of the difficulties people face in accomplishing their tasks. To achieve this, a survey was distributed to a wide range of university students, focussing on those diagnosed with ASD.

The survey included questions designed to gain insight into the challenges they face in managing tasks effectively, how they approach this issue and what tools they use. Although the main focus was on students with ASD, responses were also collected from NT individuals to serve as a comparative 'control group'. This approach allowed for a nuanced examination of the differences and similarities between these two groups and shed light on possible differences in task management.

At the beginning of the preliminary analysis, the responses were processed using the Qualtrics software platform. This initial analysis aimed to recognise patterns, and dependencies between the questions and the overall distribution of responses. However, in order to deepen the insights hidden in the data, a more comprehensive analysis was conducted using the Python programming language and various libraries, including Pandas for data manipulation and preprocessing, Matplotlib for data visualisation, Seaborn for statistical data visualisation and other relevant Python libraries for specific analysis tasks. Specialised statistical methods were used to uncover correlations, trends and meaningful patterns in the responses. The exact statistical techniques used in this phase of analysis are explained in the results section to provide a transparent and comprehensive understanding of the analysis methods used.

4.2 Focus Group

This section describes the methodology for conducting two focus groups, a crucial phase that drives the project following the survey analysis. These focus groups, anchored in Hevner's design research cycles [30], are critical to gathering in-depth insights and feedback that are crucial to the iterative design and development of the system. This iterative process ensures that the design of the system is not only innovative but also meets the practical needs and challenges identified through empirical research. The focus groups play a key role in transforming theoretical concepts into actionable design elements, bridging the gap between

academic research and practical application.

4.2.1 Focus Group 1 - Analyzing the Requirements

Upon analyzing the survey data, key system requirements were identified. These findings provided the foundation for formulating questions about potential design solutions and functionalities, which were subsequently discussed with HCI experts. The primary goal of the first focus group was to examine and refine the vital features required by the system to cater to the specific needs of students with ASD. This process included assessing existing tools to pinpoint where they fail to address the needs of these students. Such an evaluation is fundamental to the overarching objective of this work, which is to develop a more inclusive and effective digital task management tool tailored to the unique challenges faced by students with ASD.

In the focus group discussions, the complete list of identified system requirements was presented to provide participants with a thorough understanding of the system's intended capabilities. The discussion, however, concentrated on two key features identified as most critical based on the survey analysis: minimizing uncertainty and managing cognitive load and feeling overwhelm. These features were selected for their pronounced impact as observed in the survey results. The group also reviewed tools currently preferred by students with autism, particularly physical tools like calendars and planners. Lastly, the focus group delved into the potential benefits of automating planning and task creation. By focusing on these specific aspects, the aim was to elicit detailed and insightful feedback from the experts.

During the first session of the focus group, the following questions were thoroughly discussed.

- How can the task management system assist users in defining clear and concrete goals to minimize uncertainty?
- What features or design elements do you think would be most effective in reducing ambiguity in task management for autistic individuals?
- What potential benefits do you see in implementing automated planning systems within the task management system for autistic users?
- What level of control should the user have over automated plans?
- What personal features or task features influence their preference in the format of the plan (number of steps, complexity of language, description of subtasks, etc.)? What should be customizable by user input, and what should be adaptable to user preferences?

- How can the system help users manage tasks to prevent feeling overwhelmed, especially when dealing with complex tasks?
- How can the task management system address the issue of procrastination, which is often related to motivation and internal states?
- What aspects of these physical tools might contribute to a preference, and how could they be digitalized?

4.2.2 Focus Group 2 - Adaptation and Long-term Planning

The objective of the second focus group was to align the system adaptation ideas with the broader goals of improving task management for university students, with an emphasis on long-term planning strategies. This session focussed on the specific needs of students in the Faculty of Science at Utrecht University, focusing on their block planning practises. Understanding the challenges and approaches of these students was considered crucial as this could provide valuable insights that apply to a wider student demographic.

The structure of the focus group was carefully designed to gradually introduce participants to more complex issues. Initially, discussions centred on aspects of the user interface that could be tailored to individual user needs by identifying factors that influence features. To support this exploration, participants were presented with a visual representation of various contextual factors that influence task management, adopted from Kamsin et al 2012 [35]. This visual aid catalyzed deeper discussion and encouraged participants to reflect on these factors.

The main task for the participants was to develop adaptation strategies for the system. These strategies should address both the specific needs of individual users and the collective needs of the entire user group to achieve the project's goal of creating a universally customisable task management system.

In line with the overall aim of the project to simplify and optimise the planning process for university students, the focus group sought to uncover specific challenges and barriers to long-term planning faced by users. Long-term planning and academic tasks were revealed as the most challenging type of tasks to execute according to the survey results 12. Participants were asked not only to identify these problems but also to brainstorm and outline possible solutions. This discussion aimed to integrate technology and innovative approaches to develop a task management system that supports long-term planning, which in an academic context would be block/semester planning.

- Brainstorm and list the characteristics that define contextual factors which might influence how a person manages their tasks. The factors were categorized into task-related and user-related.

- Explore potential approaches to system adaptation that could alleviate user overwhelm based on both user and task characteristics.
- Discuss the challenging aspects of long-term planning or semester planning.
- Given the above-mentioned challenges, propose the "best" possible system that can assist with long-term planning
- Engage in discussions to share and explore each other's ideas.

4.2.3 Participants Recruitment

Participants for the focus group were recruited from a random sample of students enrolled in the HCI degree programme. Given the abstract nature of the survey results, it was deemed more appropriate to refine potential methods for digitising task management applications by consulting experts in the field. In addition, the focus group wanted to concentrate their efforts on developing an adaptive interactive system. To facilitate this, the study will be advertised during the lecture of the above-mentioned course. Each focus group consisted of four members, all of whom were either currently enrolled in the HCI program or had recently graduated. No additional characteristics of the participants were evaluated.

5 Results

This section reports on the results of the study. First, the distribution of survey responses is presented graphically, with a comparative analysis between students with OASD and NT students revealing clear patterns among students with ASD. Second, qualitative data from focus groups is presented to illustrate the application of the theoretical findings from the literature review and survey in the development of the prototype. Finally, the results of an evaluation study are presented to show the general attitudes of univeristy students towards the proposed solution, as well as quantitative data on ease of use and intention to use the system in the future. These results provide a comprehensive understanding of the effectiveness and acceptance of the prototype.

5.1 Survey

The primary analysis of the survey results presents demographic and neurodiversity-related characteristics of the participants and forms the basis for the subsequent analyses and conclusions of the study. The survey was completed by 71 participants.

Figure 5 shows the distribution of the participants' neurodiversity status. Sixty-three participants selected a single response: 25 identified as NT, 22 had an official autism diagnosis (OASD), 6 had an autism self-diagnosis, 6 had another officially diagnosed neurodiversity, and 5 had a self-diagnosis with neurodiversity. Additionally, eight respondents chose two answers, meaning that they had either two official diagnoses or self-diagnoses related to neurodiversity. Respondents who gave two answers, e.g. ADHD and autism, belong to two groups simultaneously and are treated as two separate cases. Results that include such an assumption are reported accordingly to ensure transparency. In addition, 25 respondents had an official autism diagnosis, with 13 reporting a late diagnosis and 12 diagnosed during childhood. In terms of academic level, the survey included 47 master's students, 23 bachelor's students, and 1 doctoral degree student. The distribution of participants based on their neurodiversity status and academic level is illustrated in Figure 5. The geographical distribution of the survey participants varied. Most respondents were from the Netherlands with 62%, followed by Poland with 15% of the sample and Germany with 8% and 15% from other countries around the world.

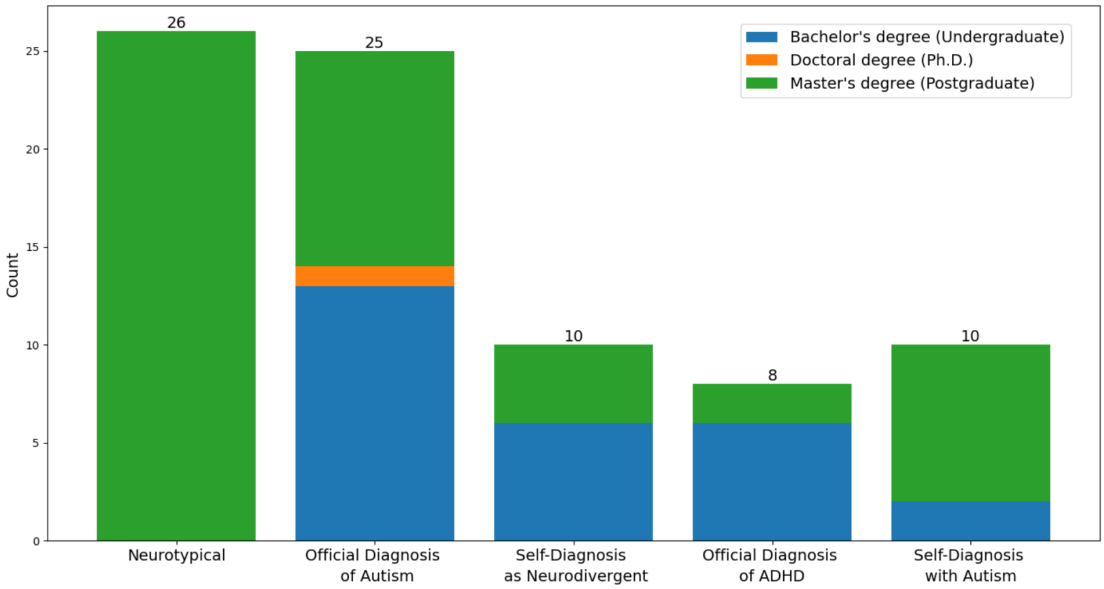

Figure 5. *Distribution of responses regarding autism diagnosis and neurodiversity with differentiation of level of education.*

5.1.1 Perceived Competency in Task Management

The section begins with an assessment of perceived competence in task management among the survey's participants. Such an investigation may support

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Table 2. *Comparative average ratings of task management skills across the official diagnosis of Autism and Neurotypical respondents. The rating scale ranges from 1 to 5, reflecting skills rated from 'not well at all' to 'extremely well'.*

	Prioritization	Breaking down tasks	Estimation of completion time	Managing deadlines	Multitasking	Unexpected changes	Work-life balance
Oficial diagnosis of ASD	2.9	3.0	2.3	3.4	2.8	2.2	2.2
NT	3.3	3.3	2.5	3.6	3.8	2.9	2.7

the hypothesis that students with ASD have more problems managing their university workload. The hypothesis was formulated as follows:

H_0 There is no significant difference in reported competency levels in task management between students with autism spectrum disorder and their neurotypical peers.

The assessment score was determined by summarising the answers to questions Q12, Q13, Q16, Q17, Q18, Q19 and Q21, which are listed in the Appendix A.2. These questions assessed various elements of task management, such as prioritising, breaking tasks into smaller components, estimating time for completion, meeting deadlines, multitasking, dealing with unexpected changes and maintaining a healthy work-life balance. Each skill was rated on a 5-point Likert scale. The detailed scores for each question can be found in Table 2. Respondents with OASD scored lower than NT students in all seven categories, with the difference being greatest in Multitasking and Dealing with unexpected changes. The smaller difference in average score was in the categories of estimating time to complete tasks and managing deadlines.

For each question, participants had five possible answers to assess their skills in different areas of task management. The cumulative score was interpreted as perceived competence in task management. Figure 6 is a boxplot visualisation illustrating the distribution and variability of perceived task management competence between participants with OASD and NT. The boxplot shows that the median score of the neurotypical group is higher and the OASD group has a wider range of scores, indicating greater variability within this group. Of note, four data points within the NT group differed significantly from the overall population. After careful examination of these responses, They were not identified as outliers, as there were no common characteristics between the individuals that could indicate a justifiable reason for their divergence

A t-test was performed to compare the means of the two groups of students with OASD and NT $p < 0.01$, revealing a significant difference between the groups, leading to the rejection of the null hypothesis. In particular, students diagnosed

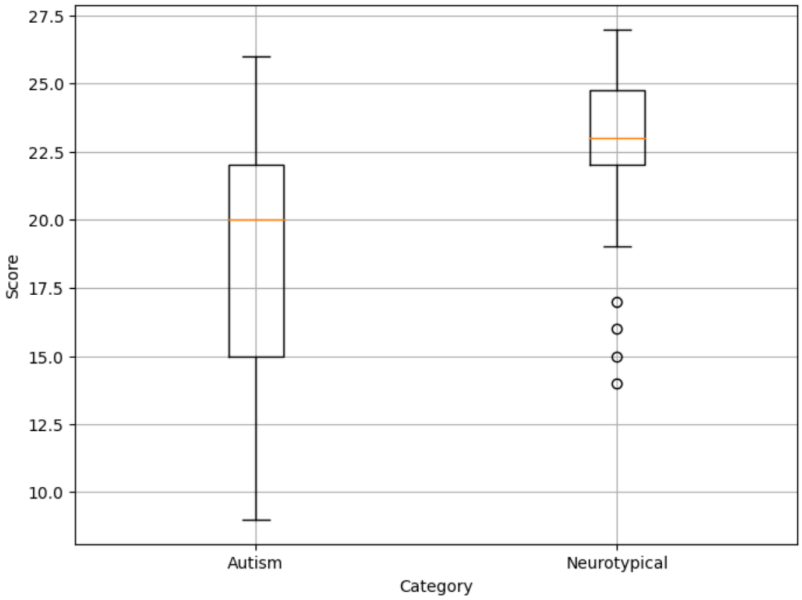


Figure 6. *A box plot comparison of task management perceived competency scores between participants with an official diagnosis of autism and neurotypical students.*

with autism (M = 18.8, SD = 4.7) tended to report a lower level of competence in task management skills compared to their NT peers (M = 22.3, SD = 3.5). In addition, the responses in the group with OASD are more widely dispersed and the standard deviation is higher than in the NT group. In the group of students with OASD, the distribution of people with different levels of education varies more than in the NT group. Therefore, the level of education could be a factor causing the significant difference between students with OASD and NT.

A t-test was performed to compare the means of the two groups of students with OASD and NT $p < 0.01$, revealing a significant difference between the groups, leading to the rejection of the null hypothesis. In particular, students diagnosed with autism (M = 18.8, SD = 4.7) tended to report a lower level of competence in task management skills compared to their NT peers (M = 22.3, SD = 3.5). In addition, the responses in the group with OASD are more widely dispersed and the standard deviation is higher than in the NT group. In the group of students with OASD, the distribution of people with different levels of education varies more than in the NT group. Therefore, the level of education could be a factor causing the significant difference between students with OASD and NT.

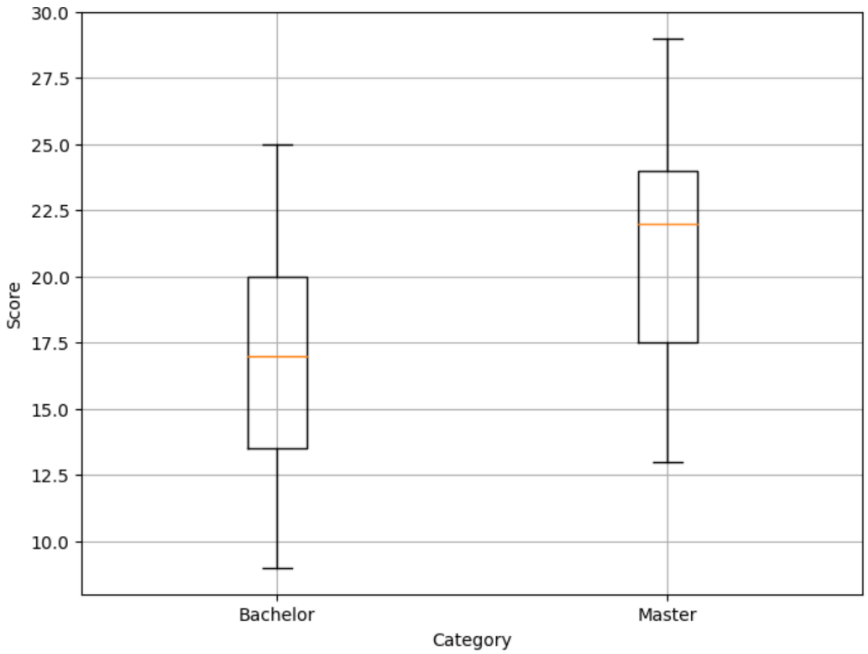


Figure 7. *A box plot comparison of task management perceived competency scores between neurodivergent participants at bachelor's and master's levels of study.*

Table 3. *Summary of calculated t-tests regarding perceived competency in task management (M - Master's students and B - Bachelor's students)*

	Condition	**Sample Size**	**Mean (SD)**	**p-value**
1	OASD NT	25 26	18.8 (4.7) 22.3 (3.5)	< 0.01
2	M B	47 24	20.9 (4.0) 16.1 (5.6)	< 0.01
3	Neurodivergent M Neurodivergent B	21 24	19.2 (4.1) 16.2 (5.7)	< 0.05

Thus, considering that 100% of NT students were at the Masters level, the intensity of the effect could be influenced by university level, but not necessarily by neurodiverse status. Since the number of participating Master's students (n=47, M = 20.9, SD = 4) is almost twice as high as that of Bachelor's students (n=24, M = 16.1, SD = 5.6), a Welch's t-test was performed with an unbalanced sample size, which revealed a significant difference between the two groups of Master's and Bachelor's students $p < 0.01$. However, after the NT participants were excluded from all responses, leaving only the responses of the officially diagnosed or self-

diagnosed participants with neurodiversity or ASD, a third t-test was calculated on the responses of the neurodivergent (self-diagnosed and officially diagnosed) Bachelor (n=24, M=16.1, SD=5.7) and Master students (n=21, M=19.2, SD=4.1). A significant difference was found with a p-value of $p < 0.05$. The results of the individual calculated t-tests are listed in Table 3. In addition, the boxplot in Figure 7 illustrates the distribution of scores for perceived competence in task management for neurodiverse participants, comparing participants with a Bachelor's degree and participants with a Master's degree. The graph shows a slightly higher median score for the Master's students and a larger interquartile range, indicating a greater spread of answers in this group. For this reason, the level of university may be an important factor contributing to the differences in the results.

5.1.2 Challenges in Task Management

The results from the next set of questions aimed to spotlight the specific challenges people with OASD face in managing tasks. It brought out the unique struggles of students with OASD, and these findings were later used to create design guidelines 4.

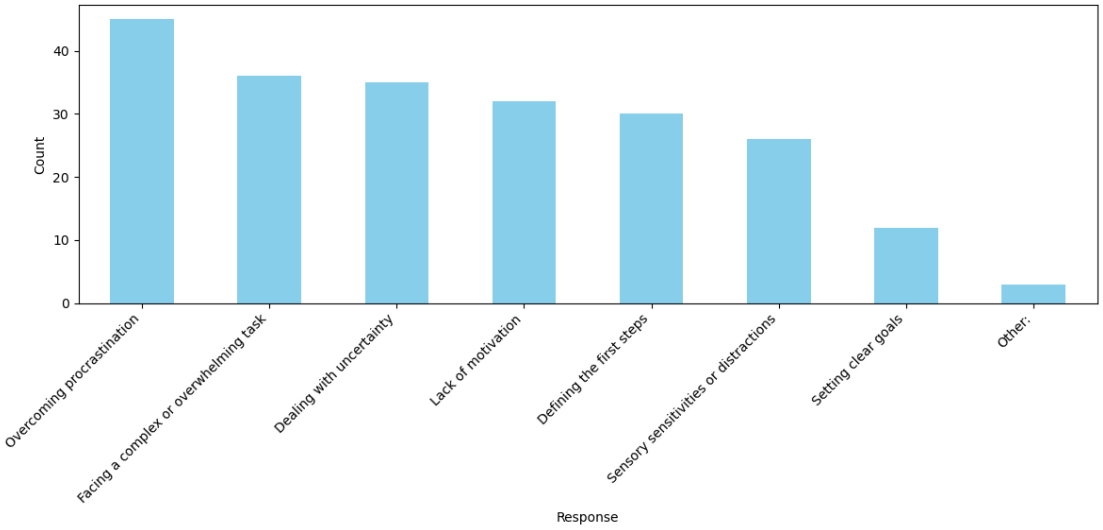


Figure 8. *Distribution of answers of all respondents. Question: When it comes to starting a task, which of the following do you find most difficult? Multiple answers allowed*

One of the questions in the survey aimed to identify the main challenges encountered when starting a task. Figure 8 illustrates the response distribution without distinguishing between neurodiverse and neurotypical respondents. The results show that procrastination is the most common challenge, selected by 43 participants, while the other five options were mentioned relatively equally often,

each with 30-40 participants. This led to a further analysis comparing the responses of NT students and those with OASD. In this case, the percentage was calculated, i.e. what percentage of each group chose each answer. As shown in Figure 9, there are notable differences in the distribution of responses between NT and OASD students. For example, 70% of OASD students indicated that dealing with uncertainty was a major challenge, compared to only 30% of NT students. In addition, more than half of OASD students chose three other options as key challenges: facing a complex task, overcoming procrastination, and defining the first step. On average, OASD students chose 3.6 out of 8 possible reasons for difficulties in completing tasks, while NT students gave an average of 2.2 reasons. This suggests that autistic students experience a wider range of obstacles when starting a task.

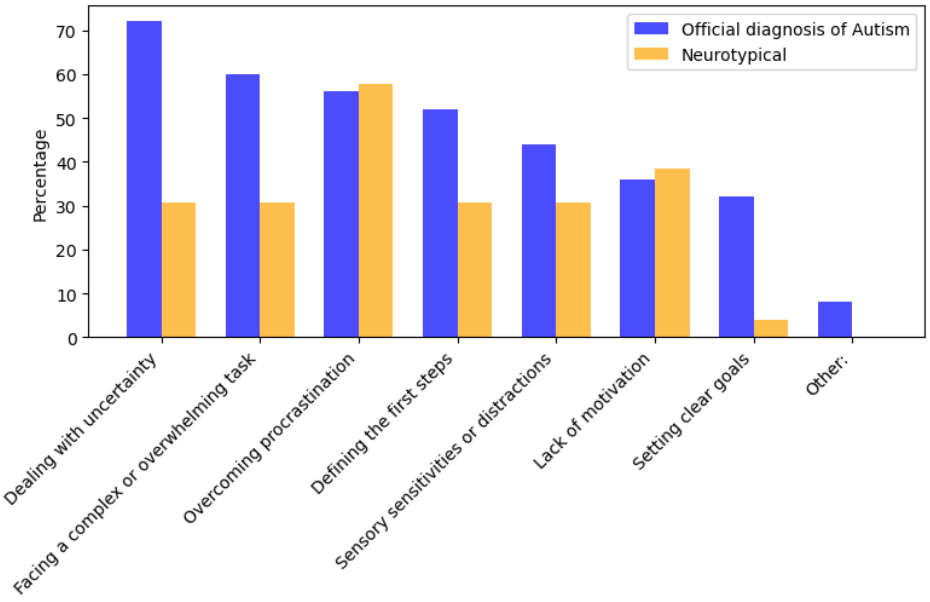


Figure 9. *Distribution of answers between students with an official diagnosis of autism and neurotypical students. Question: When it comes to starting a task, which of the following do you find most difficult? Multiple answers allowed.*

An interesting observation pertains to the distribution of responses among students with differing times of diagnosis - early versus late. On average, individuals with a late diagnosis tend to select approximately one additional option, indicating a potentially higher degree of identified challenges (see Figure 10). Furthermore, the reason more common among students with an early diagnosis of autism was overcoming procrastination - 75% compared to the second group with 38%. On the other hand, students with a late diagnosis indicated that dealing with the first step - 69% was a common reason for starting a task compared to 33% in the second

group. Another disproportion between those two groups was setting clear goals which was chosen by 54% of students with late diagnosis and only 8% of students with early diagnosis. Dealing with uncertainty was chosen with a similar frequency in both groups. The results suggest that there may be significant differences in the experience of challenges depending on the time of diagnosis.

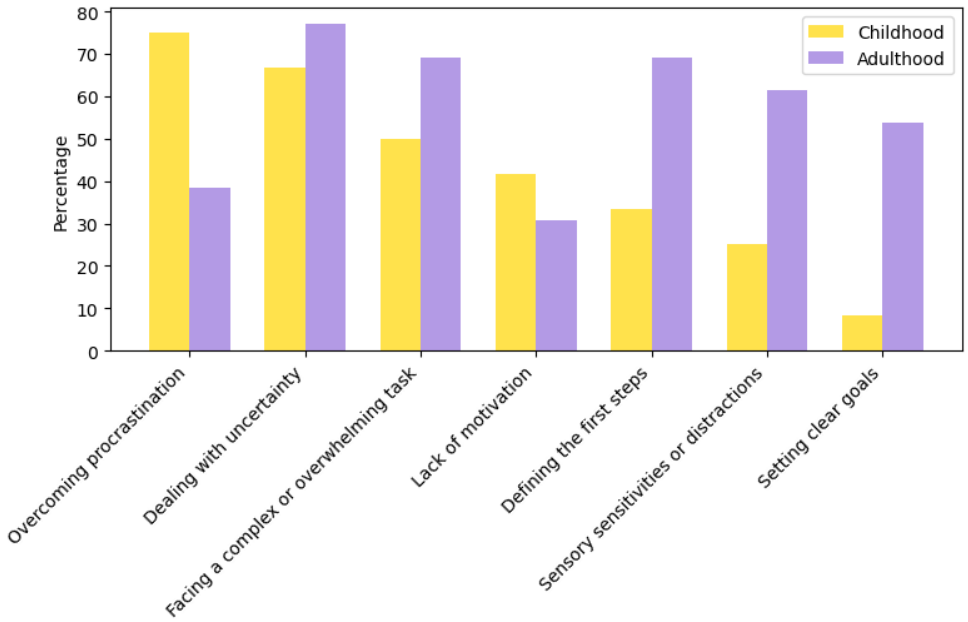


Figure 10. *Distribution of answers between students with an official diagnosis of autism in childhood and adulthood. Question: When it comes to starting a task, which of the following do you find most difficult? Multiple answers allowed.*

The survey also explored common challenges in task management. Figure 11 shows the responses, which were categorised into two groups: OASD and NT. The most common problem for both groups was estimating the time needed to complete a task, with 64% of OASD and 54% of NT respondents citing this as a difficulty. There was a significant difference in breaking tasks into smaller steps, with 40% of OASD respondents finding this challenging, but only 12% of NT respondents. Consistent with previous findings, OASD students on average chose more challenges (2 out of 5 options) than their NT counterparts (1.5 out of 5). This data emphasises the particular challenges that students with OASD face when completing tasks, but also shows similar patterns in both groups.

The survey also questioned participants about which academic tasks they found most challenging to manage and execute, the distribution is shown in Figure 12. Interestingly, everyday tasks such as laundry and grocery shopping were cited by 44% of individuals with Autism, compared to just 23% of NT individuals.

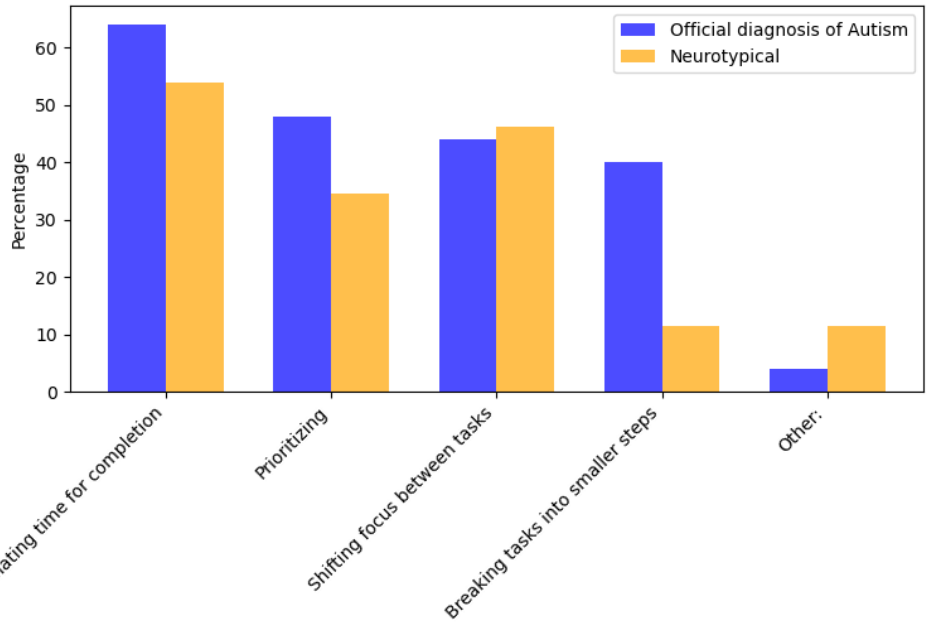


Figure 11. *Distribution of answers between students with an official diagnosis of Autism in childhood and adulthood. Question: Which of the following difficulties or challenges do you encounter when it comes to managing tasks? Multiple answers allowed.*

However, a significant finding was the shared difficulty both groups faced with academic and long-term tasks. Over 50% of respondents from each group marked these as the most challenging to handle. This similarity highlights a common area of struggle across both autistic and NT populations in managing complex or prolonged academic tasks.

Students with an OASD face a wider range of challenges in task management compared to their NT peers, especially in initiating tasks and dealing with uncertainty, as shown in the survey results in Figures 9 and 11. In addition, time management and breaking tasks into smaller steps are significant difficulties for OASD students, more so than NT students. Academic and long-term tasks were identified as universally challenging 12. Defining the challenges of students with autism can help identify issues that should be addressed by the system to meet the specific needs of the target group.

5.1.3 Task Management Strategies

The next section of the results looks at the strategies and techniques students use to deal with situations that disrupt their schedule and present challenges. The aim was to gain a deeper understanding of the different approaches and methods students use to manage tasks in different circumstances.

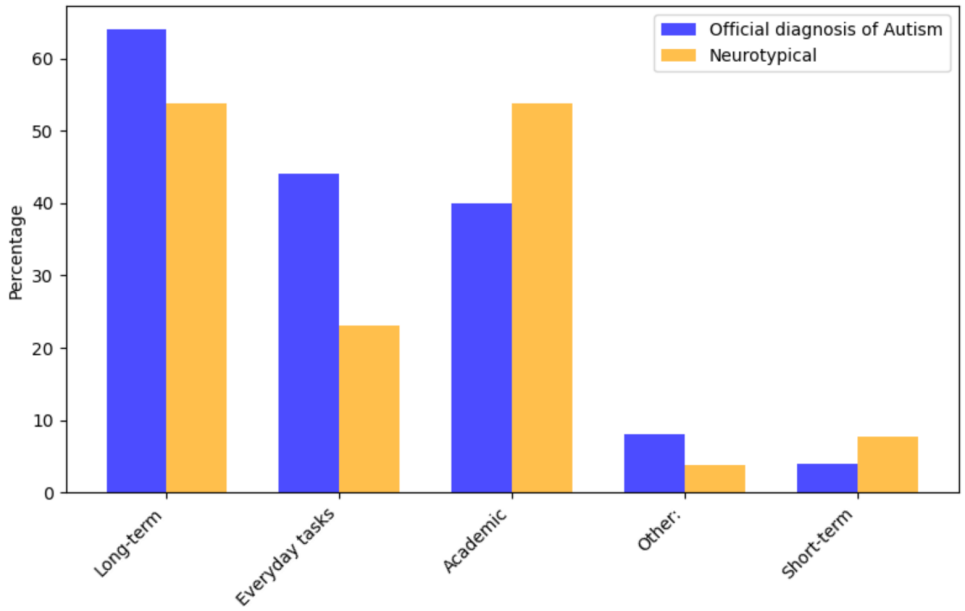


Figure 12. *Distribution of answers between students with an official diagnosis of autism and neurotypical students. Question: When it comes to performing tasks, which types of tasks do you find the most challenging to execute? Multiple answers allowed.*

When asked how well participants were able to deal with disruptions and unexpected changes in their schedules, participants with OASD generally rated their skills lower than their NT counterparts, as shown in Table 2. The survey also explored the most common strategies used by students in such a situation, as shown in Figure 13. Notably, 24% of OASD participants reported not handling disruptions well, a choice not made by any of the NT participants. The predominant strategy among NT participants, chosen by half of them, was to assess the urgency and importance of the new task before making adjustments. In contrast, only 37% of the OASD group chose this strategy. Overall, NT participants tended to choose a greater number of strategies, particularly those requiring immediate, independent action, than their OASD counterparts.

In terms of strategies for procrastination and deadline management, students with OASD chose on average fewer options (2.6 out of 7) than their NT peers (3 out of 7), as shown in Figure 14. For NT students, the most popular method for combating procrastination and meeting deadlines was creating a to-do list or schedule, chosen by 86%. The second most popular strategy was setting specific deadlines or milestones for each task, chosen by 66%. In contrast, the OASD group showed no preference for a single strategy; instead, three options were chosen with similar frequency: creating a task list or schedule (57%), breaking tasks into smaller, manageable steps (53%) and creating a study environment (53%). This

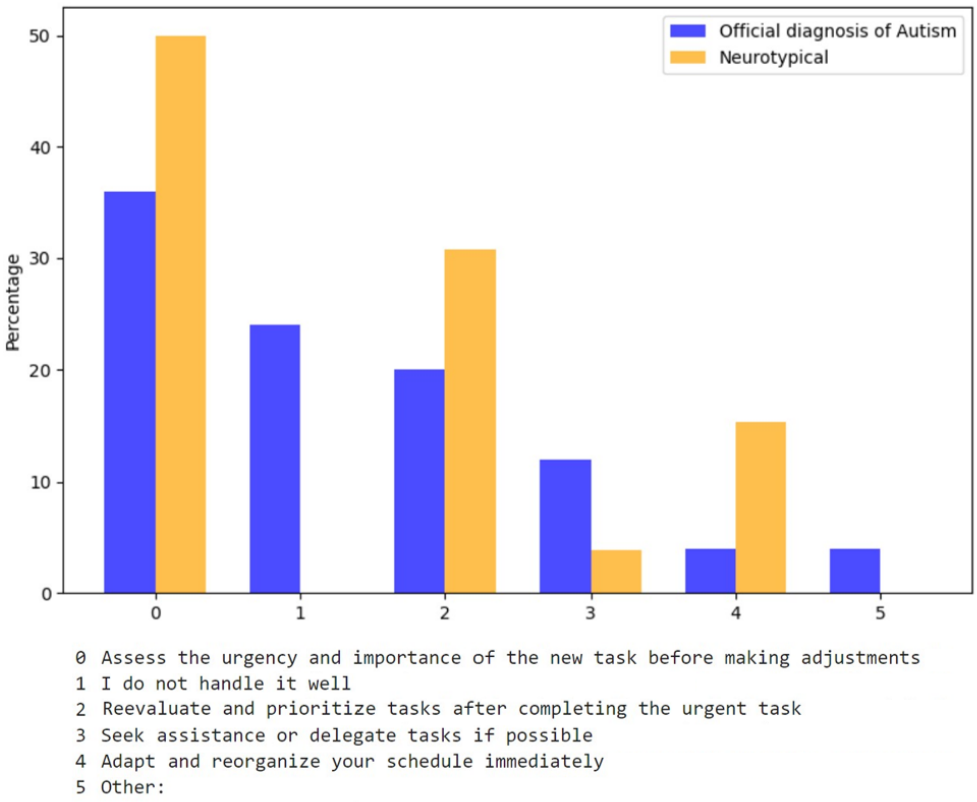


Figure 13. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: How do you handle situations when unexpected or urgent tasks arise and disrupt your planned schedule or task priorities?*

difference in approach in the OASD group emphasises the need for individual and varied strategies in dealing with procrastination and deadline management, while in the NT group, two strategies appear to work effectively.

The survey included a question on the preferred methods for task management (Figure 15). Interestingly, 44% of participants with OASD stated that they use a mix of digital and physical tools for task management, a method that is less common among their NT counterparts, with only 19% using this approach. In addition, 32% of respondents stated that they do not use external tools for tracking academic tasks and instead rely on their memory; this method was chosen by 19% of NT participants. In contrast, the predominant choice of NT students was the exclusive use of digital aids at 46%, compared to only 16% in the OASD group (Figure 16). These data show that task management preferences diverge between students with OASD and their NT peers. It also shows that OASD participants

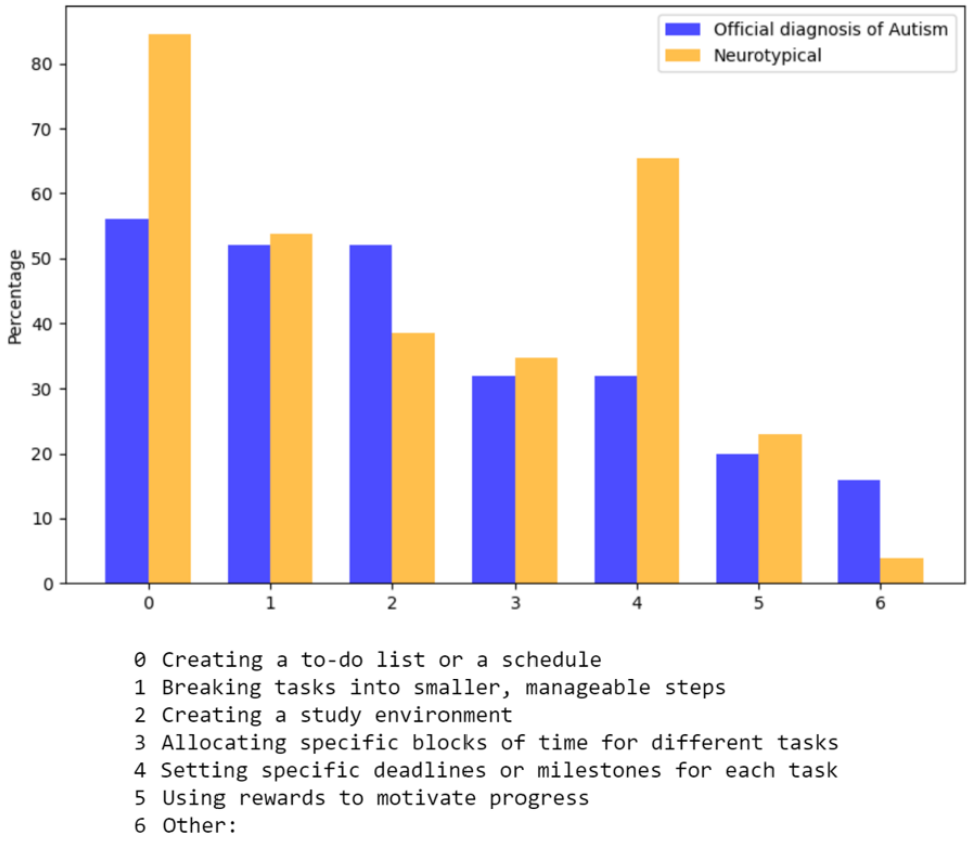


Figure 14. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: Which strategies do you find the most effective for overcoming procrastination and managing deadlines? Multiple answers allowed.*

rely more heavily on mental planning and digital tools alone are less popular.

Thirteen participants with OASD and nine NT participants answered a question about the physical methods they use. Figure 16 shows the distribution of their preferences for physical organisation methods for academic tasks. The top two methods were pen and paper to-do lists, favoured by 69% of OASD and 77% of NT participants, and planners or notebooks, chosen by 69% of OASD and 44% of NT participants. A significant difference was found in the use of physical calendars: 53% of OASD participants used them compared to only 11% of NT participants. It is worth noting that the physical calendar was not very popular in all other groups of participants in relation to their neurodiverse status, with no more than 10% of each group used it. Sticky notes were favoured by 67% of NT participants, but only by 15% of those with OASD. These results show clear differences in the preference

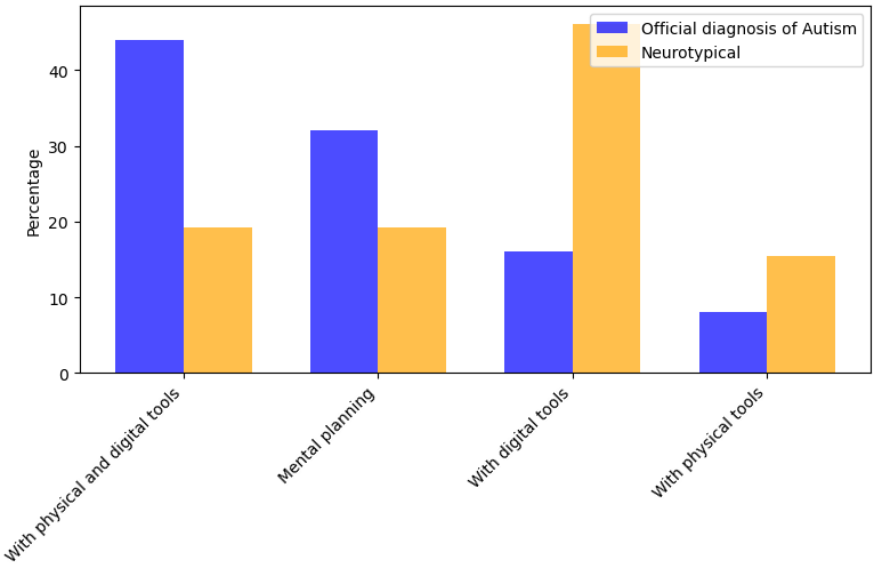


Figure 15. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: How do you typically organise and track your academic tasks?*

for sticky notes and physical calendars between NT and OASD individuals.

In short, OASD participants often rated their ability to deal with disruption and procrastination lower and showed different preferences in organisational tools. Exploring strategies and ways to manage tasks can provide an important indication of what form and type of functionalities in the system would be beneficial for the target group of students with OASD.

5.1.4 Use of Dedicated Digital Tools

The results of this group of questions aim to find out what kind of digital tools students use. The reasons for not using external tools and the shortcomings of existing apps were also investigated. Dedicated digital tools are defined as applications and extensions of software products (Google Tasks, Microsoft To-Do) that are available on the market and have been developed specifically for task management.

The first assessment in this section related to the question of whether respondents had ever used a specific digital tool to manage their tasks. 46% of respondents stated that they have never used a digital tool to manage their tasks (N = 33), while 35% stated that they have used such tools in the past but no longer do so (N = 24). Finally, 21% stated that they regularly use an external tool to manage their tasks (N = 15, including 5 respondents with OASD). When asked about the use of specific tools for task management, 16 participants answered

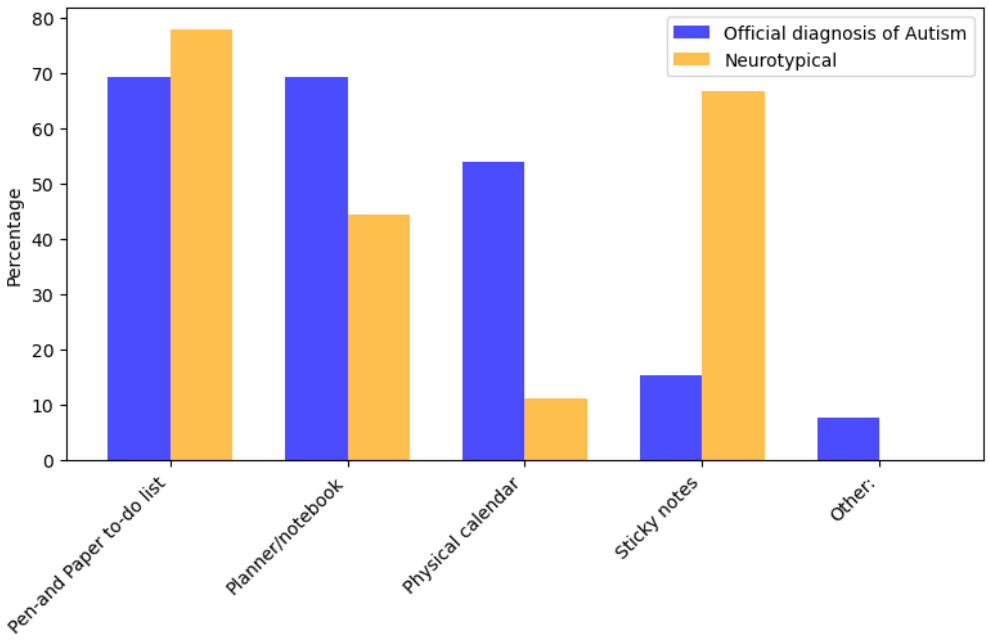


Figure 16. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: What kind of physical methods do you use? Multiple answers allowed.*

OASD and 15 NT (see Figure 18. Interestingly, the majority of participants with OASD did not opt for any of the specific digital tools that were offered to them as an option. Instead, 64% opted for an alternative digital tool. Some of the alternative tools mentioned were Apple Reminders and various types of digital calendars. In addition, three participants with OASD specifically mentioned using the app 'Finch', a habit creation app with supporting animal characters.

Another question aimed to understand the reasons for the non-use or very rare use of dedicated digital tools for task management. The distribution of responses can be seen in Figure 19. A total of 20 responses were collected from people with an OASD, and 19 responses were from NT people. The main reasons given by people with an OASD were being overwhelmed with the tools and feeling unsure of where to start (50%). In contrast, only one NT participant chose this option. The second most common reason was the lack of satisfactory tools (40% OASD). The *other* option was chosen by 30% of participants with an OASD. Many responses indicated that users were reluctant to use external aids for fear of having another application on their phone that could become an additional source of distraction. Physical methods seemed to be more effective for them. The reasons given by the majority of OASD users were related to not finding the right app as the options available were too overwhelming. On the other hand, NT respondents simply do not see the benefits of using dedicated task management tools and still manage to

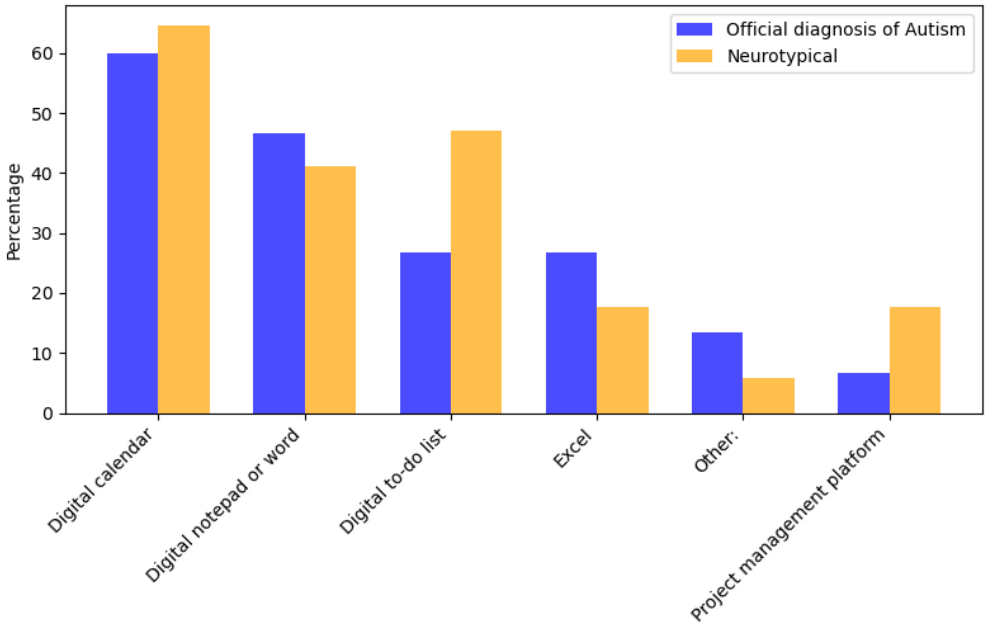


Figure 17. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: What kind of digital methods do you use? Multiple answers allowed.*

be productive.

Following the questions on the use of dedicated digital tools, around 35% of respondents stated that they had previously used digital tools but no longer use them. Respondents were also asked about their reasons for giving up digital tools, as shown in Figure 20. A striking 75% of respondents with an OASD chose the option that using these tools requires too much effort. In addition, 44% of respondents chose the option 'Other' and manually indicated the reasons why they no longer use the tool. Among the 6 responses, some stated that they had forgotten about the tool, which falls under the 'decreasing engagement' category. Another answer, distraction by external tools, coincides with the answers to an earlier question in the survey.

No clear reasons were given for questions about specific functions or aspects of the task management tools that were unsatisfactory or did not meet users' needs. The initial analysis aimed to break down the responses to this question by comparing them with the responses to the question about the digital tools used; the sample size is too small to derive conclusive results or directions for further research. However, based on the responses of 14 people with OASD and 15 NT individuals, some differences were found in aspects of task management that were perceived as unsatisfactory (see Figure 21). The distribution of responses is fairly equal between the options. However, compared to their OASD counterparts, NTs

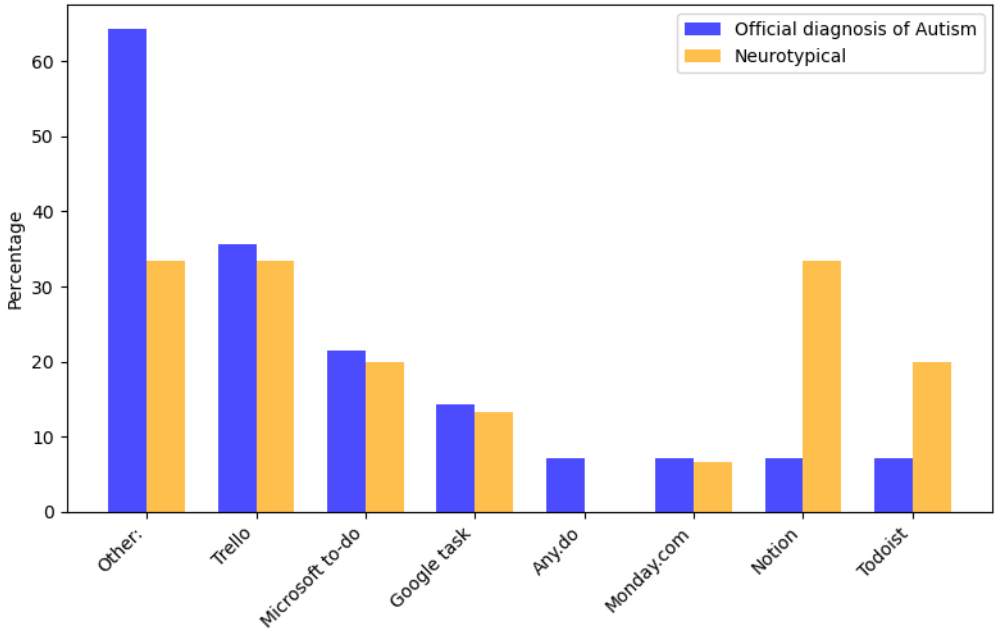


Figure 18. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: Which dedicated digital tools for task management do/did you use? Multiple answers allowed.*

tended to find other aspects disturbing. For OASD, splitting complex tasks into subtasks and task organisation were chosen by 35% of respondents. However, all other answers were chosen by more than 20% of participants, except for the lack of integration with other apps, which was only chosen by 6%. In contrast, looking at the distribution of responses for the NT group, limited adaptability to changing needs was mentioned by 34%, and the same number of people chose the option that none of the above features were unsatisfactory.

The results of this section show trends in the use of digital tools for task management among students. Participants, those with OASD used certain digital tools infrequently or avoided them because they felt overwhelmed or dissatisfied with the tools. Several respondents discontinued the use of digital tools due to the high effort involved or declining interest, favouring physical tools instead.

5.1.5 System Requirments

The requirements were formulated that address the noticeable differences in responses and to ensure that the tools developed for students with OASD are targeted to their specific needs for effective task management. The requirements are needed to ensure that the prototype created meets the needs of the intended

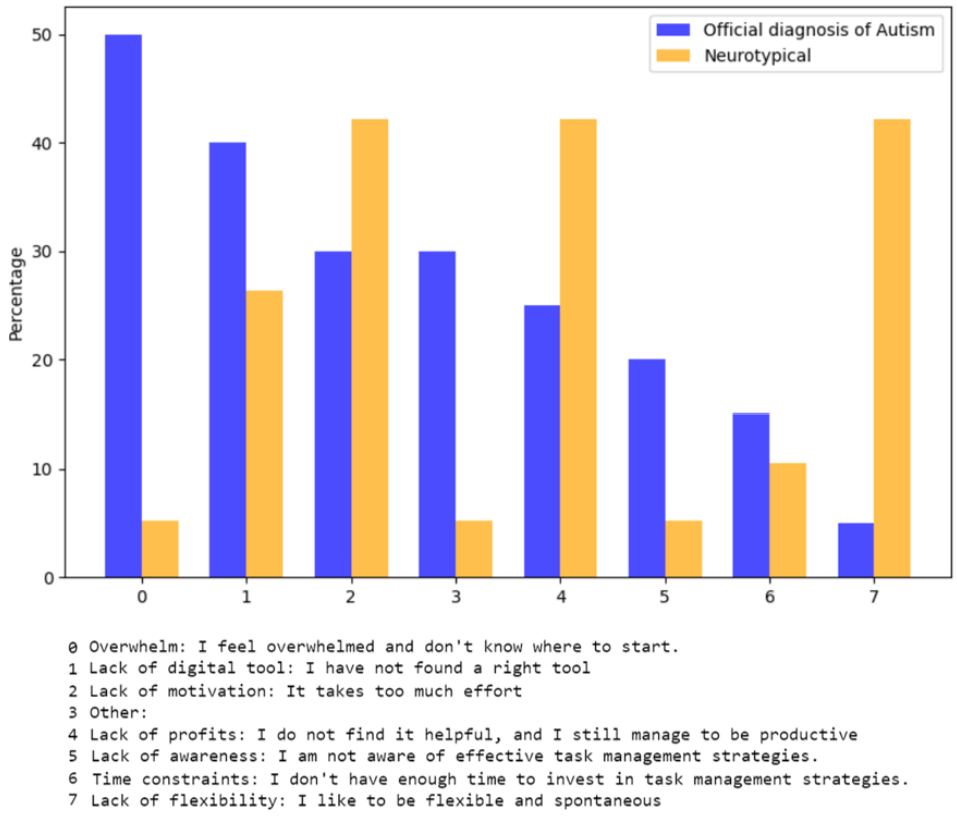


Figure 19. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: Why don't you use (or rarely) a digital tool for task management? Multiple answers allowed.*

audience. The list of defined system requirements can be found in Table 4 with the design notes and the reasons for selecting the requirement.

To minimise uncertainty, which was a major challenge for OASD students at the beginning of the tasks, the system should be designed to help set clear and concrete goals. This requirement was in response to the majority of OASD students citing uncertainty as a major obstacle, a sentiment less expressed by their NT peers (see Figure 9). Coping with cognitive load and overload was also of paramount importance. The system needs to meet the requirements of simplicity and ease of use to accommodate the higher cognitive load that OASD students report when interacting with digital tools (see Figure 19). Since OASD students prefer physical tools, the system should include elements of physical calendars and planners (see Figures 15) and 16. Considering the different strategies that OASD students use to combat procrastination, the system should include features that encourage the

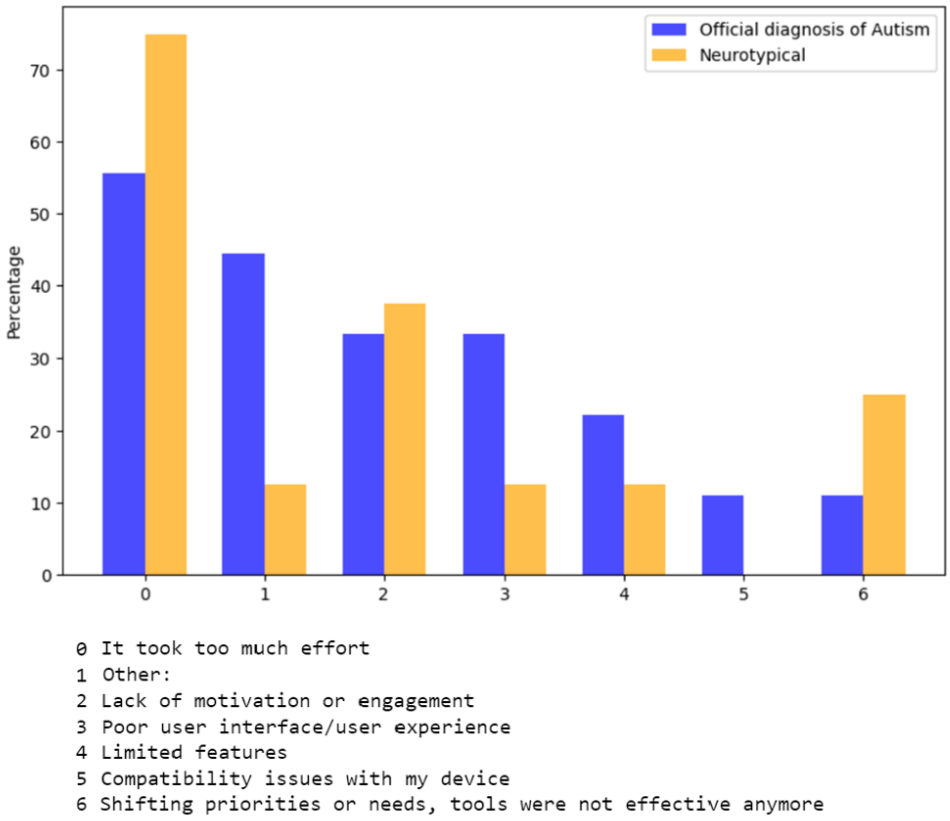


Figure 20. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: What was the reason that you decided to stop using a digital task management tool? Multiple answers allowed.*

immediate start of tasks and maintain focus, as opposed to the standard to-do lists favoured by NT students. The tool should aim to minimise distractions - a concern for users who are wary of adding another digital app to their repertoire. It should promote concentration and not contribute to a stunted attention span. Finally, making it easier to manage long-term tasks was a key requirement, as this was cited as the biggest challenge by all respondents. The system provides strategies for managing large projects effectively and addresses less commonly cited issues with this commonly recognised difficulty.

The list of system requirements will be used in the next steps as a basis for discussion in the focus groups in order to facilitate and catalyse discussion between the participants. The list of requirements derived from the survey results is not exhaustive. Nevertheless, it has been concluded that these selected items are the most relevant and can be derived from the data with greater

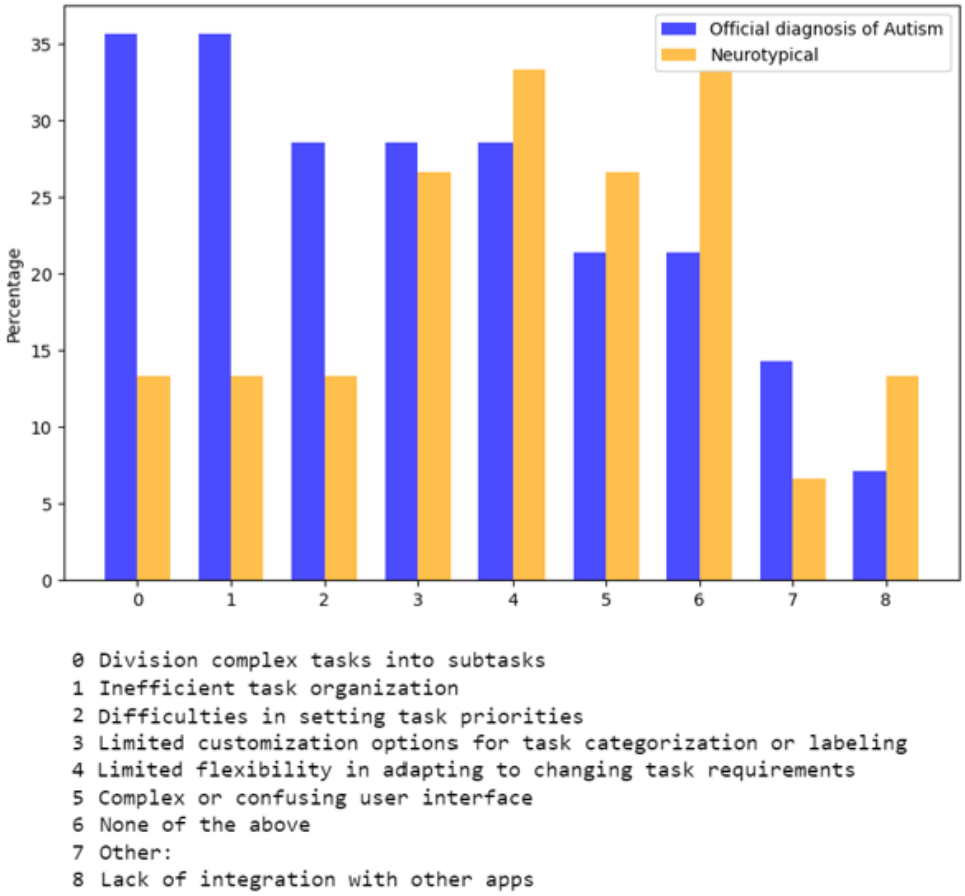


Figure 21. *Distribution of answers between students with an official diagnosis of Autism and neurotypical. Question: What specific features or aspects of the task management tools you used did not meet your needs? Multiple answers allowed.*

confidence, as the differences in the distribution of responses between OASD and NT are significant. Additional findings require further investigation to ensure a comprehensive understanding and applicability.

Table 4. *System requirements based on the results of the survey*

Requirment	Reasons	Design directions	Reference to survey results
Minimizing Uncertainty	Dealing with uncertainty was chosen by the majority of students with OASD as the most difficult part of starting a task.	Assist in defining clear, concrete goals to reduce ambiguity.	Figure 9
Managing Cognitive Load and Overwhelm	Digital tools are often overwhelming for students with autism. They often do not know where to start and lack awareness of strategies they could use.	Design tool in the way the flow of the application is straightforward and the interaction are understood.	Figure 19
Familiarisation with the tools preferred by students with autism	A Higher percentage of respondents with autism tend to use physical tools over digital. Physical calendars and planners/notebook tend to be more popular as a planning tool among students on the autism spectrum than their neurotypical peers.	Understand the attractive features of physical calendars and planners/notebooks and apply them to design,	Figure 15 and 16
Overcoming procrastination	To-do list was chosen as a way to overcome procrastination by the majority of neurotypical students. However, students on the autism spectrum disorder have more diverse ways of dealing with procrastination.	Explore the possibility of using digital tools to combat procrastination. Understanding reasons for procrastination and proposing the right solutions.	Figure 9 and 14
Minimizing distraction	People are sceptical when it comes to using yet another digital tool installed on their phone. They are fed up with the applications that are available on the market.	A tool that does not distract the user, but helps users to concentrate on the right task.	Figure 19
Facilitating long-term task management	The management of long-term tasks were chosen as the greatest challenge.	Provide strategies for managing long-term projects effectively.	Figure 12

5.2 Focus Group 1 - Analyzing Requirements

The initial four requirements were extensively discussed during the focus group sessions with Human-Computer Interaction students. The aim was to explore potential design solutions and opportunities for digitization. The collected data was analyzed using grounded theory. Initially, the data from interviews were coded, and various design solutions related to the system requirements were differentiated. Subsequently, links between these design solutions were identified to form main categories.

The primary topic of discussion with participants centered on the development of a task management tool designed to minimize uncertainty and provide clear, well-defined goals, thus reducing ambiguities in the process. A consensus among participants highlighted the significance of categorizing tasks, a feature that could also be integrated as a recommendation system. Over time, the system could learn based on the user interactions how to assign appropriate labels and categories. Additionally, it was noted that the task creation process should be structured to promote productive habits, ensuring users have a clear understanding of their task objectives. In terms of the app's design, the participants stressed the importance of focusing on one task at a time.

Based on the discussion, three main categories emerged concerning the characteristics of the system's workflow:

1. **Task Clarity and Structure**: a clear and well-structured approach to tasks within the system. Easily comprehensible task descriptions and organized task lists aim to minimize uncertainty. Moreover, it would potentially improve the user experience and facilitate task prioritization.

2. **Personalized Recommendations**: The system should be able to learn and adapt to individual preferences and habits. Personalized task recommendations based on previous interactions were viewed as a valuable feature. That could ensure a positive attitude and long-term engagement with the app.

3. **Minimization of Cognitive Load**: The system should be designed in a way that minimizes cognitive load by focusing on one task at a time and providing intuitive navigation. Possibly streamlining the interface and simplifying interactions would help in keeping users engaged and in a state of flow.

To ensure that the app fulfils all requirements, an investigation into the most accurate design for students with autism is required. Investigate how the core functions such as the process of task creation, task visualisation or adaptations of the task management system are designed to meet the requirements of users on the autistic spectrum. As a result, three aspects were identified that need to be considered when designing the task management system.

1. Guiding the user through task and project creation
2. Displaying ongoing tasks effectively
3. Exploring potential adaptation of the system

5.3 Focus Group 2 - Adaptation and Long-term Planning

The next focus group built on the results of the previous focus group to gain deeper insights into the design of task management support. The aim was to explore possible adaptations and work out the requirements for a system for long-term planning.

During the focus group, different characteristics of users were discussed. The results and categorization of the most important features are presented in Figure (23). The classification was extended with additional factors that take into consideration the unique challenges of students with autism With a comparison with contextual factors from Figure (3). The aforementioned graph consist of the contextual factors that were mentioned as valuable to consider by most of the participants. Considering the nature of the study, participants focused mostly on features related to mental health, such as additional struggles. They emphasized the importance of tracking users' external factors that influence their motivation or ability to work on assignments. It was also mentioned that users should be asked about their biggest struggles when it comes to task management to tailor the system to address those issues. Last but not least, the user should specify the goals of using the app, as it may ensure higher engagement if they are reminded why they decided to use the app in the first place.

When considering task features that should be taken into consideration while building an app, a lot of attention was drawn to interest and motivation levels, which participants emphasized are crucial when dealing with procrastination and various other struggles. Different triggers of low motivation levels were distinguished. Motivation can be influenced by familiarity and importance, which can stem from personal or external reasons. The most valuable task features discussed during a focus group are shown in the graph with contextul factors on the right side 3

The last part discussed the adaptation of a system based on users' and tasks' characteristics. Two categories of adaptation were distinguished: user-level adaptation which adjusts features describing the user, and task-level adaptation, where the adaptation is dependent on task characteristics (see Figure 22). The adaptation displayed in Figure 22 was chosen based on the discussion with participants. First and foremost, participants drew attention to including the internal state of the user to track motivations. To positively influence the user's motivation, methods involving positive reinforcement could be applied. Additionally,

ensuring that the user can track progress and see achievements on an ongoing basis would be useful. Incorporating functions for intermediate check-ups to match a person's predefined goals and expectations with the actual work done was also highlighted as a potential solution. The participants emphasized the importance of having an adjustable user interface (UI), ensuring that the interface adapts to the specific user's needs. This includes aspects like the colors of the interface and the way tasks are displayed. Moreover, all the participants agreed that having the option to filter or browse through tasks by category or project would significantly improve control over one's tasks and provide a better overview of all the tasks. Another important feature was to balance the types of tasks within a day or a week. For example, achieving a balance of tasks based on their size or type to avoid having similar tasks grouped, such as having writing assignments for the entire week. This approach would ensure a variety of tasks to keep users motivated and engaged.

Having an overview of possible adaptations and features that the system might adapt, users were asked to think of an ideal system for planning long-term tasks, more specifically a tool for the semester schedule. Based on the insights gathered from the discussion on long-term planning, a comprehensive and effective long-term planning system should have several key features. First and foremost, it should facilitate the process of breaking down complex tasks into manageable components, accompanied by a clear timeline that allows individuals to visualize the beginning and end of each task. It's important to avoid overwhelming the user with too many tasks at once, promoting a sense of control and predictability in their schedules. Real-time progress tracking is crucial, enabling users to gauge their speed in completing tasks, and the system can adjust accordingly. The system should ensure that users always have a clear overview of their daily agenda, including goals, expectations, and potential consequences, providing a motivating framework. Integrating a Gantt chart or a similar visual representation offers an insightful overview of all tasks and assists in effective planning and organization. Additionally, intermediate check-ins and the ability to revise plans iteratively contribute to flexibility and adaptability. An important aspect is the ability to account for unexpected events such as illness or vacation and automatically reorganize the plan accordingly. The system should strike a balance between structure and flexibility and provide options based on the user's emotional state to optimize productivity and overall well-being. These considerations should guide the development of a user-centred long-term scheduling system that takes into account people's different needs and preferences in effectively managing their tasks and goals.

To summarise, the study examined the characteristics of the users and in particular, highlighted the mental health characteristics that are crucial for effective

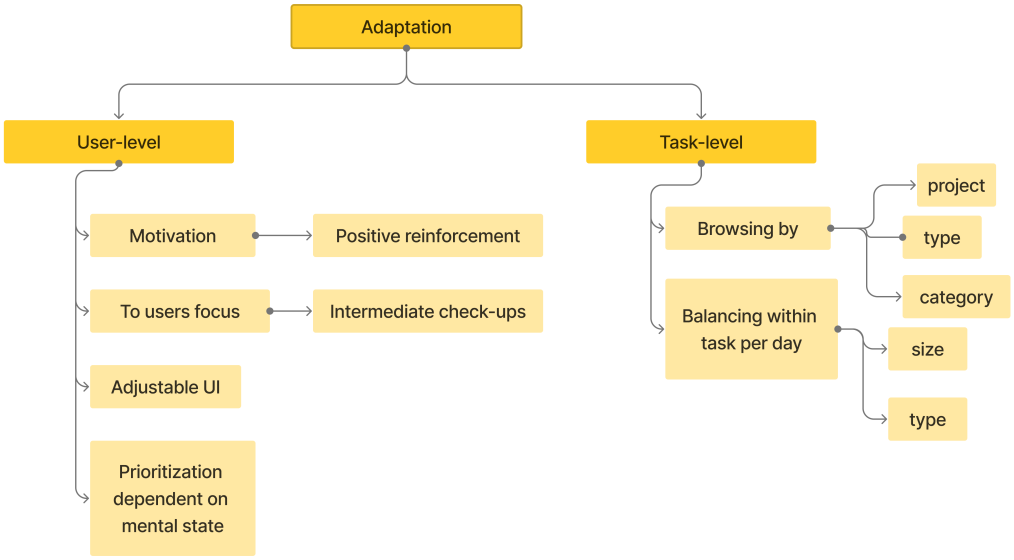


Figure 22. *Proposed Adaptation of the task management system, divided into user and task level, discussed in the focus group.*

task management. In addition, adjustments were proposed at both the user and task levels within the system, focussing on users' internal state, positive reinforcement and flexibility. Furthermore, the essential features of a long-term planning system were described, focussing on task breakdown, real-time progress tracking and adaptability to unexpected events. The results will be used to determine the design of the system to support term planning for students with ASD.

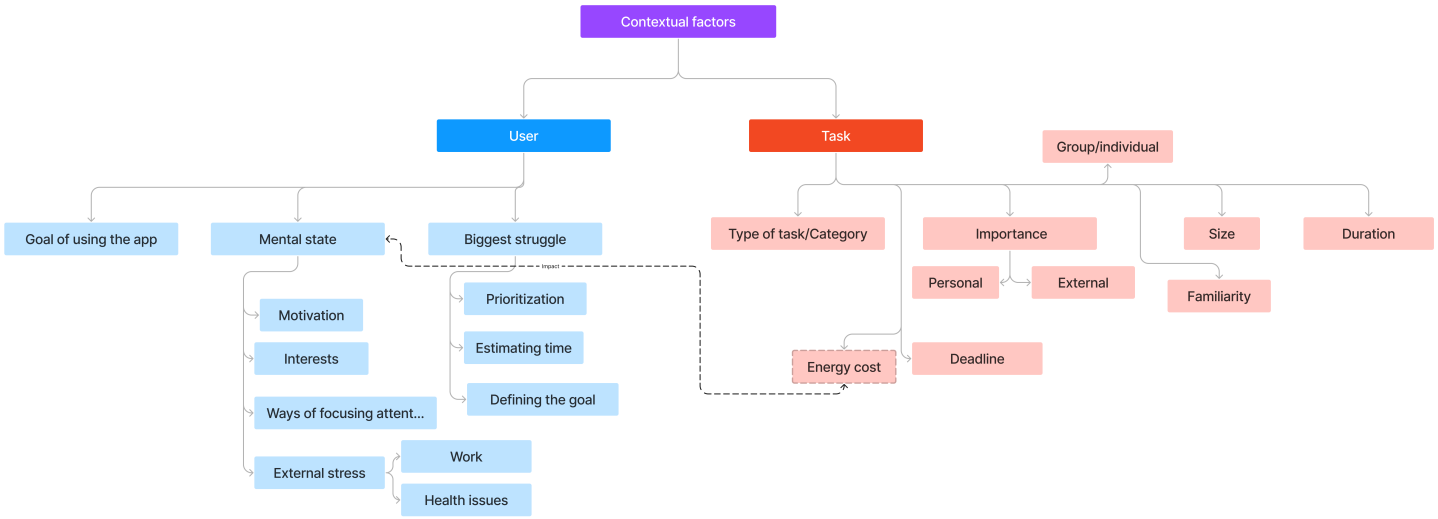


Figure 23. *Contextual factors of the task management system that were differentiated based on the results of the focus group.*

6 Prototype Design

In the following section, the design decisions are presented, together with a detailed description and justification of the solutions incorporated. The prototype was designed and developed based on all the data from the literature review and the studies conducted. First, the results of the survey were analysed to create a theoretical framework for the problem by defining the system requirements 4. Subsequently, this theory was translated into a design solution in focus groups by focussing on the possible functionalities of the application considering the requirements.

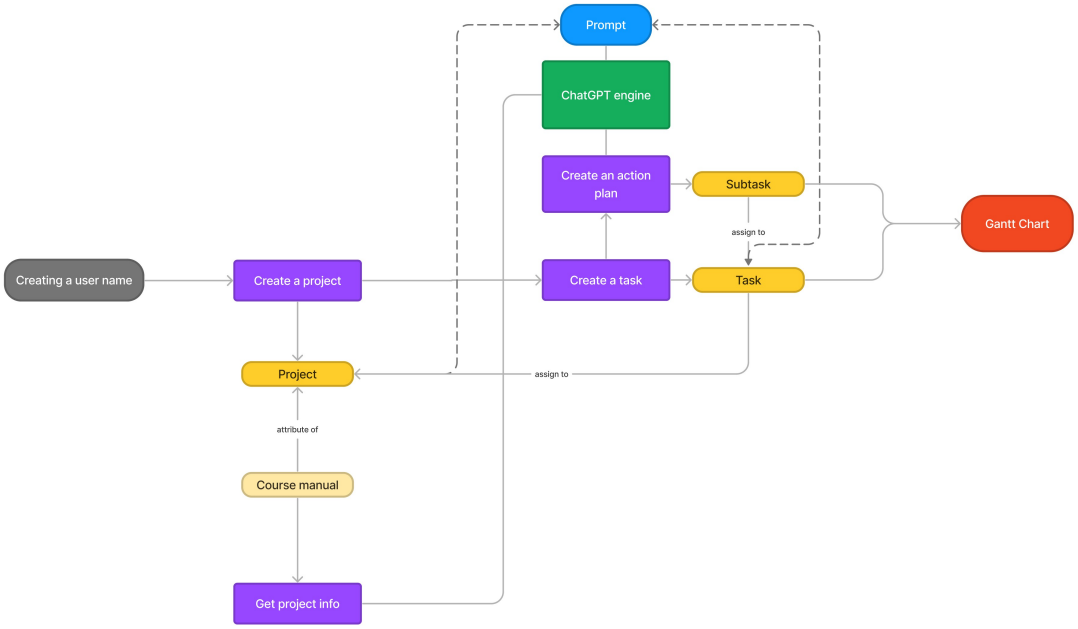


Figure 24. *Workflow diagram of the task management system for academic semester planning.*

Based on the findings across all participant groups, it became evident that the most challenging academic tasks are those that are long-term in nature 12. These tasks are inherently complex and require thorough planning to keep track of the necessary actions and corresponding timelines. Additionally, effective management of these long-term tasks is crucial to reduce the likelihood of procrastination and last-minute completion, which often leads to reduced task quality, high stress levels and lower satisfaction. In response to these challenges, the focus of the prototype was placed on the management of long-term tasks, with an emphasis on semester planning in the university context. During the second focus group, the participants

discussed the requirements for such a system, which served to outline the main objectives of the system. The first was to create a system that would provide a comprehensive overview of tasks due in the coming months, thereby mitigating the difficulties of managing long-term academic commitments and promoting proactive, organised task handling. The identified functionality that is critical to effective task management and lacking in existing tools, was the automation of breaking tasks into smaller components, as indicated by the results of the survey 11 and previous research [38, 53]. Considering the challenges highlighted in the corresponding section on the task management process, in particular, task initiation [11, 53], and taking into account the survey results on task initiation 9, it was concluded that automating the creation of subtasks could reduce uncertainty and facilitate task initiation.

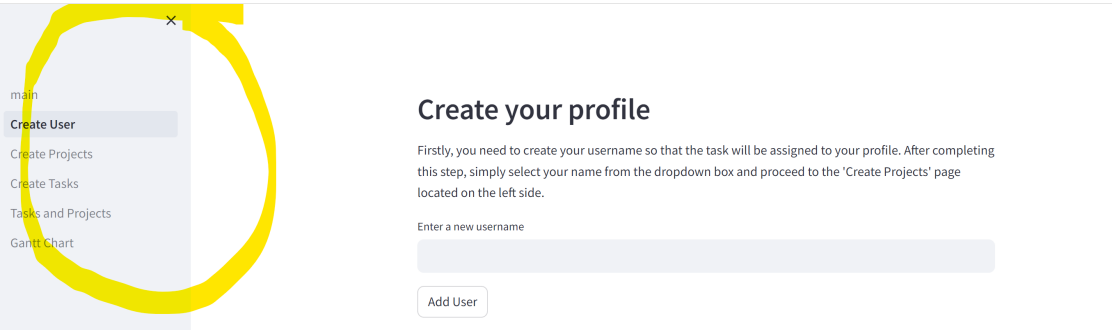


Figure 25. *Page navigation in the prototype*

The general flow of the prototype with its functions and objects is shown in Figure 24. The prototype was developed using the open-source Python library for web development Streamlit [61], which enables rapid deployment of data-based applications. Due to this choice, certain design decisions were constrained by the limitations of the Streamlit framework, e.g. the navigation bar on the left side (Figure 25), or the general user interface of the prototype with its colours and the shape of the buttons or various elements of the interface. To generate the most precise subtasks that meet user requirements, the generative language model ChatGPT- 3.5 was used. The integration of ChatGPT facilitates the rapid development of applications, especially in the generation of subtasks, the creation of precise and contextual titles and descriptions, and the personalisation of content through integration with course manuals. The scalability and flexibility of ChatGPT make it possible to process a wide range of tasks from different subject areas and to create precise subtasks. To create the subtasks and extract information from the course manuals, prompts have been defined for accurate output. The specific prompt used can be found in the Appendix B. In addition, LangChain[39], a framework for creating applications based on language models, was used. This

framework enables the upload of different document types and answers queries based on the documents provided. This approach enables the inclusion of the course manual and ensures more targeted subtasks based on the actual requirements of the course. Before creating projects and tasks, students must provide their username so that projects and tasks are assigned to the correct user. The instructions and page interface can be found in the Appendix F.2. The current system is a prototype that is still at an early stage and has some limitations in terms of usability. Therefore, there are written instructions at the beginning of the prototype and on each page for ease of use and smooth interaction during the evaluation of the system.

The system consists of six pages, the sequence and content of which are outlined in Figure 26. The first page, entitled *Menu*, presents the aim of the prototype and contains information about the evaluation study carried out. This is followed by the *Create user* page. The next two pages are *Create project* and *Create task*. The last pages provide an overview of the tasks and projects. The first page is called *Tasks and Projects* and the last one is the *Gantt chart*, which provides a graphical representation of the tasks in the form of a Gantt chart. Each of these pages is discussed in the following sections, describing their content in detail and providing the necessary justifications.

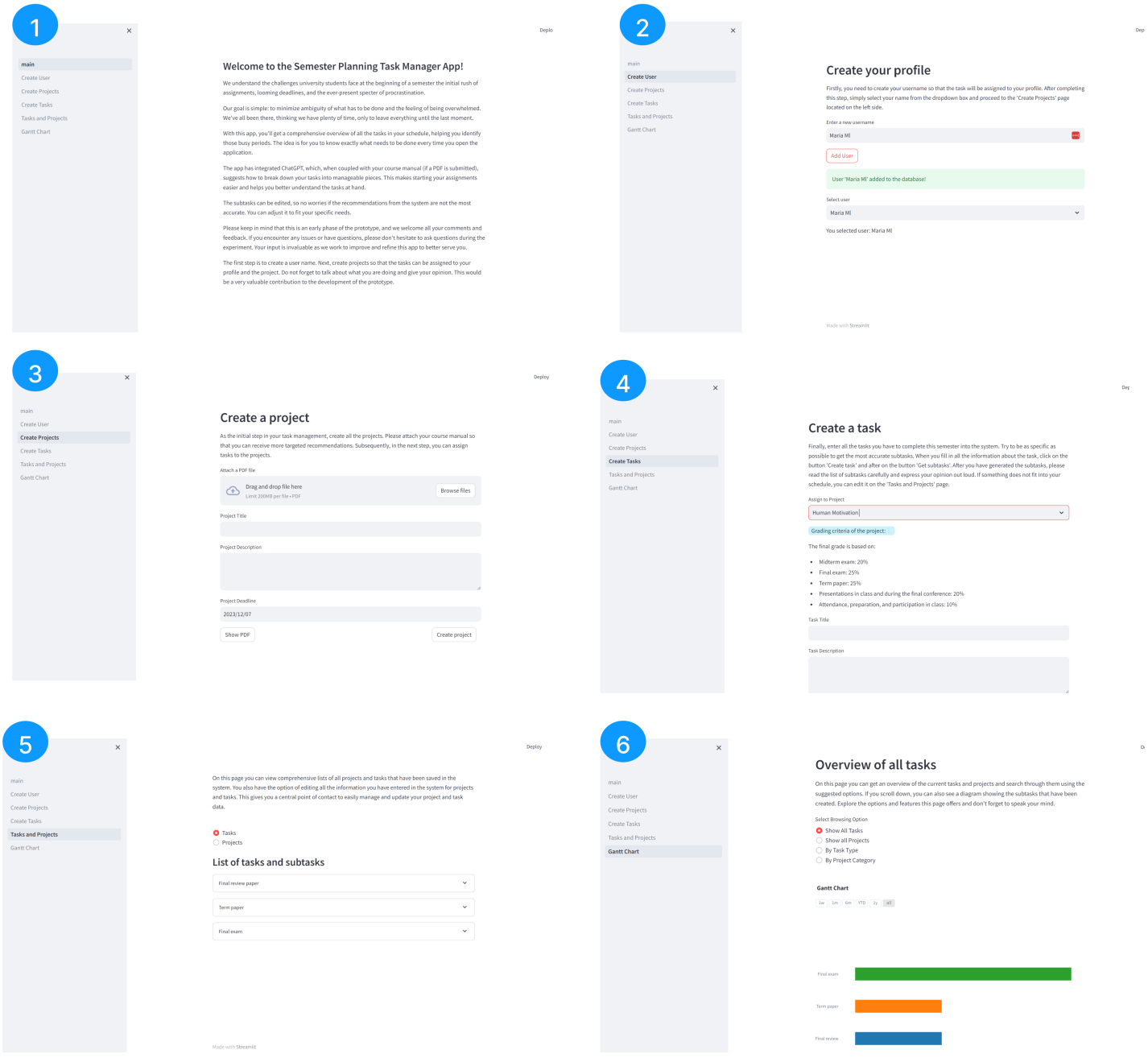


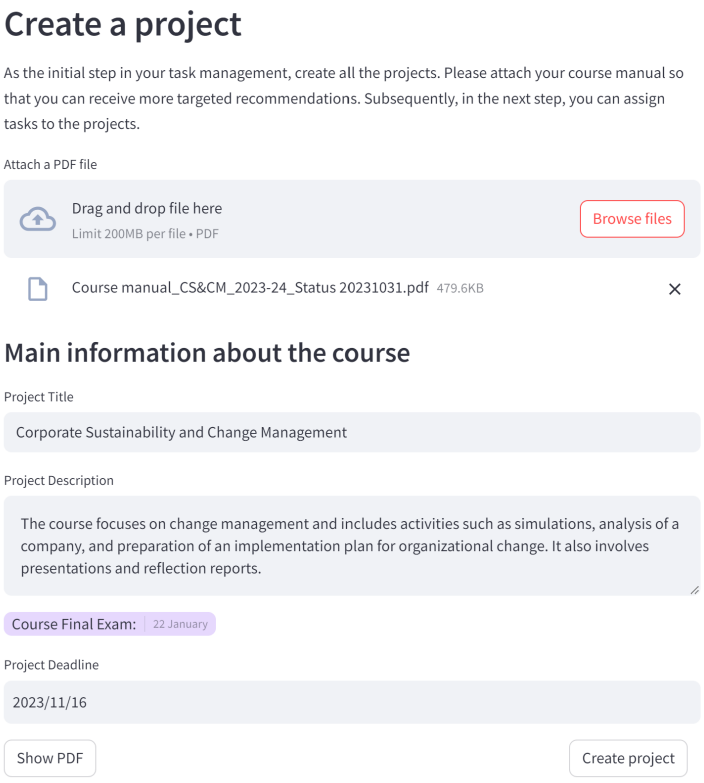
Figure 26. *Sequential layout of the pages of the prototype, illustrating the flow and content of the individual sections.*

6.1 Page 3 - Creating Projects

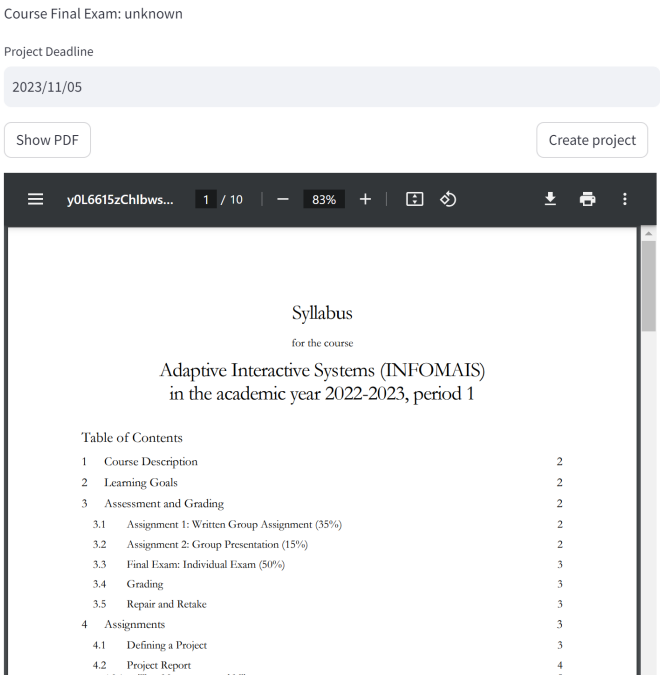
The first step in the application is to create projects that allow the user to categorise and assign tasks within relevant projects to improve organisation. This feature is particularly useful in the academic environment where university work is usually structured in the form of courses. Each course can be identified and managed as a separate project. Users have the option of attaching a course manual to their projects, which plays a crucial role in the next step. The integration of the course manual enables the creation of more targeted subtasks, as this process is directly influenced by the content of the course manual.

The page of project creation is illustrated in Figure 27a. This stage is optimized through the automatic generation of essential elements like the project's title, description, grading criteria and exam date, directly from the course manual. The information is extracted by using the Langchain Python library (for more specific queries used in extraction, see Appendix B). While the title and description are populated in text boxes for user review, the date of the final exam is presented as a suggestion rather than a definitive input, due to occasional challenges in its detection. The primary goal of these features is to minimize user interaction time with the application. Specifically, the extracted grading criteria highlight the core components of the course and recommend necessary tasks for course completion. The aim is to minimise uncertainty about what is expected of students and to guide users through the process of creating a semester plan by providing them with recommendations on what needs to be entered into the system. Additionally, the application could benefit from an automatic timetable feature, which organizes tasks based on the structure of the course handbook. All would be automatically differentiated and generated from the information in the PDF document. However, due to limited time, such functionality was not incorporated. In cases where the user lacks a course manual, an alternative project creation method is available that does not require PDF upload. To ensure accuracy, users can view the uploaded PDF file to confirm the correct manual has been attached (see Figure 27b).

This part of the application streamlines the project creation process by intelligently extracting and utilising key information from the course manuals. This approach significantly improves the user experience and ensures that the application is adaptable, efficient and tailored to the specific needs of the academic environment.



(a) The process of project creation



(b) Course manual overview

Figure 27. *Screenshots illustrating the project creation process and the integration of the course manual into the task management application*

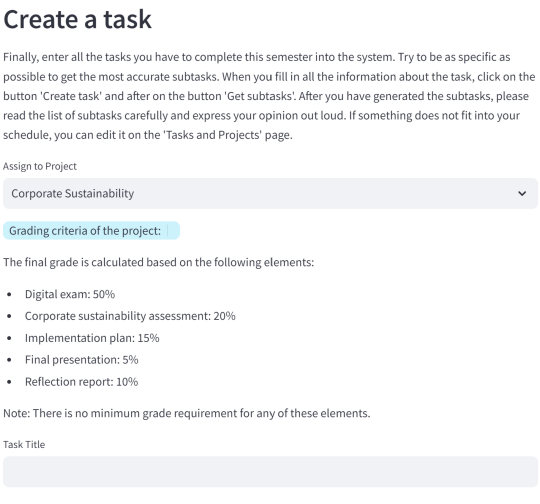
6.2 Page 4 - Creating Tasks

In the application's next phase, users create tasks for their projects, primarily focusing on ongoing university courses (refer to Figure 28a). The first step involves selecting a project, followed by a display of the project's grading criteria (see Figure 28a). This feature aims to inform users about elements impacting the final grade, guiding them in defining appropriate tasks for the course. This approach minimizes the need for users to repeatedly consult the course manual or search for information externally, thereby reducing interaction time and cognitive load.

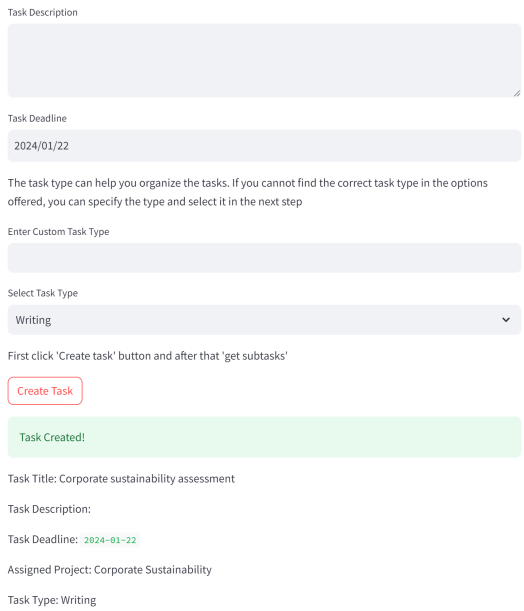
Upon project selection, users enter essential task details: title, description, deadline, and task type. Task types facilitate task categorization, improving organization and visibility in the Gantt chart, where tasks can be filtered by type. The system allows for the creation of custom task types, providing personalization and catering to individual categorization styles. To assist users who might find too much flexibility overwhelming, predefined task types such as reading, writing, studying, and coding/programming are suggested.

After task entry, the system confirms the creation of tasks (see Figure 28b). The subsequent feature introduces a function for generating subtasks (named as getting an action plan on the Figure 24), tailored to the selected project. These subtasks are formed by combining information from the course manual and the language model ChatGPT - 3.5. The Subtasks and the following Start and Finish dates are presented in a table format (refer to Figure 28c), the system also estimates the time required for each subtask. This functionality aids in efficiently displaying subtasks on the Gantt chart and offers a clear view of the time commitment for each task. This novel support for breaking down tasks into manageable segments is a unique offering not found in existing market tools. It addresses the need to minimize uncertainty and procrastination by providing clear, actionable steps. Thereby reducing the feeling of being overwhelmed with both the system and the workload.

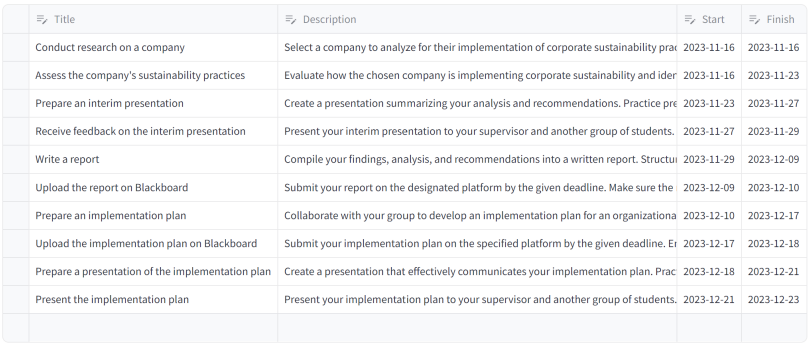
The Create a task page simplifies task management for university courses by integrating course details and automating the creation of subtasks. This feature not only increases productivity but also reduces stress and allows students to focus on learning and achieve their academic goals with greater clarity and organisation.



(a) Task detail entry



(b) Confirmation of task creation with user input summary



Title	Description	Start	Finish
Conduct research on a company	Select a company to analyze for their implementation of corporate sustainability prac	2023-11-16	2023-11-16
Assess the company's sustainability practices	Evaluate how the chosen company is implementing corporate sustainability and ider	2023-11-16	2023-11-23
Prepare an interim presentation	Create a presentation summarizing your analysis and recommendations. Practice pre	2023-11-23	2023-11-27
Receive feedback on the interim presentation	Present your interim presentation to your supervisor and another group of students.	2023-11-27	2023-11-29
Write a report	Compile your findings, analysis, and recommendations into a written report. Structu	2023-11-29	2023-12-09
Upload the report on Blackboard	Submit your report on the designated platform by the given deadline. Make sure the	2023-12-09	2023-12-10
Prepare an implementation plan	Collaborate with your group to develop an implementation plan for an organizationa	2023-12-10	2023-12-17
Upload the implementation plan on Blackboard	Submit your implementation plan on the specified platform by the given deadline. Er	2023-12-17	2023-12-18
Prepare a presentation of the implementation plan	Create a presentation that effectively communicates your implementation plan. Prac	2023-12-18	2023-12-21
Present the implementation plan	Present your implementation plan to your supervisor and another group of students.	2023-12-21	2023-12-23

(c) Generated subtask list with scheduling details

Figure 28. *Screenshots illustrating the task creation interface show the user input, task confirmation and the division into subtasks in the task management system*

6.3 Page 5 - Overview of Tasks and Projects

The concept for the next page of the prototype is to showcase all ongoing tasks and projects in the form of to-do lists. A screenshot of the current view of this page can be seen in Appendix F.1. This page did not undergo extensive development as it was not the main focus of evaluation studies. However, the fundamental idea behind this page is to enable users to edit all information related to tasks and projects, including modifying subtasks and their deadlines. Tasks are organized in a list and prioritized by urgency, determined solely by their deadlines. Users can access detailed information on demand by clicking on the title of a task or project. This interaction reveals all related details, allowing users to customize everything to meet their needs. This particular page of the app was not tested during the evaluation study, as it requires additional refinement and exploration to determine the most effective and user-friendly design.

6.4 Page 6 - Gantt chart

Various methods for visualizing ongoing tasks exist, such as the Kanban technique used in Trello. However, the prototype in focus integrates a Gantt chart, a visualization not commonly seen in existing tools. The rationale behind this choice is the potential of Gantt charts to effectively display workload. These charts offer a clear visual layout that is crucial for organizing academic tasks, managing time efficiently, tracking progress, comprehending task relationships, and modifying study plans according to changing schedules or workload demands.

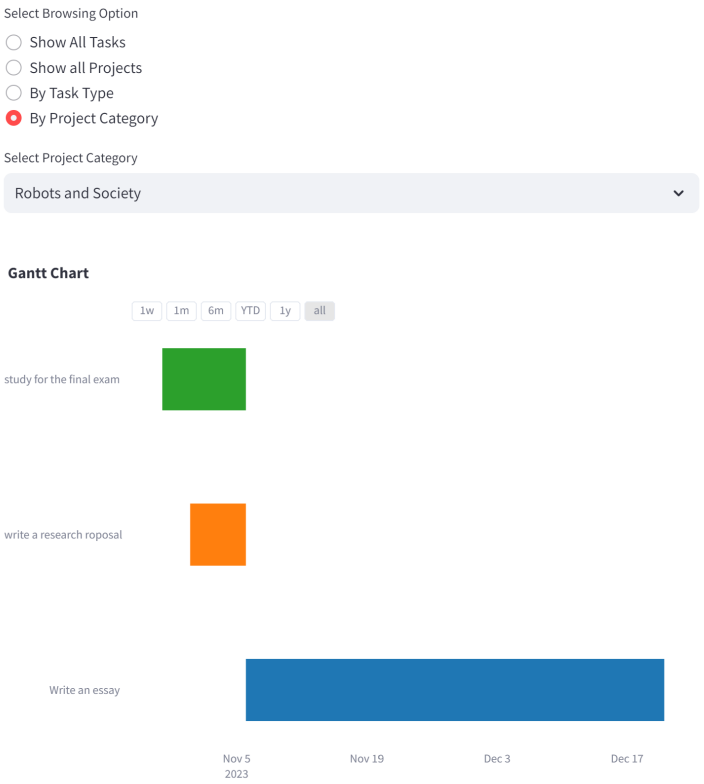
The Gantt chart visualization provides users with an overarching view of each task's required time, optimal start times, and the necessary allocation of time for activities. It plays a crucial role in identifying periods with heavy workloads, thus aiding in decision-making. Users gain a clear understanding of their upcoming tasks through this app. While the Gantt chart has several advantages, its creation can be a tedious task, and many people don't recognize its usefulness due to the effort required. Hence, the automatic creation of a Gantt chart for every task at hand can be beneficial. However, the Gantt chart also has limitations, as it fails to present the context of tasks and show dependencies between them [22]. Moreover, it can become illegible with too many tasks displayed. The decision to introduce a visualisation method with a timeline is supported by the results of the survey, in which the majority of participants chose estimating the time to complete tasks as challenging (see Figure 11). Gantt charts provide an approximate duration for each task, which is particularly beneficial for individuals with ASD as it offers a clear timeline and compensates for potential distortions in time perception [34].

Within the prototype, two distinct Gantt charts are incorporated. The primary chart presents a comprehensive overview of tasks and projects (refer to

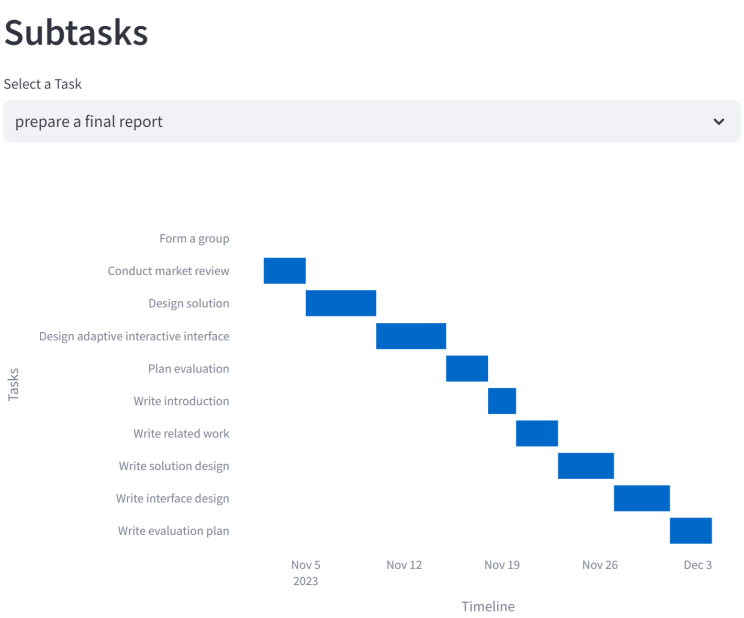
Figure 29a). This chart is designed to enable users to employ filters for an overall view of all tasks and projects, or to narrow down to specific types of tasks or projects. Additionally, it offers the capability to filter tasks according to their assigned projects. This particular functionality was mentioned during the second focus group (Figure 22). It is anticipated to enhance the user experience and facilitate more informed decision-making processes.

Furthermore, the prototype empowers users to customize their daily task lists. This customization is achieved through the application of filters, which can be based on individual motivation levels or other personal factors. For instance, a user engaged in tasks from course A may find it necessary to switch focus to a different course, or perhaps alter their activity type from coding to writing. The significance of motivation as a key element in task management has been underscored in previous research (Figure 23) and was also a focal point in the discussions of the second focus group (Figure 3). The secondary Gantt chart within the prototype (Figure 29b) is designed to display subtasks, contingent upon the user's selections. This feature allows for an in-depth view of all the components essential for the completion of a task, including the estimated time allocation for each segment.

The chapter on the design of the prototype contains a detailed description of the integrated functions. The prototype contains pages that facilitate the creation of projects and tasks, using information from course manuals for a personalised approach. This is further enhanced by the use of ChatGPT to create subtasks for complex and long-term assignments. An important feature of the prototype is the integration of Gantt charts. These charts provide users with clear visual timelines and an overview of workload distribution. The next step in the development of the prototype is to conduct user studies, focussing on students with ASD. These studies are essential to ensure that the tool meets the different needs of its users.



(a) Filterable overview of tasks and projects



(b) Detailed view of subtasks within the selected task

Figure 29. *Screenshots for the visualisation of tasks and subtasks in Gantt chart format.*

7 Evaluation

This section presents a comprehensive evaluation of the prototype for improved semester planning. The methodology includes a mix of thinking-aloud and semi-structured interviews to capture real-time user feedback. The evaluation focuses on assessing the efficiency of the prototype in breaking down tasks and integrating course handbooks for planning and visualising tasks through a Gantt chart. This analysis aims to identify the strengths of the prototype, highlight areas for improvement and assess its overall impact on efficient semester planning.

7.1 Methods

7.1.1 Study design

The final phase of my study aims to evaluate the effectiveness of the proposed solution in supporting students with semester planning. To achieve this, a think-aloud session was conducted to capture the immediate feedback and thoughts of the individuals interacting with the system. The study took place at the beginning of the new block in November so that participants would be actively involved in the planning. This timing ensures the relevance and applicability of the study as students use the tool for their immediate planning, which increases the authenticity and practicality of the feedback.

Participants are first asked to answer questions about their demographics: level of education, degree programme and neurodivergence status. They are also asked two questions about their task management skills: Do you consider yourself an organised person when it comes to managing your university workload? Do you use digital tools to support your task management? These factors could significantly influence the experience with the prototype and the opinions of the users.

Participants are familiarised with a prototype where each page explicitly guides them through the expected actions. The introductory page provides an overview of the project, explains the functions of the prototype and gives an overview of the structure of the study. Detailed information can be found in the appendix under C. In addition, each subsequent page begins with a short introduction. The participants are then asked to express their observations according to the Think aloud protocol. After the participants have successfully entered information about tasks and projects into the system and explored the possibilities of the Gantt chart, a semi-structured interview is conducted with the participants. The main objective of the interview is to gain immediate insights into the participants' opinions and to identify potential areas of improvement for the system. Four components of the prototype are discussed with the participants.

Firstly, the focus will be on the functionality that allows the course manual to

be attached. The aim is to ensure that participants formulate their opinions on their first impressions and potential areas for improvement. Secondly, the impression of the functionality that enables manageable subtasks to be created will be more prominent. Similarly, the goal was to capture impressions, improvements, possible shortcomings of such functionalities and participants' concerns when integrating such a system. The next component will be task visualisation. The aim is to find out whether the Gantt chart is a suitable graphic in such a context. To understand participants' opinions and how they believe it could improve the organisation of their schedule.

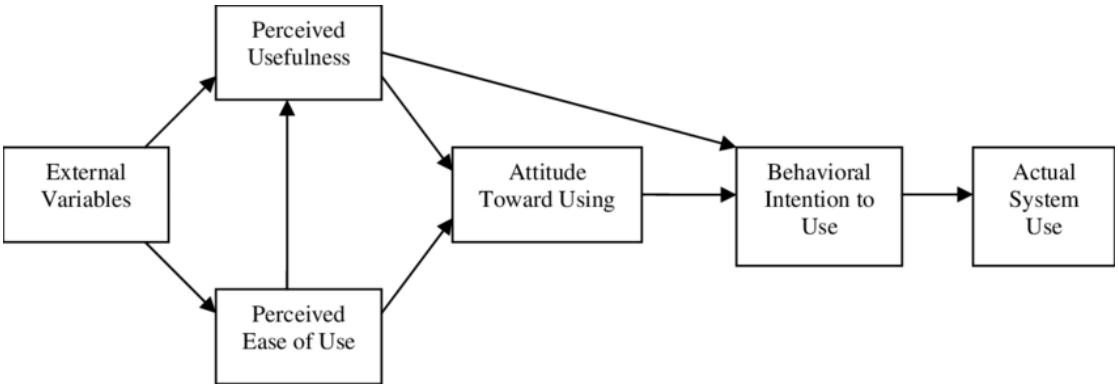


Figure 30. *Technology acceptance model(TAM)*

In this study, a key focus was the assessment of the system's effectiveness in aiding semester planning and identifying which parts were particularly useful. Additionally, considerations were made regarding potential enhancements to increase the system's efficacy. Utilizing the prototype with actual tasks enabled participants to provide more insightful feedback on the features essential for creating a successful timetable.

The evaluation was based on the Technology Acceptance Model (TAM), concentrating on assessing perceived usefulness—the extent to which users believed that the task manager would facilitate semester planning, and perceived ease of use—the extent to which users believed the technology would be user-friendly and not overly complex. Another crucial element assessed was the behavioural intention to use, which measured the participants' willingness to use the prototype if given the opportunity. A visual representation of the TAM components is depicted in Figure 30.

To gather comprehensive insights, the following three main questions were asked of the participants after interaction with the prototype:

1. What features of the task manager do you find most appealing?

2. Are there any concerns or challenges you face in using the task manager?

3. Do you have any suggestions for improving the task manager?

In addition, certain discussion topics were specified for the interviews to ensure that the participants' opinions on all important functions of the prototype were comprehensively recorded. A subset of these questions were also asked during the Think aloud study sessions to encourage participants to verbalise their thoughts and actions. This approach was necessary as some participants may not spontaneously comment on their actions. This strategy was important to obtain detailed feedback from the users.

Topics to cover of the semi-structured interview:

- **Course Manual:**
  - **Initial impression**: What are your initial thoughts on getting information from the course manual?
- **Breaking Tasks:**
  - **Initial impression**: What were you thinking when you encountered the feature of breaking tasks into smaller tasks?
  - **Improvements**: How would you improve this part? What changes or additional features would make breaking tasks into smaller pieces more effective or easier within this tool?
- **Data Visualization, Gantt Chart:**
  - **Initial impression**: What are your initial thoughts on viewing tasks in a Gantt chart format within this task manager?
  - **Usability**: Do you find it easy to identify the sequence of tasks and their dependencies using this visualization?
  - **Improvements**: What search or filtering options would help you better locate specific tasks/projects?
  - **Effectiveness in task management**: Do you think that the Gantt chart visualization could support your task management needs effectively? Why or why not?
- **Semester Planning:**
  - **Support**: Was the product helpful in structuring your semester plan?

– **Improvements**: Can you suggest any additional functionalities that, if incorporated into this app, would significantly enhance its support for semester planning?

The whole study session is finished with a short questionnaire that follows TAM the exact questions can be seen in the appendix E.

7.1.2 Particpants Recruitment

The final prototype was tested with both NT and neurodivergent students. Recruitment for the study was randomised, with participants recruited from support groups for neurodivergent students in Utrecht and via advertisements in lectures. The challenge of recruiting a substantial number of students with ASD for the final phase of the research led to an expansion of the participant pool. This included not only NT students but also students with various forms of neurodiversity. This approach is in line with the Microsoft Design Group's guidelines for inclusive design [24], which indicate that technologies developed for a specific group may have wider benefits. For example, an application originally designed for people with autism may also be useful for people with temporary impairments such as anxiety or for people with temporary personal challenges that affect their planning skills. Consequently, the final prototype was evaluated by non-autistic individuals and individuals with a spectrum of neurodiverse conditions.

7.2 Results

Table 5. *Participants Information in the Evaluation Study. The last three columns display perceived intentions to use in the future, usefulness, and ease of use of the task manager. Each concept was rated on a scale from 1 (Strongly Disagree) to 5 (Strongly Agree).*

Neurodivergent	Skilled in TM	Tools	Education	Intentions to use	Usefulness	Ease of Use
Neurotypical	Definitely not	None	Master's	4	5	4
Self-diagnosed	Probably not	Digital	Bachelor's	4	4	3
Self-diagnosed	Probably not	Digital/Physical	Master's	2	3	3
Self-diagnosed	Neutral	Digital/Physical	Master's	2	4	3
Self-diag. ASD	Probably yes	Digital/Physical	Bachelor's	5	4	4
Official ADHD	Probably not	Digital/Physical	Bachelor's	4	5	4
Official ASD	Definitely not	Physical	Bachelor's	4	4	3
Official ASD	Definitely not	Digital	Bachelor's	4	5	4

The Think-aloud study involved eight participants: two with an official ASD diagnosis, one with a self-diagnosis of autism, three who identified as neurodivergent and one with an official ADHD diagnosis. The participants had different educational backgrounds: three had a master's degree, while five were pursuing a bachelor's

degree. To assess the impact of the intervention, three key constructs were quantitatively analysed: Perceived usefulness, perceived ease of use and behavioural intention to use. These were assessed based on the average responses to four, three and two survey items respectively. Participants' detailed responses, including their self-assessed task management skills, tools used for task management and level of education, are systematically presented in Table 5. After the interaction, participants answered three questions about the most interesting features of the system, challenges and suggestions for improvement. These findings are summarised in Table 6, highlighting the recurring themes for most participants.

All participants agreed that the most interesting feature of the prototype was the automatic generation of subtasks, which they found extremely useful. Second in usefulness was the prototype's integration with ChatGPT to extract information from the course manuals. This integration allowed the system to independently generate a project title, description and due date taken directly from the course material. Participants recognised the potential of this feature and commented on further opportunities to use the course manual and ChatGPT. For example automatic creation of tasks to pass the course. When it came to creating project descriptions, participants' opinions differed. Some favoured a detailed description of the course content, while others preferred task-oriented lists. These different preferences emphasise the need for flexible description creation to meet different user requirements.

Another notable feature was the Gantt chart, which was valued for its ability to visualise subtasks. Participants particularly appreciated the chart's ability to display multiple groups of subtasks from different tasks in a single, cohesive view. Although the overview function of the Gantt chart was well received, it was not rated as favourably as the gantt chart with subtasks. This was mainly because users had difficulty recognising the usefulness of the chart, especially when it came to a limited number of tasks. It was also difficult to recognise the potential of the task browsing feature in the Gantt chart as it requires continuous use of the prototype to see the impact over time. Most participants had difficulty identifying the start and end date of the project and indicated that the Gantt chart interface could be improved.

When using the prototype, the participants faced several challenges and expressed various concerns. One main problem was the inaccuracy of the system-generated schedule for subtasks, especially the start and end dates. This led to discussions about the need for a more personalised approach to scheduling, tailored to users' individual needs and work patterns. Another major challenge was determining the appropriate level of detail in the task descriptions. Participants found it difficult to find a balance between too much and too little information and how the amount of information affects the accuracy of the generated subtasks.

They also pointed out that a clear distinction needs to be made between tasks for groups and those for individuals. Another problem was the lack of a function to automatically adapt the schedule to changes. As was the functionality that deals with uncompleted tasks. This lack of flexibility was seen as a potential source of stress and possible procrastination, especially if users were unable to achieve their goals due to unforeseen changes in their schedules. Finally, the prototype's inconsistent terminology led to confusion among users. For example, the interchangeable use of 'project' and 'course' in different contexts led to confusion. This inconsistency emphasises the need for consistent and precise language throughout the system to improve user understanding and experience.

Participants made several suggestions for improving the system. One important suggestion for improvement was the introduction of an option to manually select a start date for tasks or projects. This feature would give users more control and flexibility when planning their schedules. Another important suggestion was the integration of the Gantt chart with external calendar systems. Such integration would allow users to synchronise their project schedules with their personal or professional calendars, streamlining their planning process. In addition to integration, participants also emphasised the need to improve the visibility and usability of the Gantt chart. This could include improving the graphical interface of the chart to make it easier to interpret and use. In addition, better customisability of the data within the Gantt chart was requested so that users could adapt the schedules to their specific requirements. Some participants also recommended a function to mark periods where work is impractical or impossible due to external factors such as holidays, personal commitments or other unavoidable events. This feature would help to create more realistic and achievable schedules that take into account possible interruptions or non-working time.

The Think-Aloud study provided valuable insights into the features and functions of the prototype system. Participants particularly appreciated the automatic generation of subtasks and the integration with ChatGPT to extract course material, which emphasised the system's potential to improve task management. However, issues such as inaccuracies in the schedules generated by the system and a desire for more personalised task descriptions were also noted, indicating key areas for improvement. These findings highlight the importance of striking a balance between automated features and user-driven customisation to optimise the usability and effectiveness of task management tools. Following the Think Aloud session, participants completed a short questionnaire to provide quantitative feedback on their experience with the app. The results of this questionnaire are explained in more detail in the following sections.

Table 6. *Participant feedback on the prototype during the think-aloud study sessions.*

Most Interesting Features	**Challenges and Concerns**	**Improvements Suggested**
Subtask generation	Start/finish date accuracy	Gantt chart accuracy and clarity
Gantt chart integration	Task description clarity	Control over subtasks and charts
Detailed subtask timelines	Complex Gantt charts	Workload assessment tools
ChatGPT for syllabus	Relevance of subtasks	Planning with non-working days (holidays)
	Navigation issues	Calendar integration
	Adapting to schedule changes	Concise task descriptions
	Handling incomplete tasks	More guidance for complex tasks
		System feedback integration
		Notifications for task management

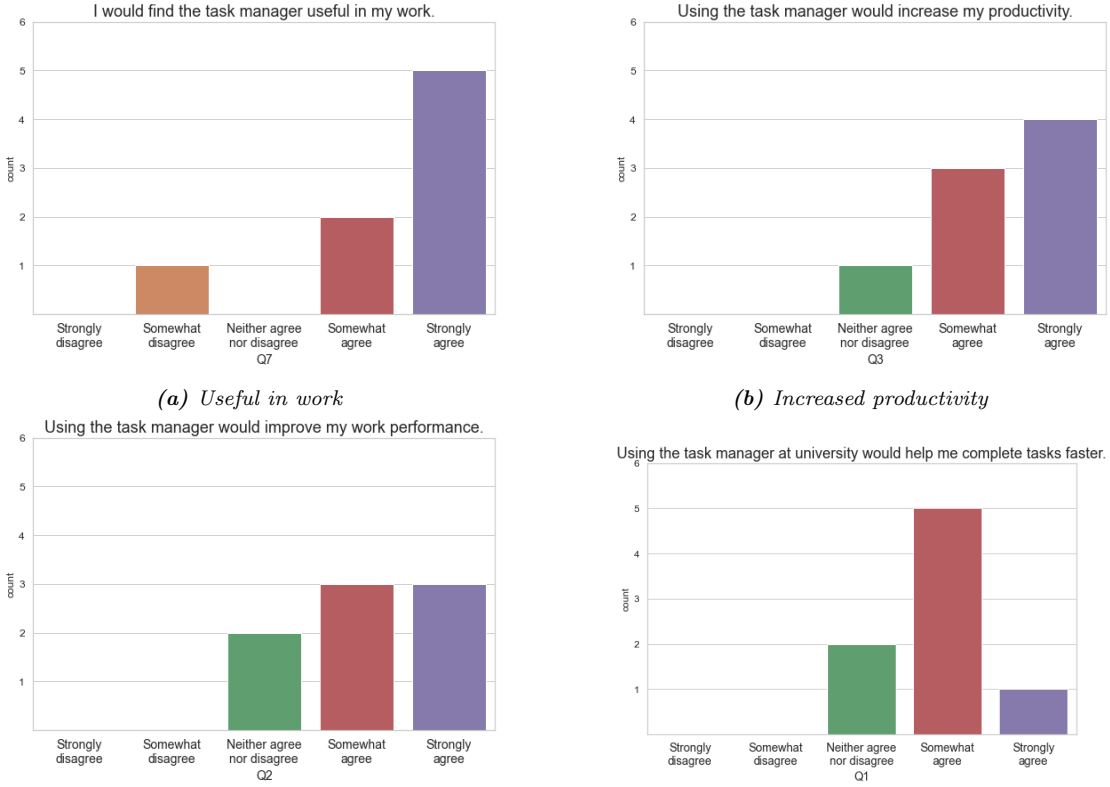
7.2.1 Perceived Usefulness

The first assessed construct in the post-session questionnaire was perceived usefulness. Four questions were asked in this category to assess the potential impact on work, productivity, performance and speed.

In the Think-aloud study, participants generally expressed positive surprise regarding the task management tool's ability to break down tasks into manageable pieces. Many were impressed by its accuracy, though some noted inaccuracies in the subtask lists or unexpected task sequencing. Despite these issues, the consensus was that the tool would be beneficial for work organization. The post-study questionnaire revealed that seven out of eight participants found the task manager useful for their work, with five strongly agreeing. Only one participant, who encountered inaccuracies in generated subtasks and deadlines, did not recognize its potential usefulness (refer to Figure 31a). Regarding productivity enhancement, seven participants believed the tool would increase their productivity (see Figure 31b), with one remaining neutral. Six participants agreed that the task manager could improve their work performance (see Figure 31c), and the same number felt it could help complete tasks faster (see Figure 31d) in both questions two people chose the neutral option. Generally, participants perceived the product as useful.

With only one chosen disagree option in all four questions.

The survey results revealed that participants positively viewed the prototype's ability to organize work by breaking down tasks, with a majority acknowledging its usefulness and potential to enhance productivity, despite some noting inaccuracies in task sequencing. Overall, the prototype was perceived as beneficial for work organization, performance, and speed, with an overwhelming majority in agreement across all assessed constructs of perceived usefulness.



(a) Useful in work

(b) Increased productivity

(c) Improve the work performance

(d) Help to complete tasks faster

Figure 31. *Distribution of the responses to the questions about perceived usefulness.*

7.2.2 Perceived Ease of Use

The following questions focussed on assessing the perceived ease of use and how effortlessly users were able to operate the prototype. Some difficulties encountered included participants occasionally struggling to follow complex or lengthy instructions, leading to confusion about the required actions. Many were hesitant about what steps to take next. The majority found the page navigation not intuitive. A common problem was the lack of immediate customisability of generated subtasks by the system. Participants expressed a desire for more control

at each stage of task or project creation. However, most appreciated the prototype's clear and simple user interface.

After the interaction, participants answered three questions about the system's ease of interaction. The first question on the clarity and understandability of the system was answered predominantly positively: six somewhat agreed, one strongly agreed and one neutral (see figure 32a). For the second question, the flexibility of the system, opinions were more mixed: five were neutral, two somewhat agreed, and one somewhat disagreed (see Figure 32b). When asked how easy it is to learn the task manager, the answers were evenly split: three somewhat disagreed, three somewhat agreed, and two strongly agreed (see Figure 32c). Overall, the ease of use rating was lower than the usefulness rating, with more neutral (6 out of 24) and somewhat disagree (4 out of 24) responses. Nevertheless, the majority of responses were positive (14 out of 24), including four strong agrees and no strong disagrees.

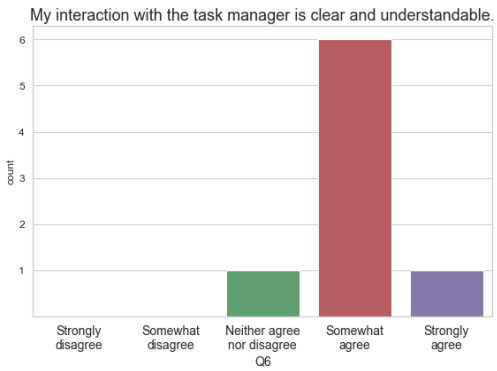
The results indicated that participants struggled with complex instructions and unintuitive navigation in the prototype, yet appreciated its clear interface; they expressed a need for greater customisability. Survey responses on ease of use were mixed, with overall positive feedback tempered by neutral and negative reactions regarding the system's flexibility and learnability.

7.2.3 Behavioral Intention to Use

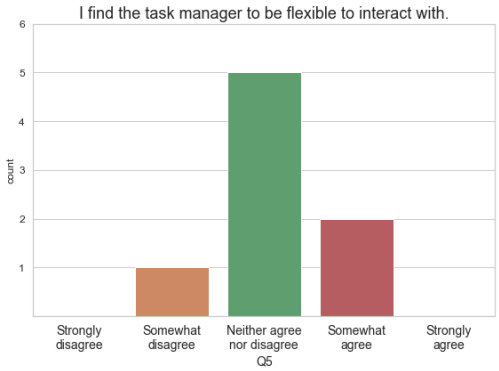
The last section on the results of the evaluation stems from the last two categories: perceived usefulness and perceived ease of use, assessing participants' behavioural intentions to use the system. In the thinking aloud study, participants expressed a positive attitude towards the potential use of the system. In particular, three participants enquired whether they could obtain copies of the subtasks generated by the system and two asked whether they could use the system immediately.

Two key questions were asked in this category. The first question was aimed at whether participants could imagine using the system in the long term. The answers indicated a generally positive outlook with five participants agreeing on this question, with details provided in the analysis of the figure 33a. The second question related to the likelihood of frequent use if the opportunity arose (see Figure 33b). In this case, four participants fully agreed, two somewhat agreed, and there was one neutral and one somewhat disagreeing response. It is noteworthy that those who were neutral or disagreed were the same participants who found the most inaccuracies and undesirable results in the subtasks generated by the system.

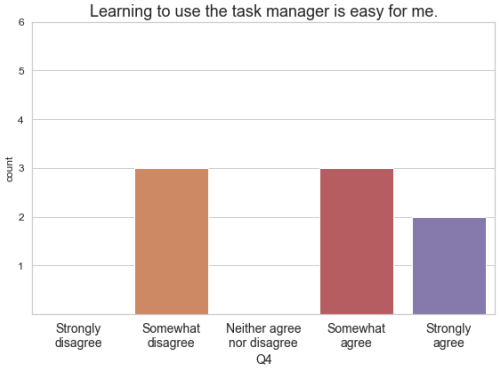
In the results section, participants showed a positive behavioural intention to adopt the task management system, with some showing immediate interest in using its features. Responses to the key questions about long-term and frequent use were overwhelmingly positive, although some participants showed hesitation



(a) interaction is clear and understandable



(b) Flexible to interact with



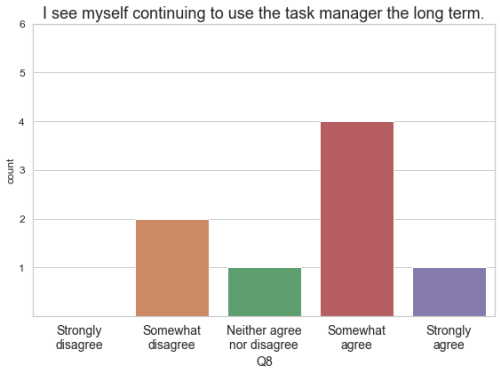
(c) easy to use

Figure 32. *Distribution of the responses on the questions about perceived ease of use.*

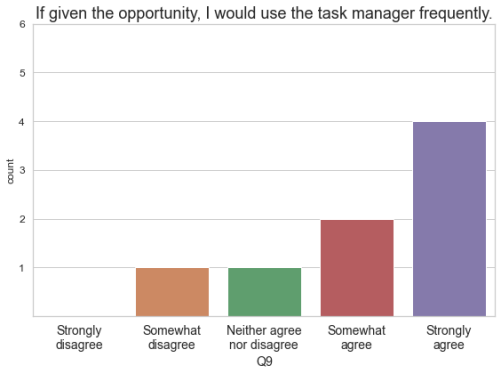
related to experiences with inaccuracies in the system's functions.

8 Discussion

This discussion aims to synthesize the insights gained from extensive research, which included a survey, focus groups, and a think-aloud evaluation study, on a task management app developed specifically for university students with autism. The research sought to understand the unique challenges these students face in managing academic tasks. The survey collected quantitative data on the students' challenges and strategies in task management, as well as their use of digital tools to support this process. Focus groups provided qualitative insights, revealing HCI professionals' perspectives on potential design solutions. These solutions were informed by the system requirements formulated based on the survey results. The think-aloud study offered a practical assessment of the prototype in real-world scenarios, uncovering its effectiveness and areas for improvement. This discussion



(a) Continuing to use the task manager in the long term



(b) Use the task manager in the future

Figure 33. *Distribution of the responses to the questions about behavioral intention to use.*

will not only address the effectiveness of the app in aiding task completion for the target group but will also consider the wider implications of the findings for the development of assistive technology for students with autism. It will highlight key findings, discuss the relevance of these results in the context of existing literature, and make suggestions for future research and development in this area.

8.1 Survey

RQ1: How do students with autism perceive their task management skills and how do they compare to neurotypical students in terms of task management?

First and foremost, the survey responses have highlighted various challenges and strategies in the task management process for students with OASD in comparison to their NT peers to highlight the unique patterns. The results underscore the significance of creating tailored tools for this specific group. The survey results lead us to hypothesize that current management tools fall short in meeting the needs of individuals on the spectrum. In the subsequent section, different factors influencing the design of task management applications will be considered, providing guidelines for the development of future tools. Since comprehending their unique problems and needs is essential for developing highly personalized tools.

RQ1.1 Are students with ASD less confident in their task management skills compared to NT students?

The survey results indicated significantly lower perceived competency in task management abilities among university students with OASD compared to their NT peers, as depicted in Figure 6. This result emphasizes the need for specific

tools and support systems for students with OASD, who consistently rate their skills lower in all aspects of task management (see table 2). The clearest difference is observed in multitasking, which is consistent with existing research on this topic suggesting that people with ASD have difficulty managing multiple tasks simultaneously, including managing everyday tasks, due to impairments in EF [57]. This is closely followed by the challenge of coping with unexpected change, which is in line with the survey results indicating difficulties in adapting to change in students with OASD (see Figure 14) and who frequently reported that they do not cope well with unexpected change, while NT students never chose this option. The smallest discrepancy in terms of self-confidence was found in the estimation of completion time, where both OASD and NT students reported similar levels of self-confidence. This contradicts the findings that individuals with ASD have problems with time processing [9, 34], which may result in them being unable to correctly estimate the time to complete tasks. However, estimating task completion is a complex skill that requires consideration of many factors about the nature of the task, our abilities, and our previous history with the completion of similar tasks, and therefore might present a similar challenge for NT students. Lower confidence in task management appears to be associated with impaired EF in autistic people ([43, 31, 25]), including (*autistic inertia*) [11], i.e. difficulty initiating, completing or switching tasks, which affects task management skills. Therefore, task management skills without adequate support may lead to increased stress and risk of burnout [18].

When discussing these results, it is important to maintain a nuanced perspective. The discrepancy in self-confidence between NT and OASD participants could be partly influenced by their different educational backgrounds. A significant difference in self-confidence was found when comparing neurodivergent students at Bachelor's and Master's levels, as shown in Figure 7. This shows that among neurodivergent students, those with a Master's degree have higher self-confidence in their task management skills. All NT participants were Master's students, while the OASD group was evenly split between Bachelor's and Master's graduates (see Figure 5). This difference is significant as master students tend to have more experience of university work and may have developed more effective task management strategies, which could contribute to their higher confidence. Therefore, the possible influence of educational level on task self-confidence should be carefully considered when interpreting these results.

In addition, a significant decrease in mean task confidence scores was observed in the master's student group when NT individuals were excluded. Specifically, the average score for NT master's students was 22.3, while it dropped to 19.2 for neurodivergent master's students, indicating a significant discrepancy (see Table 3). Besides, research indicates that individuals with OASD often face challenges

connected to the impairments in executive functions [31], affecting their ability to effectively plan and organize tasks [25]. Thus, the differences in task management between NT individuals and individuals with OASD cannot be dismissed based on differences in educational level alone. This emphasises the need for a comprehensive approach to supporting people with ASD in task performance that takes into account both educational level and inherent cognitive differences.

RQ1.2 What are the unique challenges in task management faced by students with Autism Spectrum Disorder?

The results of the survey showed that students diagnosed with OASD reported, on average, a higher number of challenges related to task management skills, indicating their potentially greater difficulties in this area. Various facets of task management appear to be more challenging for this group (see Figure 9 and 11). In particular, starting a task is a problem that is often observed in people with ASD [11]. Another challenging aspect is the occurrence of unexpected changes in the schedule, which is related to the concept of intolerance to uncertainty, which was more pronounced in individuals with ASD [66]. In the following part, the common challenges of people with ASD are discussed based on the results of the survey, and the potential reasons for this are explained.

Among the various challenges assessed, students with OASD had particular difficulties in dealing with uncertainty and in coping with tasks that were either complex or perceived as overwhelming (see Figure 9). Intolerance to uncertainty was associated with increased levels of anxiety in individuals with autism, as shown in the results of Boulter et al. [10]. Our survey results are consistent with this association. Uncertainty about a student's specific expectations can increase anxiety and thus hinder the start of a task. These problems are linked: Lack of clarity in understanding task requirements and determining the actions needed to fulfil them. It all can create significant barriers to task management. Finally, long-term tasks emerged as the most challenging to execute (see Figure 14). The management of long-term tasks requires the consideration of various factors, which makes it a multifaceted undertaking. In this study, the focus of the prototype was on the organisation of long-term academic tasks, which was examined in detail, during focus group 2, in order to develop a prototype.

No clear differences were found between NT and students with OASD in terms of task management challenges (see Figure 11). Both groups cited estimating time to complete tasks as their most common challenge, with over 50% of participants in both groups choosing this option. This finding is related to perceptions of task management competence, where students with OASD did not report significantly lower scores than their NT counterparts 2. However, students with OASD found it more difficult to break tasks down into smaller steps than students with NT. This

is consistent with previous discussions of the difficulty of students with OASD in managing tasks [49, 25]. Their greater difficulty in breaking tasks into manageable chunks may exacerbate the challenges they face in completing complex tasks, as they find it difficult to both initiate and organise these tasks effectively. In addition, the strategy of breaking tasks into smaller, more manageable chunks has been recommended as an effective method of teaching task management skills [53]. Thus, automating this process, as highlighted in previous research [38], could be beneficial.

Although the sample size may limit the generalisability of the conclusions, the survey data provided interesting insights into the distribution of responses regarding task challenges between students diagnosed with ASD at different life stages: childhood diagnosis versus adulthood diagnosis (defined as 12 years or older). The survey results indicate notable differences in the distribution of responses when it comes to the challenges faced when starting a task (see Figure 10), suggesting that individuals face different challenges depending on the timing of their ASD diagnosis. One plausible explanation for these results revolves around the development of coping strategies in individuals diagnosed early in life. Individuals diagnosed early in life likely had the opportunity to become aware of their condition from childhood and received customised tools and interventions to compensate for their impairments. Moreover, individuals diagnosed with ASD in adulthood may have had little to no awareness of their neurodivergent disorder. This lack of early awareness may have led to a phenomenon known as 'masking', which is characterised by hiding or suppressing the behaviour to blend in the NT norms [48, 40]. This is where those affected adapt to NT norms and strategies without realising their inherent cognitive differences. This masking behaviour could lead to difficulties in coping with tasks, as these individuals may lack the tailored tools and coping mechanisms developed by those diagnosed earlier in life.

Since the number of late ASD diagnoses is increasing and is higher among women [3, 40]. This situation highlights a group of individuals who have been inadvertently overlooked both in research and in the development of technologies for ASD. These individuals, who begin developing coping strategies later in life, represent an important but underserved population that deserves attention in research and technological innovations to improve their quality of life and cognitive support.

To summarise, this part of the survey highlights the challenges that students with ASD face when managing tasks, particularly when initiating tasks, dealing with uncertainty and completing complex or long-term tasks. It is hypothesised that students who are diagnosed with ASD later in life may face additional difficulties due to a lack of early coping strategies. These findings emphasise the need for specialist support and tailored tools for people with ASD.

RQ1.3 Are there specific task management strategies preferred by students

with Autism Spectrum Disorders?

This section deals with the results of a survey on the methods of task management for students with ASD. The aim is to find out whether there are common strategies for this group or whether the needs are highly individualised and not dependent on neurodivergent status.

In examining the strategies for task management, respondents with OASD tended to select fewer proposed options compared to NT respondents. Conversely, they chose a greater number of options on average for questions related to challenges. This observation suggests that individuals with autism might face more significant challenges in handling tasks, possessing fewer strategies and effective solutions.

Procrastination, often cited as a hindrance in task initiation, was also explored 14. While a large majority of NT students manage procrastination by creating to-do lists and setting deadlines for each step, the strategies among OASD participants were more varied, with no single method predominating. The diversity of coping mechanisms in OASD students could be attributed to different causes of procrastination, possibly related to the severity of executive function challenges that require different approaches. Moreover, before task lists can be used effectively, tasks must be clearly defined, a process that can be challenging for students with OASD. Therefore, automating the process of creating to-do lists could help students with ASD overcome procrastination.

The second aspect investigated was the use of physical and digital tools for task management. Among participants with OASD, a combination of both physical and digital tools emerged as the most popular choice, followed by mental planning (see Figure 15). In contrast, the NT group predominantly favoured digital tools, with other options selected at similar frequencies. This indicates a slight preference for physical tools among students with OASD. The specific tools used by OASD students included pen-and-paper to-do lists, planners/notebooks, and physical calendars (Figure 16). Notably, physical calendars were seldom chosen by NT respondents, while sticky notes were quite popular among NT students but less so among those with OASD. Understanding the tool preferences of OASD students can reveal the appealing features of these systems and how they might be effectively digitized. Discussions in focus groups revealed that physical tools are valued for the greater sense of control and flexibility they offer. Additionally, with the increasing number of apps available for smartphones, there is a general reluctance to install new apps unless they are deemed essential. This insight suggests that digital solutions for OASD students need to offer significant advantages to be considered over traditional physical tools.

To conclude, the data suggest that individuals with ASD tend to have less established strategies for coping with tasks, have difficulty adapting to unexpected

changes, and demonstrate a variety of approaches to dealing with procrastination. The fact that ASD participants favour physical tools over digital tools also emphasises their tendency towards tangible, flexible systems.

RQ1.4 What are the main reasons for and against the effectiveness and usability of existing task management tools for people with autism spectrum disorder?

The final part of the survey aimed to analyse specific digital tools used for task management and assess their popularity. The purpose of this analysis is to identify the strengths and weaknesses of existing tools to determine the design and functionality of potential solutions. Understanding why certain digital tools are favoured or disregarded sheds light on the areas where these tools fail to meet users' needs.

Interestingly, only a small proportion of respondents stated that they use special digital tools for task management (see figure 15). This indicates a potential gap in the market for tools tailored to the needs of students. None of the existing tools proved to be the first choice for students, with calendars, simple to-do lists and personalised systems via Word documents or Excel spreadsheets being the most commonly used (Figure 17). Notably, these tools lack specific design features tailored to efficient task management. A slightly higher percentage of respondents stated that they used to use external tools but no longer do so. The survey explored the reasons for not using tools, with the majority stating that using them was too much effort (Figure 20). However, among participants with OASD, there was no definitive consensus on reasons for not using digital tools, suggesting that personal factors may influence the adoption or abandonment of tools.

In addition, a significant number of respondents either do not currently use external tools or have used them in the past. The reasons given by the NT group were related to profitability, motivation and preferences for using external tools. For the OASD group, on the other hand, the reasons were the inadequacy of digital tools, the feeling of being overwhelmed with the existing tools, the reluctance to use another external tool on the phone, and the preference for physical tools that seem to fulfil their needs sufficiently (Figure 19). The reasons cited by the OASD for using task management tools can be divided into two main areas. Firstly, the interface and flow of these digital tools can be confusing and lead to a feeling of being overwhelmed. This complexity in design is not necessarily intuitive for them. Secondly, ASD students favour physical tools such as calendars and notebooks (Figure 15 and 16). These tools offer more flexibility and the reasons for their appeal to this population need to be explored further. In contrast, NT individuals' aversion to digital task management tools has other reasons. They do not perceive these tools as sufficiently useful to justify their use, as they remain productive without

them (Figure 19). In addition, they see digital tools as a potential distraction that limits their flexibility and concentration. This may mean that NT students do not necessarily need external tools to successfully manage their university workload, as they rely on EF and a minimal type of task management. Finally, a significant percentage of NT participants indicated that specialised digital tools limit their flexibility and spontaneity, while this option was only chosen by one participant with OASD (Figure 19). Looking at the most frequently chosen option to the question presented in Figure 20. This could suggest that flexibility is not desired by OASD individuals and that there is a need for digital tools to compensate for impairments in EF, but the tools are too overwhelming or there is simply nothing usable for students with OASD.

To summarise, the study provides important theoretical guidelines for the development of assistive devices for students with ASD to compensate for their impairments in EF. First, it shows that students with ASD have lower confidence in their task management abilities, which may be associated with greater difficulties and higher stress in coping with academic work. The survey emphasises the challenges they face when dealing with uncertainty, starting assignments or coping with long-term, overwhelming tasks. Furthermore, it suggests that there may be a significant difference in the extent of challenges depending on the timing of ASD diagnosis. Individuals with a late diagnosis of ASD may have greater difficulties. In addition, the study indicates that students with ASD have fewer strategies than their NT peers but experience more challenges, highlighting a gap and a need for tools to support them and teach them effective task management strategies. The tools on the market do not appear to meet the needs of ASD students as they cause cognitive overload and are too complex without adequate support, suggesting that physical tools may be a more appropriate solution. All of these factors indicate a need for targeted solutions for ASD students and also provide guidelines for the development of such solutions.

8.2 Focus Group - Analyzing Requirments

The system requirements (see Table 4) based on the survey results, differentiating the most relevant challenges and characteristics of students with ASD that might influence the functionalities and design of the system. Formulated requirements aimed to inform design decisions and facilitate discussion in the focus groups, which aimed to translate the theory into practical solutions for the application's functions. The following section discusses the results of the focus groups on the design of task management apps for university students with ASD.

RQ2 How can a task management tool be specifically designed to support long-term task planning for students with Autism Spectrum Disorder, considering

their unique cognitive needs?

The investigation described in RQ2 to develop a task management tool specifically designed for students with ASD was enhanced through focus group sessions with students from the human-computer interaction field. These sessions focused on uncovering effective design strategies and opportunities for digital inclusion. An important goal was to find ways to reduce uncertainty when interacting with such systems and to define clear, achievable goals when creating tasks. Further requirements are listed in table 4. The following section looks at the key insights and discussion points that emerged from these focus group interactions and provide valuable perspectives for the development of the tool

1. **Task Clarity and Structure:** The focus group emphasised the need for a clear and well-structured approach to tasks within the system. This includes creating easy-to-understand task descriptions and organising task lists to minimise uncertainty. Such a structured approach is crucial for students with ASD as it meets their need for predictability and routine [40], facilitates the prioritisation of tasks, helps with the start of a task and improves their user experience.

2. **Personalized Recommendations:** An important feature was the system's ability to learn and adapt to individual preferences and habits. Already stated as a key feature of UI to consider [55]. Personalised task recommendations based on previous interactions were seen as valuable to ensure a positive attitude and long-term engagement with the app. This adaptive feature can cater to the different interests and strengths of students with ASD, thus increasing motivation and engagement. In addition, such an approach minimises interactions with the app, making it less burdensome and minimising the effort required from a user to maintain the app.

3. **Minimization of Cognitive Load:** The design should focus on minimising cognitive load by allowing focus on one task at a time and providing intuitive navigation. Streamlining the user interface and simplifying interactions can help to maintain engagement and promote a state of 'flow', which is particularly beneficial for students with ASD who can experience cognitive overload with complex user interfaces. Clear and simple navigation and interface were mentioned as a rule of proper UI for individuals with ASD in the past research [55, 59] A structured approach can help minimise uncertainty by providing a step-by-step approach that makes it clear what needs to be done at that moment.

4. **Guided Task and Project Creation:** The task creation process must be structured in such a way that users have a clear understanding of the

objectives of each task. By defining the tasks precisely, users are clear about what is expected of them, making it easier to initiate tasks. In addition, this approach reduces cognitive load by ensuring a sequential order of tasks. Such structured guidance helps to encourage productive habits and alleviate feelings of overwhelm, a common problem in students with ASD (Figure 20 and 9).

5. **Effective Display of Ongoing Tasks:** How ongoing tasks are displayed is crucial. Effective visualisation can help with easy tracking and management of tasks, making the process more manageable and less daunting for the user. It should make it easier for the user to decide which activity to engage with. Especially beneficial for the management of long-term tasks that require consideration of multiple steps, which was differentiated as one of the requirements (Table 4).

6. **Exploring System Adaptation:** Exploring possible adaptations of the task management system to meet the specific needs of students with ASD is crucial. This process requires a comprehensive understanding of key functions such as task creation, project creation and task visualisation methods and how these can be adapted to meet the particular needs of individual users. This requires a thorough analysis of the characteristics of the users and the nature of the tasks, looking at how the various functions and elements of the user interface can be customised accordingly. Such customisation is particularly important as it aims to reduce the time spent interacting with the application and potentially reduce the feeling of being overwhelmed which often occurs during such interactions (see Table 4).

These insights provide a comprehensive guide for developing a task management tool for students with ASD. The emphasis on clarity, structure, personalisation, and minimal cognitive load meets the specific needs of this population. In addition, it aligns with a previous study on designing digital applications for people with ASD. [55, 59].

8.3 Focus Group - Adaptation and Long-term Planning

To deepen the understanding and refine the design strategies for a task management system tailored for students with ASD, a second focus group was conducted. This session was particularly important as it followed on from the first focus group where the findings, although insightful, were somewhat generalised and lacked detailed guidance on explicit design actions. This subsequent discussion served to crystallise these initial ideas into more concrete, actionable design strategies that focus on the specific needs and preferences of students with ASD.

Internal State

The importance of mental health in the process of task management was a central theme of the discussion. Mentioned as an important user characteristic (see Figure 23). Considering that students with ASD have an increased risk of developing mental health problems largely due to challenges such as academic workload (explored in pat research [14, 25, 64].), it is crucial to consider the impact of these factors on mental health when designing the system. In addition, participants emphasised the importance of recognising the additional difficulties that each user faces, particularly how external factors impact motivation and ability to complete tasks and understanding the individual internal challenges of task management that can impact wellbeing. The ability for users to indicate their main problems and goals when using the app was seen as an important feature to address this, as it can lead to more effective user-centred design and increase engagement by ensuring that the app's features directly address individual needs.

A lot of attention was drawn to the internal state of the user (see Figure 23). Interest and motivation were identified as other key factors in dealing with procrastination and other challenges. Participants recognised that these aspects are often influenced by personal and external factors, such as the perceived importance and familiarity of tasks. This realisation is crucial for the development of features that adapt to users' different levels of motivation and interest. These results are in line with the findings from previous research [35], which indicated that internal factors influence what type of activity the user is more likely to engage in and can influence prioritisation, as people are more likely to perform a task that is familiar to them and in such a case start a task more easily.

Adaptation

Adaptation features were a central theme, with two categories being distinguished before the focus group was conducted: User-level adaptation and task-level adaptation. User-level adaptation includes but is not limited to, adapting the app to the person's characteristics, including their internal state and motivation level. The extensive list of contextual factors discussed during the focus group is presented in the diagram 23. Adaptation at the Task level, on the other hand, is based on the nature of the tasks themselves. In the study, various factors were distinguished for the categorisation of a task, including basic factors such as importance, size, type/category, but also an energy cost that is closely linked to the user's mental state. Based on these factors, possible adaptations to the system were discussed. For example, functions for tracking progress and achievements as well as for carrying out interim checks were proposed to harmonise the actual work with the predefined goals and thus positively influence motivation and task completion. Adapting the UI to

individual needs, including customisable aspects such as UI colours and task display methods, was seen as advantageous. In addition, features that allow users to philtre or browse tasks by category or project were highlighted as important for better task management and control. Another interesting suggestion was the balanced distribution of task types over certain periods, e.g. avoiding consecutive similar tasks. This approach aims to keep the user motivated and engaged by ensuring a variety of tasks and thus preventing monotony. The proposed adaptation should not only provide a better overview of ongoing tasks, but also facilitate prioritisation, and enable a better decision on which task the user should focus on.

The following information helps develop a user-centred, adaptable and engaging task management tool that highlights the complex and nuanced needs of the user group. They ensure that the app does not require too much effort and does not overwhelm the user with all the options and features it offers.

8.4 Evaluation

RQ3 How useful is the prototype for task management in aiding semester planning for university students?

The development of the prototype was based on extensive user studies, including a survey and two focus groups with HCI experts. The prototype was developed with a focus on supporting students, especially students with ASD, and facilitates semester planning. Its main feature is the integration of ChatGPT to create personalised action plans using course manuals. In addition, the prototype includes a Gantt chart to visualise tasks to give users an overview of their responsibilities and support them in decision-making. A detailed explanation of all functionalities and the reasons for certain design decisions can be found in the *Prototype design* section (6). The subsequent *Evaluation* section presents the results of a think-aloud study that was conducted to evaluate the prototype. This evaluation highlights the potential strengths of the system, identifies areas for improvement and suggests considerations for future improvements.

Satisfaction

The evaluation of the prototype task management application revealed promising insights, particularly regarding its potential to support neurodiverse students. See Table 5 for the grading of the system depending on neurodiversity status. The majority of participants provided positive feedback, indicating that the prototype could significantly impact their work performance, productivity, and task completion speed. Notably, in the questionnaire responses after interacting

with the prototype, none of the participants chose the "strongly disagree" option for any of the satisfaction-related questions about the app; only a few selected "somewhat disagree." This trend suggests that the participants generally had a positive reception towards the prototype.

Moreover, feedback from two participants with an official autism diagnosis and one with a self-diagnosis was overwhelmingly positive. They rated the app highly in terms of usefulness and expressed a strong intention to use it. This feedback serves as a robust indicator of the application's applicability and potential benefit for individuals with autism, suggesting that the task manager could be a valuable tool in supporting their organizational needs and enhancing their task management skills.

However, two participants were hesitant. One, an HCI student already working as a UX researcher, occasionally criticised the prototype for not meeting certain standards of 'proper' design. These shortcomings included the lack of system feedback, the non-intuitive navigation and the confusing use of terminology (such as the interchangeable use of 'project' and 'course' in the prototype). Consequently, this participant had higher expectations of the system interaction in the case of design. Another participant, who took a more neutral stance, noted inaccuracies in the subtasks generated by the system, a core function of the application. Furthermore, this person pointed out that they were able to create the subtasks themselves with relative ease, suggesting that the system did not make the work much easier. This led to a more sceptical view of the app's usefulness and underlined the importance of improving the accuracy of subtask generation.

Trust

Some participants expressed scepticism about the results of ChatGPT, describing them as 'typical ChatGPT responses' Opinions and perceptions about generative language models such as ChatGPT can have a significant impact on user trust, which is a crucial factor for the acceptance of applications that use these technologies. To increase trust, it is essential to provide clear explanations about the underlying technologies, their application and the reasons for the generated recommendations, thus increasing the transparency of the system.

Strengths and Areas for Improvements

The participants' feedback on the prototype during interaction with the tool is shown in Table 5. In general, the participants were positively surprised by the function for creating subtasks and the way the tasks are visualised in the form of a Gantt chart. However, they also pointed out some areas that are challenging and should be improved.

Subtasks Generation

The potential for integrating subtasks generation with course manuals was recognised, but there was a clear need for improved accuracy in this feature. Some subtasks, such as "Write a final draft," were too complex for some participants, suggesting that a more detailed breakdown of tasks could be beneficial or being able to recursively generate subtasks. Conversely, some tasks generated by the system were considered unnecessary, indicating a need for finer-tuned output. Each subtask is generated with start and finish dates; however, the app currently does not calculate these dates accurately. Despite its significant potential, particularly for visualizing subtasks in a Gantt chart, this feature requires refinement for precise deadline representation and to allow users flexibility in adjusting these dates to suit their needs. Participants highlighted the need to adjust deadlines, noting that the typical time required for certain subtasks might differ from general expectations. Additionally, the ability to modify start and finish dates directly on the Gantt chart was desired for immediate visualization of changes. This lack of user control over the results of the system affects the evaluation of the quality of recommendations, user satisfaction and trust in the system [36]. Furthermore, some courses had separate documents for schedules and information about the content of the course, but the system does not support attaching multiple documents to one course. In some course manuals, information indicated that more details about assignments were available on Blackboard, underscoring the importance of allowing multiple file attachments for a course. Understanding how PDF documents are parsed into input for the ChatGPT model is crucial for query accuracy, making further investigation into this area important for future enhancements.

Gantt Chart

On a positive note, the inclusion of a Gantt chart was well-received, although preferences for visualization forms varied among users. This suggests a need for multiple visualization options, such as calendars, to accommodate diverse preferences. Some participants expressed that the Gantt chart should be used in conjunction with a calendar. This aligns with survey findings indicating that students with OASD have a slight preference for both physical and digital calendars (see Figures 15 and 16). Overall, the second Gantt chart, which displays the subtasks of a task, was perceived as very useful and has the potential to positively influence task completion. The first chart, however, was difficult for participants to appreciate due to the small number of tasks inputted into the system, making it challenging to see its potential impact on their work. Only one person mentioned understanding the purpose behind browsing tasks by type to switch task types if needed. Hence, additional explanation may be necessary for users to understand

the goal of this functionality. Alternatively, the usability of this function can be assessed only during a long-term study that evaluates the actual use of the system throughout the day.

Navigation

Although the user interface of the prototype was not the focus of the evaluation and the user interface was determined by the use of the Streamlit framework, participants expressed satisfaction with the clarity and cleanliness and appreciated the lack of unnecessary distractions. However, the majority found the navigation aspect unintuitive and pointed out that they were familiar with the use of buttons. The application lacks a consistent flow and there are no intuitive buttons to go to the next section. As simple and clear user interface and navigation were indicated as an important aspect of digital applications for people with ASD [55, 59]. This problem with the navigation of the prototype could be improved as participants often did not know which steps to take next and the additional written instructions were perceived as too long. In addition, participants often wondered what they should include in the task description and how they could influence the accuracy of the generated subtasks. A possible solution would be to guide the users and give them additional information about what exactly should be included in the description. To summarise, although the prototype has potential with its clean and tidy design, it fails to effectively guide users through the process of task and project creation.

Personalisation

An important observation was the prototype's limited ability to capture personal user preferences. Each participant named some unique features that would improve their task management abilities and had different expectations of the prototype. Users with strong organisational strategies expressed a desire for the app to adapt to their existing methods, while users without such strategies were more receptive to the options offered by the app. Similar results have been obtained in past research that people with developed strategies prefer to apply them and adapt to their needs rather than follow imposed strategies [65]. This suggests that the system needs to be adapted to the different levels of experience and organisational skills of users. In order to meet individual requirements, the prompts for extracting information from the course manual should be tailored to the specific needs. To do this, different task types such as group projects or individual tasks need to be considered to improve the accuracy of the suggested subtasks. The system should also use different prompts tailored to the nature of these tasks or projects

In conclusion, while the prototype shows considerable promise, especially for neurodivergent students, the feedback points to the specific areas for improvement, particularly in generated subtasks accuracy and personalisation. Addressing these concerns could significantly enhance the app's effectiveness and user satisfaction.

8.5 Limitations

This research, though offering valuable insights, is marked by several limitations. The survey was conducted with a limited number of participants, resulting in a small sample size. This constraint limits the scope of the research and may not accurately reflect the broader population's needs and perceptions. Additionally, the randomness in the distribution of responses cannot be entirely ruled out, adding an element of uncertainty to the findings.

Furthermore, the method of data collection to determine the challenges and strategies of students with ASD, which was conducted through a survey, did not go deep enough to explore the reasons and motivations behind participants' responses. This superficial approach prevents a deeper insight into users' behaviour and preferences. In addition, the answer options were predetermined, which prevented participants from expressing their attitudes. Although there was an *other* option for almost every question, users were usually led to choose one of the suggested answers. The participant pool of the survey consisted mainly of Dutch students, which limits the generalisability of the results to other demographic groups and cultural contexts. This demographic bias could affect the applicability of the results in different settings. Finally, the unbalanced distribution of Master's and Bachelor's graduates does not allow for conclusive conclusions as to whether the level of education primarily influences the differences between the group of OASD and NT students.

With regard to the application prototype used in the study, it was found that the application was limited in its functionality and usability. These limitations may have significantly affected the user experience and the nature of feedback on the application. The lack of certain basic functions of task managers, such as notifications and extensive control options for the user, could have influenced the users' attitude towards the prototype. It is also important to note that participants occasionally encountered bugs and technical problems during the think-aloud study sessions. These incidents may have affected user attitudes and overall experience with the system. In addition, the primary target audience of the application was people with ASD. However, the evaluation was conducted with a mix of NT and neurodivergent students who may not accurately represent the intended user group. This discrepancy raises concerns about whether the application fully meets the specific needs of the intended users.

These limitations indicate that while the findings provide initial insights into the application's usability and user experience, they should be interpreted cautiously. Future research involving a more diverse and larger sample, more in-depth analysis, and targeted evaluation with the intended user group is recommended to further validate and expand upon these findings.

8.6 Future work

The prototype's success in aiding neurodiverse students with task management highlights the importance of further development in this area. The critical next step involves the further development of the prototype, incorporating direct user feedback. This iterative process will ensure that the system's design and functionality are closely aligned with the actual needs and preferences of its users. Engaging with a diverse user base for feedback will be crucial in this phase to encompass a wide range of perspectives and requirements.

Another key area for future work is improving the accuracy of the system, particularly in generating and managing subtasks. Enhancing accuracy is essential for building user trust and ensuring that the system can effectively aid in task management without adding confusion or error. This could involve advanced algorithms for task analysis and decomposition, as well as user testing to refine these features.

Personalization remains a core focus, especially in terms of user-based adaptation. Future efforts should delve deeper into how the system can adapt not just to general user characteristics but also to nuanced aspects of each individual's behavior and preferences. This could involve integrating more sophisticated data analysis techniques to discern patterns in user behavior and preferences over time. Furthermore, a significant area of future work involves focusing on internal motivation within the prototype design. Understanding and incorporating elements that can influence and enhance a user's internal motivation will be crucial. This might involve integrating psychological principles and motivation theories into the system's design, ensuring that the app not only assists with task management but also positively influences the user's motivation to engage with tasks.

These future work directions aim to build upon the current project's achievements, addressing its limitations and expanding its capabilities. The final goal is to create a more effective, accurate, and user-centric task management system that can adapt to individual users' needs.

9 Conclusion

The aim of this study was to develop a personalised assistive technology for university students with ASD, with a focus on improving their task management skills. The conclusions of the study are significant and multifaceted, highlighting several important aspects.

Firstly, extensive literature reviews and surveys have highlighted the particular challenges faced by students with ASD, particularly in the area of executive functioning, as they have less confidence in their ability to manage tasks effectively. The study emphasises the need for tailored resources for students with ASD due to the observed differences with NT students. Furthermore, current options are inadequate and lead to cognitive overload. Insights for design and development come from focus groups that identified critical shortcomings of current task management tools in relation to the specific needs of autistic students. Key areas for improvement included the task creation process, user interface, personalisation and task visualisation. In addition, personalisation proved to be an important aspect of the study. The study showed the importance of a task management system that adapts over time to users' preferences, activity patterns and contextual factors such as motivation and energy levels. Although these factors were not fully integrated into the prototype, they are important considerations for future development.

The final component of this study was the development and evaluation of a prototype to support semester planning for people with ASD. This prototype has features that breaks down large tasks into smaller, more manageable steps. These steps are generated based on course manuals, utilizing the generative language model ChatGPT-3.5. The system is designed to reduce the feeling of overwhelm and uncertainty that autistic students often experience and thus facilitate the initiation of tasks. In particular, the prototype includes a visual representation of tasks and subtasks using a detailed Gantt chart timeline. The visualisation through a Gantt chart was especially appreciated, highlighting the prototype's potential in managing complex tasks. However, improvements are still needed to increase accuracy and provide more explicit guidance during the task processes. In addition, both the functionalities and the user interface need to be personalised. The encouraging response to the prototype emphasises its significant potential in supporting neurodiverse students in the university environment. This research contributes to understanding how technology can be customised to meet the needs of people with ASD. This could promote a more inclusive educational environment and improve academic outcomes for students with ASD, but is not limited to them.

In conclusion, the study emphasises the need for and effectiveness of developing assistive technologies specifically tailored to the unique needs of students with

ASD. It also presents a framework for the development of assistive technologies to support task management for students with ASD. And the effectiveness of a solution developed based on the guidelines constructed. While the prototype developed is promising, it also demonstrates the need for continued refinement and adaptation to ensure that these tools effectively support the intended users.

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A Appendix A: Online survey materials

A.1 Introduction and informed consent to the survey

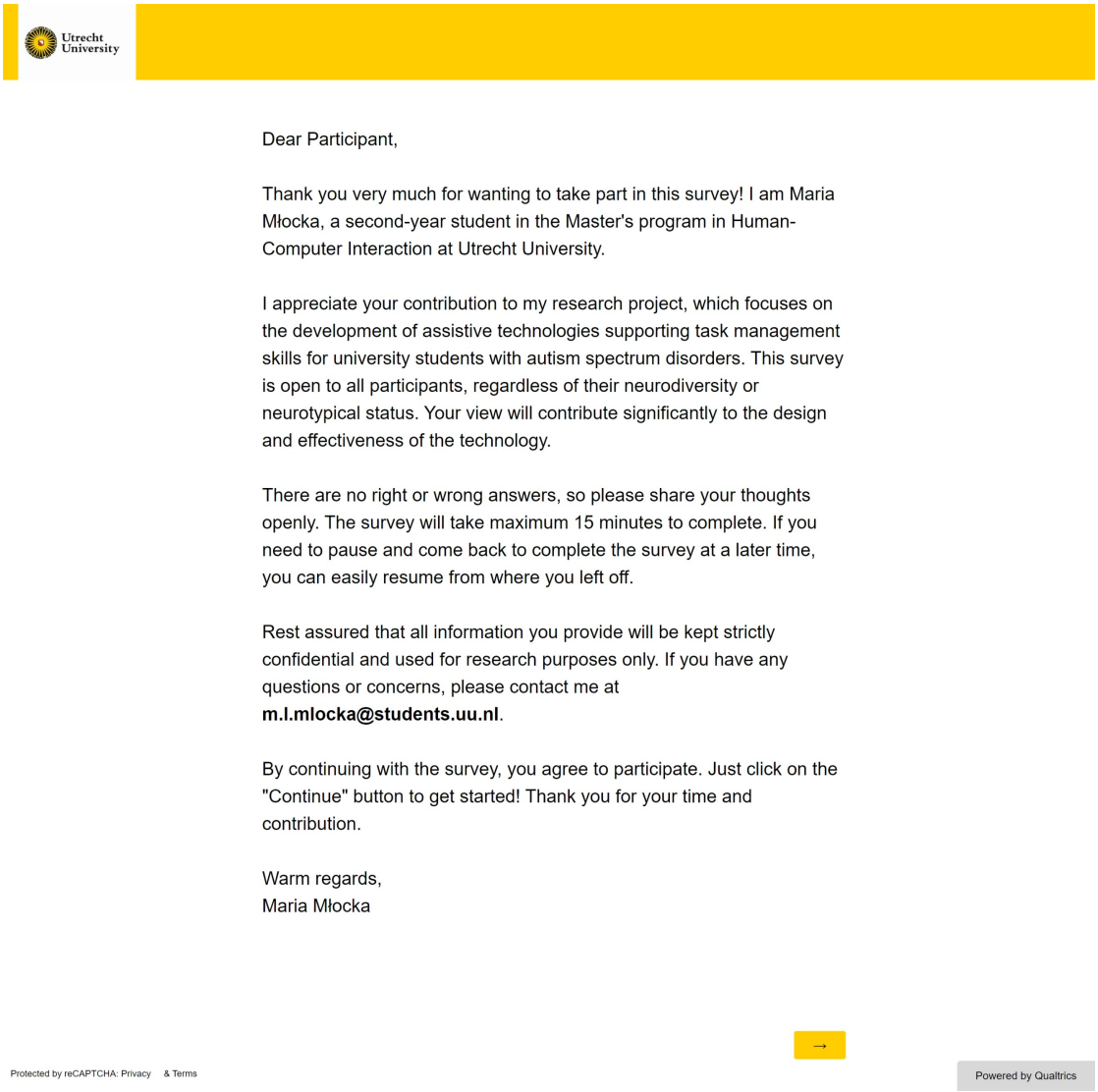


Figure 34. *The initial information given to participants in the online questionnaire.*

A.2 Questions about perceived competency in task management skills

The rating scale ranges from 1 to 5, reflecting skills rated from 'not well at all' to 'extremely well' or the answer adjusted to the phrasing of the question.

1. **Q12: Prioritization** How well do you prioritize tasks?
2. **Q13: Breaking down tasks** How well do you believe you are able to break down complex tasks into smaller, manageable steps?
3. **Q16: Estimation of time completion** How confident are you in your ability to estimate the time required to complete a task accurately?
4. **Q17: Managing deadlines** How well do you believe you manage and meet deadlines for your tasks and assignments?
5. **Q18: Multitasking** Do you perceive yourself as skilled in balancing multiple tasks or responsibilities simultaneously?
6. **Q19: Unexpected changes** How well do you believe you handle unexpected changes or disruptions to your planned tasks or schedule?
7. **Q21: Work-life balance** How effective do you believe your task management strategies are in reducing stress and maintaining a healthy work-life balance?

B Appendix B - ChatGPT Prompts

B.1 Query to extract the title, description, final exam and grading criteria date from course manual

```
query_title = "You have a course manual of the
    univeristy course. Can you give me the title
    of the course from the given document?
    Give just a title. If you do not find
    the title give the answer unknown"

query_description = "Based on the given document,
    summarize what the course is
    about in not more than 255 characters.
    Be precise about the content of the course.
```

```
        Do not repeat words. In the summarization,
        do not mention the title of the course.
        Instead, write 'course' or a similar word."

    query_exam = "Based on the given document,
        find the date of the final exam.
        Give it in a format DAY-Month and do
        not put any other text.
        If there is no info about final exam give an
        answer unknown and nothing more."

    query_grading = "Based on the given document.
        Give what consitutes on the final grade.
        If the answer is not stated clearly in
        the document put 'Unknown'."
```

B.2 Query to create subtasks

```
query =  f"""
Generate a comprehensive step-by-step guide for students to
successfully complete the primary{'{task_title}' task, with
additional details provided in the '{description}' section.
This task has been delegated by a fellow student
for the '{project}' project, and its deadline is set for
'{time}' days. Your guidance should be tailored to the
task's complexity and difficulty. Ensure the response
is structured in JSON format and comprises all
essential steps. Each step should have a title to offer
a concise overview and a one or two-sentence description
to minimize ambiguity. The number of steps should be
proportional to the task's difficulty and complexity.
For tasks like "study for the exam," keep the steps
general and limited to a maximum of 5. Exclude steps
that involve minimal effort or time. Please include only steps
that demand active work from the student
and are indispensable for project execution.
Your response should not exceed 10 steps.
The response format should adhere to the following
```

```
structure and include all steps required to accomplish
the main task in a JSON file:
in the response ONLY steps should be included.


{{ Action_plan[

    "Title": "general description",
    "Description": "1-2 sentences about what need to be done",
    "Deadline": "estimation of how long it takes to complete
    a subtask in days but include only numbers. Take into
    consideration the deadline of the main project.
    Make sure that sum of days needed to complete the
    task will take exactly and not more "{time}" "
  ]
}}

"Ensure that if you sum up all the numbers in the 'deadline'
column of the JSON file the sum is equal to '{time}'.
If it does not match,
estimate again time required to complete the task.
"""
```

C Appendix C - Instruction in the Prototype

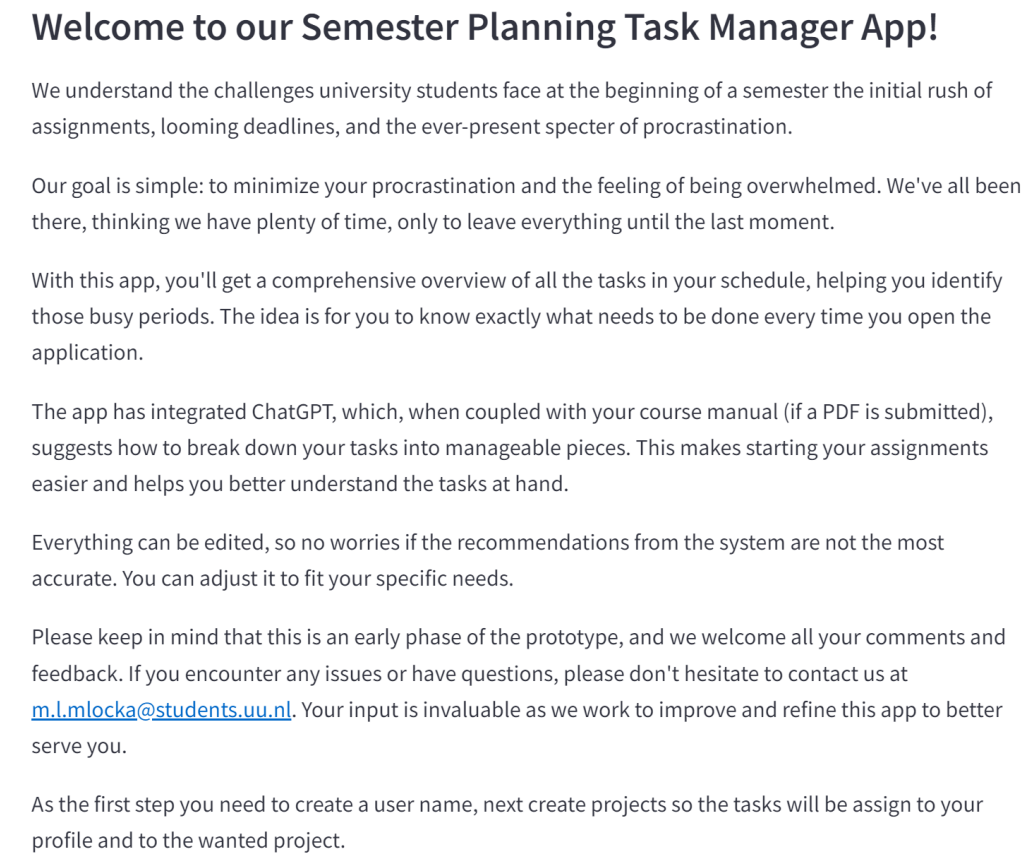


Figure 35. *The initial information given to participants during the evaluation.*

D Appendix C: Informed Consent Form Evaulation

Introduction

You are invited to participate in a think-aloud study conducted by Maria Młocka as part of a Master's thesis project in Human-Computer Interaction at Utrecht University. This study aims to assess the usefulness and effectiveness of a prototype designed to support semester planning, with the overarching goal of enhancing the user experience of the semester planning application.

Procedures

If you agree to participate, you will be asked to plan the coming semester using the prototype. Your task will be to organize all projects and assignments for the coming semester using the course manual. This will be followed by a 10-minute discussion to gather your insights and experiences with the app. You will then be asked to complete a short questionnaire, which is expected to take no longer than 5 minutes. With this questionnaire, we would like to get your opinion about the Task Manager. The entire study is expected to be completed in about 20 minutes.

Voluntary Participation

Participation in this study is entirely voluntary. You may choose not to participate or withdraw from the study at any time.

Confidentiality

We will collect anonymized information, including your thoughts and comments. The study will be recorded. Your data will be kept confidential, and no identifiable information will be shared. The data will be stored securely to protect your privacy. Your data will be kept for 2 months and then anonymized or deleted. You can access, correct, or withdraw your data at any time. Your data will not be shared without your explicit consent.

Questions and Concerns

If you have any questions about the study, you can contact Maria Młocka at `m.l.mlocka@students.uu.nl`. If you have concerns about the study, you may contact the supervisor of this project, Dr. Hanna Hauptmann, at `h.j.hauptmann@uu.nl`.

Consent Form

I have read the information provided above, and I understand the nature and purpose of the study. I voluntarily agree to participate in the think-aloud study.

In participating in this study, you agree to the following statements below:

- I confirm that I am at least 18 years of age or older.

- I confirm that the study has been explained to me. I have been given the opportunity to ask questions about the study, and these have been answered sufficiently.
- I consent for the researcher to record my voice during the study.
- I consent that the material I contribute is being used anonymously for the HCI master thesis or other education-related purposes.
- I understand that participation in the study is voluntary and that I can withdraw at any time without giving any reason.
- I understand that I can request to rectify or delete any data collected from me.
- I agree to participate in the study.

Name Participant

Signature

Date

E Appendix D: Technology Acceptance Model (TAM) - post-session questionnaire

This questionnaire is designed as a follow-up evaluation for the Think Aloud Study. It comprises a series of questions. Respondents are asked to express their level of agreement with each statement using a Likert scale to the questions from 6 to 14. The options available for responses are: 'Strongly Disagree,' 'Somewhat Disagree,' 'Neither Disagree Nor Agree,' 'Somewhat Agree,' and 'Strongly Agree.'

1. Do you identify as neurodivergent? Please select the option that best describes your situation: (Self-diagnosed with autism, Official diagnosis of autism, Neurotypical, official diagnosis of neurodivergent, self-diagnosed as neurodivergent)
2. Do you consider yourself skilled in managing tasks? (Likert scale)
3. Which types of tools do you use to support the process of task management? Please select the option that best applies to you: (digital, physical or combinations of physical and digital)

4. What is the level of education you are currently pursuing? (Master's degree, Bachelor's degree)
5. What is the name of the program in which you are currently enrolled?
6. Using the task manager at university would help me complete tasks faster.
7. Using the task manager would improve my work performance.
8. Using the task manager would increase my productivity.
9. I would find the task manager useful in my work.
10. Learning to use the task manager is easy for me.
11. I find the task manager to be flexible to interact with.
12. My interaction with the task manager is clear and understandable.
13. I see myself continuing to use the task manager in the long term.
14. If given the opportunity, I would use the task manager frequently.

F Appendix E: Screenshots from the Prototype

F.1 Page with Overview of Tasks and Projects

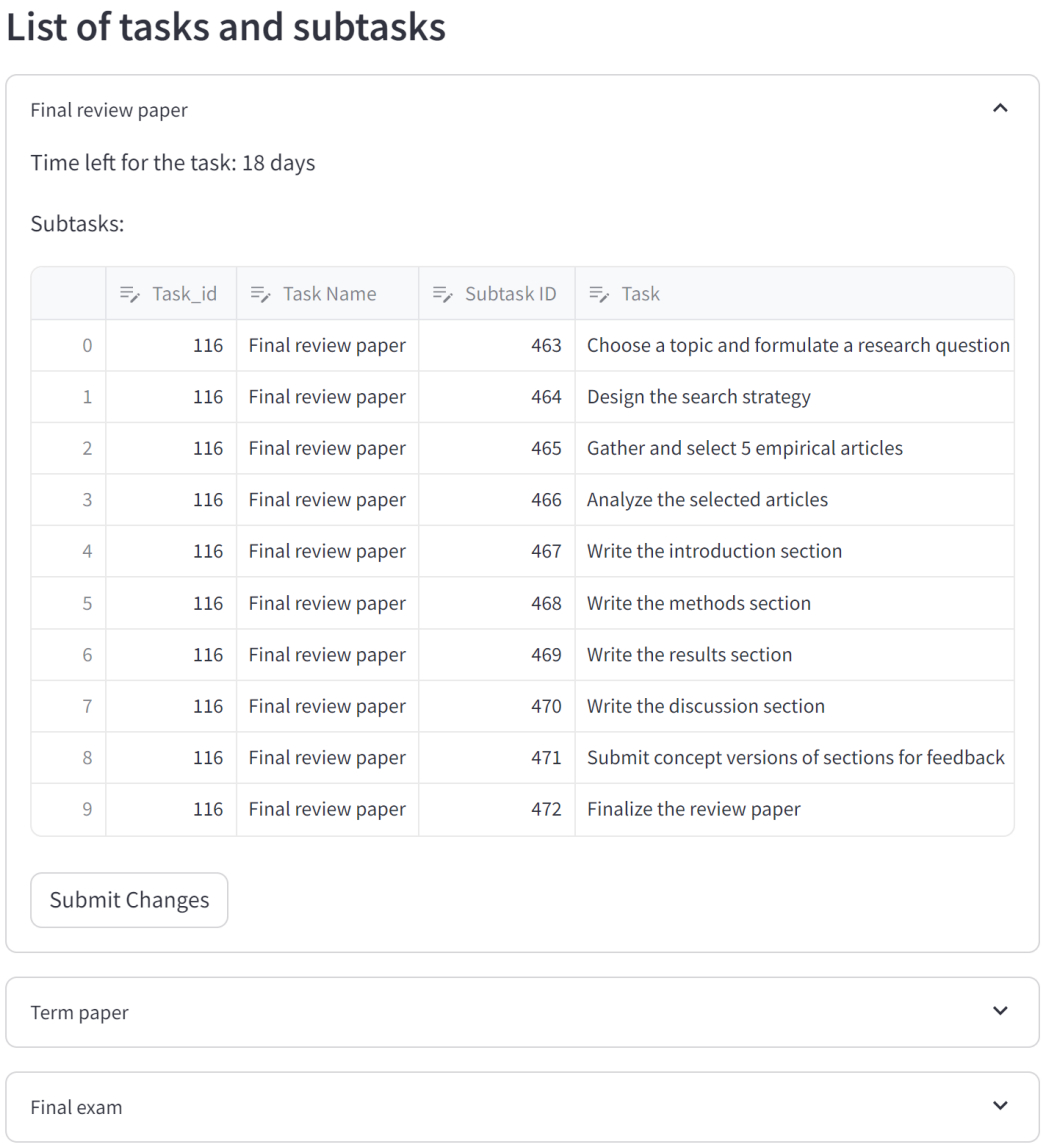


Figure 36. *Tasks list with the possibility to edit details of tasks including subtasks details.*

On this page you can view comprehensive lists of all projects and tasks that have been saved in the system. You also have the option of editing all the information you have entered in the system for projects and tasks. This gives you a central point of contact to easily manage and update your project and task data.

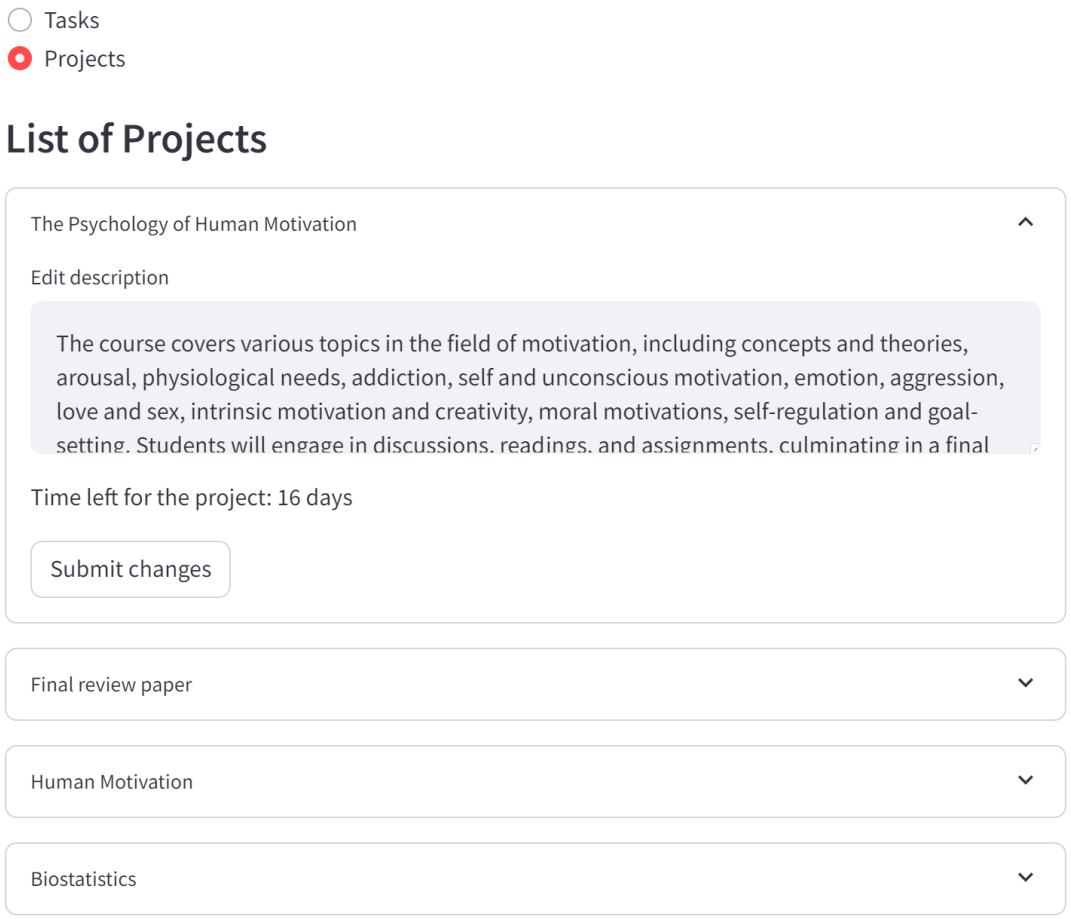


Figure 37. *Projects list with the possibility to edit details of projects.*

F.2 Page for username creation

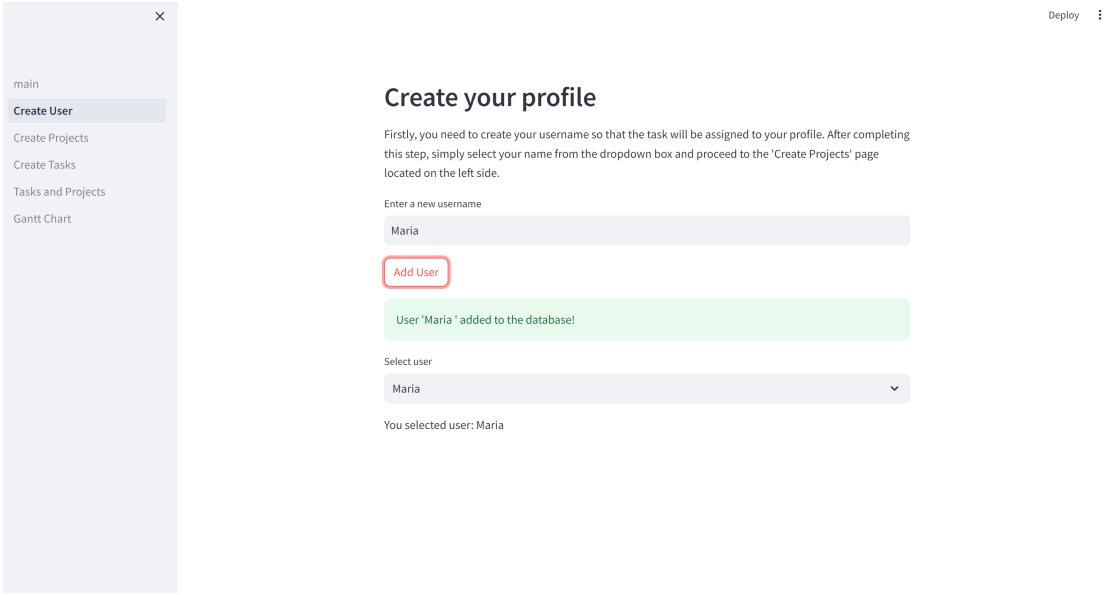
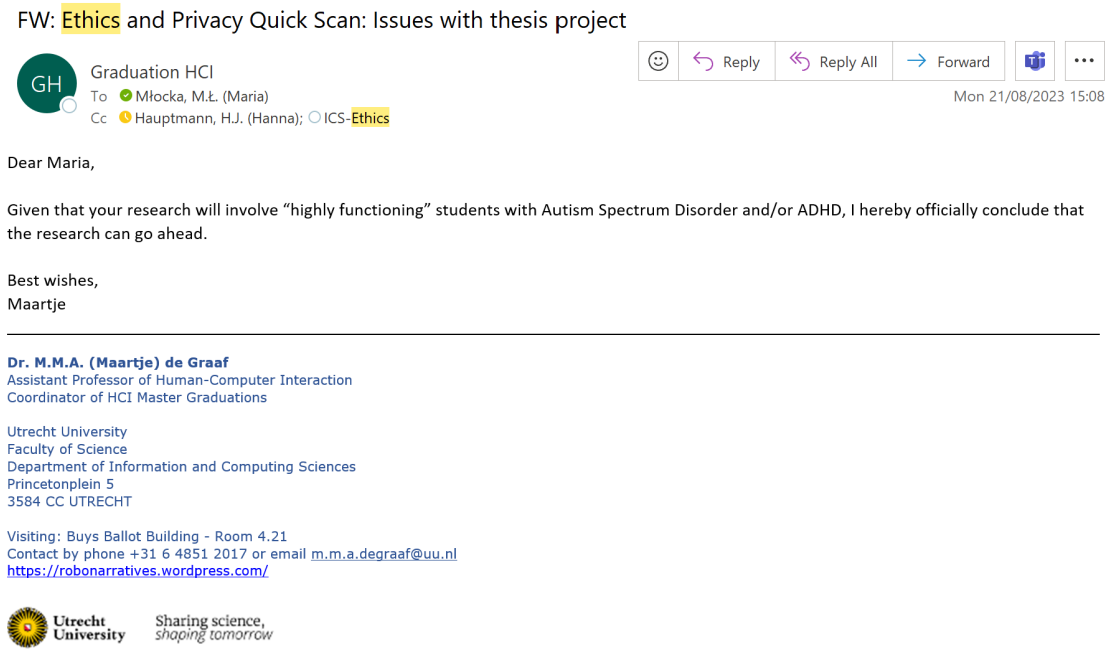


Figure 38. *Page with functionality to create a username.*

G Appendix F: Ethics Scan



FW: Ethics and Privacy Quick Scan: Issues with thesis project

Graduation HCI
To Młocka, M.Ł. (Maria)
Cc Hauptmann, H.J. (Hanna); ICS-Ethics

Reply | Reply All | Forward

Mon 21/08/2023 15:08

Dear Maria,

Given that your research will involve "highly functioning" students with Autism Spectrum Disorder and/or ADHD, I hereby officially conclude that the research can go ahead.

Best wishes,
Maartje

Dr. M.M.A. (Maartje) de Graaf
Assistant Professor of Human-Computer Interaction
Coordinator of HCI Master Graduations

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Figure 39. *Ethics and Privacy Quick Scan - approval email*