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Bachelor in Computer Science

CHALLENGES AND OPPORTUNITIES FOR NEURODIVERGENT SOFTWARE ENGINEERS

MODERN CODE REVIEWS AND BUG FINDING

MASTER IN COMPUTER SCIENCE

NOVA University Lisbon
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ABSTRACT

Context: People with neurodiversity, such as [Autism Spectrum Disorder \(ASD\)](#), may struggle to integrate and succeed in society. As neurodiverse individuals increase in software engineering, understanding and supporting their challenges, especially in code reviews, are crucial. However, knowledge about these specific challenges remains limited.

Objectives: This study explores the experiences of individuals with [ASD](#) in diverse software engineering contexts, aiming to create a more inclusive environment for neurodivergent software engineers. We align with the United Nations' Sustainable Development Goals 4 (Ensure inclusive and equitable quality education) and 10 (Reduce inequality within and among countries) to enhance the representation and success of individuals with [ASD](#) in higher education and the software engineering industry.

Methods: The research uses the Socio-Technical Grounded Theory methodology, which uses semi-structured interviews to formulate a theory on the skills and challenges of individuals with [ASD](#) in software development. Seventeen individuals in software engineering roles with [ASD](#) were interviewed, followed by an evaluation survey.

Results: Our research describes the strengths of autistic individuals in software development, such as logical thinking, hyperfocus in programming, learning of new programming languages, and attention to detail. We also highlight challenges such as preferring written communication, adapting to new software, and social communication struggles, stressing the need for tailored workplace support. Our proposed recommendations for companies include flexible communication methods, structured training, supportive environments, and personalized professional development, aiming for inclusive workplaces for autistic software developers.

Conclusions: Autistic individuals offer unique skills and traits in software development and code reviews, differing from neurotypical individuals. With specific accommodations, most challenges they face can be mitigated. Companies should actively consider them in job applications due to their significant contributions.

Keywords: Autism Spectrum Disorder, Software Engineering, Neurodiversity, Code Reviews

RESUMO

Contexto: As pessoas com neurodiversidade, como a [Perturbações do Espectro do Autismo \(PEA\)](#), podem ter dificuldades em integrar-se e ter sucesso na sociedade. À medida que o número de indivíduos com neurodiversidade aumenta no campo da Engenharia de *Software*, é crucial compreender e apoiar os seus desafios, particularmente no contexto de revisões de código. No entanto, o conhecimento sobre estes desafios específicos continua a ser reduzido.

Objetivos: Este estudo explora as experiências de indivíduos com [PEA](#) em diversos contextos de Engenharia de *software*, com o objetivo de promover um ambiente mais inclusivo para engenheiros de *software* neurodivergentes. Adicionalmente, alinhamos com os Objetivos de Desenvolvimento Sustentável 4 (Assegurar uma educação de qualidade inclusiva e equitativa) e 10 (Reduzir a desigualdade dentro e entre países) das Nações Unidas, com o objetivo de melhorar a representação e o sucesso dos indivíduos com [PEA](#) no ensino superior e no setor da engenharia de *software*.

Métodos: A investigação usa a metodologia de *Socio-Technical Grounded Theory*, que recorre a entrevistas semi-estruturadas para formular uma teoria sobre as competências e os desafios dos indivíduos com [PEA](#) no desenvolvimento de *software*. Entrevistámos 17 indivíduos em funções de Engenharia de *Software* com [PEA](#), seguidos de um questionário.

Resultados: A nossa investigação descreve os pontos fortes dos indivíduos com [PEA](#) no desenvolvimento de *software*, tais como o pensamento lógico, o hiperfoco na programação, a aprendizagem de novas linguagens de programação e a atenção ao pormenor. Também destacamos desafios como a preferência pela comunicação escrita, a adaptação a um novo *software* e as dificuldades de comunicação social, sublinhando a necessidade de apoio personalizado no local de trabalho. As recomendações que propomos para as empresas incluem métodos de comunicação flexíveis, formação estruturada, ambientes de apoio e desenvolvimento profissional personalizado, com o objetivo de criar locais de trabalho inclusivos para programadores com [PEA](#).

Conclusões: Os indivíduos com [PEA](#) oferecem competências e características únicas no desenvolvimento de *software* e nas revisões de código, diferindo dos indivíduos neurotípicos. Com adaptações específicas, a maioria dos desafios que enfrentam pode ser

atenuada. As empresas devem considerá-los ativamente em candidaturas de emprego devido às suas contribuições significativas.

Palavras-chave: Perturbações do Espectro do Autismo, Engenharia de *Software*, Neurodiversidade, Revisão de Código

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GLOSSARY

- Computer mediated communications** any human communication that occurs through the use of two or more electronic devices [21].
(p. 84)
- Neurotypical** not affected with a developmental disorder and especially autism spectrum disorder; exhibiting or characteristic of typical neurological development [59]. (p. 5)

ACRONYMS

ADHD	Attention Deficit Hyperactivity Disorder (<i>pp. 5, 7</i>)
ASD	Autism Spectrum Disorder (<i>pp. iv, 1–6, 8, 9, 80, 82, 83, 85, 86, 88, 89, 91, 92</i>)
ASQ	Autism-Spectrum Quotient (<i>pp. 7, 8</i>)
CMC	Computer mediated communication (<i>p. 84</i>)
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (<i>p. 6</i>)
GT	Grounded Theory (<i>pp. 15–17</i>)
HFA	High Functioning Autism (<i>pp. 7, 87</i>)
IDE	Integrated Development Environment (<i>pp. 36, 37, 49, 77</i>)
NDI	Neurodivergent Individuals (<i>pp. 1, 2</i>)
PDD-NOS	Pervasive Development Disorder-Not Otherwise Specified (<i>p. 7</i>)
PEA	Perturbações do Espetro do Autismo (<i>p. v</i>)
STGT	Socio-Technical Grounded Theory (<i>pp. 17, 30</i>)
VCS	Version Control System (<i>pp. 10, 81</i>)

INTRODUCTION

Code Reviews is an important part of software development that helps to ensure the quality and reliability of the software. However, for **Neurodivergent Individuals (NDI)**, this process can present some challenges. With this thesis, we aim to explore these same challenges, as well as the opportunities that neurodivergent software engineers or students in this field face during code reviews as well as programming in general. By gaining insight into their experiences, this study aims to identify where neurodivergent individuals, more specifically individuals diagnosed with **ASD**, are particularly good and how their skills can be leveraged in software development teams. Additionally, we intend to provide recommendations for making code reviews more accessible and accommodating for these individuals. This intention also applies to programming.

This chapter will provide an overview of the context of the problem, the motivation behind it, and the objectives of this thesis.

1.1 Context and Description

NDI are people who have a variation in human neurocognition and whose neurological states are atypical [55]. This atypical state comes with many challenges, e.g. poor communication skills, difficulty working in teams, and low emotional intelligence [9]. However, it also has some advantages, such as attention to detail, fine motor skills, logical reasoning, and concentrativeness [47], particularly for companies in the computer science industry [9].

For example, many people with **ASD**, one of the conditions included in the neurodiversity umbrella term, have an interest in technology and when in school, are more likely to pursue education and careers in STEM (science, technology, engineering, and mathematics) subjects [92]. In the United States, an estimated 49,000 autistic students graduated high school in 2015 [93], with many expected to pursue higher education. As promising as this sounds, research [5, 89] has indicated that these students have lower graduation rates and lower rates of post-graduation employment, compared to those without **ASD**. In 2020, it was estimated that the post-secondary graduation rate of students with **ASD** is

only 38.8% [89]. Therefore, it is highly important to do research about individuals with higher levels of functioning as they exit high school.

Research also shows that most of the population of autistic individuals tend to be good at focusing on tasks, attention to detail, and having a way of thinking that is good for many Software Engineering activities[83]. Due to the current and growing lack of skilled workers in technology, it is especially important to consider hiring individuals with Autism. To provide individuals with ASD with equal employment opportunities that align with their skills, it is crucial to investigate how we can make education more inclusive and accommodate these students. Sylvia Stuurman et al. discuss inclusive education and create a set of guidelines for that same purpose for students within the autism spectrum, based on the differences in the cognitive style that characterizes autism and the cognitive demands in Software Engineering [83].

One important area of research is the NDI's performance in **code reviews**. Code review is a well-known best practice in both the open-source and proprietary software industries, and it involves having other team members criticize changes to a software system [53]. Because the software industry continues to grow and there is a shortage of skilled professionals in the field, we would gain immensely from the unique skills of neurodivergent individuals.

Because the number of employees in software engineering is growing and having NDI can be a challenge and, as said before, accommodations may be required, it is essential to know where NDI can thrive and achieve the most success.

An important aspect of software engineering is identifying and fixing bugs in code. To gain a deeper understanding of how individuals with ASD might excel in this area, an interview study is going to be conducted to understand what are the strengths and challenges for autistic individuals in code reviews and software development. This way we will be able to gain valuable insights into how to best use the strengths of individuals with autism in the software engineering field.

1.2 Motivation

All the conditions that are part of neurodiversity are important and deserve to be studied. While it would be ideal to work with all neurodivergences, the reality is that time constraints limit the scope of my work. Therefore, I have decided to focus on ASD as my primary area of focus within neurodiversity. This decision was partially influenced by the abundance of research and resources available on ASD, making it easier for me to delve into this topic and make meaningful contributions. However, I want to emphasize that all neurodivergences are valuable and deserving of attention, and I hope to contribute to the understanding and support of all neurodivergent individuals.

According to the Centers for Disease Control and Prevention, the prevalence of ASD has significantly increased in recent years, with approximately 1 in 44 children currently being diagnosed with the condition. This is a marked increase from the prevalence in

2000 when 1 in 150 children were diagnosed with ASD. Boys are also significantly more likely to be diagnosed with ASD than girls, with the condition occurring 4 times more commonly in males [24]. The higher prevalence of ASD may be due, in part, to an increase in the number of diagnoses being made. In addition, nowadays women tend to have children later in their life [50], and according to a review made in 2012 by Sandin et al., there is an association between advancing maternal age and risk of autism [70, 26].

Much research about ASD is focused on children and the development of technology to diagnose this condition earlier or to help with their condition (examples: [46], [84], [96]). This is understandable because usually, appropriate interventions at a young age are valuable in the treatment of it. In this thesis, I'm going to focus on young adults in the field of Computer Science.

Morris et al. conducted a survey that reinforced the suggestion of the interviewees that neurodiverse software developers perceive themselves as more skillful at focusing intensely on tasks and noticing patterns in code than neurotypical employees [56].

The software development industry relies heavily on code reviews and bug finding as an important quality assurance process. However, these processes are often performed by neurotypical individuals who may not have the same strengths and abilities as those with ASD.

Research has shown that individuals with ASD possess exceptional attention to detail and a strong ability to focus on repetitive tasks [22], making them well-suited for identifying specific kinds of bugs in code. Additionally, individuals with ASD may have a different perspective on problem-solving, which can lead to the identification of bugs that may have been missed by neurotypical individuals.

This dissertation aims to explore the potential benefits of incorporating individuals with ASD in code reviews and bug-finding processes and to identify strategies for promoting the inclusion of individuals with ASD in Software Engineering.

1.3 Objectives

By the end of this dissertation, the objective is to increase understanding of how individuals with ASD detect errors in source code and perform code reviews compared to neurotypical individuals. We aim to identify in which tasks of code reviewing they excel and how can their skills be used at their maximum. Additionally, we aim to explore potential strategies for providing better support for people with ASD in Software Engineering, especially when performing code reviews.

The **research questions** that are going to guide this dissertation are:

1. How can we help individuals with ASD thrive in the field of Software Engineering?
2. What strengths and challenges do individuals with ASD have when conducting code reviews?

3. How can software development teams and companies leverage the skills of individuals with [ASD](#)?

1.4 Document Structure

The remainder of this dissertation is organized as follows:

- [Chapter 2 Background](#) - This chapter provides a context for the research being conducted and explains some key topics. In this thesis, we focused on Neurodiversity, Autism Spectrum Disorder, Code Reviews, and Bug Finding. It also tackles the methodology we are going to use - Grounded theory.
- [Chapter 3 Recruitment and Interviews](#) - It explains the methodology employed for data collection and the specific recruitment techniques harnessed during the process. Furthermore, it offers insights into the target population that was interviewed, accompanied by pertinent statistical data. In addition to this, the chapter delineates the procedural intricacies of conducting interviews, as well as a comprehensive description of the transcription methodology implemented.
- [Chapter 4 Data Analysis](#) - It describes the stages of the emergent mode of our theory. We explain our coding process by giving some examples and how we got to theoretical structuring.
- [Chapter 5 Theory Development](#) - It goes into several categories and relationships between the categories that we found by analyzing our data. It presents the theory on the challenges and opportunities for autistic individuals when programming and conducting code reviews.
- [Chapter 6 Theory Discussion](#) - This chapter reflects on the theory and the different impacts of its categories. It also presents some context-based new software development practices.
- [Chapter 7 Evaluation Survey](#) - In this chapter, it is discussed the evaluation survey and the analysis of its data.
- [Chapter 8 Related Work](#) - This chapter provides an overview of the research that already exists that is related to the topic of this dissertation, such as Autism Coding Camps, Guidelines to Improve the life of Autistic People.
- [Chapter 9 Conclusion](#) - It presents the conclusions of the thesis as well as possible future work.

BACKGROUND

2.1 Neurodiversity

Neurodiversity describes the idea that people experience and interact with the world around them in many different ways. It acknowledges that there is no one "right" way of thinking, learning, and behaving, and differences should not be considered as shortcomings [9]. On the other hand, *Neurotypical* is the word to describe the individuals that don't have a neurodivergence. While the term *neurodiversity* is most often used in the context of *Autism Spectrum Disorder (ASD)*, it can also be applied to other neurological conditions such as *Attention Deficit Hyperactivity Disorder (ADHD)* and dyslexia. Additionally, in a higher education context, the concept of neurodiversity has evolved to include many types of learning disabilities, including Asperger's Syndrome as well as dyslexia, dyspraxia, and dyscalculia [36].

According to the National Cancer Institute, an estimated 15-20 percent of the world's population exhibits some form of neurodiversity [80]. In 2014, the *ADHD* worldwide-pooled prevalence was 5.29% [64]. Considering dyslexia, in 2011, 10% of the population had it, which represents 70 to 80% of the language-based learning disabilities [66].

Neurodiversity has become a movement in the late 1990s, so far dominated primarily by autistic individuals who see their condition as a characteristic to be respected rather than a disease to be cured. This movement has had a very positive impact on how society views and understands autism and aims to increase acceptance and raise awareness for all neurodivergent individuals. The neurodiversity movement is historically connected to a shift away from psychoanalysis and toward a neurobiological and genetic understanding of autism. The emergence of this movement was accompanied by the development of two opposing viewpoints: *pro-cure* which is expressed by neurodiversity advocacy groups and *anti-cure*, expressed by parents and practitioner groups. The pro-cure perspective believes in seeking and using therapies, including behavioral and psychopharmacological treatments, while the anti-cure viewpoint argues against the use of these therapies and supports accepting and valuing neurodivergent individuals as they are, without trying to cure their conditions [62].

Neurodivergent individuals may exhibit behaviors such as poor communication skills, difficulty working in teams, low emotional intelligence, and poor persuasiveness. However, they may also possess unique strengths that can improve productivity, quality, innovation, and engagement in the workplace. As John Elder Robison said, "People with differences do not need to be cured; they need help and accommodation" [9]. In this dissertation, we adopt this viewpoint, recognizing the value of accepting and appreciating these individuals while leveraging their exceptional abilities. As software engineers, we can contribute by developing tools and environments that empower neurodiverse developers, promoting inclusivity and enabling them to thrive as essential members of the software engineering community.

2.2 Autism Spectrum Disorder

ASD is a lifelong neurodevelopmental condition characterized by particular cognitive styles, communication behaviors, social interactions, and repetitive behaviours[99]. Although it can be detected in the early years of life, many people do not receive a diagnosis until much later.

In this thesis, we are going to be using the terms **ASD**, autism, and autism disorder interchangeably.

ASD can be detected as early as 18 months old, and it can be diagnosed by the age of 2 [46]. The diagnostic criteria for **ASD** are outlined in the [Diagnostic and Statistical Manual of Mental Disorders \(DSM-5\)](#). One of the most commonly used methods for diagnosing autism is **Autism Diagnostic Interview-Revised (ADI-R)**, which involves a highly standardized interview with a parent or caregiver, conducted by an experienced interviewer, and the results are scored and interpreted using a Diagnostic Algorithm, a Current Behaviour Algorithm, or both. Another method is the **Autism Diagnostic Observation Schedule (ADOS)**, which consists of various activities that allow the professional to observe social and communication behaviors [69]. Because **ASD** is a spectrum, it presents itself in different degrees of severity, from severe to milder forms. [DSM-5](#) classifies it into three different severity levels. These levels are determined by the level of support an individual requires to function in daily life:

- **Level 1** - Individuals included in this group typically have very subtle symptoms that do not interfere with their ability to function at school, work, or in relationships.
- **Level 2** - Individuals in this group need more support, such as speech therapy to improve language skills or interventions aimed at social skills and reducing repetitive behaviors.
- **Level 3** - Individuals included in this group depend a lot on support for most tasks, and always need to have someone around to assist them. They may have difficulty

with social interactions, communication, and adaptive skills, making it hard for them to participate in age-appropriate activities.

Another way to classify individuals with autism is by their level of cognitive functioning. When an individual with autism has an intelligence quotient (IQ) within the normal range or above, they are said to have **High Functioning Autism (HFA)**. On the other hand, if they meet all of the **HFA** criteria except for issues with communication or a history of language delays, they are considered to have **Asperger Syndrome** [12], which is now classified as Level 1 or Level 2 Autism. There is still another disorder that is called **Pervasive Development Disorder-Not Otherwise Specified (PDD-NOS)**. The latter disorder does not have specific criteria and it is often used to diagnose children that have some autistic symptoms but also present other disorders, such as **ADHD** or learning disorders [91].

In recent years, the categorization of autism has evolved into a single autism spectrum based on two domains, social communication, and restricted, repetitive, or unusual sensory-motor behaviors. This spectrum includes subtypes such as:

- Asperger's Disorder;
- Pervasive Developmental Disorder Not Otherwise Specified;
- Autistic Disorder;
- High Functioning Autism.

People with Autism can often present strengths to the software engineering field such as attention to detail, logical reasoning, focus, systemizing, consistency, visual skills, creative solutions, retentiveness, repetitive tasks, numbers, auditory skills, and concentrativeness [47], which can translate into valuable qualities in this sector.

2.2.1 Prevalence

The prevalence of autism continues to rise. In Portugal alone, 50 thousand people were diagnosed with some perturbation from the Autism Spectrum in 2020 [49]. According to the Centers for Disease Control and Prevention, the prevalence of autism is approximately 1 in 44 children currently. Although we could not find specific data on the prevalence of autism among college students, there is a study conducted by Baron-Cohen that suggests an elevated prevalence of autistic individuals in STEM-related careers [12]. Another study conducted in 2011 in the US, focused on **HFA** among college students. This research included a sample of 685 students, where 667 participants had complete **Autism-Spectrum Quotient (ASQ)** data. The participants were undergraduate students enrolled in a large, technology-oriented, public university in the southeastern United States. Based on the data, they estimated that between 1 in 130 and 1 in 53 college students likely meet the criteria for **HFA** [95].

To the best of our knowledge, there is only one study that discusses the prevalence of individuals with ASD regarding Computer Science majors, to this date, conducted by White et al. [95]. The results of this study indicated that there is a relation between computer science majors and higher scores on the autism traits measurement tool called ASQ. They found that the majority, over 50 percent of the university students who scored high on the ASQ were pursuing computer science, compared to just 28 percent of those who had lower scores. This indicates that, in general, computer science students tend to score relatively high on the ASQ.

To the best of our knowledge, no studies focus specifically on the prevalence of autism in the population of Software Engineering students and professionals. However, Stuurman et al. [83] focus slightly on this topic but never give an estimate of the prevalence, as said in the study *measuring the prevalence of autism among students is difficult. It is not possible, for obvious reasons, to diagnose each student as part of an investigation.*

2.2.2 Strengths and Challenges of Autistic People in Software Engineering

People with Autism often have difficulties adapting and finding employment, though they have specific characteristics that are great for working with technology. These people usually have a strong aptitude for technical subjects, such as coding and programming, and may excel in tasks requiring focus, concentration, and factual knowledge [86]. Additionally, autistic individuals may be attracted to software development due to the repetition and precision required in this field [13].

Some of the benefits that these individuals can bring include high levels of concentration and focus, reliability and dependability, attention to detail, and accuracy [22].

Stuurman et al. [83] did research about the difference between the cognitive thinking style of individuals with Autism and computational thinking. They categorize the computational thinking style into three components:

- algorithmic thinking
- computational steps and algorithms
- abstraction and decomposition

The researchers found that abstraction is a skill that is challenging for individuals with an autistic cognitive style, and that generalization is difficult for them. They also found that for the skill of decomposition, students with an autistic cognitive style may face barriers. On the other hand, they highlighted bottom-up algorithmic thinking as a notable strength within autism. Comparing the autistic thinking style to engineering thinking, they found that individuals with autism excel in synthesis tasks, showing no significant difficulties in this area. Moreover, they noted that concrete thinking, which is the default cognitive mode for students with an autistic cognitive style, is also managed without notable difficulties.

Van Hees et al. conducted interviews with 23 autistic students still attending university, living in Flanders, to better understand the challenges and benefits they face in higher education. Regarding benefits, these students presented strong memory, focus precision and dedication, analytic skills, remarkable powers of observation, sincerity, and impartiality, and finally willingness to listen to others [88].

Individuals with Autism often struggle with social and emotional skills, usually present repetitive behaviors, and may lack nonverbal communication skills [60], which can make it difficult for them to interact with others and be considered for employment. Beyond the profound social-communication problems that are often characteristic of ASD, the condition is also associated with a range of non-social symptoms such as hypersensitivity and hyposensitivity to perceptual stimuli [44].

More specifically, students with this disorder can face difficulties with new situations and unexpected changes, social relationships, problems with information processing and time management, and many of them have doubts about disclosing their condition. These struggles can also lead to mental health issues, such as feeling overwhelmed, stressed, anxious, depressed, tired, and isolated [88].

In this thesis, I'm going to focus on individuals with ASD levels 1 and 2, as most individuals with autism working in the software engineering field have one of these two latter forms.

2.2.3 Current interventions and support strategies

ASD is recognized as a condition for which various treatments and therapies are available that can greatly improve the quality of life for individuals with autism. The emergence of the autistic community, a group composed of people with autism, is helping to shift this perspective. The actions and activism of this community are moving autism away from being viewed as a biomedical diagnosis and into a political issue. Community members are advocating for a change in societal attitudes towards autism, and for autism to be seen as a characteristic of an individual rather than a deficiency [11].

One way to improve the inclusion of individuals with autism in society is by providing specific accommodations that help them overcome their challenges and fully use their abilities. These accommodations can enable individuals with autism to learn, adapt, and thrive in their environment. As suggested by an article by Sally Lindsay and colleagues, there are various strategies that can be implemented to support individuals with autism in the workplace, for example, [45]. These measures are going to be discussed later in chapter 8.

2.3 Software Engineering

Software Engineering is defined as “The established and use of sound engineering principles in order to obtain economically developed software that is reliable and works

efficiently on real machines” by Fritz Bauer [32] at the first conference on Software Engineering in 1968. This area is evolving rapidly, and it plays a vital role in today’s technology-driven world. It is present in our lives in every aspect, including living, working, learning, and education [2].

2.4 Code Reviews

Code review is a widely used software engineering practice in both open source and industrial contexts [10]. Here we are going to focus on **Modern Code Reviews**. This form of code review has evolved from its traditional focus on discovering defects to a more collaborative approach for solving problems [53].

In the early days, code reviews used to be conducted in in-person meetings with the reviewer(s) and the author of the code, with dedicated time allocated for preparation [30]. However, the modern reviewing process is considered to be lightweight, more informal, and asynchronous, occurring regularly in practice nowadays, and there are even tools that support this process [17], such as *Gerrit*. These tools specifically connect changes to a software system recorded in a [Version Control System \(VCS\)](#) to the related code review [53].

2.4.1 Importance of Code Reviews

Code Reviews play a crucial role in software development. By catching defects before the testing phase, code reviews can significantly reduce the number of defects found during the testing phase in small development teams [53]. In fact, an inspection can lead to the detection and correction of anywhere between 50 and 90 percent of defects [27]. One of the key benefits of code reviews is the ability to review code without actually running the software. This is especially important in situations where the code is not yet complete, the necessary hardware may not be available, or the proper environment has not been set up.

In a study by Bacchelli and Bird [10], 17 industrial developers were observed and interviewed while performing code reviews, and 165 managers and 873 programmers were surveyed. Their findings showed that code reviews provide a wide range of benefits to software teams, including knowledge transfer, increased team awareness, and improved problem-solving. The study also highlighted the importance of understanding the context and changes in the code during the review process. Overall, Bacchelli and Bird’s study highlights the many benefits that code reviews can provide to software teams and the importance of considering the context and changes in the code during the review process.

2.4.2 Code Review Processes

We can have formal and informal reviews. Walkthroughs and demonstrations are considered informal. Inspections and audits are considered formal.

The most common software review processes are [51, 74, 75]:

- **Formal:**
 - Inspections;
 - Audits;
- **Informal:**
 - Walkthroughs;
 - Demonstrations.

Code **inspections** are one of the first formalized processes for code reviews. They can be described as a formal, efficient, and economical method of finding errors in design and code. An inspection team is chosen, consisting of members who take on specific roles such as moderator, designer, coder, and tester. The collaborative nature of this setup requires strong social interaction and communication skills. These synchronized meeting inspections should take around 1 hour not exceeding more than two hours and should be conducted regularly. According to Fagan, delaying early error detection can lead to longer project schedules and increased costs [30]. In the meetings, there are several problems that can be detected. These include issues that remain unresolved, issues for which changes were made only to improve readability or enforce coding standards, and issues for which changes were made to fix requirements or design violations, or to improve system efficiency [65].

In order to perform inspections in the most effective and efficient way, **reading techniques** can be applied when going through the artifacts. The most common way of measuring the effectiveness of a reading technique is its ability to find as many defects in the product as possible [27].

The most common reading techniques are [27, 6]:

- ***ad hoc* reading** - This is a non-systematic way of finding defects and with this technique, the inspectors do not follow guidelines or directions.
- **checklist-based reading** - more systematic than the *ad hoc* technique. Here the reviewers are provided with a list of general defect classes to check against.
- **defect-based reading** - In this technique, the defects are classified and a set of questions is developed for each defect class. They are tailored to a specific formal notation.
- **perspective-based reading** - With this technique the inspectors adopt a certain perspective choosing different roles such as tester, designer, and user, and then try to answer questions specific to that role.

Although **pair programming** is not a type of code review, it should be analyzed because it includes code reviewing processes. Pair programming is where two programmers develop software side by side on one computer, according to Cockburn and Williams [20]. This approach has its advantages and disadvantages. Some argue that it is inefficient to allocate two individuals to a single task, while others contend that it leads to faster development, cleaner code designs, and easier maintenance. Cockburn and Williams also note that while the development cost increases by around 15%, the benefits in terms of reduced testing, quality assurance, and support costs justify this investment. By catching errors during development rather than later stages, pair programming facilitates a more streamlined defect removal process [20].

A more recent approach to code reviews is the **pull-based model**, which is one of the most popular contribution models in distributed software development. In this model, external contributors can propose changes to a software project without needing access to the central repository. To do that, one can create a fork of the central repository, work independently and, whenever ready, request to have their changes merged into the main development line by submitting a pull request. This method is mostly adopted by collaborative platforms such as: *BitBucket*, *Gitorius*, and *GitHub*. It allows for more reviews but also creates the need for more qualified reviewers. Because anyone can submit a review, it is necessary to analyze them and to decide which ones should be accepted/rejected, which is done by a responsible manager of the core team [97].

Figure 2.1 provides a simplified overview of the workflow of these modern code reviews. First, the author of the code creates a set of patches with a description of the changes and submits that information to the code review tool, creating a pull request. Then, the patch is assigned to one or more reviewers, which are notified by the code review tool. During the review, the tool highlights the changes and the reviewers thoroughly inspect the patch and look for issues. Then the reviewers provide feedback to the author and discuss any issues that were found during the review. The author proceeds to update the code. This process repeats until no more issues need to be resolved, the reviewers approve the changes and the patch is merged into the project repository [17].

2.4.3 Tools

Modern code reviews are often supported by tools, preferably integrated into the development environment (IDE) [15]. Code review tools are increasingly being adopted as a solution to the challenges faced by traditional code inspections. These tools assist in mitigating the disadvantages of traditional code reviews, such as the significant time investment required both before and during formal code inspections, as well as the high costs associated with them.

A common review tool is *CodeFlow* [10]. It is a collaborative code review tool that allows users to directly annotate source code in its viewer and interact with review participants in a live chat model. This allows for the author and reviewer to work on the review at the

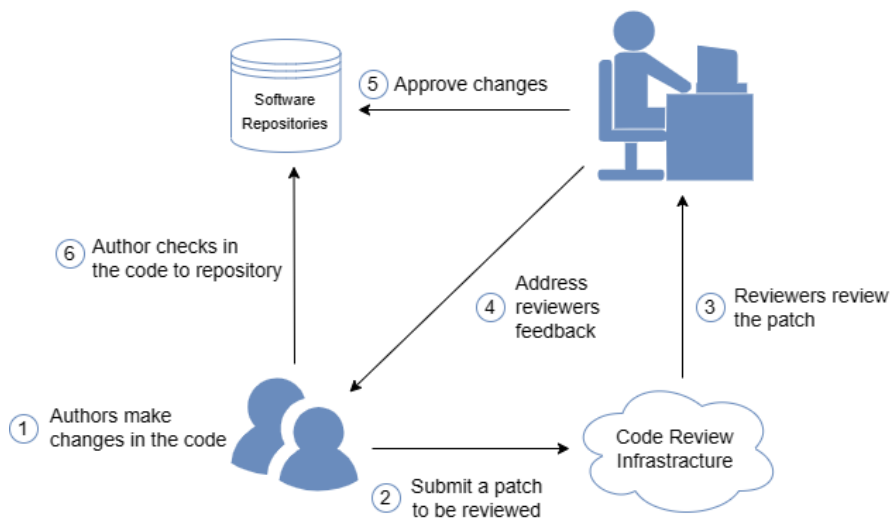


Figure 2.1: Workflow of Modern Code Review [17, 68]

same time, the communication is synchronous and comment threads act similar to instant messaging. Other popular code review tools include Google’s *Mondrian*, Facebook’s *Phabricator* or open-source *Gerrit*, *Github’s* review system, which works with pull requests [10].

Additionally, **static analysis** tools, also known as source code analyzers, can examine the text of a program without attempting to execute it, in order to find and fix bugs vulnerabilities, and security risks. In comparison to only using code reviews, this tool makes it faster, which actively demonstrates that a program can be evaluated with more frequency. Static analysis also has the potential to be applied before a program reaches a level of completion at which testing can be meaningfully performed. One advantage of a source code analyzer is that is painless and easy. Modern approaches to static analysis can now process on the order of millions of lines of code quickly and efficiently [52]. Some of the best static code analysis tools in 2023 include *SonarQube*, *Checkmarx SAST*, *Synopsys Coverity*, *Micro Focus Fortify Static Code Analyzer*, *Veracode Static Analysis*, *Snyk Code* [98].

2.5 Bugs in Code

A bug is a program behavior that deviates from its specification [4] that every programmer has likely encountered at some point. Even well-tested code written by experts contains a surprising number of obvious bugs, which results in unwanted outcomes for both end users and developers [41]. A failure is an event that occurs when the delivered service deviates from the correct service. A fault is the cause of a failure, and *bugs* and *defects* are synonyms of faults [85]. Detecting defects in software is a persistent topic since every software has bugs [87]. There are several automatic techniques and tools to help find bugs and improve software quality. However, there is still a lot of work that the developer needs to do on his own. One of these techniques is code inspections, which we referred to

in section [2.4.2](#).

David Hovemeyer and William Pugh make a distinction between bugs and style [\[41\]](#). They report that bug checkers use static analysis to identify code that violates specific correctness properties and may cause the program to malfunction at run time. They note that adhering to style rules is important for the readability and maintainability of code, but breaking them does not necessarily result in bugs. It is a good idea to follow style rules when someone is doing a large project with other developers, and that way, everyone can follow the code better. Tools like *PMD* and *CheckStyle* are widely used for style checking. On the other hand, bug checkers are not as much used as one would expect [\[41\]](#).

These researchers even developed an open-source tool, called *FindBugs* in 2004. It was designed to detect code idioms also known as "bug patterns" which are likely to be errors. These bug patterns are places where code does not follow the usual correct practice in the use of a language feature or library API. It initially detected 50 bug patterns. This tool which used static analysis tools to detect bugs in code was abandoned in 2015 and gave place to *SpotBugs*. The latter being a fork of the previous tool, with now being able to detect around 400 different types of bugs and bad practices in Java code [\[79\]](#).

In programming, the most common errors can be classified into 5 different categories [\[42, 73, 85\]](#):

- **Syntax errors or Compile time error** - Errors that prevent code from running due to incorrect syntaxes, such as missing semicolons, brackets, or class not found. These errors are detected by the Java compiler and an error message is displayed while compiling.
- **Semantic errors or Logic errors** - Errors that occur when the program compiles and runs, but produces an incorrect result or no output when it should be producing output. These errors are not detected by the compiler or JVM. The Java system does not know what the program is supposed to do, so it provides no additional information to find the error.
- **Runtime errors** - Errors that are detected during the execution of a program. These can occur when a user enters invalid data or when a program asks the computer to do something it cannot reliably do. These errors are not detected during compilation and are detected by the JVM while the program is running.
 - **Memory errors** - Errors that are a specific type of runtime error. They are caused by improper handling of memory objects. These errors include stack overflows and are very difficult to detect and fix because they depend on the state of the program.
 - **Concurrency errors** - Also an error that is a type of runtime error. These occur when multiple threads or processes are executed concurrently in a program. They have synchronization problems among the concurrent tasks in concurrent programs, leading to data races and deadlocks.

2.5.1 Summary

Education for developers is important for identifying and avoiding making errors in source code and programming in general. Developers who can understand the best practices and who know the most common mistakes in their programming languages can write code with fewer bugs. This is important because they can understand better how to use automated tools and techniques more efficiently for identifying and even preventing bugs in the code. Writing code that is less likely to have bugs is going to make development less time-consuming and more cost-effective in the long run. In addition, developers need to continue their education on new technologies in order for them to perform better.

2.6 Grounded Theory

Grounded Theory (GT) is a research method, founded by Glaser and Strauss, that seeks to generate a theory from the data collected during the research process. The initial analysis of the data begins without any preconceived categories. As interesting patterns emerge, the researcher repeatedly compares these with existing data and collects more data to support or refute the emerging theory. This method starts with a systematic, inductive approach to collecting and analyzing data to develop theoretical analyses [19]. This method adopts a more inductive approach but moves its analyses beyond induction. In contrast, many qualitative studies remain solely inductive. This method distinguishes itself from other methods by its comparative and iterative nature in every stage of analysis, making it an explicitly emergent method [19].

As Morses, one of Glaser and Strauss's students wrote [61]: "*Grounded theory is a way of thinking about theorizing from data so that the end result is a theory that the scientist produces from data collected by interviewing and observing everyday life*".

The process of **GT** consists of several **key components** that guide the researcher towards generating a theory [61]:

1. **Constant comparison:** This is the basic method used to create a theory out of empirical data. It involves repeatedly comparing new data with existing data in order to identify patterns.
2. **Theoretical sensitivity:** This refers to the ability of the researcher to be analytic.
3. **Theoretical sampling:** This is used to guide the next stage of data gathering. It is driven by developing the theory and it is not determined in advance.
4. **Theoretical saturation:** This phase indicates that researchers have thoroughly explored and understood the studied category, with no new data insights emerging. It

ensures data collection reaches a depth where additional information does not significantly change understanding. This stage is crucial for developing comprehensive insights and theories, and increasing study credibility.

The process of **GT** [61] starts with the researcher selecting a topic and beginning to gather data. This can be done by contacting communities or groups and conducting semi-structured interviews, which are recorded and then transcribed. The data analysis begins with Open Coding, which involves close reading and interrogation of the transcripts. During this phase, the focus shifts from the research field to the analysis of the data, as the researcher engages in simultaneous data collection and analysis [19].

Using constant comparison, the researcher generates concepts from the data and identifies emergent patterns and connections between pieces of data. Then theoretical sampling is used to guide the next stage of data gathering and to further develop and verify the concepts. This process continues until it reaches theoretical saturation.

Over time, Grounded Theory has evolved into three different versions. The first version was introduced by Barney Glaser in 1967 [34], one of the founding fathers of **GT**, and adheres to the original method. The second by Anselm Strauss and Juliet Corbin [82], and the third by Kathy Charmaz [19].

The original version was developed specifically for sociologists with language, format, and examples that may be a challenge for Software Engineering researchers to easily access and comprehend. This creates an obstacle for many software engineers who already struggle to grasp the traditional **GT** guidelines. To address this issue, Rashina Hoda introduced **Socio-Technical Grounded Theory** [40], to meet the needs of the software engineering community and improve the quality of **GT** outcomes in this field.

2.6.1 Socio-Technical Grounded Theory

Socio-Technical Grounded Theory is an iterative and incremental research method for conducting **GT** studies in *socio-technical* fields. It combines traditional techniques such as interviews and observation, and modern research techniques to generate novel, useful, concise, and modifiable theories.

This theory adaptation still uses traditional analysis techniques, comprising steps and procedures adapted from the three different versions of traditional **GT**, such as open coding and constant comparison, but complements it with modern analysis techniques such as sentiment analysis, data mining, and NLP. [40].

Some advantages of this new version of **GT** include exploring the use of cutting-edge tools and techniques such as artificial, virtual, augmented, and mixed-reality devices and platforms to achieve immersive and experiential data collection in natural and alternative realities. The improving efficacy of automation tools promises to ease and augment many research steps such as transcriptions, data collection, and even analysis.

In the **Socio-Technical Grounded Theory (STGT)** method there are two stages: Basic Data Collection and Analysis, and Advanced Data Collection and Analysis. For this thesis, we are going for the second stage because it leads to Theory Development.

In the advanced stage of **STGT**, researchers are presented with a choice between two modes of theory development: **emergent** and **structured**. The emergent mode allows for iterative and targeted data collection and analysis, facilitating the organic emergence of theory as recommended by Glaserian **GT**. This mode is more used when we have a broad initial topic where basic Data Collection and Analysis leads to strong categories but unclear theoretical structure. The structured mode enables a structured development of theory through structured data collection and analysis resulting in a mature theory that is structured and can be further integrated through theoretical integration. This last mode is used for relatively narrow initial topics where basic Data Collection and Analysis lead to a clear theoretical structure. These modes are depicted in Figure 2.2.

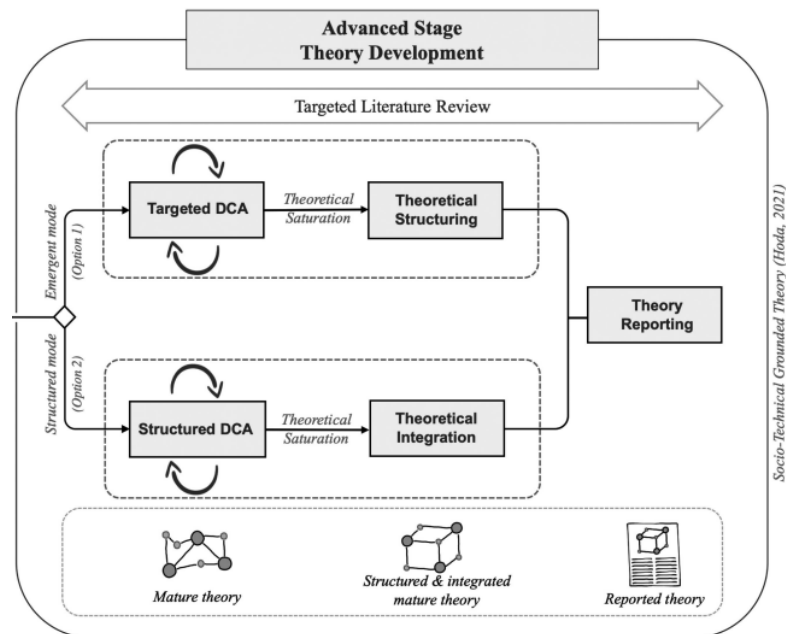


Figure 2.2: Socio-Technical Grounded Theory Method - Advanced Stage [40]

Both modes include a targeted literature review and theoretical sampling. Both modes also have advanced memoing and theoretical saturation in common, which are going to be described in Chapter 4. We selected the emergent mode over the structured mode because the emergent approach is ideal for investigating complex or broad phenomena lacking clearly defined categories or relationships initially. This mode offers flexibility in data collection and analysis, allowing patterns and themes to emerge naturally without predefined categories. In contrast, the structured mode is preferable when researchers have specific hypotheses or theories to test, and research questions are well-defined with clear expectations of outcomes or categories to explore.

RECRUITMENT AND INTERVIEWS

To initiate the theoretical investigation, it was essential to recruit individuals who satisfied the specified criteria for this study. Our search targeted individuals with a condition within the Autism Spectrum, as well as a certain level of expertise in software engineering, particularly in code reviews but not limited to it.

3.1 Population

The sample for our study was taken from several different sources. We were looking for individuals who had already some experience in this area. This is because these individuals would probably have a deeper understanding and experience of code reviews. Besides workers, we also interviewed some students, most of them already on their masters. Although these individuals could not provide a deeper understanding of code reviews, because they are not so used to doing that, they could give information on other topics such as their academic experience and their learning experience.

We could outline two distinct profiles:

- **Worker** - This was the primary target group for our study, given their expected experience. The participants in this category were mostly able to answer all of the questions during the interview because they had more experience in the field and in performing code reviews.
- **Student** - This group of individuals ended up not being so effective for the research, due to their limited experience in performing code reviews. However, they could provide an interesting point of view on programming and the learning process.

Table 3.1 presents some key details about the interviewees. In total, we conducted 17 interviews for our study. However, we could only include 16 of them in our analysis since one participant did not provide consent by signing the required form. Therefore, the statistics presented below will only include 16 of the interviews. The interview we took out was I-11.

The statistics tell us that 31,3% of the participants were students, 68,7% were already working and some were in the field of Computer Science; the majority of the participants were highly educated having a bachelor's or/and a master's. Regarding the age when they were diagnosed, the minimum age was 4 years old and the maximum age was 44 years old. We also noted that most of the participants were diagnosed at a late age. There were only two exceptions where individuals did not receive their diagnosis relatively closer to their current age. This could indicate that the majority of our participants might be considered highly functional, given the late age at which they were diagnosed, as we can see in Figure 3.1.

In terms of the gender distribution among the interviewees, 6 individuals (37,5%) identified as Female, while 10 individuals (62,5%) identified as Male. No participants identified as non-binary. The gender distribution in our study is noteworthy because typically women represent approximately one-quarter of autistic individuals. Additionally, women are underrepresented in the field of Computer Science, which would typically result in even fewer expected participants. However, in our sample, we managed to surpass this percentage.

ID	Age	Diagnosed Age	Gender	Occupation	Academic Degree
I-01	33	31	Female	Mechanical engineering student	Master
I-02	28	27	Female	Web design and special education student	Master
I-03	45	40	Male	IT industry worker	High school
I-04	41	41	Male	Unemployed	Bachelor
I-05	43	37	Male	Software developer	Master
I-06	25	6	Female	Bio-informatics student	Bachelor
I-07	33	32	Female	Computer science student	Bachelor
I-08	24	4	Male	Data engineer	Master
I-09	42	41	Male	Unemployed	Master
I-10	26	15	Male	Data engineer	Post graduation
I-12	26	23	Male	System Analyst and Developer	Bachelor
I-13	47	44	Male	Electrician	Bachelor
I-14	33	25	Male	Data Analyst	Master
I-15	34	32	Male	Linguistics Student	Master
I-16	20	19	Female	IT intern	High School
I-17	33	Late twenties	Female	Data Analyst	Bachelor

Table 3.1: Demographic details of interview participants

The average age for the interviewees is 33.31 years old, with the oldest being 47 years old and the youngest being 20 years old, the standard deviation is 8.255 years and the median is 33 years old. We can see this data in the Kernel Density plot for the age distribution of the participants in Figure 3.1, where the highest age density is between age

25 and age 35.

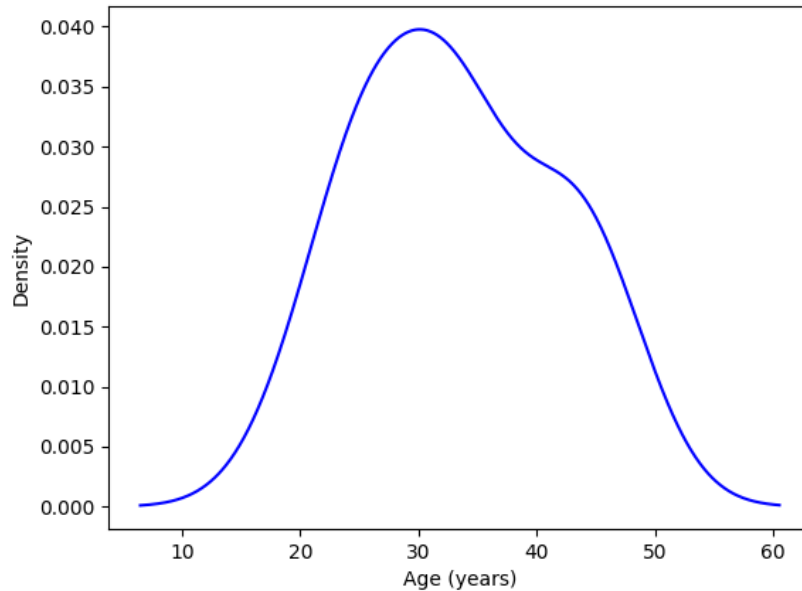


Figure 3.1: Kernel Density Plot for Age Distribution

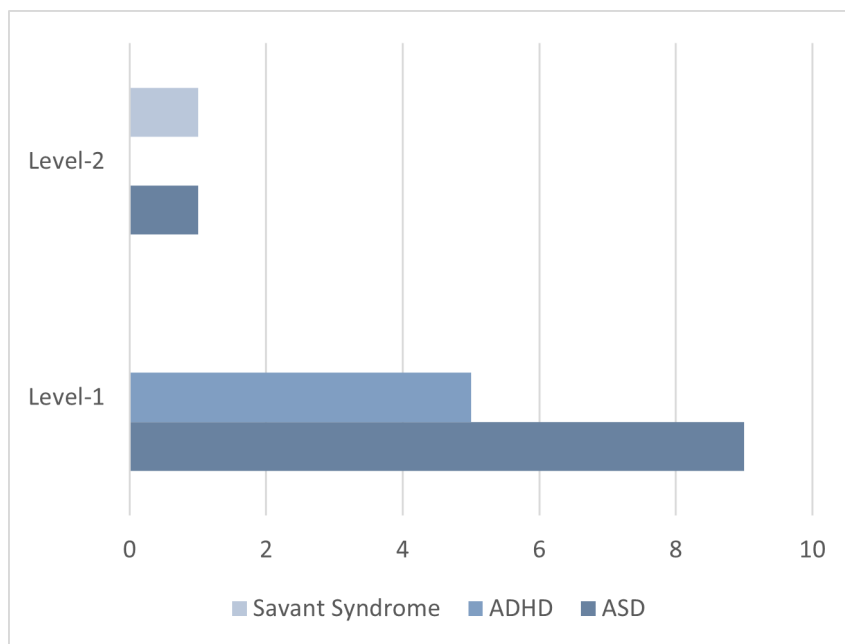


Figure 3.2: Distribution of ASD Diagnoses among Study Participants

Regarding the participants' diagnoses, we initially requested participants with a diagnosis of the Autism spectrum without specifying the specific level. There were some participants whose diagnosis was Asperger Syndrome, but this syndrome was removed in 2013 with the publication of DSM-5. Therefore, in our study, we referred to individuals previously diagnosed with Asperger Syndrome to ASD level-1. Out of the participants

we recruited, we had 14 individuals with ASD level-1, out of which 5 also had a diagnosis of ADHD. Additionally, 2 participants received a diagnosis of ASD level-2, and among them, 1 was identified with Savant Syndrome. We did not have any participants with a diagnosis of ASD level-3. For a visual representation of this information, please refer to Figure 3.2.

Concerning the nationalities of the participants, our interviews included 7 participants from Portugal, 8 from Brazil, and 1 participant from Poland. The distribution of nationalities can be observed in Figure 3.3, providing a visual representation of this data.

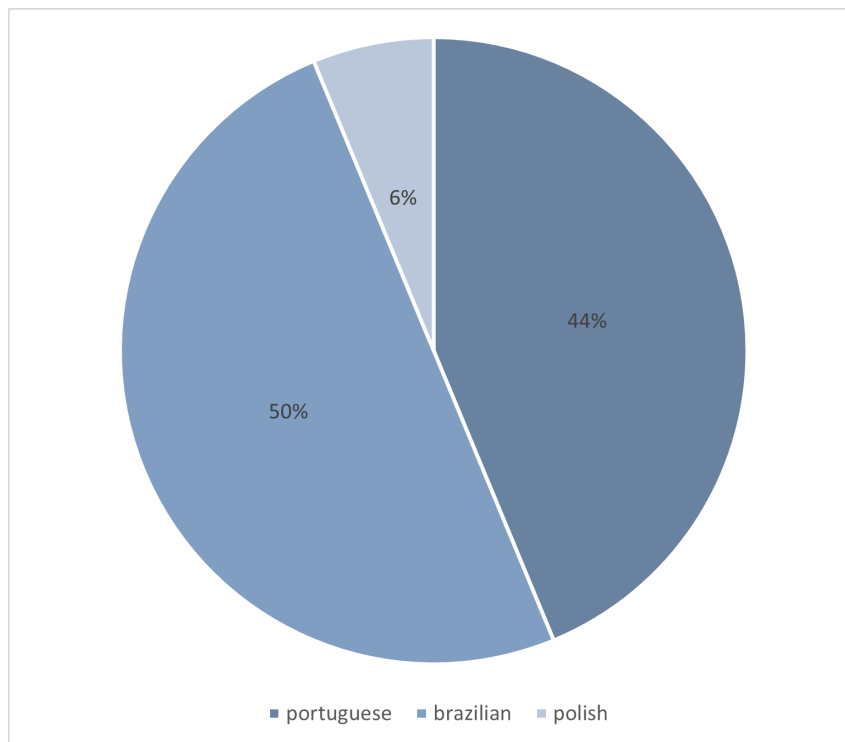


Figure 3.3: Distribution Of the Participants' Nationalities

3.2 Recruitment Methods

Several strategies were used to recruit participants for this study. Initially, we reached out to multiple autism associations in Portugal via email, as well as computer science departments in universities from Portugal. Additionally, we actively made efforts to engage with Autism Spectrum groups on social media platforms, such as *Discord*, *LinkedIn*, and *Facebook*. Although the response from autism associations was limited, we received the most positive feedback from a Facebook group.

Given the minimal response rate from our initial outreach, we attempted to contact *Specialisterne*, a company that has done a lot to include people with disabilities, particularly those on the autism spectrum. Our first attempt was to contact *Specialisterne* Iceland but we got no answer. Our second attempt was to contact *Specialisterne* Brazil and Portugal,

and this yielded the majority of our participants.

In addition, we relied on the **snowball method**, which involved participants sharing the study with individuals they believed would be interested and met the criteria for participation. In figure 3.4 we can see the different sources for this study and how many participants we got from the snowball method.

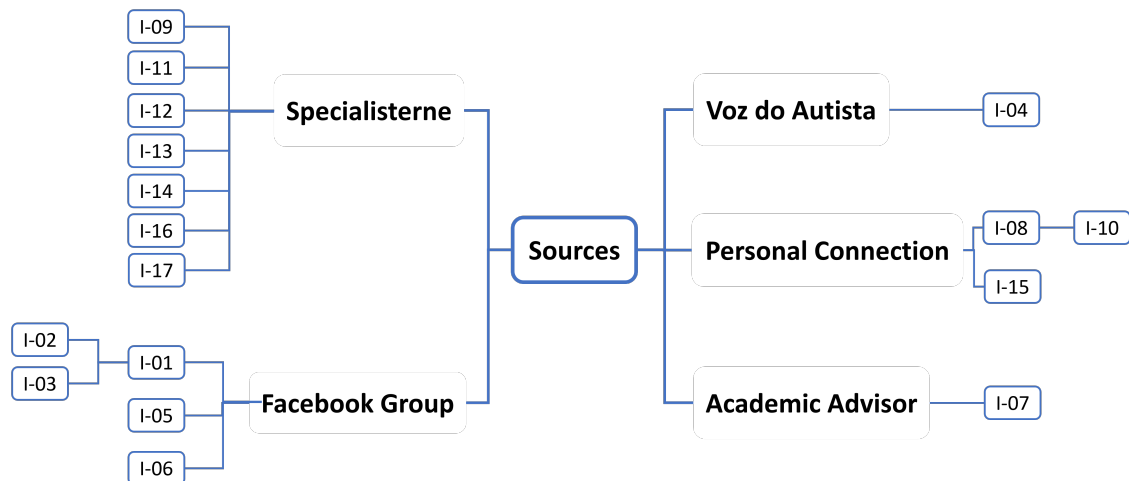


Figure 3.4: Recruitment Sources

3.3 Consent Form

To ensure compliance with both the General Data Protection Regulation (GDPR) and the Association for Computing Machinery (ACM) Policy on research involving human participants and subjects, we developed a consent form that was used for recording interviews and to guarantee anonymity. The form was prepared in both English and Portuguese, and it outlined the purpose of the study. Additionally, the form emphasized that the participant’s anonymity would be maintained throughout the study. Before the interview began, participants had to sign the form to indicate their consent. We would like to clarify that all the interviews used in this study were exclusively from participants who had formally consented by signing the form.

We carefully designed the study in a way that mitigates potential risks to participants and assessed relevant regulations to determine that the research did not involve significant ethical concerns or risks.

The consent form was divided into two sections. The first section provided an overview of the study and requested permission to record the interview. The second section outlined the participant’s rights, such as the right to withdraw from the study at any time and the voluntary nature of their participation. This approach ensured that all participants were fully informed and had given their informed consent before the interview began.

3.4 Interview Conduction

For the interviews, we decided to adopt a semi-structured interview. By following this approach, we were able to ask the questions scripted beforehand but also to ask new questions in the moment, that made sense and that came from what the interviewee said. Before asking for the interviews we also decided to make a small introduction about the study with a thank you to all participants. All the interviews were conducted online, with the Zoom platform.

In the preparation phase of this dissertation, we structured the questions for the interview, dividing them into the following sections:

- This first section tackles the demographic characteristics of the participant. It is extremely important for gathering information about the participants, and for later getting some statistics, including some questions about their diagnosis and what they do currently, for a living.
- The second section refers to the participants' experience while programming, addressing the challenges they may face while doing so.
- The third section concerns the bugs they can encounter while programming or doing code reviews.
- The fourth section refers to the participants' experience with code reviews, challenges they may face with them, how they conduct them, and others.
- The fifth section is about giving and receiving feedback and how they cope with it.
- The interview ends with a question about how they think the workplace culture should change in order to be more accommodating for people with autism.

This structure was followed for all of the interviewees, except for the first three. These three participants had interviews with a slightly reduced number of questions compared to the rest, a step that aligns with the adaptable nature of grounded theory methodology. We recognized the need for additional questions later on, in order to refine the interview approach and better suit our theory development process.

The final version of the structure for the interviews can be found in [Appendix A](#).

Before beginning the interviews, we decided to do a mock-up interview, with a neurotypical computer science engineering student. This way we could see if the structure of the interview worked and check its duration. This interview lasted around 35 minutes, so when recruiting participants, we told them that the interview would last between 30 to 45 minutes at most.

The average interview duration is 27,94 minutes, aligning closely with our initial estimate. It is important to note that we began timing from the exact moment we asked the first question to ensure accuracy. There were some interviewees who could not answer

all our questions because they did not have the right qualifications, resulting in a shorter interview duration. The maximum duration observed is 49 minutes, and the minimum duration time is 17 minutes. The standard deviation is 7,51 minutes.

During the interview, we would simply ask the questions and let the interviewees think for themselves what the question meant. It even happened for the same question, having answers with completely different contexts from the participants. It happened once or twice that the interviewee did not understand what we meant with the question and we had to clarify, but it was rare.

Of all the participants, there were three who were not capable of answering all of our questions. We attributed this to the fact that these participants were students who had a limited background in code reviews. Although their prior disclosure of this information before the interview was conducted, we considered their participation essential, particularly for questions unrelated to code reviews.

At the conclusion of each interview, we expressed our gratitude once again to the participants and kindly requested them to share this study with individuals who might have an interest in participating. We also sought their permission to reach out if any questions arose during the transcription process and to contact them at a later stage for their input on a survey related to the theory developed in the study. We received affirmative responses from all participants, with some even expressing interest in receiving the results of the study upon its completion.

3.5 Interview Transcriptions

After conducting each interview, we immediately proceeded with the transcription process to minimize the workload and make efficient use of the intervals between scheduled interviews. For recording the interviews, we used Zoom's record functionality, which captures video and audio separately. The video files were promptly deleted upon completion of each interview, while the audio files will be deleted upon the conclusion of this thesis.

Given that the majority of our interviews were conducted in Portuguese, we encountered challenges in finding automatic transcription software for this specific language. We were able to find a lot of software for the English language but not for Portuguese. On top of that, we also had to make sure the software complied with GDPR regulations. Consequently, we opted to use the software called *oTranscribe*¹, which, although not automatic, provided a more user-friendly interface to transcribe the interviews.

The interface included functionalities such as pausing, fast-forwarding, and changing the speed of the audio. Before using this software, we thoroughly reviewed its privacy policy to ensure compliance with the regulations stated above. The policy included information about what data is collected, how it is used, and how long it is stored. It

¹<https://otranscribe.com/>

also provided information about how to request the deletion of personal information and how to contact the company with privacy-related questions or concerns. Additionally, the policy indicates that *oTranscribe* takes measures to protect the Personally Identifiable Information (PII) provided by users and that third parties who may receive PII are required to use it only for the purpose they are assisting with.

Although this process was very time-consuming, it ensured that no mistakes were made and that all interviews were well transcribed, without losing any information. For an interview lasting around 30 minutes, the transcription process generally took between 1.5 to 2 hours, varying based on the quality of the interview audio. Additionally, breaks were occasionally necessary during the transcription process to maintain accuracy and prevent transcription fatigue. This approach allowed us to sustain a high level of focus and attention to detail, contributing to the precision of our transcriptions. However, a few interviews presented instances where certain words were not entirely comprehensible. Nonetheless, through contextual analysis, we were able to comprehend the intended sentence structure.

A challenge was also faced when transcribing because of some words or sayings with the participants from Brazil. As the interviews were being conducted, we realized that some of the words in some questions were not being understood by the Brazilian participants. To address this issue, we decided to incorporate Brazilian Portuguese words into our questioning to enhance comprehension and facilitate communication.

DATA ANALYSIS

As described in section 2.6.1, there are two modes of Theory Development. We opted for the **emergent mode** over the structured mode. This approach is used when we are studying a broad phenomenon. In this mode, we emerge with some strong and some not-so-strong categories and indicative relationships.

This mode of theory development includes the following steps: Targeted Data Collection and Analysis; Advanced Memoing; and Theoretical Structuring.

The stage of Targeted Data Analysis involves two fundamental processes: *Targeted Coding* and *Constant Comparison*.

4.1 Targeted Coding

Targeted Coding is the same procedure as Open Coding, but applied in a targeted manner.

This first phase of data analysis is the process of representing textual raw data into condensed formats that best capture its essence and meaning. In this phase, we are open to any and all codes that may emerge. This implies we are likely to get large amounts of codes.

Following an incremental approach to Grounded Theory, we commenced this phase by concurrently conducting interviews and beginning the coding process. As interviews progressed, we carefully reviewed each transcription and identified relevant pieces of data, which we highlighted in bold. To efficiently organize this information, we utilized an Excel document, allocating each interview to a separate sheet. After this, we used an online tool called *Miro*¹, a visual whiteboard collaborative software, to facilitate the process of arranging the data from the interviews.

For our first approach, we chose to organize the data by addressing each question individually. We compared the highlighted parts in the Excel sheets and wrote down the important information in Miro for each question. This approach was preferred over directly creating codes because the participant's responses contained rich and relevant

¹<https://miro.com/>

insights that justified specific attention. So, inside a question, we grouped quotes that were similar instead of generating a code. At this point, we realized there were some similar quotes that were arising from different questions. For example, some people mentioned that communication was hard in more than one question. Using Miro, we were able to easily notice these relations between multiple questions. We coded these related quotes and aligned the resulting codes in a table.

The first column of the table has the code and the second column has the quotes from the participants that are associated with that same code. The third and last column of the table has the number of quotes that are associated with that code. This table is depicted in Appendix B.

After that, we proceeded to group the quotes that shared common ideas or codes. This allowed us to retain the context of each participant's response while also acknowledging similarities across different interviews.

In the end, we did a final look at all the interviews and were able to find some new codes.

Below, we provide examples illustrating the process of open coding by utilizing raw data from various interviews. These examples aim to demonstrate the execution of this phase.

In our interviews, we asked the question:

How do you think the industry and workplace culture could better support individuals with your diagnosis in the field of software development?

And from I-04 we got the answer:

With the creation of specific programs for autistic people. I think there should be ethical training for people before they join the company. I was working in a company where I suffered a bit of bullying because people have no respect because instead of giving space for the person to work, sometimes they focus too much on the person.

Code: Need for Autism Education and Inclusion

Code: Social Challenges

The former code was generated from the sentence *"With the creation of specific programs for autistic people. I think there should be ethical training for people before they join the company."* It summarizes the idea of providing tailored support and accommodations to meet the unique needs of individuals with autism. This participant mentions the importance of creating specific programs for autistic individuals in the workplace.

With the latter code generated from the sentence *"I suffered a bit of bullying because people have no respect"*, the participant highlights the social challenges faced by individuals with autism in the workplace. They mentioned experiencing instances of bullying and a lack of respect, indicating potential difficulties in social interactions. This code points to

the need for increased awareness and sensitivity among colleagues and management to create a more supportive and understanding atmosphere for individuals with autism.

For another example, this time more related to Code Reviews, we asked the following question:

Have you encountered any situation where you feel your diagnosis has given you an advantage during a code review? And what about when programming?

And from the participant identified as I-10, we got the following answer:

I don't know how to answer the question properly because I don't know what normal is, I have no idea what normal is. So I'm going to assume that often being able to see patterns comes in handy, both in the data that we're working with and how to process it. And logic, I feel like maybe understanding logic will be a little bit easier for me, but again, it's unfair for me to be saying this without knowing what it is... this is normal for me. This is my recent job, I have been here for two months, and in the previous one we had domain knowledge, I would look at the data and very quickly I could tell if it made sense or not if we had to recalculate this. This is what I noticed when people said "That was quite fast, how did you notice that?", I don't know if that's normal or not, but for me, that's perfectly normal.

From this answer, we could generate several distinct codes: Autistic Problem-Solving Strengths; Logical Thinking; and Difficulty in Defining Normal. The first code captures the participant's indication of their unique approach to problem-solving that aligns with the traits often associated with individuals on the Autism Spectrum that we discussed in Chapter 2.2. The participant discusses their ability to perceive patterns, a skill that proves valuable in comprehending complex data and its processing. The quote indicates that this inherent ability aids them in quickly identifying anomalies or inconsistencies within the data. The participant implies that their approach to problem-solving involves a distinct cognitive process that might be influenced by their neurodivergent perspective. In the second code - Logical Thinking, the participant highlights their inclination toward logical thinking as another facet of their cognitive approach. While they may not fully understand the conventional definition of "normal," they anticipate that their capacity to understand logic might offer an advantage in their work. Their confidence in logical thinking suggests a particular cognitive style that potentially aids them in comprehending intricate data relationships and problem-solving. The last code we could identify from the quote above - Difficulty in Defining Normal, pertains to the participant's perspective on the concept of "normal." The participant expresses their challenge in comprehending or defining what is considered "normal," possibly indicating a level of detachment from societal norms or standards. Their comment that they are uncertain about what normal is could be seen as a reflection of their individual experience and unique cognitive processing, which might not align with societal models.

This process of this first phase was very important for us to get familiar with the data and get a bigger picture of it.

4.2 Constant Comparison

The second process we mentioned in Targeted Data Analysis is Constant Comparison.

Constant comparison is the process of constantly comparing derived codes within the same source and across sources to identify key patterns in the data. Constant comparison concretely manifests an inductive approach, leading from specific instances toward general patterns, within the study context. Constant comparison is applied at increasing levels of abstraction to raise the codes to the concept level, concepts to sub-categories (where applicable), and category levels. So, this process was done across the entire data analysis.

With this process, several important categories emerged after analyzing the codes.

For a first approach, we looked into the codes and tried to organize them into distinct groups, and only after we tried to give a name to those groups. These categories were straightforward, such as "communication" or "focus", as they encompassed codes that revolved around these specific themes.

During the process of Targeted Coding, we noticed that some codes could be grouped under common categories. One such code was "Hyperfocus on Programming," which contained quotes from participants describing their intense focus on specific tasks, including programming, viewing it as both an advantage and an admirable quality.

However, later on, we came across quotes from different participants, expressing contrasting views on hyperfocus. Some described it as a disadvantage, referring to it as something that "hinders" their abilities. To capture this ambivalence, we consolidated these quotes under the code "Ambivalent Effects of Hyperfocus."

Additionally, we encountered quotes from participants discussing difficulties in maintaining focus, prompting us to create the code "Focus Issue" and making small mistakes due to the lack of focus. All three codes: Hyperfocus on Programming, Ambivalent Effects of Hyperfocus, and Focus Issue; formed a higher abstraction concept that we termed "Focus."

Through this process, we observed how the theme of focus played a significant role in participants' experiences, presenting both positive and negative aspects.

As we progressed, several categories emerged during this stage of analysis. However, we could not determine a core category. Instead, several important categories were identified, a phenomenon that is often anticipated in Grounded Theory methodologies.

4.3 Advanced Memoing

Memoing is an imperative procedure and it is the mechanism through which a researcher's reflection is systematically documented and used for theory development. Memos can be in the form of written notes, sketches, annotated images, or photographs.

Advanced memoing serves to confirm and strengthen existing relationships, reject unsupported indicative relationships, and establish new links between (sub)categories. Our memos were written next to the codes and categories that were starting to emerge. This way we were able to start establishing relationships between codes and categories, beginning with an idea of a theory.

One of the first memos to appear was: It appears that individuals with autism may possess inherent problem-solving advantages and cognitive strengths that are not always apparent to them. Their different perspective and processing styles might contribute to their unique abilities, leading to advantages in certain tasks.

This stage proceeded until we reached theoretical saturation, and by now we had established all the codes we were going to use and the categories as well as most of the relations between them.

4.4 Theoretical Structuring

According to the [STGT](#) theory and the approach - emergent mode - we have chosen, the next phase in this process is Theoretical Structuring.

When we reach a point of theoretical saturation, we have the option to present the theory as it emerges. However, following [STGT](#)'s recommendations, we can choose to engage in theoretical structuring, which involves two main steps.

Firstly, we need to explore and identify the genre of theories that best aligns with our findings. This includes considering different types of theories, such as process, taxonomy, degree, and strategies, and determining which one fits our data the most accurately.

Secondly, we should investigate whether the emergent theoretical structure naturally aligns with an existing theoretical template, like the Six C's model (contexts, causes, consequences, contingencies, conditions, and covariance) or a process template with defined stages and entry/exit indicators. If we find that our emergent structure fits well with one of these existing templates, we are encouraged to use it to further refine and structure our theory. This step helps in providing a clearer and more organized representation of our research findings.

While theoretical structuring is an optional step, it is highly recommended in the research process, so we opted to do it.

4.5 Theoretical Saturation

Theoretical saturation is the point we aim to reach, it is when we are no longer getting new data from the interviewees, and therefore we stop making them. If the group of the participants is more diverse it is expected to reach this point later in the investigation. In this case, as we saw in section [3.1](#) the group is very diverse, having people from different countries and, more importantly in this case, with different backgrounds professionally. Additionally, the fact that they have varied autism conditions, will also likely impact them.

The graph 4.1 displays the number of new codes per participant. The data shows an overall declining trend in the number of new codes assigned to participants. This decrease suggests that the coding process has likely reached theoretical saturation, meaning that new codes are becoming less frequent as the study has captured most of the relevant information.

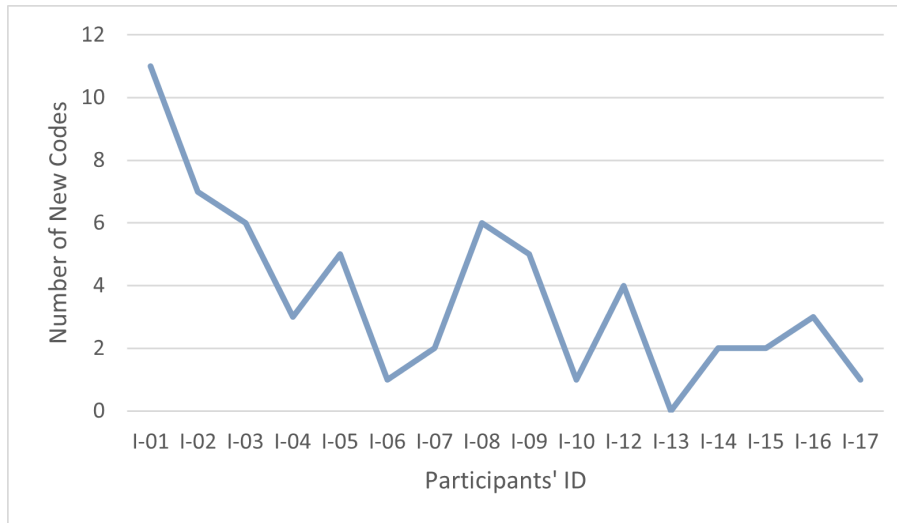


Figure 4.1: Number of New Codes per Participant

THEORY DEVELOPMENT

Having formulated our codes, we proceeded to categorize them into distinct groups. As the categories began to emerge, we started identifying relationships between them. In total, we identified twelve categories and eleven relationships. These categories and their respective relationships can be seen in Figure 5.2.

5.1 Categories

These categories unfolded progressively as we analyzed each individual code. Our aim was to cluster codes that related to analogous subjects or categories. Notably, specific codes were found to align with more than one category. In the subsequent sections, we explain the identified categories, accompanied by their respective descriptions, and offer some illustrative examples.

5.1.1 Communication

Communication was a recurring topic among the participants, frequently brought up even outside of questions directly related to it. Although two types of communication have emerged, there was a clear predominance of a preference for written communication.

- **Written Communication** - The majority of participants expressed a preference for written communication. They justified this preference by explaining that written messages allow them to refer back to the conversation if needed, as compared to voice communication, which can be easily forgotten. When they are the recipients of the communication, they strongly prefer written exchanges. However, when initiating communication with others, they feel more indifferent and are comfortable with either written or verbal communication methods.
- **Verbal Communication** - Among the participants, two individuals showed a preference for verbal communication when they were on the receiving end of the interaction. Interestingly, one participant went a step further, expressing a strong preference for communication through spoken words and even suggested the addition of visual

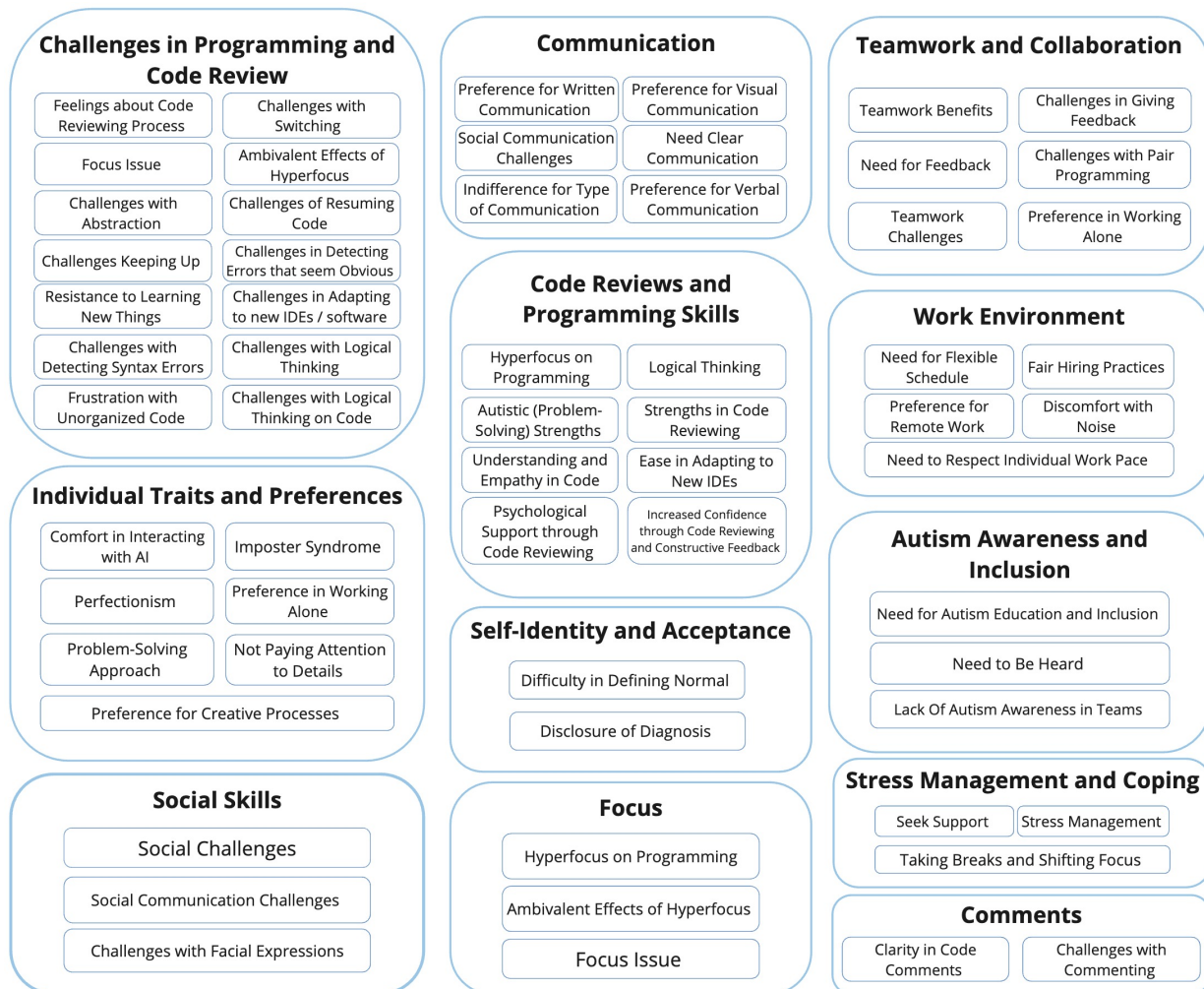


Figure 5.1: Categories and Codes

aids, such as drawings: *The best way to communicate with an autistic person when they want them to program is with a drawing. I-01*

In addition to expressing a preference for written or visual communication, some participants emphasized the importance of clarity in the information provided. They pointed out that clear instructions enable them to perform tasks more effectively. In contrast, they highlighted that at times, the information can be overly abstract and lacking objectivity, which can lead to confusion and hinder their ability to understand and complete tasks efficiently.

5.1.2 Social Skills

Social skills were frequently brought up by the participants, even though we did not directly inquire about them. The majority expressed having limited social skills, leading to challenges in managing their professional lives. Some participants reported feeling fearful of offending or hurting colleagues when providing feedback or engaging

in conversations. Many of these concerns centered around giving feedback during Code Reviews or discussing specific tasks. Interestingly, some participants shared effective strategies they had developed to cope with their lack of social skills. For instance, they would seek assistance by having someone review their feedback before sending it or taking notes of their thoughts on a notepad before communicating them. Others mentioned taking extra time to carefully think about their words, going over them 3 or 4 times before delivering the message. One participant stated a preference for feedback to focus primarily on technical aspects rather than including remarks about the colleague's social skills. They believed that this approach would reduce the likelihood of accidentally causing harm or saying something inappropriate. In addition to the communication aspects, the participants highlighted other social challenges they encountered. One prevalent issue was the limited respect they received from some colleagues, with one participant even enduring workplace bullying. Moreover, some participants expressed difficulty in relating to others and empathizing with their perspectives. One individual specifically mentioned facing challenges due to a social disability in handling soft skills. Another related challenge revolved around the interpretation of facial expressions. Some individuals found it challenging to accurately identify and interpret emotions conveyed through facial cues, leading to potential misunderstandings in social interactions. These challenges also extended to their work environment. One participant even emphasized the importance of using emojis for expressing emotions: *with emoji, because this is important, it may not seem important, but it is because you are expressing some facial expression I-14.*

5.1.3 Code Reviews and Programming Skills

This category forms the central focus of this thesis, and it has yielded several intriguing findings.

We were able to explore and find out the strengths our interviewees presented, regarding code reviews and programming. These strengths largely center around their exceptional problem-solving abilities. When faced with challenges, these individuals exhibited a distinct approach, showing a keen determination to root out errors and devise solutions. Participant I-03 corroborates this perfectly by saying:

When the autistic person detects a problem, I speak for myself, he goes the second mile, and he goes beyond. This makes us able to solve problems more quickly, objectively, and assertively.

Moreover, one of the participants shared their strategy of following the path of least effort, thereby optimizing computational efficiency. This strategic mindset is paired with an impressive capacity to not only read but also memorize code, contributing to their agility in programming tasks. Interestingly, this aspect - memorizing code - is also linked to the imposter syndrome, a condition that only one participant in our study reported. In collaborative settings, these individuals often find themselves arriving at solutions ahead of others, occasionally confusing due to their rapid problem-solving abilities but at the same time making them aware of this very same skill. What's intriguing is that many of them only

really noticed this knack when they observed others tackling programming tasks. This skill not only highlights their capacity to promptly recognize patterns but also demonstrates their ability to handle complex sets of data with ease. Additionally, the participants' talent to quickly identify specific errors serves as a testament to their unique problem-solving strengths. Altogether, these aspects highlight how the distinctive problem-solving methodologies of individuals on the autism spectrum contribute significantly to their excellence in code reviews and programming tasks.

Regarding code reviews, several participants found their diagnosis to be advantageous as it aided them in scrutinizing code with precision, thereby reducing the likelihood of errors. Notably, one participant explicitly mentioned that their diagnostic ability enabled them to conduct code reviews and programming tasks more efficiently than their peers.

An intriguing insight emerged during the study, shared by one of the participants. This individual emphasized the importance of code reviewing in boosting their self-confidence. They talked about it several distinct times during the interview, expressing how much psychological support they found through the code review process. Moreover, engaging in helpful discussions and receiving feedback during code reviews contributed to an increase in their self-assurance. Feeling understood and supported by their peers also played a crucial role in making them more comfortable and confident in their work. These findings highlight the valuable impact of code reviews on one's professional growth and self-belief.

In terms of logical thinking, two participants believed their diagnosis offered them a specific advantage over their colleagues. They expressed that comprehending logic came more naturally to them.

Besides all the strengths and specific characteristics described above, we decided to also consider hyperfocus as a skill. The skill of hyperfocus helped the interviewees a lot when programming and reviewing code. While it proved to be highly beneficial for most participants, it's worth noting that some individuals also identified it as a challenge. Consequently, we opted to allocate it to a separate category, acknowledging its dual nature as both an advantage and, in some cases, a limitation.

5.1.4 Focus

The most prominent observation, as anticipated from our research, was the phenomenon of **hyperfocus**, particularly in the context of coding. Many participants viewed their hyperfocus as an advantageous trait, aiding them in maintaining concentration and accomplishing tasks. For instance, participant I-16 remarked in three different moments:

We [autistic individuals] have the matter of hyperfocus, we start doing one thing, and if we focus too much on this thing, we end up producing a lot. We have a great production because we are hyper-focused on what we are doing + in programming the hyperfocus also enters + I can give a much greater focus to a way of writing the code and the code is very coherent, it is very accurate, so I think that in this part in the programming itself helps a lot.

In addition to many participants considering hyperfocus as an advantage, we also encountered more ambivalent perspectives. Some individuals described experiencing both benefits and challenges related to their hyperfocus. One recurring theme was the difficulty they faced in diverting their attention away from a task once they were deeply engrossed in it. Moreover, some participants highlighted the struggle they encountered in disengaging from thoughts about a problem even when they encountered it. Interestingly, some participants expressed difficulties in maintaining focus on tasks, particularly when the instructions were unclear. This issue ties back to the communication category, where we discussed the significance of providing clear instructions to support task engagement.

5.1.5 Challenges in Programming and Code Review

After analyzing the category that delves into the skills of programming and code reviews, we will examine the challenges the participants encountered while performing these tasks. We encountered several different challenges that are going to be discussed below.

The challenge that we most encountered was using a new [Integrated Development Environment \(IDE\)](#) or software. Sometimes when moving from job to job individuals need to work with different [IDE](#) or software and sometimes there is no other alternative. Although this is not directly related to challenges with programming, it is the tool individuals use to do so.

The sentiment expressed by these participants underscores the complexity of the challenge. Adapting to new tools, interfaces, and development environments can prove to be a significant hindrance, with nuances in functionality and features often differing from what individuals are accustomed to.

Some interviewees said they expressed some initial resistance and reluctance, while others described a relatively swift adaptation process. Moreover, the struggle is not limited to learning new tools; transitioning between different [IDE](#) also presents its own challenges.

While this was the case for most of our participants, it's important to note that three individuals did not encounter difficulties when transitioning between [IDE](#) or learning new software. They confidently mentioned their ability to adapt smoothly without any issues.

The journey of adapting to new software emerges as a multifaceted process. Seeking guidance from experienced peers, gradually immersing oneself into the new environment, and embracing incremental challenges all play a role in overcoming the initial obstacles.

A notable perspective arises from the experience of feeling a "disaster" when encountering new [IDE](#). This perspective highlights the challenges of adapting to fresh technological approaches, mainly when individuals are accustomed to a specific technological setup. This challenge isn't just about learning new software; it's also about altering established ways of doing things. If someone has already mastered a particular method, making a change can be especially tough.

This challenge does not have to be entirely specific to **IDE** or to the software. In fact, three other participants also showed resistance to learning new things. Despite having this resistance, it is interesting that they are aware of the difficulty and that it takes more time for them to adapt, indicating that it is more time-consuming and showing some irritability from their side. Another interesting thing was their willingness to learn, so despite having all these challenges related to learning new things, they are still eager to learn. This also ties into the challenge of switching, whether it's between different software or tasks. This can be a drawback when trying to come up with alternative solutions when blockers are encountered.

This becomes clearer when we consider the insights shared by Participant I-16, which effectively illustrate the points discussed earlier:

It's a disaster at first because I'm used to something, (...), then a person brings me a new IDE, a new tool, I need to understand how that tool works, and it gives some problems, some bugs, that I had no idea existed (...) I'm already with the technology that I'm already used to so when it changes, I have a hard time adapting. I don't have as quick an adaptation to a new technology as people usually have. When they are already in the technological environment they can easily adapt to a new IDE, but I can't.

Additionally, to these challenges, we also uncovered an obstacle related to resuming to code. Individuals encounter difficulties in re-establishing focus on programming tasks after interruptions or breaks. For instance, when they need to pause and then resume their work, they struggle with re-engaging their thought process and reasoning abilities. This challenge highlights the intricacies tied to regaining cognitive flow within the programming context.

More closely associated with programming and error detection, some participants voiced difficulties in identifying syntax errors, such as missing commas or closing braces. Furthermore, we observed a trend where the majority of individuals who raised this concern were utilizing **IDE** that either did not highlight these types of errors or were simply working with simple text editors.

Also within the context of detecting errors, additional participants highlighted their struggles with identifying errors that appear obvious. Interestingly, these minor mistakes were deemed more challenging due to a lack of attention. This observation is intriguing considering the significant number of participants who indicated a tendency for hyperfocus in programming tasks. What's noteworthy is that the participants who had previously mentioned experiencing hyperfocus also reported grappling with this lack of attention, which offers a surprising twist in expectations.

Another participant shared their experience of encountering situations in which they struggled to keep up and found their thought process to be slower than that of their colleagues. This revelation emerged during a conversation about pair programming and the dynamics of collaborating with another individual. The participant highlighted the difficulty they faced due to their slower pace compared to their colleagues. While just one participant voiced this observation, it is important to note that this perspective was

presented by the final interviewee, leaving us without the opportunity to corroborate it with other interviewees. Nevertheless, despite being a singular account, it offers an interesting angle that we deemed valuable to include as a recognized challenge within this category.

One significant code within this category, "Challenges with Abstraction," resonates deeply with the participants' experiences, reflecting the distinctive cognitive processes tied to autism.

Navigating abstraction within programming presents a substantial challenge for these individuals. For individuals with autism, the abstract nature of these concepts might pose heightened challenges due to differences in cognitive processing.

Participants' accounts illustrate how the complexity of abstract ideas can be especially perplexing. This struggle is intensified when deciphering abstractions created by others (related to the need for clear communication), necessitating an even deeper understanding of their thought patterns and cognitive structures. The cognitive divergence associated with autism can potentially add another layer of complexity to this process.

Moreover, the participants' experiences indicate that as projects evolve into higher levels of abstraction, the intricacy deepens, aggravating the challenge. The quote:

Participant I-12 captures the essence of this struggle: *The biggest difficulty I find when programming is to do abstraction, the concepts are very abstract. If there is some abstraction and I have to understand the abstraction of the other person, then it is even more difficult. When I developed something more abstract, it gets more complicated*

Linked to coding, particularly concerning its visual elements, participants expressed concerns about the structure and organization of the code. Given that individuals with autism have the inclination to adhere to rules and patterns (improve this information), it came as no surprise when they conveyed feelings of frustration upon encountering unorganized code that didn't align with their standards.

Participant I-01 further illustrated this sentiment:

If someone sends me a code to look at and the code is not organized in a way that is logical to me, the first thing I do is reorganize the whole code, which is extremely frustrating for me.

Finally, address logical thinking. In the previous category, we talked about logical thinking as a skill but some participants also identified it as a challenge. In fact, the majority of the participants found it challenging. Not just logical thinking alone but also logical thinking on code reviews. When asked what was the most challenging when programming, they said logical reasoning. As a consequence, they sometimes can become trapped in the development phases of projects.

As said previously, this challenge extends to code reviews as well. Concerns were raised during interviews regarding understanding the logic behind others' code or created by others. In code reviews, this challenge is particularly relevant, as reviewers must decipher the logic behind unfamiliar sections of code to effectively assess their functionality, efficiency, and adherence to best practices.

Additionally, concerning code reviews, a participant noted that the process of reviewing code was not tailored to accommodate autistic individuals. This often led to heightened stress during the review process. This situation could potentially be linked to challenges in social interactions and difficulties in verbal communication.

5.1.6 Work Environment

In this category, not all participants were able to provide firsthand information. Some were still studying and had no prior work experience. However, others shared valuable insights based on the experiences of their friends and acquaintances who had been employed or had professional work experience.

The majority of the participants stated their preference for remote work. Most of them viewed remote work as an added value, enabling them to concentrate more effectively and work in a comfortable environment, ultimately leading to increased productivity.

Linked to this preference for remote work, some participants stressed the importance of having a flexible schedule. They valued the freedom to choose their own work hours, which contributed to a better work-life balance. Moreover, this flexibility also extended to the need for breaks. Autistic individuals sometimes required more frequent breaks to enhance their productivity, and the ability to take these breaks without drawing unnecessary attention from colleagues was highly appreciated. Of course, this aspect also has implications for the broader issue of inclusion and awareness, which will be further explored in category 5.1.9.

An important aspect that emerged was the participant's observation regarding fair hiring practices. One individual highlighted the concern that some companies might hire people with autism not solely based on their qualifications but rather due to fulfilling autism quotas, making it more of an obligation than a genuine recognition of their abilities. As said by participant I-16:

As much as the company hires a person who is part of the spectrum, it hires more as if it were an obligation (...) So, I see that they hire more as a rule and not as an opportunity really for the person to show what skills they have.

This observation highlights a crucial aspect within this category, emphasizing the need for an inclusive and supportive workplace.

There was another participant who felt this unfairness himself. Saying that

"They treated me as if I was incapable, they gave me simple problems and did not let me participate in making more complex and technical decisions. I-03".

This quote perfectly demonstrates this concerning aspect. The feeling of being seen as incapable and given only simple tasks can be demoralizing and can lead to depression.

Both quotes mentioned above highlight the need for companies to ensure that individuals with autism are given equal opportunities and more important treated with respect, just as they would with neurotypical individuals. By providing autistic individuals the chance to participate in more complex and technical decisions, companies can benefit from

their unique perspectives, problem-solving abilities, and creativity. Doing this can also encourage individuals to be more open about their diagnosis in the workplace, instead of trying to hide it, knowing they will be respected.

Another important aspect that was referred to by 7 participants is the significance of accommodating individual work rhythms in the workplace. For some individuals with autism, articulating themselves can be challenging, and comprehending tasks may require more time. They feel more respected when the workplace offers, for instance, space and opportunities for asynchronous question-asking. Additionally, having the freedom to express their individual traits without facing judgment from their peers adds to this feeling of respect. A great example of this can be seen from what Participant I-03 shared when asked about ways a company could better support individuals on the Autism Spectrum:

It is necessary to leave the autistic be free and autistic. Produce what he has to produce in the way he feels most comfortable

In terms of the workspace, a number of participants expressed discomfort with noise. Some even mentioned that the chatter of people talking caused them to lose focus. This aspect could potentially explain why a significant portion of them leaned towards remote work or sought flexibility in their schedules.

5.1.7 Teamwork and Collaboration

This category addresses several key aspects of how individuals with autism engage in team activities and their points of view about collaboration. There were three types of codes that emerged in this category:

- **Teamwork** - The participants highlighted both positive aspects and challenges associated with collaborative work. In terms of benefits, they expressed the value of learning from fellow team members and having a resource for consultation (which also correlated with the psychological support garnered through code reviewing). However, a significant majority of participants acknowledged that working in a team posed substantial challenges. They pointed to communication as the most demanding aspect and also emphasized the lack of respect and character.
- **Feedback** - When asked about giving feedback, we found that it presented a significant challenge for the interviewees. They often felt nervous, especially if the feedback involved soft skills, preferring to stick to technical aspects. However, despite the difficulty in giving feedback, they generally felt more at ease when receiving it. One participant even mentioned that getting feedback was important as it boosted their confidence in their work.
- **Pair Programming** - We asked about pair programming directly, but not many of the participants had experienced that in a professional way, and others had experienced it but only in an academic way. From the four responses we received, it's clear that they all found pair programming to be quite challenging and complicated. They

mentioned that it felt even tougher than working on their own, and they often felt more pressure during these collaborative sessions. Participant I-05 provided a clear illustration of this concept: *I used to isolate myself a lot and I would rather be alone, even for hours on end, than have to deal with other people because my way of seeing things and theirs is completely different.*

From this category, it becomes evident that a majority of the interviewees faced challenges when working within a team or alongside others. However, they generally found the feedback to be valuable and beneficial.

5.1.8 Individual Traits and Preferences

This category explores the various ways in which participants uniquely approach their work and interact with their environment.

We already suspected that individuals with autism had close attention to detail. We found that some participants seemed to have some level of perfectionism when it came to completing tasks. They also showed their meticulous and comprehensive approach to their work, particularly when it comes to coding.

We found that the participants expressed a strong inclination toward thoroughness, often exceeding requirements to ensure a comprehensive understanding of their tasks and to ensure they were well completed. While this commitment may initially appear to be a desirable trait in an employee, they reported sometimes having feelings of being overwhelmed. This derived from the challenge of determining when their work reached a satisfactory point, often resulting in a struggle to recognize when to stop. This dedication to precision can sometimes hinder their work, leading to false expectations and notions of perfectionism.

A participant even opened up about experiencing imposter syndrome, which is a psychological occurrence where individuals start to doubt their skills and question if they are good enough. In this particular case, the participant was referring to the code sent to the reviewing process and that they sometimes take a lot of time making it perfect and wondering if it is really good to be sent.

Additionally, some participants noted that they could see code in a different way, offering an interesting approach that set them apart. Others mentioned that their autism allowed them to spot patterns more clearly. They also emphasized the importance of paying attention to smaller details, as it helps them catch errors effectively.

A perfect example of this is what Participant I-14 said:

You can see the patterns of activities, it [autism] helps you at a certain point or even be aware of some detail of the code that is not making sense.

As we have seen before, most participants leaned toward working independently rather than in teams. Additionally, they showed a level of comfort when it came to working alongside AI. Interestingly, a few even expressed a preference for interacting with AI chatbots over real people, they felt more comfortable and relaxed. Some also

mentioned using web browsers and AI tools to spot errors and discover solutions. Notably, one participant humorously shared that they've been playfully compared to a robot – particularly a chatbot – due to their methodical behavior and speech patterns.

5.1.9 Autism Awareness and Inclusion

This topic was brought up in several moments of the interviews by several participants, however, it came up more often in the last question of the interview where it was asked if they could think of something they would like to be changed in the workplace culture.

Our initial thoughts were that a lot of work needed to be done regarding inclusion. It appeared that these particular individuals might not have felt adequately listened to or accommodated.

Upon analyzing the gathered information, our findings were indeed aligned with our initial thoughts. The need to improve inclusivity was very obvious, and to work on this, a number of different strategies were suggested by the interviewees. Some suggestions included organizing workshops, courses, or even informal discussions centered on autism awareness and effective approaches for engaging with individuals facing this condition.

Some participants referred to the creation of specific programs for autistic people. Although some companies have already embraced such initiatives, they remain relatively uncommon, particularly within the context of Portugal.

Another important point that participants brought up was about working in teams and alongside peers. They emphasized the need to make others more aware of their unique experiences and challenges. One participant referred to it as their "issue" and highlighted the importance of explaining to others why they might communicate or behave differently. This way, any potential misunderstandings can be avoided, and everyone can work together more smoothly.

Participant I-16 said: *I think offering information about the autistic spectrum for the whole team is very important. It can be a class, a call, like a workshop with the information of what is the autistic spectrum so that we can feel comfortable working with other people + Making people in the company aware of what is the spectrum is very important for inclusion*

Even though the strategies we discussed earlier are important, it's essential to remember that most of the time, these individuals simply want to feel like they are being heard. It's important to understand that people on the autism spectrum have their own unique ways of behaving and interacting with others. Simply affording them the space to be heard and share their experiences can yield substantial benefits.

Furthermore, the focus on listening and understanding comes from realizing that these individuals have diverse characteristics and ways of communicating. When we embrace and appreciate their differences, we create an environment where they can truly thrive and contribute. Just the act of giving them a chance to express themselves can lead to a more inclusive and productive workplace.

Despite the valuable strategies we discussed earlier, a fundamental issue arises from the teams' limited comprehension of autism. As one participant openly revealed, *"I see that the teams we work with have no idea what autism is. They have no idea I'm part of the spectrum, they have no idea what's going on."* This unawareness can inadvertently create an environment where these individuals struggle to feel acknowledged or comprehended. Thus, integrating active listening and a deeper understanding of their experiences isn't solely about implementing strategies, but also about cultivating enlightenment within the teams.

5.1.10 Self-Identity and Acceptance

Exploring the theme of self-identity and acceptance within the context of autism, a series of meaningful quotes come together to shed light on a complex picture of this personal journey. One participant mentioned the struggle to understand what "normal" really means, the quote highlighting the confusion and challenge of defining something that seems ever-changing.

Amongst the exploration of self-identity, the topic of disclosing one's autism diagnosis emerges as an important thread. In one interview, a person talks about how they told their workplace about their diagnosis, but it didn't go well. They were treated as if they couldn't handle complex tasks anymore, which shows the importance of creating an environment that appreciates diverse strengths and it connects very well with the previous category which emphasized the importance of autism awareness and inclusion in the workplace.

In contrast, someone else talked about how they don't advertise their diagnosis but are open about it when asked by their team. This shows the delicate balance between being honest about one's identity without letting it define everything.

Furthermore, we also discovered a different perspective that highlights how empowering it can be when people know about one's place on the autism spectrum. The emphasis here is not on constantly explaining oneself, but rather on letting people know for practical reasons. More than just an explanation, disclosure becomes a tool for fostering an environment of support and awareness. The importance of acquainting colleagues with the challenges that might arise, such as sensory crises, is emphasized to foster an informed and empathetic workplace.

5.1.11 Stress Management and Coping Mechanisms

This category explores diverse strategies employed by individuals navigating challenges such as stress and anxiety when one is coding.

One common idea is the inclination to reach out to colleagues for assistance. Seeking guidance from those who have undergone similar experiences emerges as a valuable approach. Furthermore, the notion of asking for help when feeling overwhelmed is emphasized by one participant. This demonstrates a vital willingness to acknowledge personal limits and rely on the support of others to find a solution.

Collaboration surfaces as another recurring theme. Engaging with team members showcases the importance of leveraging collective wisdom for problem-solving and alleviating stress.

Amidst individual coping mechanisms, strategies for recalibrating and recharging personal batteries stand out. Taking breaks to unwind, or engaging in repetitive movements to ease anxiety, reflect personalized techniques for managing stress.

Furthermore, the art of prioritization is illuminated. Shifting the focus to different tasks as a means of regaining control illustrates adaptive strategies for maintaining equilibrium.

This is connected to a topic we discussed in a previous category 5.1.5 where we addressed the challenges of switching tasks. They both have to do with interruptions, although from different perspectives. The first one was about people being interrupted, while the second one was more about people voluntarily interrupting things they are doing. Nevertheless, both end up in context switching, which was perceived as a challenge in the other category, but as a coping technique in this one.

if I realize that some task is making me a little anxious or overwhelmed, I try to move on to another one and try to be more in control of myself, (...), and then I try to go back to that task that might be more difficult or that is not going well for me. I-08

Regarding challenges when coding, strategies such as stepping away from the task and returning with a renewed perspective resonate. Additionally, physical movement finds prominence as a means of alleviating stress. Participant I-09 stated their difficulty when managing stress by saying:

It is complicated for me to manage anxiety when the code has many errors

Additionally, there were only two/three participants who stated having no stress or anxiety when programming so they had no strategies for it.

To conclude, the quotes below collectively show how individuals tackle stress and employ coping strategies. They emphasize the importance of seeking help, working together, and finding ways to recharge. Altogether, these experiences form a rich tapestry of approaches that people use to manage stress and maintain their well-being, both in their professional and personal lives.

5.1.12 Comments

The interviews highlighted a significant theme revolving around code reviews, focusing on the subject of code comments. Among the participants, it emerged a common challenge related to effectively commenting code. Many faced difficulties in striking the right balance in terms of the number of comments to make. Despite these challenges, it became evident that the participants recognized the importance of commenting on the code. They demonstrated a genuine effort to engage in this practice, understanding its role in facilitating code reviews and enhancing code comprehension for others who interact with it.

Furthermore, the discussions underscored another crucial aspect: the clarity of the comments. Participants acknowledged that it is not sufficient to merely insert comments; the content these comments have, hold equal significance. Inappropriate comments were recognized as potential sources of discomfort and frustration. One participant went beyond what we expected and made a suggestion to enhance the code review experience, keeping in mind individuals on the Autism Spectrum. Their suggestion was to incorporate brief explanatory comments within different code blocks. These comments would help clarify the purpose and functionality of each specific piece of code. Participant I-02 made this very evident by saying:

It's important to comment the code to make sure other people will understand it as well

5.2 Relationships

As mentioned earlier, the categories discussed in the above sections can sometimes be connected with one another. While we touched upon certain relationships during our category descriptions, we will now delve deeper into making these connections more apparent and providing a more comprehensive explanation. In Figure 5.2 we can observe the prepositions about the relationships among them.

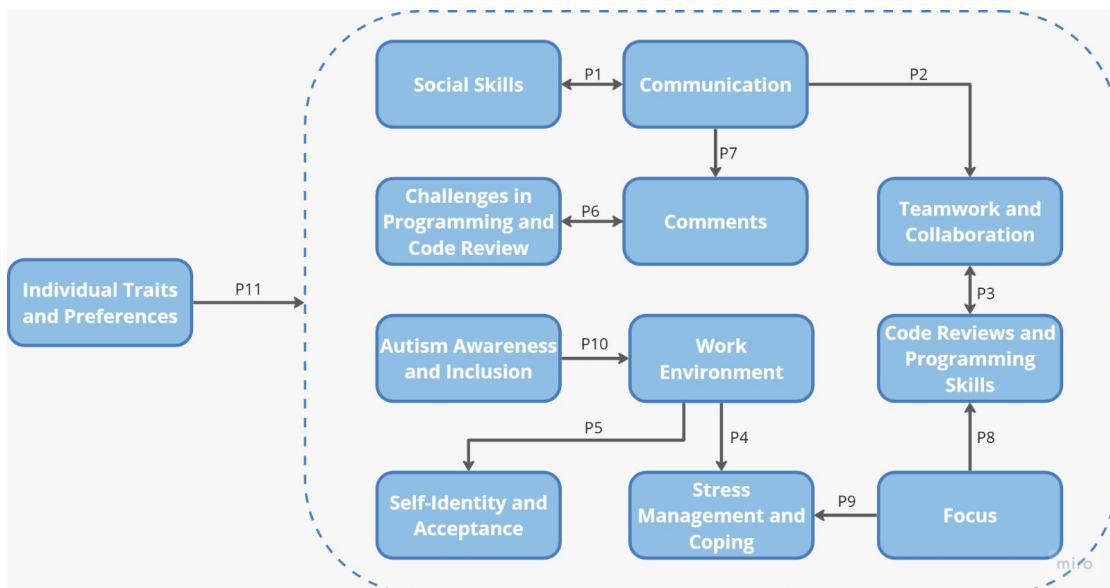


Figure 5.2: Categories and Relationships

- **Social Skills** \longleftrightarrow **Communication**

P1: These individuals have poor social skills, and this will negatively impact their communication. If they can communicate better, then their social skills and interactions with others will also improve.

- **Communication** \longrightarrow **Teamwork and Collaboration**

P2: If the communication was better, collaboration between these individuals and their colleagues could be better. Effective communication plays a crucial role in successful teamwork and collaboration. Challenges in communication can lead to difficulties in giving and receiving feedback, which can impact team dynamics.

- **Code Reviews and Programming Skills <—> Teamwork and Collaboration**

P3: Code reviewing is good when collaboration works.

- **Work Environment —> Stress Management and Coping**

P4: Safe work Environment with good policies that allow one to work from home, helps individuals manage stress and find better mechanisms to cope with it.

- **Work Environment <—> Self-Identity and Acceptance**

P5: The work environment influences the acceptance of these individuals. If they are in a safe work environment, they are going to be more willing to share their diagnoses.

- **Comments <—> Challenges in Programming and Code Reviews**

P6: If comments are well made, code reviewing will be easier. And vice versa.

- **Communication —> Comments**

P7: If they know how to communicate, then the comments will be better and make more sense.

- **Focus —> Code Reviews and Programming Skills**

P8: Their ability to hyperfocus helps them with code reviews and also programming.

- **Focus —> Stress Management and Coping**

P9: Their ability to hyperfocus diminishes their stress.

- **Work Environment <—> Autism Awareness and Inclusion**

P10: Autism Awareness and inclusion improve the work environment.

- **Individual Traits and Preferences —> All Categories**

P11: Individuals' traits and preferences affect how someone interacts with every category we described above.

5.3 Validation

As a crucial step in the validation process, we conducted an evaluation survey detailed in Chapter 7 to complement our qualitative data analysis. This survey was meticulously prepared to correspond with the key codes and categories identified through grounded

theory analysis. Participants, including software engineers both with and without autism relevant to our research context, were invited to share their insights and perspectives, which we then analyzed quantitatively. Through comparing the results obtained from both the interviews and the survey, we successfully validated our theoretical framework.

As part of the member-checking validation method, we sent the survey to participants who took part in our interviews. Despite reaching out to all 17 interviewees, we received responses from only three participants. These responses, although limited in number, played an important role in refining and validating our theory. Through their answers, we gained valuable insights and validations for certain aspects of our theory. For instance, one participant highlighted the benefits of working from home, which we incorporated into our theoretical framework. While we did not receive additional suggestions, the responses provided direct feedback on specific statements within our theory.

5.4 Limitations

While we tried our best to cover a wide range of topics, it's essential to recognize that our study, like all studies, has its limitations. One notable limitation is our sample size; we would have liked more participants, but we ended up interviewing 17 individuals and had data from 16 to work with. Although this number might seem small, it was pretty good considering our specific criteria for selecting participants.

Another limitation arises from the fact that a few of our interviewees didn't have direct experience with code reviews. Even though they had a strong understanding of programming, it's essential to acknowledge that their insights might not fully align with the main focus of our thesis, which is code reviews. As a result, not all interviewees were able to address every question we asked during the interviews.

The third limitation concerns our choice of data collection method. We opted for semi-structured interviews, which, may have had implications for participant recruitment. If we had chosen online questionnaires, a method that required no direct interviews or calls, we might have been able to include a larger number of participants. In an attempt to mitigate this limitation, we offered the option for participants to engage in asynchronous interviews, but none chose this alternative. When deciding on the data collection method, we chose semi-structured interviews due to their advantages in terms of data validation and our ability to conduct in-depth interviews that encouraged comprehensive responses. Given the nature of our research questions, which often required more complex answers beyond simple "yes" or "no" responses, this method seemed more appropriate. To soothe this limitation, we employed a combination of both interview and survey methods.

THEORY DISCUSSION

With our theory, its categories, and their relationships laid out, it is time to discuss our findings. This discussion will shed light on several critical aspects of our research, providing valuable insights into the implications, significance, and practical applications of our theory.

6.1 Struggles and Standard Software Development Practices

Comparing the challenges faced by individuals with autism to standard development practices reveals some noteworthy observations. One area of notable contrast is pair programming, which is a significant component of modern programming methodologies. Based on our interviews, it is evident that many participants feel uneasy about participating in pair programming. This discomfort arises from difficulties in collaborating with others in general. Additionally, participants find it challenging to express their thoughts and understand how their peers think and code. One aspect that is positive about pair programming is the fact that you receive constant validation of your work, something that some of our participants also revealed to be important to them. These insights highlight the importance of considering more flexible and inclusive approaches to software development practices. Another notable aspect is code organization, formatting, and style guidelines. Several participants expressed frustration when encountering disorganized code that does not adhere to their preferred formatting standards. These sentiments can understandably interfere with the effectiveness of pair programming sessions, as they can lead to distractions and communication barriers, especially given that pair programming relies heavily on verbal interaction. Many interviewees showed a preference for written communication instead, further complicating collaborative efforts in pair programming. However, it is worth noting that adhering to code formatting and styling guidelines is a standard practice in coding. This adherence can help ease the frustrations reported by our interviewees when dealing with code that does not meet their formatting expectations. Therefore, emphasizing and following these guidelines can contribute significantly to improving collaboration and reducing frustration in collaborative coding environments.

While individuals with autism encountered unique challenges during pair programming, it is important to note that when it came to code reviews, the differences in challenges between them and neurotypical individuals were not as pronounced. This might stem from the fact that code reviews typically involve minimal interpersonal interaction, which is a primary challenge for many autistic and neurodiverse individuals. Interestingly, some of the participants did experience difficulties during code reviews, primarily in terms of expressing their thoughts effectively, which can be considered more of a communication problem rather than a code review problem. Many expressed concerns about unintentionally causing hurt feelings when providing feedback during code reviews, highlighting a communication problem. This challenge does not directly interfere with code review tasks but significantly affects collaboration and team spirit.

In addition to practices like pair programming and code reviews, continuous learning, and professional development are fundamental in software development. However, many participants encountered challenges when trying to master new software tools or transitioning between different IDEs. A significant number also showed resistance towards embracing new learning experiences, extending not only to learning new software or IDEs but also to exploring new approaches and moving away from established practices. These observations underscore the need to develop tailored strategies that align with the unique learning preferences and tendencies of individuals with autism within the context of their professional growth. Our literature review revealed that individuals with autism often struggle when adapting to new circumstances, explaining why many interviewees expressed difficulties in this area. Interestingly, while they face challenges with new software, they excel in learning new programming languages. Several interviewees, including one with Savant Syndrome, mentioned being able to grasp a new programming language in a single night. Additionally, they exhibit remarkable persistence in identifying bugs and rectifying errors, which proves advantageous during code reviews.

Online collaborating tools are also a great advantage for autistic individuals. Although they can also present some disadvantages. One advantage is the communication is not being done verbally.

6.2 Agile Can Be a Problem for Autistic Individuals

The Agile methodology is becoming increasingly popular among IT companies. This iterative and collaborative approach to software development involves breaking the project into phases and emphasizes continuous collaboration and improvement [94]. Although this methodology is becoming very popular, for individuals with autism working in the software industry, Agile can present unique challenges that may hinder their productivity and overall work satisfaction.

The main challenge revolves around social interaction. Agile places a strong emphasis on constant communication and collaboration among team members. While this approach can enhance project outcomes, it can be particularly intimidating for individuals with

autism. As we saw from the interviews, many individuals on the autism spectrum struggle with various aspects of social interaction, such as interpreting non-verbal cues, analyzing facial expressions, understanding group dynamics, and engaging in spontaneous conversations. The high degree of social interaction inherent in Agile can lead to feelings of discomfort and stress for these individuals. This already happens in their work life and not one participant mentioned using this methodology, but many of them mentioned the stress of having to talk with people when giving them feedback or just talking about the product they were developing.

Another characteristic of the Agile methodology is flexibility and change. The ever-evolving nature of Agile projects, characterized by frequent changes in project direction and priorities, can be problematic. Many participants from our interviews said they thrived on predictability and routine. The constant shifts and adjustments in Agile projects can disrupt their comfort zones, potentially leading to heightened anxiety and reduced productivity. Additionally, this Agile principle demands an ability to adapt quickly. For those who have the ability to hyperfocus, this adaptability can be challenging, as they may become intensely focused on a particular task or approach and resist change.

Another principle with which individuals with autism may experience challenges is Simplicity – the art of maximizing the amount of work not done – is essential. This involves abstract thinking and adapting to evolving requirements, which may pose difficulties for those who struggle with abstraction. We had many interviewees presenting challenges regarding abstraction. Through our interviews, we encountered several participants who expressed difficulties with abstract thinking and adapting to changing project needs, highlighting the significant impact such challenges can have in software development contexts. Finding strategies to support individuals with autism in developing abstraction skills and managing evolving project requirements is crucial for fostering their success and inclusion in software development teams.

While Agile offers many benefits for software development, it is important to recognize that it may not be an ideal fit for everyone, especially individuals with autism. However, with thoughtful accommodations, increased awareness, and inclusive practices, the software industry can create an environment where individuals with autism can thrive in Agile development teams. These accommodations may involve providing clear communication channels, flexibility in work arrangements, and sensitivity to individual needs, ultimately cultivating a more inclusive and diverse software development community.

6.3 Accommodating Autistic Individuals in the Workplace

A growing trend in the corporate world, particularly within the tech sector, is the adoption of remote or hybrid work practices. Many tech companies now provide their employees with the option to work from home, which can be highly advantageous for individuals on the autism spectrum, facilitating their integration into these workplaces without compromising productivity or quality of work. Our interviews revealed a strong

preference among participants for remote work due to challenges faced in traditional office settings, such as distractions, frequent interruptions, and difficulties focusing amidst ambient noise. The flexibility offered by hybrid or remote work environments allows autistic individuals to work from the comfort of their homes, leading to increased productivity compared to office settings. While one participant expressed a preference for office work, it was acknowledged that this sentiment was not representative of most autistic individuals, who generally favor remote work arrangements. This underscores the importance of providing flexible work options to accommodate diverse needs and working styles, ultimately contributing to a more inclusive and productive work environment for neurodiverse talent in tech companies.

6.4 Hiring Individuals with Autism

Accommodating individuals with autism is crucial, and legal protections should be in place to safeguard their interests. Our interviews and theoretical analysis led us to a significant observation: many individuals with autism, particularly those with level 1 autism (as seen in the majority of our interviewees), are hesitant to disclose their diagnosis during the hiring process. While some eventually felt comfortable sharing their diagnosis after starting their job, resulting in positive experiences, others encountered negative outcomes. The varying experiences highlight the importance of clear guidelines and regulations for companies regarding autism disclosure and accommodation. In the context of software engineering companies, hiring individuals with autism offers substantial benefits beyond inclusivity; it can significantly enhance productivity and bring unique perspectives to the team dynamic.

In Portugal, laws establish employment quotas and define disabled individuals, but the inclusion of neurodivergences such as autism remains unclear due to vague definitions. While distinctions are made between intellectual and neurological disabilities in some legal contexts, consistency is lacking in laws related to employment quotas. Recent policies like Council of Ministers Resolution No. 119/2021 aim to address the rights of autistic individuals, although their impact is limited. Similarly, at the European level, a non-binding resolution emphasizes equal employment opportunities for individuals with autism and disabilities, reflecting ongoing efforts to ensure disability rights. However, regulations in countries like Spain and France do not explicitly include autism spectrum disorder in disability employment quotas, posing challenges in workforce recognition and accommodation [1, 29].

Therefore, advocating for legal frameworks that promote understanding, accommodation, and fair treatment for neurodiverse individuals is essential not only for their well-being but also for the overall success of companies and teams.

EVALUATION SURVEY

In the context of our thesis research, we decided to conduct an evaluation survey to verify our theory.

To conduct this study, we created a detailed survey form. It is important to understand that a survey is a method used to understand people's thoughts, attitudes, and behaviors [31]. Within the context of our research, the primary objective of the survey is to gather quantitative data, offering numerical insights into various aspects of our study population.

Questions are crucial in this process. The answers we receive will be the foundation of our analysis. Surveys are focused on a specific group of people, not the entire population. By doing this, we can make meaningful conclusions without having to survey every single person, saving time and resources while still getting valuable insights [43]. This targeted approach is a vital part of our thesis research.

7.1 Objective

The evaluation survey aims to evaluate the theory that was developed in the previous chapters and understand if the characteristics we found apply mainly to autistic individuals or if they are relevant to a wider audience, including neurotypical individuals. By comparing responses from both groups, we hope to get a clearer picture of the theory's scope.

To achieve the objectives of the survey, the necessary resources primarily include online tools and platforms. The survey was conducted online, utilizing the *SosciSurvey*¹ platform for its administration. *SosciSurvey* is an online survey platform designed for research, academic, and professional applications. Offering a diverse range of features for survey design, data collection, and analysis, it proved to be a fitting choice for our needs. Key advantages of this platform include its ability to present questions in a random order to participants, ensuring unbiased responses, and its support for advanced functionalities such as survey logic and branching. Additionally, this platform offers several question types, including the verbal anchor, which was the type used for the majority of our

¹<https://www.soscisurvey.de/>

questions. These features align closely with our requirements and were important factors in selecting this platform for our survey, to the detriment of other options.

7.2 Survey Design

There are two common types of survey design: cross-sectional and longitudinal. For our thesis, we employed a cross-sectional approach, where participants provide information at a single fixed point in time. Opting for self-administered questionnaires delivered through the Internet, we aimed to enhance accessibility and reach a broader audience. This method allows participants to respond at their convenience, aligning with the efficiency and inclusivity objectives of our survey [72].

The survey was structured in the following manner:

- First section - brief explanation about the survey and its purpose.
- Second section - demographic questions.
- Third section - questions related to the categories found in the theory.

For the third section, we have opted for verbal anchor-type questions, with an example provided in Figure 7.1. This question format is particularly advantageous as it allows participants to express their responses on a scale of 1 to 5, allowing them to articulate the extent of their connection to the question. Additionally, we have incorporated a residual option to prevent respondents from defaulting to the neutral position (Neither Agree nor Disagree) in the verbal anchor.

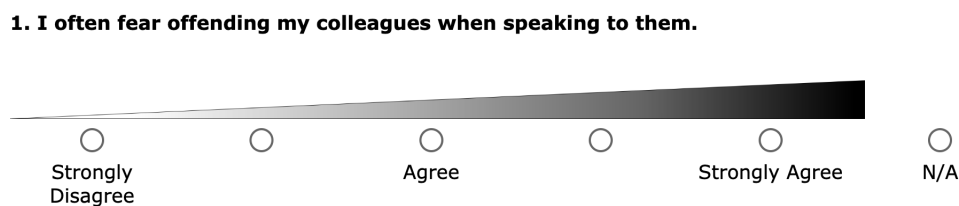


Figure 7.1: Verbal Anchor-Type Question Example

7.3 Questions

In table 7.1 we can see a condensed version of the survey questions we selected, focusing solely on questions related to the categories, excluding the demographic questions. The questions in the survey are presented randomly to the participant, to ensure that participants encounter questions from different categories in a varied sequence. We selected all questions based on our developed theory. However, to prevent the survey from becoming overly lengthy and to improve the likelihood of participant engagement,

we opted to confirm only 2/3 key points from each category. Our approach guarantees the representation of all categories within the survey, with each category featuring at least one related question. The maximum number of questions addressing a single category is limited to five, maintaining a balanced distribution.

Category	Id	Question	Type
Demographics	Q1	What do you do professionally?	Closed (MC)
		...	
Communication	Q01	I often fear offending my colleagues when speaking to them.	Verbal anchor
	Q04	It is easier to use written communication rather than verbal communication.	Verbal anchor
	Q05	I prefer to communicate with others by using written communication rather than verbal communication.	Verbal anchor
Focus	Q03	I often feel I can't focus after someone interrupts me.	Verbal anchor
	Q16	I often experience hyperfocus when programming.	Verbal anchor
	Q17	I see hyperfocus more as a hindrance than as an advantage.	Verbal anchor
Teamwork and Collaboration	Q06	I have trouble giving feedback about other people's work.	Verbal anchor
	Q07	I have trouble receiving feedback about my work from other people.	Verbal anchor
	Q15	Receiving feedback is good for me and it makes me feel confident about my work.	Verbal anchor
	Q22	I often feel difficulties understanding other people's code.	Verbal anchor
	Q25	I have trouble doing pair programming.	Verbal anchor
Social Skills	Q02	I have difficulties reading emotions.	Verbal anchor
	Q08	I have difficulties relating to others and empathizing with my colleagues.	Verbal anchor
	Q09	I don't interpret facial expressions well.	Verbal anchor
Stress Management and Coping	Q11	If I encounter a problem or a bug in my code, I don't rest until I can solve it.	Verbal anchor
	Q30	I get stressed when I can't solve a bug.	Verbal anchor
	Q31	I voluntarily interrupt what I'm doing as a coping mechanism for stress management.	Verbal anchor

Code Reviews and Programming Skills	Q10	I have very strong problem-solving capabilities.	Verbal anchor
	Q12	I have a very easy time memorizing code.	Verbal anchor
	Q13	I usually find the solution first then my peers.	Verbal anchor
Individual Traits and Preferences	Q14	I need constant validation of my work.	Verbal anchor
	Q26	I pay close attention to detail.	Verbal anchor
	Q27	I feel comfortable working with AI tools.	Verbal anchor
	Q28	I am a perfectionist.	Verbal anchor
Challenges in Programming and Code Reviews	Q18	I have trouble using different IDEs.	Verbal anchor
	Q19	I have difficulties learning new programming languages.	Verbal anchor
	Q20	I have trouble adapting to new tools and software.	Verbal anchor
	Q21	I often get feelings of anxiety when the code is not formatted in a certain way.	Verbal anchor
Work Environment	Q23	I prefer remote work rather than in person.	Verbal anchor
	Q24	I get too distracted in the office.	Verbal anchor
	Q34	I feel included in the company that I work in.	Verbal anchor
Autism Awareness and Inclusion	Q29	I feel there is a lack of autism awareness in my team in the company that I work in.	Verbal anchor
Comments	Q32	Comments are very important.	Verbal anchor
	Q33	I have difficulties commenting on the code.	Verbal anchor

Table 7.1: Questions (simplified and condensed excerpt)

7.4 Recruitment Methods

To recruit autistic participants for the evaluation survey, we chose to employ the methodologies outlined in Section 3.2, as part of the target audience remains consistent. We also reached out to participants from our interviews, inviting them to participate in the survey. Additionally, we extended invitations to individuals who had expressed interest in participating in interviews but did not respond to our follow-up emails.

As mentioned in 7.1, for our research we also need to include non-autistic individuals

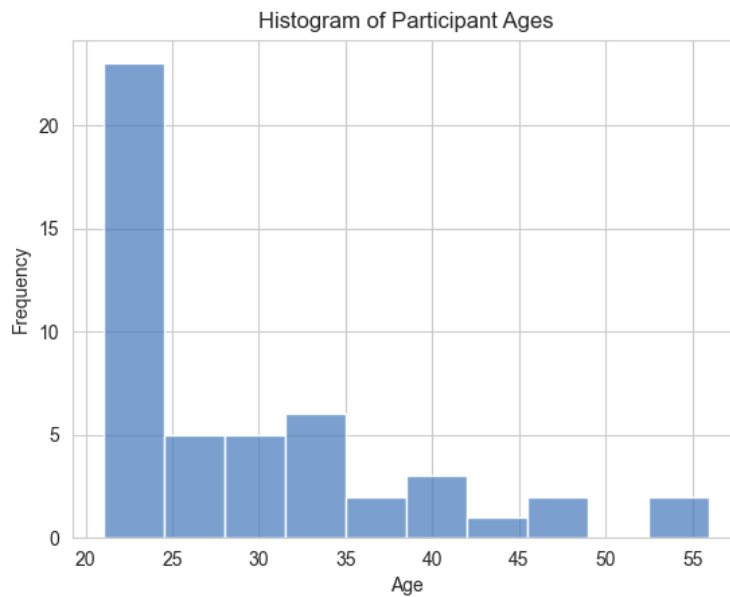


Figure 7.2: Histogram Age Distribution

so, we broadened our recruitment approach. In addition to the methods previously mentioned, we opted to distribute the survey within software developers' group chats on platforms such as *LinkedIn*, *Twitter*, *Slack* channels, and *Whatsapp* groups. It is important to emphasize that the channels used to share this survey were dedicated exclusively to software developers and individuals within the tech industry, ensuring that respondents possessed the necessary competencies to engage meaningfully with our survey.

Additionally, we emphasized specific qualifications for participation, targeting individuals with relevant job roles, skills, or experience levels within the tech industry. To address privacy and consent concerns, we implemented measures to anonymize survey responses and provided clear information on data handling practices. Before collecting any data, we obtained explicit consent from participants and provided them with clear information on our data handling practices. The online survey tool we utilized already ensured anonymity, and we reinforced this by refraining from collecting personal identifiers such as names. Despite some challenges encountered during outreach, such as limited response rates in certain groups, our approach yielded valuable insights from both autistic and non-autistic individuals, enriching the diversity of perspectives in our research findings.

7.4.1 Demographics

Understanding the demographic profile of survey participants is crucial for interpreting and contextualizing the survey findings. In this section, we provide an overview of the demographics of the respondents who participated in our survey. A total of 88 responses were collected, with 49 individuals completing the survey, forming the basis of our analysis.

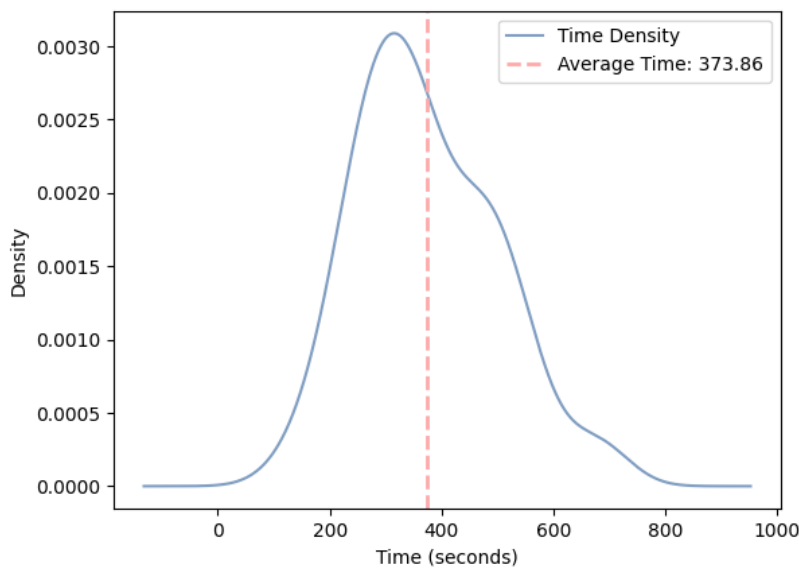


Figure 7.3: Kernel Density Plot for Survey Completion Time

Of all the participants that answered the survey, 11 stated having a diagnosis of autism, with the remaining 5 being self-diagnosed. We can observe in the histogram 7.2 that the average age for the participants is 29,45 years old, with the oldest participant being 56 years old and the youngest being 21 years old. Regarding gender, 17 participants identified as female, 31 as male, 1 as non-binary, and the others did not answer. The number of female individuals was quite high, considering that there are many fewer women in the software engineering field who also have autism.

Regarding the time the participants finished the survey, our demographic analysis focused solely on individuals who successfully completed the survey. The distribution of completion times is visualized in Figure 7.3. The maximum time of completion for the survey is 681.0 seconds which corresponds to 11 minutes and 11 seconds, while the minimum completion time was 139,0 seconds, roughly 2 minutes and 19 seconds. The average time is 373.86 seconds which corresponds to 6 minutes and 14 seconds.

Among the total individuals diagnosed, only 5 completed the survey and responded to questions related to the categories. Consequently, our analysis will be concentrated on these 5 responses to ensure a more focused and meaningful assessment, as opposed to the entire pool of 11 individuals who reported having autism.

In terms of geographic distribution, the majority of participants are from Portugal (31), followed by Belgium (6), the United States of America (3), Brazil (3), and Canada (1). Considering the level of qualifications, the data reveals that the largest proportion of participants (27) hold a master's degree, while eighteen possess a bachelor's degree. Additionally, one participant holds a PhD, and three others indicated varying qualifications, such as being in the process of completing their bachelor's degree.

Another demographic information that is important to highlight is the number of people who answered the survey, which we also interviewed to develop our theory. We shared the survey with all the people we interviewed to develop our theory as well as other individuals who initially took interest in this study. From all the interviewees we got 5 answers to the survey, despite having sent the survey to the interviewees several times. From the 5 answers, only three individuals completed the survey until the end.

7.5 Analysis and Results

7.5.1 Statistical Analysis

Performing statistical tests is essential for rigorously analyzing data and drawing reliable conclusions from research findings. These tests help us determine whether observed differences or relationships in the data are statistically significant, meaning they are unlikely to have occurred by chance. For our statistical analyses, we used Python, a programming language. Within Python, we leveraged the *scipy.stats* library, which provides numerous statistical functions and tests for data analysis. This library facilitated our statistical analyses, including tests such as the *Mann-Whitney U* test and the *Shapiro-Wilk* test, ensuring robustness and accuracy in our data interpretation process. Additionally, before conducting these tests, we pre-processed our data using Python. This pre-processing stage involved essential tasks such as managing blank or missing values to uphold data integrity throughout our analyses.

We employed specific tests to examine our data thoroughly for our statistical analysis. We chose the *Mann-Whitney U* test, which assesses whether a significant difference exists between two independent groups [54]. In our case, the two groups are the autism group and the non-autistic group. Given our non-parametric data and the comparison between two sample groups, this test was well-suited for our analysis. While we also considered employing a *T-test*, it assumes a normal distribution of the data, which is only applicable to one of our sample groups—the autistic group sample. When data do not meet the parametric assumptions of the *t-test*, the *Mann-Whitney U* tends to be more appropriate [54]. The assumptions for the *Mann-Whitney U* test include having both samples as random samples from their respective populations, ensuring independence within each sample and between the two samples, using a measurement scale that is at least ordinal, having a continuous and skewed distribution of scores, and ensuring similarity in the shape of the distribution between groups [54].

To assess whether our sample data followed a normal distribution, we employed the *Shapiro-Wilk* test. Detecting non-normal data is crucial because using parametric tests such as the *T-Test* on non-normally distributed data can lead to inaccurate conclusions. Confirming data normality is essential for researchers to select suitable statistical tests and ensure accurate interpretation of results. Throughout our analyses, we maintained a significance level of 0.05 for the *p-value* to determine statistical significance. A *p-value*,

or probability value, is a number describing how likely it is that the data would have occurred by random chance (i.e., that the null hypothesis is true). The level of statistical significance is often expressed as a p-value between 0 and 1. The smaller the p-value, the less likely the results occurred by random chance, and the stronger the evidence that the null hypothesis should be rejected. The null hypothesis (H_0) states no relationship exists between the two variables being studied (one variable does not affect the other), in our case, the two groups. It states the results are due to chance and are not significant in supporting the idea being investigated [16].

We used the *Mann-Whitney U* test, which is used to compare two samples from continuous distributions. This test, as said before, was executed using Python and the statistical analysis library *scipy.stats*². Specifically, when employing the *Mann-Whitney U* test function from the library, we identified seven hypotheses with a significant difference between the two groups. Interestingly, Question 12 - "I have a very easy time memorizing code" emerged with the lowest p-value, indicating the most significant difference between the groups.

Following the test, we applied *Bonferroni* corrections to the p-values to address the issue of multiple comparisons and control the family-wise error rate (FWER). The FWER represents the probability of incorrectly rejecting the true null hypothesis, essentially indicating the risk of a false positive. Alongside the *Bonferroni* method, we also considered the *Holm-Bonferroni* method, which is a modified version offering increased statistical power compared to *Bonferroni*. While the *Bonferroni* correction is straightforward to compute, it may lack statistical robustness, unlike the more potent *Holm-Bonferroni* method. This adjustment is crucial in reducing the likelihood of obtaining statistically significant results by chance, thus ensuring the reliability of our findings [8]. Using this method with a significance level (α) of 0.05, we found no significant differences between the means of the two groups. All the statistical results can be consulted in Figure 7.4 and Figure 7.5.

In addition to the statistical tests mentioned above, we used *Cronbach's Alpha* to measure the relationship between a group of questions, known as a scale. In our study, each category represents a scale, and each question within that category serves as an item in the scale. *Cronbach's Alpha* quantifies the internal consistency of a scale, indicating the reliability of its measurements [23]. We applied *Cronbach's Alpha* to assess the reliability of all categories except for Autism Awareness and Inclusion. This exclusion was due to the requirement of having at least two items for the measure, and this particular category only contained one question. To implement this measure we used the *pingouin* library³ in Python. We were guided by table 7.2 of George and Mallery [33] to interpret the alpha values. The results for each category can be found in Figure 7.4. We observed that seven of our categories exhibited an 'Unacceptable' level of internal consistency. This could be attributed to several factors, such as a low number of questions within these

²<https://docs.scipy.org/doc/scipy/reference/stats.html>

³https://pingouin-stats.org/build/html/generated/pingouin.cronbach_alpha.html

Categories	Questions	Total n answers (non-autistic)	Total n answers (autistic)	Mean total	Mean Aut	Mean Non-Aut	Standard Deviation
Communication	Q01	44	5	2,796	3,600	2,705	1,258
	Q04	44	5	2,816	3,800	2,659	1,349
	Q05	44	5	2,776	3,800	2,659	1,295
Focus	Q03	44	5	3,245	3,800	3,182	1,182
	Q16	41	5	3,739	4,600	3,634	1,021
	Q17	38	5	2,070	2,600	2,000	0,856
Teamwork and Collaboration	Q06	44	5	2,694	2,200	2,750	1,326
	Q07	44	5	2,367	2,800	2,318	1,202
	Q15	44	5	4,143	4,000	4,159	0,791
	Q22	44	5	3,122	3,600	3,068	1,013
	Q25	39	5	2,614	3,200	2,538	1,125
Social Skills	Q02	44	5	2,265	3,000	2,182	0,995
	Q08	43	5	1,917	2,400	1,860	0,964
	Q09	44	4	1,958	3,250	1,841	1,031
Stress Management and Coping	Q11	44	5	3,673	4,000	3,636	1,144
	Q30	44	5	4,102	4,400	4,068	0,823
	Q31	42	5	3,319	2,600	3,405	1,235
Code Reviews and Programming Skills	Q10	44	5	3,694	3,600	3,705	1,084
	Q12	44	5	2,673	3,800	2,545	0,987
	Q13	43	5	2,750	2,200	2,814	0,887
Individual Traits and Preferences	Q14	44	5	2,816	3,600	2,727	1,380
	Q26	44	5	3,776	4,000	3,750	0,963
	Q27	39	4	3,651	3,750	3,641	1,066
	Q28	44	5	3,612	3,800	3,591	1,077
Challenges in Programming and Code Reviews	Q18	43	5	2,500	2,600	2,488	1,111
	Q19	44	5	2,224	2,200	2,227	1,006
	Q20	44	5	2,388	3,400	2,273	1,151
	Q21	44	5	2,837	4,000	2,705	1,264
Work Environment	Q23	43	5	3,313	4,600	3,163	1,274
	Q24	41	5	2,761	3,000	2,732	1,099
	Q34	37	5	4,071	4,600	4,000	0,947
Autism Awareness and Inclusion	Q29	24	4	3,000	3,250	2,958	1,122
Comments	Q32	44	5	4,000	4,200	2,250	0,979
	Q33	44	5	2,429	1,800	2,500	1,021

Figure 7.4: Statistics from each Category

Categories	Questions	p-value (Mann-Whitney u)	Bonferroni Correction	Holm-Bonferroni Correction	Cronbach's Alpha	Internal Consistency
Communication	Q01	0,1176	FALSE	FALSE	0,753	Acceptable
	Q04	0,1051	FALSE	FALSE		
	Q05	0,0792	FALSE	FALSE		
Focus	Q03	0,2737	FALSE	FALSE	-0,315	Unacceptable
	Q16	0,0344	FALSE	FALSE		
	Q17	0,1451	FALSE	FALSE		
Teamwork and Collaboration	Q06	0,3960	FALSE	FALSE	0,372	Unacceptable
	Q07	0,3811	FALSE	FALSE		
	Q15	0,6367	FALSE	FALSE		
	Q22	0,2062	FALSE	FALSE		
	Q25	0,2127	FALSE	FALSE		
Social Skills	Q02	0,0398	FALSE	FALSE	0,834	Good
	Q08	0,4346	FALSE	FALSE		
	Q09	0,0398	FALSE	FALSE		
Stress Management and Coping	Q11	0,6961	FALSE	FALSE	-0,031	Unacceptable
	Q30	0,4558	FALSE	FALSE		
	Q31	0,1937	FALSE	FALSE		
Code Reviews and Programming Skills	Q10	0,7769	FALSE	FALSE	0,394	Unacceptable
	Q12	0,0058	FALSE	FALSE		
	Q13	0,1522	FALSE	FALSE		
Individual Traits and Preferences	Q14	0,1923	FALSE	FALSE	0,366	Unacceptable
	Q26	0,6641	FALSE	FALSE		
	Q27	0,9135	FALSE	FALSE		
	Q28	0,6425	FALSE	FALSE		
Challenges in Programming and Code Reviews	Q18	0,8999	FALSE	FALSE	0,765	Acceptable
	Q19	0,7592	FALSE	FALSE		
	Q20	0,0397	FALSE	FALSE		
	Q21	0,0319	FALSE	FALSE		
Work Environment	Q23	0,0154	FALSE	FALSE	0,190	Unacceptable
	Q24	0,4861	FALSE	FALSE		
	Q34	0,5792	FALSE	FALSE		
Autism Awareness and Inclusion	Q29	0,8357	FALSE	FALSE	-	-
Comments	Q32	0,4196	FALSE	FALSE	-1,097	Unacceptable
	Q33	0,1535	FALSE	FALSE		

Figure 7.5: Statistics from each Category (continued)

Cronbach's Alpha	Internal Consistency
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Table 7.2: Interpretation of Cronbach's Alpha

categories, with most of them containing only two or three questions, or simply poor inter-relatedness between items within the category. Among these 'Unacceptable' results, we also encountered negative values for *Cronbach's* alpha. This may indicate potential issues such as sampling errors or inadequacies in the collected sample's ability to effectively measure the respective questionnaire instrument. In such cases, options may include eliminating statements that contribute to the construct's ineffectiveness or collecting data from a new sample. However, due to the limited number of items in these categories, eliminating items is not a feasible option, leading to challenges in improving the measure's appropriateness. On a positive note, two categories demonstrated an 'Acceptable' level of consistency, while one category showed a 'Good' level of internal consistency, indicating that certain areas of our assessment are meeting the desired standards for reliability.

Additionally, for each category, we generated a Likert scale graph with each question having in comparison to the autistic group (Aut.) and the non-autistic group (Non Aut.), which complements the statistical tests we performed. It was anticipated to observe minimal statistical differences from the tests due to the notably small sample size in one of the groups (specifically, the autistic group). As sample size decreases, achieving statistical significance becomes increasingly challenging. With only 5 members in this group, it is unsurprising that few statistically significant relationships were detected. However, this does not mean that there are no differences between the groups which do not present statistical significance. With these graphs, we can take a different perspective and consider some differences that we cannot see from the tests. And, while statistical tests like the *Mann-Whitney U* test, offer quantitative evidence to support conclusions about the differences observed, Likert scale graphs provide a qualitative overview of responses. By using both approaches, we can gain a comprehensive understanding of the data, confirming patterns identified visually with statistical significance tests.

7.5.2 Communication

The Likert scale graph (Figure 7.6) presents the results of the survey, offering insights into participants' perspectives on various aspects related to communication. Regarding the first question, *I often fear offending my colleagues when speaking to them.*, as depicted in the graph, it is notable that the autistic group displays a higher percentage of agreement, with only 20% disagreeing (which represents 1 out of 5 participants). The average response to

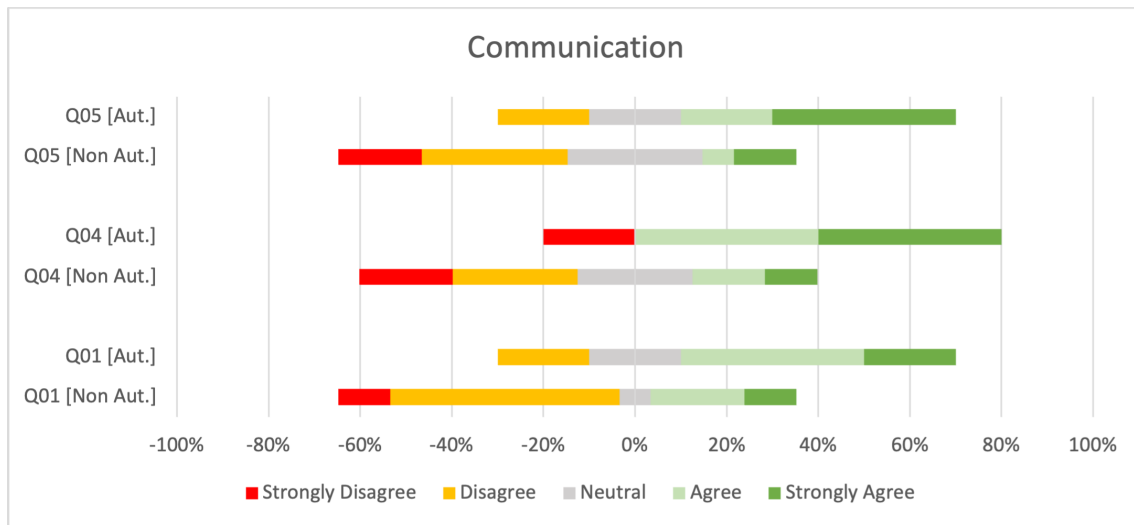


Figure 7.6: Communication Likert Scale Graph

this question is 2.80, indicating that the majority disagrees with the statement. Conversely, the mean for the non-autistic group is 2.70, with 50% expressing disagreement.

In our survey, we intentionally incorporated two similar questions placed randomly to assess participants' attentiveness and discourage random responses. For both statements, autistic individuals demonstrated a notable inclination toward agreement, confirming that they prefer to use written communication instead of verbal. Although we can see a higher level of agreement, we can also observe that for Question 4, there is a small percentage of disagreement. In contrast, non-autistic individuals expressed a tendency to disagree with both questions. This disparity underscores a distinct variance in communication preferences between the two groups, with neurodivergent individuals showing a more favorable disposition towards written communication compared to individuals without autism.

Despite the differences presented above, none of the questions in this category exhibited statistically significant differences between the two groups.

7.5.3 Focus

Figure 7.7 represents the three questions within the Focus category. For Question 3, *I often feel I can't focus after someone interrupts me*, the average is 3.45, so the majority of the participants agree with the difficulty of focusing after being interrupted. Regarding the autistic group, 80% agree with it. However, for the non-autistic group, 20% are neutral on the issue and ~52% disagree with it.

The results for Question 16, *I often experience hyperfocus when programming*, is 100% of agreement (40% agree and 60% strongly agree) for the autistic group, having a mean of 4.6. On the other hand, the non-autistic group, has a 20% neutrality, a small percentage of disagreement, and a mean of 3.63.

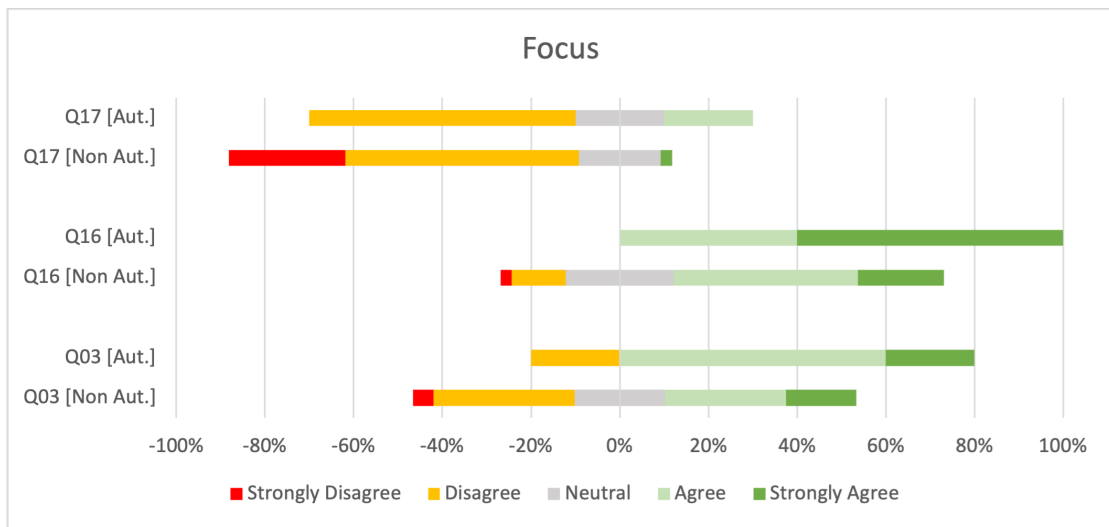


Figure 7.7: Focus Likert Scale Graph

For Question 17, both groups of individuals disagree with the statement. Notably, non-autistic individuals strongly disagree with 23% strongly disagreeing, and only 1 participant agrees with it. The total mean is 2.07, representing an overall disagreement with seeing hyperfocus more as a hindrance than as an advantage.

Within this category, Question 16 emerged as the sole indicator of a significant statistical difference between both groups, as confirmed by the *Mann-Whitney U* test (p-value = 0.0344).

7.5.4 Teamwork and Collaboration

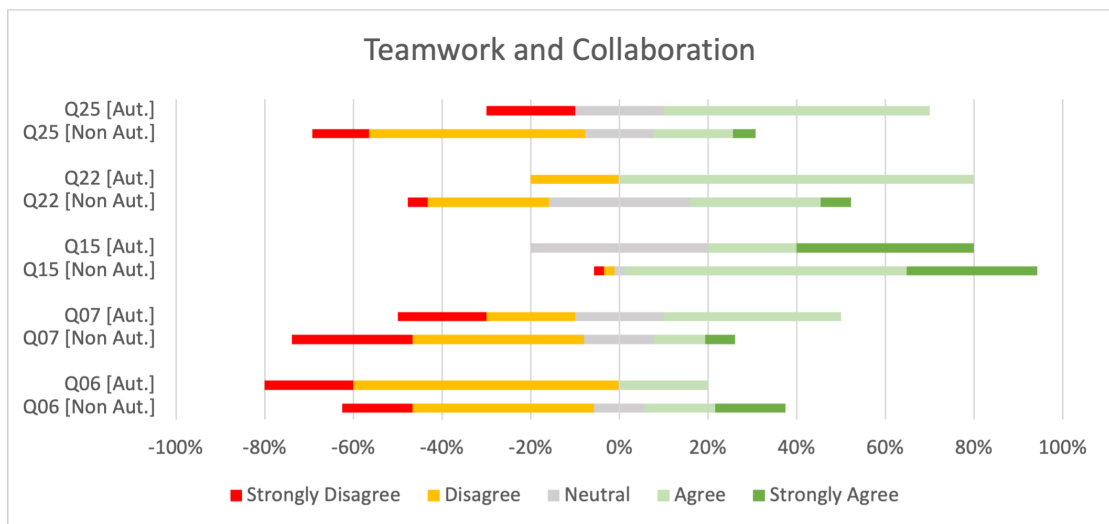


Figure 7.8: Teamwork Likert scale graph

Figure 7.8 is the visual representation of responses for the five questions within the Teamwork and Collaboration category. Regarding Question 6, *I have trouble giving feedback about other people's work*, the total mean score is 2.694, indicating an overall tendency towards

disagreement, approaching neutrality among participants. Within the autistic group, 80% expresses disagreement with experiencing difficulty in providing feedback to others. Interestingly, in the non-autistic group, there is an equal number (7) of participants who agree, strongly agree, and strongly disagree, with the remaining participants expressing disagreement. Question 7, *I have trouble receiving feedback about my work from other people*, yields an equal split between agreement and disagreement within the autistic group. The average for the latter group is 2.80. The non-autistic group has ~66% of participants disagreeing with having trouble receiving feedback.

Question 15, designed to explore reliance on feedback among autistic individuals, did not yield a significant difference between the two groups. Both groups agree with the statement, suggesting a shared appreciation for the positive impact of feedback. Within the autistic group, 40% of participants remain neutral, with no reported disagreement. Conversely, approximately 93% of non-autistic participants agree with the statement. The overall mean score is 4.143.

For Question 22 the overall mean score is 3.122, representing a sense of neutrality regarding feeling difficulty understanding other peoples' code. Within the autistic group, the mean is 3.6, and for the non-autistic group is 3.068. For the autistic group, we can see that 80% agree with it, with the rest disagreeing. The standard deviation for this question is 0.79, suggesting that the responses were clustered closely around the mean. This reinforces the initial observation of minimal differences between the two groups.

Question 25, *I have trouble doing pair programming* reveals a mean score of 3.20 within the autistic group, indicating varied responses. Among autistic participants, 60% agree with the statement, while 20% remain neutral, and an additional 20% strongly disagree. In contrast, the non-autistic group exhibits a higher level of disagreement, with approximately 55% expressing disagreement (43% disagreeing and 11% strongly disagreeing). These results suggest a notable divergence in attitudes towards pair programming between the two groups. Despite containing the highest number of questions, this category did not yield a single question that exhibited a statistically significant difference between the autistic and non-autistic groups.

7.5.5 Social Skills

Figure 7.9 depicts the Likert scale graph illustrating participants' responses to the three questions within the Social Skills category.

Question 2, *I have difficulties reading emotions*, analysis reveals a 60% neutrality rate among autistic participants, alongside 20% agreement and an equal 20% disagreement. The mean for this group precisely reached 3.0. Conversely, the non-autistic group exhibits considerably more disagreement, with 75% expressing disagreement or strong disagreement for having difficulties reading other peoples' emotions. Statistical analysis using the *Mann Whitney U* test revealed a significant difference between the two groups, yielding a p-value of 0.0398.

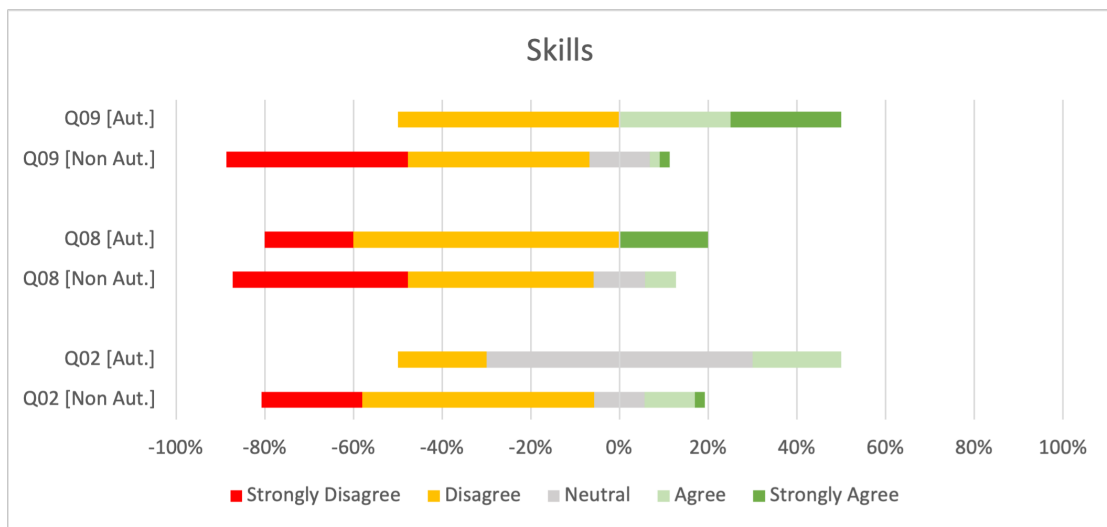


Figure 7.9: Social Skills Likert scale graph

Question 8, *I have difficulties relating to others and empathizing with my colleagues*, results reveal similarities between the two groups. The total mean recorded at 1.917 indicated a prevailing disagreement among respondents regarding difficulties in relating to others and empathizing. Despite the overall disagreement, within the autistic group, 20% of participants strongly agree with the statement, while another 20% strongly disagree, and the majority (60%) express disagreement. In contrast, the non-autistic group exhibits a notably higher percentage of strong disagreement, approximately 38%, with only 3 individuals agreeing, representing less than 1% of the group.

Question 9, *I don't interpret facial expressions well*, responses reveal disparities between the two participant groups. The autistic group presents a mean score of 3.250, indicating a tendency toward agreement, with no neutrality observed. Within this group, an equal percentage of respondents express agreement and strong agreement, while 50% express disagreement. In contrast, the non-autistic group demonstrates a significantly higher percentage of both strong disagreement (41%) and disagreement (41%). These discrepancies between the groups are further supported by a p-value of 0.0398 obtained from the statistical tests, particularly the *Mann-Whitney U* test, confirming the observed differences.

From the statistical tests, we observe that this category presents more questions with significant differences between the autistic and neurotypical groups, as indicated by the *Mann-Whitney U* test. Questions 2 and 9 emerge as the ones with the most significant differences, a finding consistent with the patterns observed in the Likert scale graph described above.

7.5.6 Stress Management and Coping

In Figure 7.10 we can see the Likert scale graph illustrating participants' responses to the three questions within the Stress Management and Coping category.

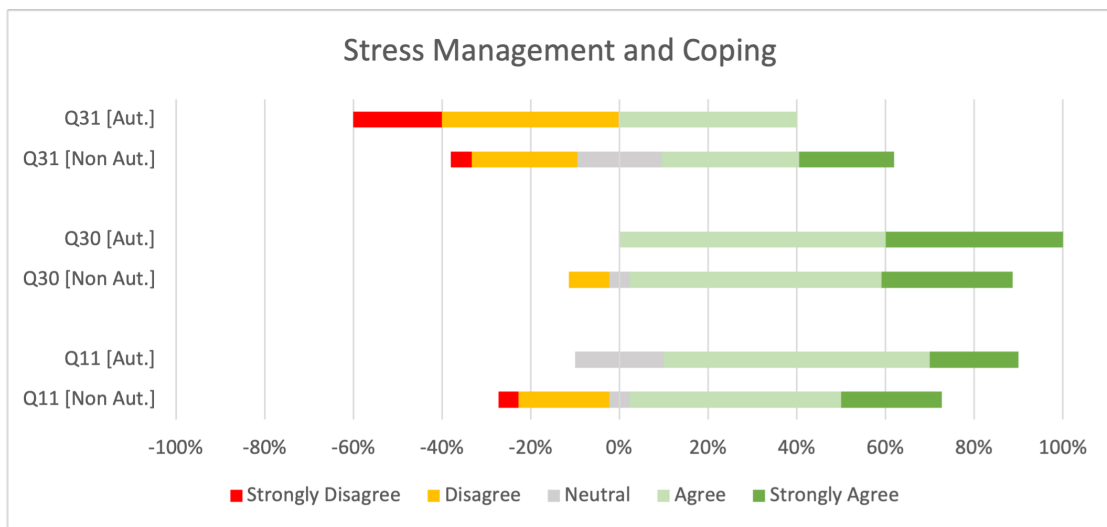


Figure 7.10: Stress Likert scale graph

Question 11 reveals distinct patterns between the autistic and non-autistic groups. Amongst the autistic group, unanimity is observed, with all participants either strongly agreeing, agreeing, or remaining neutral about their persistence in solving coding issues. The mean score of 4.0 indicates a strong inclination towards agreement as stated previously. In contrast, in the non-autistic group, approximately 48% of participants agree with the statement, while around 21% express disagreement, with an insignificant percentage strongly disagreeing.

In Question 30, both the autistic and neurotypical groups reveal strikingly similar trends in agreement with experiencing stress when unable to solve a bug. In fact, in the autism group, unanimity prevails, with no participants expressing neutrality or disagreement; instead, a significant majority (60%) agrees, with an additional 40% strongly agreeing with the statement. Regarding the neurotypical group, we found that there is a minimal percentage (0.9%) expressing disagreement or neutrality (0.4%). The overall mean score is 4.102, so both groups are leaning toward agreement.

Regarding Question 31, In the autism group, the mean score of 2.6 unveils a diverse array of responses, revealing a balanced distribution across agreement and disagreement, with 20% strongly disagreeing, 40% disagreeing, and 40% agreeing. Conversely, within the non-autistic group, the mean score of 3.405 tilts decidedly towards agreement, underscoring a higher tendency towards embracing self-interruption as a viable stress management tool.

7.5.7 Code Reviews and Programming Skills

Within the Code Reviews and Programming Skills category, Figure 7.11 presents a Likert scale graph, capturing participants' feedback on the three questions. This category, overall, presented a prevalent tendency towards neutrality across the majority of questions for both groups.

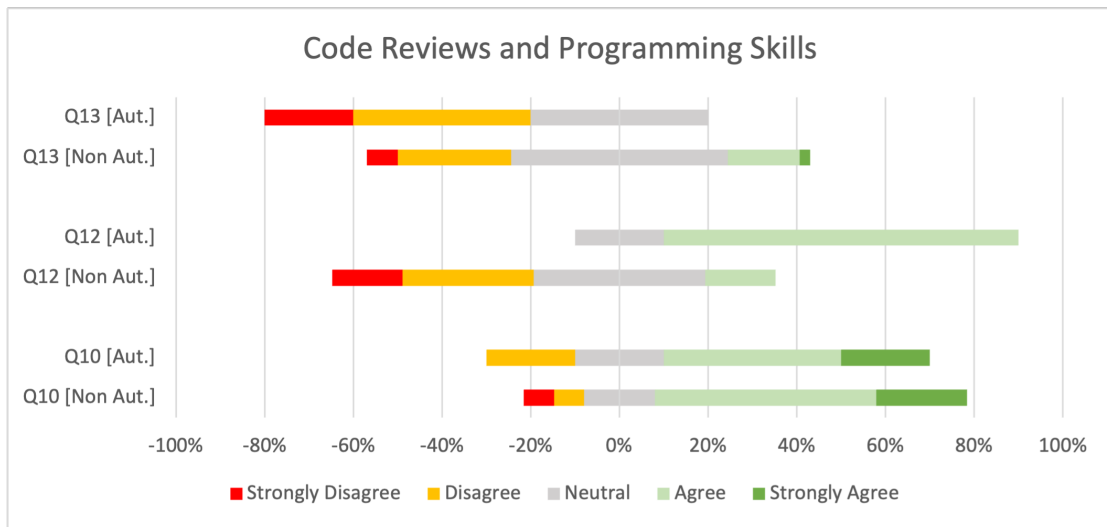


Figure 7.11: Code Reviews Likert scale graph

For Question 10, *I have very strong problem-solving capabilities*, the results reveal a minimal distinction between the autistic and non-autistic groups. The only discernible difference appears in the non-autistic group, where 0.07% of the participants express strong disagreement with having strong problem-solving capabilities. Despite this, in both groups, there are similar percentages for strong agreement, agreement, and neutrality. The autistic group has a mean score of 3.6 and the non-autistic group has a very close score of 3.7.

Question 12, *I have a very easy time memorizing code*, demonstrates clear differences between the two groups. The autistic participants predominantly agree with the statement, with 80% indicating ease in memorizing code and 20% remaining neutral. In contrast, the non-autistic group exhibits a contrasting trend, leaning more towards disagreement. Their mean score of 2.545 reflected this divergence, with 40% expressing neutrality and only approximately 16% agreeing. Notably, this question stood out as the only one in its category to show a significant statistical difference between the two groups when conducting the *Mann Whitney U* test.

The analysis of Question 13, *I usually find the solution first then my peers*, reveals contrasting perspectives between the autistic and non-autistic groups. While the autistic participants predominantly disagree with the statement, the non-autistic group exhibits more varied responses, with a significant proportion expressing neutrality. Specifically, the autistic group has 40% neutrality, 40% disagreement, and 20% strongly disagreed. In contrast, the non-autistic group shows a high percentage (~48%) of neutrality. The mean score for this group is 2.814, indicating a leaning toward disagreement with the statement.

7.5.8 Individual Traits and Preferences

Exploring Individual Traits and Preferences, Figure 7.12 presents a Likert scale graph elucidating participants' responses to the four questions in this category.

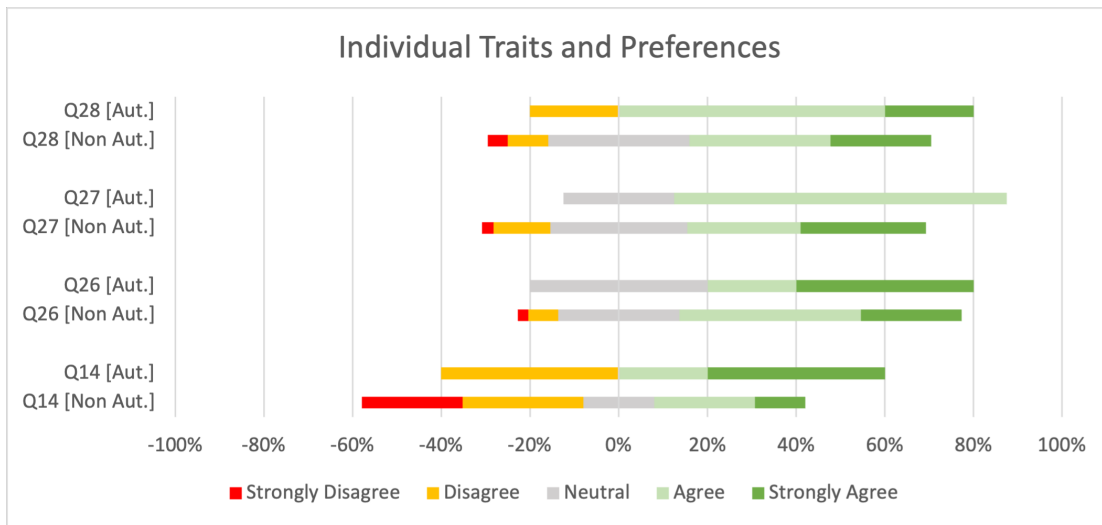


Figure 7.12: Individual Traits Likert Scale Graph

In analyzing Question 14, *I need constant validation of my work*, the graph illustrates a notable difference within the autistic group, with 40% strongly agreeing, 20% agreeing, and 40% disagreeing, indicating a relatively balanced distribution between agreement and disagreement. The mean score for this group is 3.6, suggesting a slight inclination towards agreement. Conversely, the non-autistic group exhibits a more diversified response pattern, with less than 20% strongly disagreeing. Participants in this group are distributed across the various categories of the Likert scale, displaying a comparable percentage of both disagreement and agreement.

In Question 26, *I pay close attention to detail*, the results between the two groups are quite similar. Within the autistic group, 40% of participants express neutrality, a 13% increase compared to the non-autistic group. Additionally, a significant portion (40%) strongly agrees with the statement, while there are no instances of disagreement. Contrarily, the non-autistic group demonstrates a minimal percentage of disagreement as well as strong disagreement, with the majority leaning towards agreement. Mean scores between the two groups are also closely aligned, with a standard deviation of 0.962.

Assessing comfort with AI tools (Question 27), both groups exhibit a significant degree of comfort, particularly in the autistic group where a substantial majority (75%) agrees with the statement and the rest presented neutrality. In the non-autistic group, while the majority also expresses comfort, there is a notable portion (46% combined) that disagrees or is neutral. Additionally, there is 1 participant from the autistic group and 5 participants from the non-autistic group who did not provide any response.

For Question 28, the Likert scale graph illustrates a prevalent inclination towards agreement with being a perfectionist, reflected in the total mean score of 3.61. Within the autism group, a substantial 60% of participants agree with the statement, while the non-autistic group shows a slightly higher percentage of strong agreement, alongside approximately ~32% expressing neutrality.

7.5.9 Challenges in Programming and Code Review

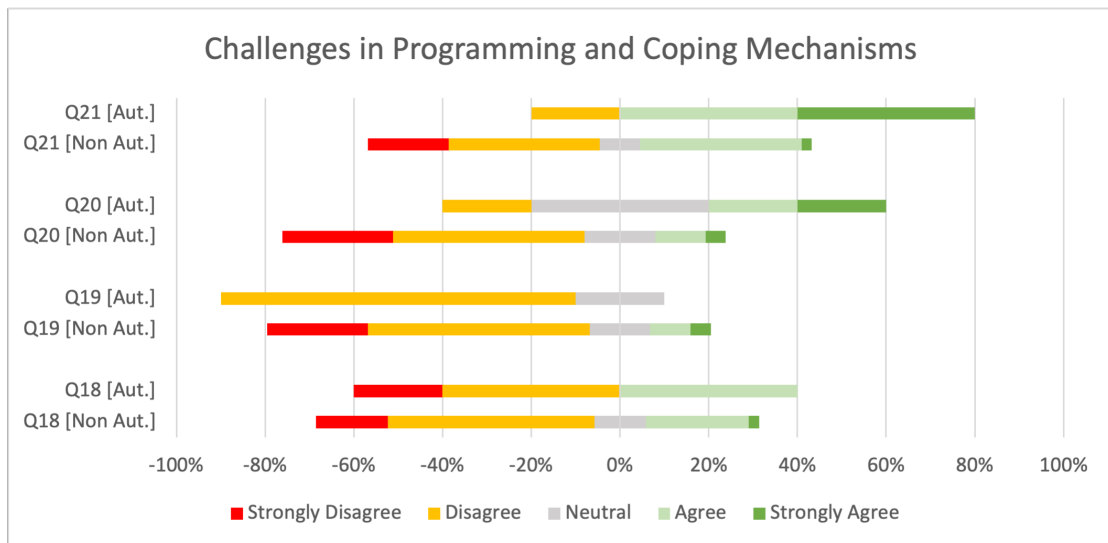


Figure 7.13: Challenges Likert Scale Graph

Regarding this category, Figure 7.13 presents a Likert scale graph showing participants' responses to the four questions in this category.

Regarding Question 18, the responses are very scattered in both groups. 60% of the participants from both the autistic and non-autistic groups disagree with experiencing difficulties in using different IDEs. Within the autistic group, we can observe a percentage of 40 when it comes to agreeing a 20% of strong disagreement, and no percentage for neutrality or strong agreement. Regarding the non-autistic group, there is a small percentage of neutrality and a minimal percentage of strong agreement. There is not much difference between the two groups, the mean for the autistic group is 2.60 and for the non-autistic one is 2.49.

For Question 19, the results show that both groups share a high percentage of disagreement with experiencing difficulties learning new programming languages. The autistic group shows an 80% disagreement rate for this question, with the remainder expressing neutrality. In contrast, the non-autistic group exhibits a smaller percentage of agreement, along with a higher rate (~23%) of strong disagreement. There is also a minimal percentage of agreement within this group. The mean score for both groups is around 2, indicating a leaning toward disagreement for this question.

Concerning Question 20, *I have trouble adapting to new tools and software*, we can see the first significant difference for this category. The results demonstrate a considerably higher agreement rate within the autistic group, totaling 40%. Neutrality is also prevalent at 40%, with only 20% expressing disagreement. Conversely, the non-autistic group exhibits a stronger disagreement rate at 25%, contrasting with the autistic group's 0% in this category. Statistical analyses using the *Mann-Whitney U* test reveal notable differences, with a p-value of 0.0397.

In Question 21, *I often get feelings of anxiety when the code is not formatted in a certain way*, the autistic group displays a significant consensus, with 80% of respondents indicating feelings of anxiety when code is not formatted to their preference, evenly split between agree and strongly agree categories. Conversely, a minority (20%) disagrees with this statement. The mean score for this group is 4.0. On the other hand, the non-autistic group, while also reflecting a notable agreement rate (approximately 52%), exhibits a contrasting 20% showing strong disagreement. The mean score for this group is 2.705. Statistically, this question revealed a significant difference between both groups when using the *Mann-Whitney U* test with a p-value of 0.0319.

In this category, comprising four questions, half of them exhibit significant differences between both groups in both statistical tests conducted—specifically, Questions 20 and 21. The consistency of these results across both tests strengthens our initial expectations and is further supported by insights gained from the Likert scale graphs.

7.5.10 Work Environment

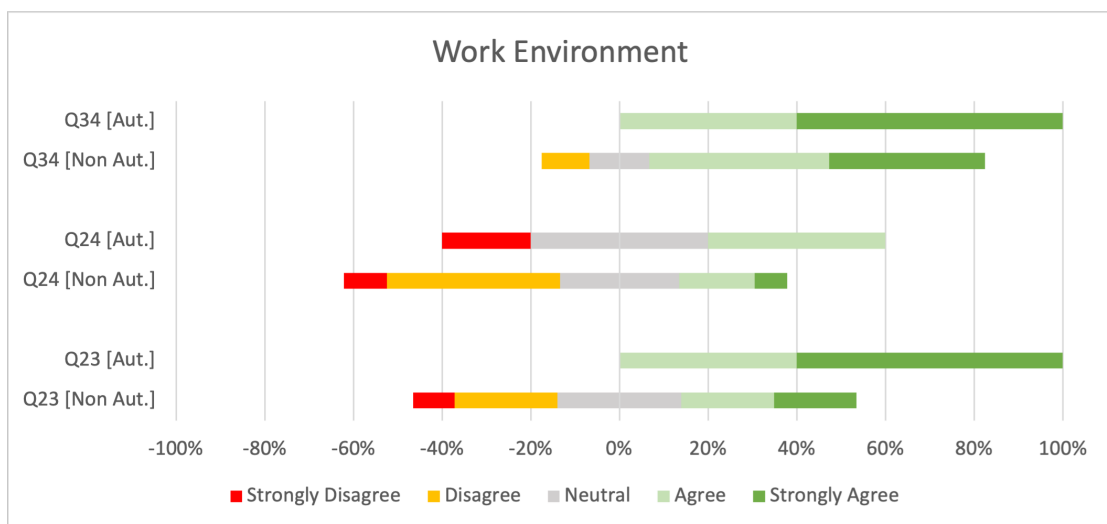


Figure 7.14: Work Environment Likert Scale Graph

In Figure 7.14 we can observe a Likert scale graph with the results from the respective three questions that are in this category.

The scales for Question 23, *I prefer remote work rather than in person*, show clear distinction preferences between the autistic and non-autistic groups. In the autistic group, 100% of respondents agree with preferring remote work, with a significant majority (60%) strongly agreeing. The mean score for this group is 4.60, reflecting strong consensus. Conversely, among the non-autistic group, fewer individuals favor remote work over in-person work. Approximately 23% disagree and about 28% express neutrality on the matter. Statistical analyses aligned with the Likert scale graph, confirming a significant difference between the two groups. The p-value for the statistical test conducted is 0.0154 (*Mann-Whitney U*), indicating statistical significance.

Question 24, comes as a follow-up to the previous question, exploring potential distractions in office environments, possibly influencing preferences for remote work. The results showed that neither the autistic group nor the non-autistic group agreed with it. The total mean score is 2.76. From both groups, there is some neutrality, 40% for the autistic group and slightly less for the other group. The autistic group has also 40% of agreement and, in contrast, 20% of strong disagreement. The non-autistic group leans even more to the disagreement side, compared to the autistic group, with a value of 39% of disagreement and approximately 1% of strong disagreement.

For Question 34, there are fewer answers than other questions, with only 37 answers from the non-autistic group. The Likert scale graph in Figure 7.14 illustrates that 60% of the autistic group strongly agree, and 40% agree to feel included in their workplace. Among the neurotypical group, a majority agree, although some individuals express disagreement. The fact that 100% of the autistic group reported feeling included is a positive outcome.

To complement these findings, an open-ended question was created to allow participants to elaborate on their responses, from which we got some interesting responses. One person from the neurotypical group said *"Our company puts a major emphasis on diversity, equity, and inclusion. Because most are like me, not the opposite."*. Others expressed feelings of exclusion such as *"Much more could be done to be inclusive. In terms of the social side, there are initiatives to do social events to make everyone feel included and accustomed to each other. In terms of inclusivity in the workplace, much more could be done."* and *"I feel there is a disparity in the way people perceive you or have expectations of you solely based on your appearance, gender, and other disparities that should be considered equal and require social adjustments to each individual is a required soft skill when working in a company."*.

7.5.11 Autism Awareness and Inclusion

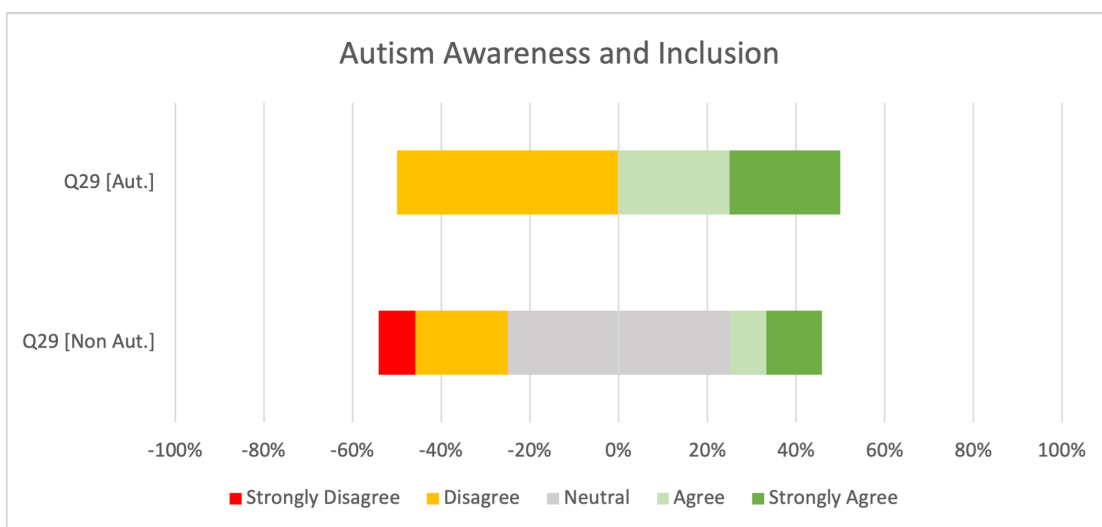


Figure 7.15: Autism Awareness Likert Scale Graph

Figure 7.15 presents a Likert scale graph, encapsulating the outcomes of the singular question of the Autism Awareness and Inclusion category.

For this category, having only Question 29, *I feel there is a lack of autism awareness in my team in the company that I work in*, we can see a clear difference between the two groups. Unlike the non-autistic group, which exhibits a neutrality rate of 50%, the autistic group shows no neutrality. Additionally, a significant number of participants did not respond to this question, with only 24 out of the total participants providing answers, representing nearly half the response rate of questions in other categories. Within the autistic group, there is an equal distribution between disagreement and agreement (25% indicating agreement and 25% strongly agreeing). The total mean score for this question is precisely 3.0.

7.5.12 Comments

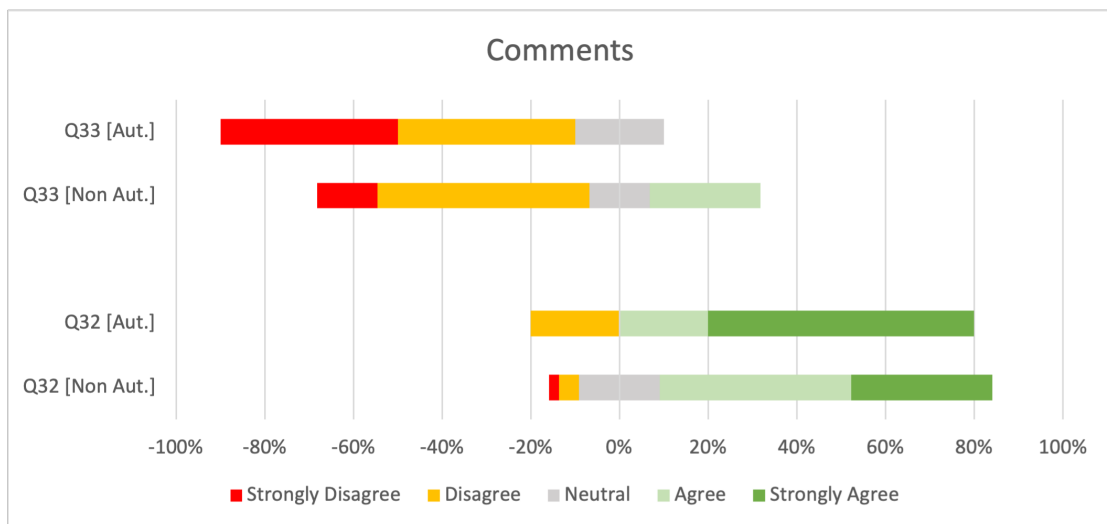


Figure 7.16: Comments Likert Scale Graph

Examining the "Comments" category depicted in Figure 7.16, we analyze a Likert scale graph presenting the results of the respective two questions.

In Question 32, *Comments are critical*, both groups express a leaning towards agreement rather than disagreement regarding the criticality of comments. The autistic group shows a significant 60% strongly agreeing, along with 20% agreement and 20% disagreement. Conversely, the non-autistic group exhibits more diverse responses, including some neutrality, along with minimal values for disagreement and strong disagreement.

For Question 33, both groups disagree with experiencing difficulties commenting on the code. Notably, the autistic group has a substantial 40% strongly disagreeing. In contrast, the non-autistic group showcases a nuanced response with 25% agreeing with the statement, alongside some disagreement and neutrality. The total mean score for this question is 2.761.

7.6 Discussion

Below we will make a discussion about the survey results, comparing it to our initial theory. In Figure 7.17, we can see all the categories with their corresponding codes.

The color scheme for the codes was determined based on their status in our survey analysis:

- Green: Codes that are highlighted in green are those that have been confirmed in our survey data. These are codes for which we found sufficient evidence or responses supporting their presence or relevance.
- Blue: Codes highlighted in blue are those that were not directly addressed or explored in our survey. These codes may represent potential areas for future research or investigation, as they were not within the scope of the current survey or analysis.
- Grey: The grey color is used for codes that were questioned or had ambiguous findings during the survey analysis. These codes were not definitively confirmed by the survey responses but were still relevant enough to be included for further investigation or analysis.

By using this color scheme, we can visually differentiate between codes that are confirmed, those that require further validation or consideration, and areas that were not covered in the current survey but may warrant attention in future studies or analyses.

In the Communication category, regarding the first question, "I often fear offending my colleagues when speaking to them.", we can conclude that it aligns with the insights gained from the conducted interviews. Our initial expectation that neurotypical individuals would not strongly identify with this sentiment was validated by the survey results. We were expecting a higher level of disagreement with the question regarding neurodivergent individuals, which was also confirmed. Additionally, for the autistic group, our theory was also confirmed. For Questions 4 and 5, our hypotheses were validated, aligning with our initial expectations. The autistic group expressed a clear preference for written communication over verbal communication, as anticipated. In contrast, the non-autistic group exhibited more varied responses but generally leaned towards disagreement with this preference. These findings highlight distinct communication preferences between the two groups and support our initial expectations regarding communication modes.

In the Focus category, our expectations were centered around traits typically associated with autistic individuals. Surprisingly, only one question showed significant differences between autistic and non-autistic groups. This unexpected outcome may stem from the way questions in this category were formulated. For instance, in Question 16, which refers to hyperfocus - a trait traditionally associated with autistic people - we found that non-autistic individuals also reported experiencing it. Although perhaps not with the same intensity as autistic individuals experience when doing certain activities, such as programming. While there was a subtle difference evident in the Likert scale graph for

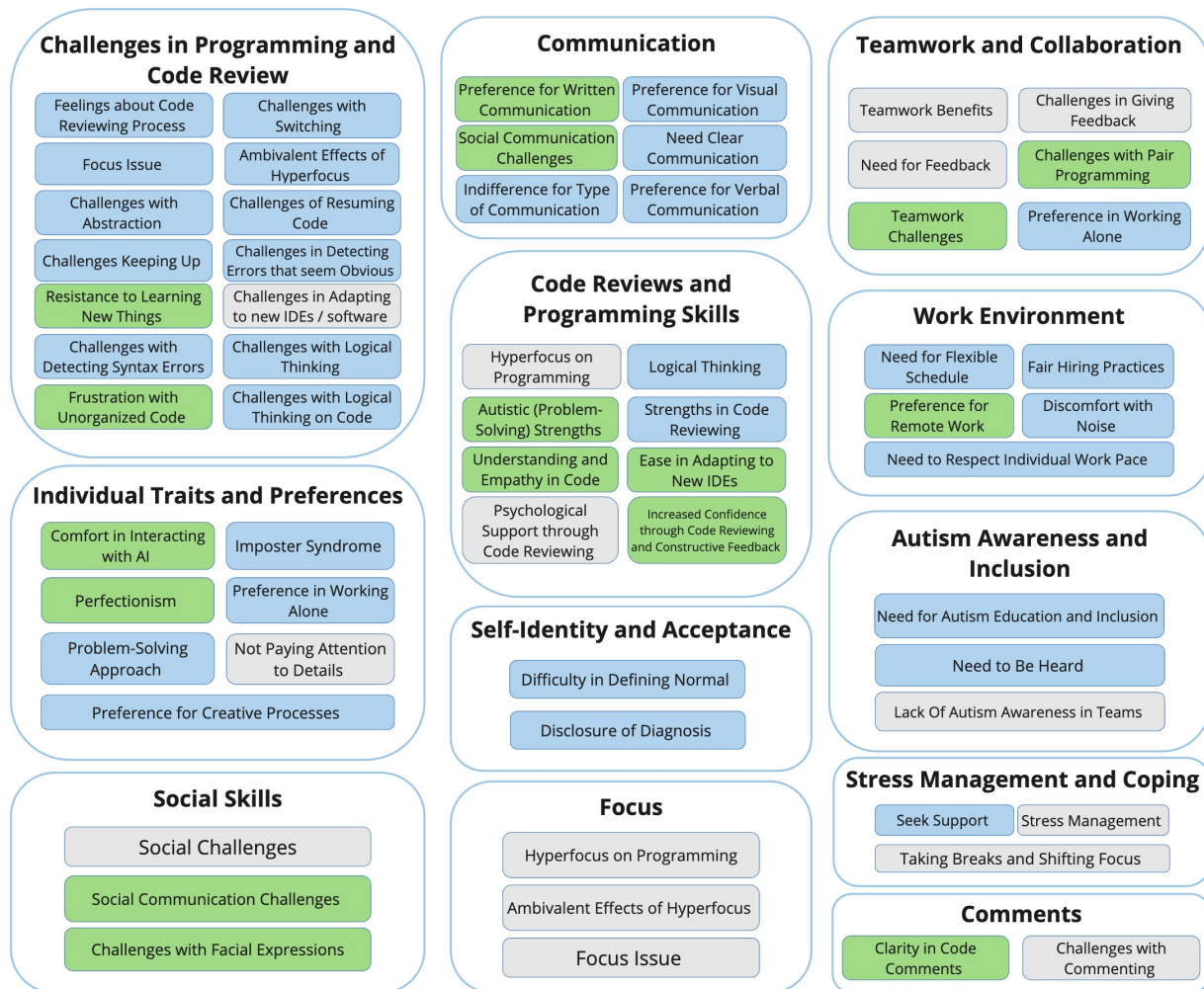


Figure 7.17: Categories Overview after Survey

this question, the statistical analysis highlighted a significant disparity between the two groups regarding hyperfocus. This shows that we need to be extra careful when designing survey questions to accurately capture unique traits, even if they seem predictable at first glance.

Moving to the Teamwork and Collaboration category, which features the most questions (5), none of them exhibited statistically significant differences between the two groups. Despite the absence of such differences, a detailed analysis of the Likert scale graph for this category allowed us to draw conclusions about variations between the groups and gain insightful observations. Questions 6 and 7 dealt with giving and receiving feedback, respectively. Our initial expectation, based on insights from interviews, was that most autistic individuals would agree with these statements. However, the surprising outcome was that the majority of participants from both autistic and non-autistic groups disagreed. While we anticipated disagreement from the non-autistic group, it was unexpected from the autistic group based on our interview insights. Additionally, the significant level of strong disagreement from both groups was also unexpected. This discrepancy highlights

the complexity of understanding individuals' perspectives in survey responses compared to verbal interviews. Question 15, which also focuses on feedback importance, revealed a notable percentage of neutrality within the autistic group. It is important to note that due to the smaller size of the autistic group, this neutrality only represents a minority of two participants. Interestingly, both groups predominantly agreed, aligning with our expectations from the autistic group. However, rephrasing the question slightly might have highlighted more distinct differences between the groups. The remaining two questions in this category align closely with our expectations. We anticipated that the autistic group would experience more challenges in understanding other people's code and also face difficulties with pair programming. Correspondingly, there was a high percentage of disagreement from the non-autistic group, indicating that these statements apply more prominently to the autistic group.

In the Social Skills category, two questions revealed statistically significant differences between the groups. The question regarding reading emotions (Question 2), while showing a significant difference, did not provide substantial insights due to a high percentage of participants expressing neutrality. As anticipated, the non-autistic group disagreed with the statement, but we could not draw definitive conclusions from the autistic group's responses. However, both groups disagreed with experiencing difficulties in relating to others, which was particularly pronounced in the autistic group, confirming our expectations. The findings from Question 9 align closely with the insights gained from our interviews. This question's results confirm our expectations, suggesting that the difficulty of interpreting facial expressions predominantly applies to autistic individuals.

In the Stress Management and Coping Mechanisms category, we did not find a significant difference between both groups. As for Question 11, we initially theorized that due to their tendencies towards hyperfocus, autistic individuals would persist until they solved coding issues. Surprisingly, this approach was not unique to the autistic group, as we also noted similar responses among non-autistic participants. Similarly, the analysis of Question 30 corroborated insights gleaned from our interviews with the autism group but also found support among non-autistic participants. Consequently, we cannot draw definitive conclusions. Question 31, however, offered intriguing contrasts. Our expectations were based on our interviews where participants often cited taking breaks as a stress-coping mechanism. However, we observed this tendency more prominently in the neurotypical group, where a higher percentage of participants agreed with this statement.

Within the Code Reviews and Programming Skills category, our analysis across the three questions revealed that Question 12 exhibited significant differences in responses between the autistic and non-autistic groups. This question explored the ease of memorizing code, shedding light on distinct patterns of cognitive processing between these groups. Our observations regarding Question 12 corroborated our hypothesis regarding the strengths often associated with autistic individuals, particularly concerning code memorization. The higher agreement rate among autistic individuals in this area hints at potential strengths or inclinations that may be more pronounced within this demographic.

This inclination could be attributed, in part, to the phenomenon of hyperfocus commonly associated with autistic individuals when engaged in tasks of interest. Question 10 clarified that the skill set associated with code reviews and programming is not exclusive to autistic individuals. While this finding aligns with our initial expectations to some extent, it also hints at a broader distribution of these skills across neurodivergent and neurotypical individuals alike. Contrary to our initial expectations, Question 13 revealed unexpected outcomes regarding the timing of code solution discoveries. While we hypothesized that a significant portion of autistic individuals would agree with typically solving problems before their peers, the majority instead disagreed with this statement. This divergence prompts deeper exploration into the underlying factors influencing problem-solving dynamics within these groups and challenges preconceived notions about autistic individuals' approach to task completion. While certain skills like code memorization may show clearer patterns, other areas like problem-solving dynamics exhibit more varied responses.

In the Individual Traits and Preferences category, we expected the statements to mainly apply to the autistic group. However, we found that the non-autistic group also agreed with many statements. There were not significant differences between the groups for most questions. The only noticeable difference was in responses to "I need constant validation of my work." Both groups disagreed, but the non-autistic group disagreed more strongly. The questions in this category seem relatable to many people, not just autistic individuals. For example, Question 26, "I pay close attention to detail," resonates with many individuals, regardless of neurodiversity. This shared understanding likely led to similar responses across both groups in this category.

Regarding Challenges in Programming and Code Reviews, our survey outcomes differed slightly from the insights gathered during interviews. Initially, some interviewees mentioned difficulties in using different IDE or transitioning between them, but this sentiment was not widely shared in our survey responses. The autistic group, while displaying some agreement, had a higher percentage of disagreement on this issue. Another trait we explored was the difficulty in learning new programming languages, which our initial theory suggested might be more evident among autistic individuals. However, both the autistic and non-autistic groups largely disagreed with experiencing such difficulties. This finding suggests that challenges in learning new programming languages are not exclusive to either group. Question 20 revealed a noticeable disparity between the two groups, particularly concerning their adaptability to new tools and software. The autistic group exhibited more difficulties in this area, consistent with our expectations. Interestingly, although we anticipated a similar correlation with challenges in using different IDE due to the software adaptability issue, the survey results did not confirm this expectation. Furthermore, we wanted to verify whether feelings of frustration and anxiety when code is not formatted correctly were primarily associated with autistic individuals. The survey findings aligned closely with our hypotheses in this regard. A majority of autistic participants agreed with this statement, while the majority

of non-autistic participants disagreed with it.

Regarding the Work Environment category, Question 23 strongly supports our initial hypothesis as all autistic participants expressed a preference for remote work over in-person work. This preference appears to be more pronounced among autistic individuals, considering that some non-autistic individuals remained neutral or disagreed with this preference. Initially, we speculated that one of the contributing factors to this preference among individuals with autism could be distractions and interruptions in office environments, as reflected in Question 24. However, our findings did not align with this expectation. Some autistic participants strongly disagreed with this notion, while others remained neutral. A more nuanced understanding of this preference could have been obtained through an open-ended question, allowing participants to express their reasons for favoring remote work. This approach might have provided deeper insights into the factors influencing workplace preferences among participants.

On the Autism Awareness category, the results show that it aligns with our initial theory. The results show that in the non-autistic group, a substantial number of neutral responses suggests a prevalent lack of awareness or experience to form a definitive opinion on autism awareness in the workplace. Despite this, there is a notable proportion of disagreement with the statement, indicating that, possibly, there are more and more companies including neurodivergent individuals, or more initiatives to learn more about autism in more companies. In the autistic group, responses are evenly divided, with half agreeing and the other half disagreeing. Notably, a significant percentage strongly agrees, emphasizing a strong sentiment among this group regarding the perceived lack of autism awareness in their teams.

For the last category, the Comments, there were no differences between both groups when considering comments a crucial part of coding. However, when considering the challenges of commenting on code, our initial hypothesis was not supported by the responses from the autistic group. Contrary to our expectations, the majority of participants in this group disagreed or strongly disagreed with experiencing difficulties in commenting on code. Therefore, we were unable to draw conclusive insights from this question regarding differences between the groups.

7.7 Conclusion

The main goal of our evaluation survey was to validate our developed theory, especially how it applied to both autistic and neurotypical individuals. In many categories, our findings match what we expected, particularly in areas like communication, where we noticed a clear preference for written communication among the autistic group. However, this survey also challenged some of our initial assumptions, leading us to reconsider certain codes in our categories. For instance, we found that Social Skills, Code Reviews, and Programming Skills, and Communication align closely with our theoretical expectations. Conversely, the Focus category did not confirm our hypotheses, with none of the statements

receiving confirmation. It is important to mention that some categories, like Self-Identity and Acceptance, were not explored in this survey.

The consistency between our survey findings and interview narratives makes our assessment more reliable, highlighting the unique perspectives within each group. It is crucial to note that the lack of confirmation for certain statements does not mean we reject them. Instead, it shows the complexity and uniqueness of individuals' strengths and challenges, especially in the context of neurodiversity. These findings stress the importance of understanding individuals' abilities and challenges in a nuanced way, cautioning against oversimplifications based solely on neurodivergent status. This approach helps us avoid making assumptions that may not accurately capture the diverse experiences and perspectives within these groups.

It is essential to recognize several limitations that impact the interpretation of our findings. Firstly, the sample size of autistic participants was notably smaller than that of neurotypical individuals, with only 5 participants. This small sample size causes the autistic group non-representative of the broader autistic population. Another significant challenge is verifying the accuracy of responses. We cannot be certain of the accuracy of the responses to survey questions or the reliability of self-reported diagnoses. This issue, encountered during our previous interviews as well, persists due to the inability to request proof of diagnosis. This reliance on participants' honesty and accuracy could introduce bias into the data. Additionally, we overlooked a critical detail during the survey design—language. While the survey is in English to reach a wider audience, most of the participants from the previous interviews were Brazilian. This language disparity might have made some individuals uncomfortable in responding due to the language barrier. Another limitation relates to question formulation. For example, the Focus category showed minimal differences between the two groups across all questions, despite including a query about hyperfocus. This discrepancy suggests that refining question formulation might yield different responses. Similarly, the Code Reviews and Programming Skills category revealed many neutral responses, possibly indicating a lack of expertise in this area among participants.

In conclusion, our survey improved our understanding and made us rethink our theory. However, we need to be careful in interpreting the results due to the limitations we discussed. Recognizing these constraints is important for a more detailed understanding.

RELATED WORK

There are many studies about how Software Engineering, and computers in general, improve the lives of autistic people (e.g. [96, 90, 38]). But there are very few of them that concern students in college, more particularly, students in Software Engineering.

There are five main types of related work that fit in the context of this thesis:

- Autism Coding Camps;
- Guidelines to improve the work experience for employers with ASD;
- Guidelines to design software solutions for users with ASD;
- Software solutions to improve the life of people with ASD;
- Cases of companies that employ individuals with neurodiversity.

8.1 Autism Coding Camps

With the steady increase in the number of diagnoses of ASD [24], it is crucial to consider the future educational needs of these individuals. As children with autism grow up, they will eventually become college students, and it is essential to provide these adolescents with higher education, preparing them and society. One way of accomplishing that is by providing specialized training and support to help them develop skills in specific areas.

A great option to achieve this goal is by making **Autism Coding Camps**, where students can learn more about programming and meet new people. These camps can help reduce the stress and anxiety associated with starting a new step in their lives like college [35].

A study was conducted in 2021 where a remote video game coding camp was held for 13 days for incoming college first-year students with ASD [13]. The camp's instructors included a Computer Science professor, an autism researcher, an Applied Behavior Analysis (ABA) therapist and coordinator of the Spectrum Program [78], a Computer Science Ph.D. student, and a professional software engineer.

The researchers collaborated with Clemson University’s Spectrum Program [78], to design and implement a remote game software development camp. Due to the ongoing COVID-19 pandemic, the camp was held via Zoom every weekday. The goal of the camp was to educate the students in game design and development, with the aim of reducing the challenges that they may face as first-year college students.

During the camp, seven students learned how to build the *PacMan* game in the *MakeCode Arcade*¹ development environment and worked in teams to achieve this. At the conclusion of each camp session, the participants were asked to fill out surveys, which included 15 social collaboration true/false questions, and some open-ended questions inviting them to consider the topics addressed that day.

The researchers discovered that the students were highly enthusiastic about designing and creating their own games. An advantage of remote learning for autistic students was the option to turn off their video and microphone, which gave them the possibility to participate in the camp at their own comfort level.

The students reported that they experienced an improvement in their programming abilities, increased confidence in communication, and a better collaborative experience. They also appreciated the chance to improve their teamwork skills, such as confidently expressing their ideas to their peers and resolving disagreements with their team members. Two of the students reported that the remote learning setup reduced their anxiety and stress, which are common difficulties for individuals with autism.

Following the feedback received from students and teachers after Begel et. al’s online game coding camp [13], the instructors’ team arranged another coding camp for autistic students a year later, in 2022, using a game development environment with more advanced capabilities and features.

This time they held a two-week hybrid (remote and in presence) summer game coding camp, instead of just remotely. They had 14 high school students with autism attending the camp and aimed to expose them to programming while also helping them develop teamwork, communication, and collaboration skills. As in the previous camp, the main focus was on developing teamwork skills since this is an essential skill for success in software engineering.

In this edition of the camp, a decision was made to switch to a new two-dimensional game development platform with options for using traditional programming languages (i.e. Java, Python, C#), including a VCS, and the ability for students to work on code collaboratively. After considering a few options, they opted for *Godot*², instead of *MakeCode Arcade*, as done in the previous camp.

Overall the camp was successful in teaching students software development skills [57].

¹<https://arcade.makecode.com/>

²<https://godotengine.org/>

8.2 Guidelines and Accommodations

Individuals with [ASD](#) are more likely than neurotypical adults to be unemployed, underemployed, overqualified, and/or overeducated [45]. Even when employed, they are usually working in precarious employment. As we know, being employed results in overall well-being, which makes it so important to address these challenges. Sterling et al. in [81] found that lower levels of cognitive and social impairment were associated with more depressive symptoms; in their sample of 46 adults with [ASD](#), almost half reported significant problems with depression.

Due to difficulties with social skills, individuals with [ASD](#) tend to struggle with finding a job and maintaining it [39]. Providing workplace accommodations is important because they can help to improve work participation and productivity while supporting well-being. So, it is crucial that studies are made in order to accommodate these people and to make them more valuable to today's society.

Sally Lindsay et al. in [45] used interviews to explore whether individuals with autism disclose their diagnosis and what types of accommodations might improve their work experience.

The researchers found that disclosing in the workplace had several benefits, including increased acceptance and inclusion, access to accommodations, and greater awareness about autism. However, there were also shortcomings in disclosing, including the potential for stigma and discrimination. The study identified a range of accommodations that were received or desired by participants, including adjustments to the job interview process, flexible schedules and the option to work from home, changes to job content or working conditions, modifications to the physical environment, and disability awareness training for colleagues.

The cognitive style of thinking of autism is distinct from that of neurotypical individuals. In their work, Sylvia Stuurman et al. [83] presented a comprehensive examination of the cognitive style of individuals with autism and compared it to computational thinking. From this comparison, they were able to formulate guidelines for inclusive education and outlined some future work to be done. One of the authors of this study was a practitioner, with extensive experience as a therapist for autistic adults, which added credibility to the findings. For this study, they gathered anecdotal evidence from autistic students for 2/3 years, who shared summaries of difficulties they faced in their studies that may be related to their autism. While this anecdotal evidence cannot be used as proof, it was used to clarify certain points.

Despite the researchers' desire to collect more data, they were still able to conclude some guidelines. One of these guidelines suggested that texts should be written in a manner that minimizes the need for additional context, as individuals with autism have a thinking style that causes them to read and process texts "as is", without considering any contextual information.

They also emphasize the importance of providing explicit guidelines and support

for tasks such as interpreting academic sources, problem-solving, and finding relevant literature. Another recommendation is that teachers should receive training on autism and the cognitive style of individuals with autism, allowing them to view their course material and lessons from the perspective of autistic students.

Until now, the research I have mentioned focused primarily on guidelines and accommodations for individuals with autism in the workplace or in education.

Nevertheless, there are also solutions that can be implemented to better include these individuals in today's society and to help them cope with the challenges of adapting. Some of these solutions include software, such as websites, mobile applications, and digital games that can assist with interventions for people diagnosed with [ASD](#). According to literature reviews by Grynszpan et al. and et al. [38, 90], the majority of software solutions for [ASD](#) are in the form of prototypes that have only been tested as concepts and not fully validated. However, to build effective solutions, there are also specific guidelines that should be followed as building software for individuals with autism or with neurodiversity in general, is distinct from creating software for neurotypical users.

To address this, Aguiar et al. [3] conducted a Systematic Literature Review (SLR) to determine how to develop software solutions that are adapted to users with [ASD](#). This study, which also includes guidelines, had the purpose of defining a set of specific recommendations for developing software solutions adapted to users with [ASD](#). A total of 155 specific recommendations for developing software solutions adapted for users with [ASD](#) were analyzed and reduced to 69, which were then compiled in the *AutismGuide*. The goal of this guide is to allow more adequate software solutions to be designed and developed for individuals with [ASD](#).

The final corpus was composed of 15 articles. Hopefully, software developers can start to use this guide to create software solutions that are adapted to users' cognitive, motor, and sensory characteristics, including everyone.

The researchers that wrote the *AutismGuide* created an online survey, aimed at French-speaking and Lusophone countries, to improve the current version of the guide. The purpose of this ongoing work is to assess the relevance and compatibility of the guidelines with the needs and capabilities of individuals with [ASD](#), ensure that the guidelines are comprehensive, and consider any additional suggestions from survey participants. The researchers are also intending to test the application of the *AutismGuide* by evaluating a set of software solutions specifically designed for users with [ASD](#).

Because so many people with autism are now using technology it is crucial to design user interfaces that enable them to use technology independently, without the assistance of another person.

Nikolay Pavlov conducted a study [63] in 2014, that describes the requirements for building an accessible user interface for users with Autism and presents the user interface (UI) of Open Book, a reading assistive tool for people with [ASD](#). He does an overview of the literature that already exists, providing specific recommendations and good and improper practices.

These studies highlight the importance of guidelines and accommodations for individuals with Autism but they are also for neurotypical individuals. The studies presented guidelines for making the workplace and education more inclusive, the design of software solutions, and the design of user interfaces. These guidelines serve as a valuable resource to promote inclusivity and to design applications and technology that take into consideration the needs of these individuals.

8.3 Video Calling

Video Calling has become increasingly popular in recent years, thanks to advancements in technology. As many individuals with Autism face difficulties in having face-to-face interactions, video calling can be a great way to go around that. It can provide a safe environment for them to communicate and build relationships with others.

The COVID-19 pandemic has emphasized the use of video calling even more as a way of staying connected. As a consequence of lockdowns and social distance measures, people turned to video calling as never seen before, making them a crucial tool to stay connected. It has been not only used for personal use but has also become a way for companies, schools, and colleges to continue to establish contact and operations. So, it is important to include all people in this innovative way of communicating, including individuals with autism, and consider their needs, although they can often experience some stress and feelings of anxiety.

A study conducted in 2019 [99] aimed to understand the needs of Autistic Adults in **Video Calling**. The research team interviewed 22 autistic individuals and recorded their experiences and needs to better manage the stress associated with video calling. The participants in the study were all 18 years or older, with 12 of them having some relation with software engineering, either working or learning in this industry.

Out of the 22 semi-structured interviews they performed with autistic people, they found that the individuals often face challenges in adhering to social norms during video calling at every stage, from preparation, initiation, and conversation, to ending the call.

The researchers discovered that the participants came up with tactics to overcome the difficulties they faced in technology-based social interactions. These included adjusting their sensory environment to improve their concentration, writing notes to retain important information, and developing an understanding of their conversation partner's personality and thinking style. These strategies allowed them to have less stress and to be more present during the video call. To describe the relations between stressors, coping strategies, and [Computer mediated communications](#) preferences, they developed a neurodiversity-sensitive model of computer-mediated communication (NDS-CMC).

They suggest ways to make Video Calling more comfortable not only for autistic users but also for non-autistic ones, by identifying how and why autistic users use video calling and other [Computer mediated communication \(CMC\)](#) channels.

A follow-up study [14] conducted in 2020 aimed to design an AI-based application called Video Calling for Autism (VC4A). They used the results from their previous investigation, described in the preceding chapter, to develop an AI computer vision system to detect facial expressions and display them live, and on-screen during the call.

This application had two modes available, but in the study, they only focused on the first mode: the Expressiveness Mirror. This mode captures the facial expressions of the autistic user and displays them back to them, providing feedback on how their expressions may be perceived by others. This helps them feel more relaxed and better understood during video calls.

To design the prototype, the researchers used the Wizard of Oz prototype tool and proceeded to conduct a Wizard of Oz study to evaluate the design before building it. Five autistic adults were recruited to take part in the study and test the prototype, which consisted of five pre-recorded two-way conversations featuring neurotypical actors. The conversations used a combination of auras, emojis, and text labels to represent the facial expressions of the participants in the video. The results showed that all of the participants preferred using emojis as they were familiar and easier for them to understand and interpret.

This was a promising idea because individuals with autism often experience significant stress during video calling and have difficulty identifying the emotions of others. However, the prototype was ultimately not successful. The study's 21 subjects lost trust in the tool because it sometimes showed a happy emoji and other times showed a sad emoji for the same facial expressions. This highlights the importance of ensuring that such technology is reliable and accurate in order to be effective.

8.4 Software Solutions to Improve the Life of Individuals with Autism

As we know there is a growing interest in using technology, especially using it as a way to help individuals with Autism. In fact, there are several research studies that provide technology and applications that work as support tools for therapy, helping in the treatment of this disorder, such as speech-generating apps, mind-mapping software, and socially assistive robots.

As more neurodivergent individuals pursue higher education, specifically individuals with autism, and careers in software engineering, the potential for them to develop software solutions that are tailored to their unique needs and capabilities increases. These solutions can help to improve the quality of life for individuals with ASD and can provide opportunities for neurodivergent software engineers to make a positive impact in this field.

A study by Aresti-Bartolome and Garcia-Zapirain [7] analyzed the most significant technologies and applications developed from 2004 to 2013 used to work on issues related

to [ASD](#). For this study, the researchers divided these technologies into 4 categories: Virtual reality applications, Dedicated applications, Telehealth systems, and Robots. They found that virtual reality and dedicated applications have been widely used and have proven to be effective therapeutic tools. Telehealth systems have been widely accepted and received positive evaluations from families and doctors because the service is easy to use and convenient to access at any time. At last, robots were found to be useful in therapy because of their predictable behavior and showing improvement in repetitive behaviors and limited interests.

The areas that can be more easily treated with these technologies are communication and iteration in the first place, then social learning and imitation skills, and at last other associated conditions.

A great way to help these individuals is to give them support in performing day-to-day tasks. Bozgeyikli et al. in [18] presented a **virtual reality system for vocational rehabilitation** of individuals with disabilities (VR4VR). The system uses immersive virtual environments to evaluate and train individuals with cognitive and physical disabilities. The system provides help with six skills namely cleaning, loading the back of a truck, money management, shelving, environmental awareness, and social skills. Additionally, the system includes distractors that can affect performance on these tasks. The researchers aimed to improve job training in a safe environment for individuals with various disabilities, including those with [ASD](#), Traumatic Brain Injury, and Severe Mobility Impairment. However, their focus was solely on individuals with [ASD](#).

This study counted on the advice from 5 professional job trainers who are Florida state-approved vocational counselor experts with significant experience and insight in training this population. They first performed a user study with 9 neurotypical users and then 9 individuals diagnosed with high-functioning autism at college age. Results indicated that in all skills the average score of the individuals with [ASD](#) was lower than those of neurotypical individuals. With the distractors, the average level scores of the individuals with [ASD](#) were higher compared to those without the distractors, except for loading the back of a truck skill.

Additionally, the researchers asked the 5 professional job trainers if they thought this system would be effective in helping individuals with [ASD](#), and the average score was between 4 and 5 (with 5 being "will provide very effective training"). Furthermore, a follow-up questionnaire was given to the same 5 job trainers who worked with the 9 [ASD](#) individuals who participated in the study, asking them if they noticed any improvements after training with the VR4VR. On average, they stated that participants had major improvements in their skills. Overall, the study suggests that the VR4VR system can be a valuable tool for the vocational rehabilitation of individuals with [ASD](#), providing them with a safe and effective training environment.

Human-computer interaction can also have aspects that are relevant to Autism. Grynspan et al. [37] designed **training software** that addresses communicative challenges associated with [ASD](#). They also established an empirical protocol to evaluate the software.

For the presented study, the researchers took into account the issue of the contextuality disorder commonly observed in autism. Contextualization problems come from the fact that autistic people tend to interpret speech in a literary way rather than in reference to a context. They also experience difficulties with sarcasm, irony, and idiomatic expressions.

The study participants were divided into two groups with the same developmental age and academic level: a clinical group consisting of 10 teenage boys diagnosed with HFA and an average age of 12 years and 10 months, and a typical group consisting of 10 typically developing children (8 boys and 2 girls) with an average age of 9 years and 7 months. The experimentation was done in 13 sessions, with the first and last sessions dedicated to evaluation.

For the clinical group, the experiment was conducted in the form of a computer workshop in a specialized class for teenagers with autism in a school in Paris. They developed two software game patterns: one for training purposes and one for pre- and post-evaluation. The games displayed written dialogues that relied on pragmatic subtleties such as irony, metaphors, or sarcasm. The results showed that the participants with autism transferred learning gained via training when the simple interface was used and had poorer performances on the richer multimedia interfaces.

As more users with neurodiversity use technology to communicate and for personal use, it is important to ensure accessibility for people with these conditions. According to the literature, autistic individuals are keener on icons and images over text in user interfaces.

Autistic users are different in many aspects from neurotypical users. A way in which they are different is with user interfaces.

Rezae et al. [67] conducted a study to identify exactly how autistic users are different, using eye tracking. Eye tracking is a technique used to measure a person's eye movements while interacting with a stimulus. The study used a public transportation trip planning mobile application called *OrienTrip*. This app was built specifically for individuals on the autism spectrum. And it has even been co-designed with individuals on the spectrum.

For the study, 39 people were recruited, with 21 of them having been diagnosed with autism. The users were asked to use one or more screens in the app to complete several specific tasks, without any assistance except for task clarification. The study lasted approximately 30 minutes on average and was completed in one sitting. Afterward, participants were asked to fill out a post-study questionnaire to provide feedback on the user interface and experience of the app. While the participants were using the application, researchers analyzed their eye movements with eye tracking. Thereupon, to gain insight into participants' perceptions of the *OrienTrip* usability, they administered two surveys before and after the eye-tracking exercise. In the end, the researchers were able to make some recommendations to design more accessible user interfaces.

Results indicated that the autism group spent more time fixating on specific areas of interest, suggesting a longer understanding time and potential interest in those areas. The study highlights the importance of inclusive design in creating user interfaces that are

accessible to all individuals.

8.5 Specialisterne

A company that has done a lot to include people with disabilities, particularly those on the autism spectrum, is **Specialisterne** [77], which means "The Specialists" in Danish. This company from Denmark addresses the challenges faced by these individuals in the workplace by providing specialized IT services and appropriate training, which helps them find employment in the IT industry. The majority of its employees have a diagnosis on the autism spectrum and work as business consultants in software testing, programming, and data entry for public and private sectors.

Specialisterne was founded in 2004 by Thorkil Sonne after discovering his son, who has autism, had a unique set of skills and abilities that could be applied in the field of IT. Today, the company expanded to multiple countries, existing in more than 14 countries, and aims to create 100,000 meaningful jobs for individuals with [ASD](#) and with other neurodivergent conditions in the United States of America.

The company also offers a *Work Readiness and Preparation* (WRaP) curriculum for students, providing a proactive and structured approach to supporting autistic and neurodivergent students and their allocated support services in higher education settings.

There is also a foundation called *Specialisterne Foundation*, a non-profit organization with the goal of generating meaningful employment for one million autistic/neurodivergent individuals through social entrepreneurship, corporate sector engagement, and a global change in mindset.

Overall, Specialisterne serves as a valuable example of how neurodiversity can be viewed as an asset in the field of software engineering, and how it can provide opportunities for individuals with autism to find meaningful work. Their approach to recognizing neurodiversity and creating a more inclusive work environment aligns with the goal of this thesis which is to explore the challenges and opportunities for neurodivergent software engineers. This company recognizes that these individuals have unique strengths and abilities and can bring a lot of qualities to the IT industry. By providing specialized training and support, Specialisterne not only helps individuals with autism find employment but also equips them with the necessary skills and knowledge to excel in their roles, making them suitable for the job. This makes the company a great example for other companies motivating them to embrace neurodiversity. Besides providing all this training they also have available guidelines for developing software solutions adapted for these users.

8.5.1 Other Cases

Specialisterne is inspiring other companies to also hire individuals with neurodiversity and to embrace them.

A software development company that felt motivated by Specialisterne is **SAP**. SAP is a German multinational software company that develops enterprise software to manage business operations and customer relations [71].

In 2013, SAP announced plans to hire hundreds of people diagnosed with Autism, with a target of having people with autism represent 1% of the company's workforce by 2020. It was the first global tech company to create a program to leverage the capabilities of individuals with autism [76].

According to SAP's website [25], they have a program "Autism at Work Program" which provides hiring and workplace support, leveraging the unique abilities and perspectives of colleagues on the autism spectrum. Currently, they have 217 colleagues in this program across 17 countries.

Besides the program described above, they have an initiative called Autism Inclusion Pledge, which aims to reshape thinking about employment possibilities for individuals on the autism spectrum.

Just like SAP, several major tech companies have recognized the potential of individuals with **ASD** and are following this example by creating programs for hiring individuals on the spectrum.

Microsoft, for example, built the Microsoft Neurodiversity Hiring Program, which is based on the belief that neurodivergent individuals bring unique perspectives and innovative solutions to the workplace. By fostering a diverse workforce, companies like Microsoft can improve their culture, work environment, and customer service. Additionally, they have available various roles for which someone can apply in the sectors of Business, Management, Finance, Information Technology, Operations, and others. With this program, the company already hired about 200 people [58].

Another example is **Google Cloud** that announced in 2021 the launch of Google Cloud's Autism Career Program [28], designed to further grow and strengthen Google's existing autistic community by hiring and supporting autistic individuals.

8.6 Summary

In my research, I attempted to include studies about code reviews performed by autistic or neurodivergent individuals in the software engineering industry. However, I was unable to find any studies that specifically focused on this topic.

Instead, the majority of the research I found focused on the challenges and opportunities faced by these individuals in the workplace, such as difficulties with communication and social interactions, and guidelines and accommodations that should be made to support them.

It is important to note that this lack of research on code reviews performed by autistic individuals may reflect a larger issue in the field of neurodiversity and software engineering - the underrepresentation of autistic and neurodivergent individuals in research and in the industry as a whole.

CONCLUSION

Using the Socio-Technical Grounded Theory, we conducted interviews and an evaluation survey to outline the strengths and challenges experienced by autistic individuals in software development. This effort led to the development of a theory comprising twelve categories and eleven relationships.

We conducted a total of seventeen interviews with individuals across Portugal, Brazil, and Poland, with participants from five different sources. The majority of participants have autism level 1, with a few at autism level 2, often receiving their diagnosis later in life. Many hold high qualifications (bachelor's or master's) in software engineering and are actively employed in the field. The participants predominantly fall within the 25 to 35 age range, and the group is primarily male-dominated.

The examination of various categories revealed a connection between poor social skills and communication challenges among individuals with autism. These aspects often intersect, meaning difficulties in one area can exacerbate issues in the other. For instance, struggles with communication not only hinder interpersonal interactions but also impede effective teamwork and collaboration. It is notable that individuals with autism typically lean towards written communication due to its clarity and structured nature, which aligns with their preferences. However, in work-related contexts, a combination of verbal and written communication proves more effective for them. When communication is efficient, they demonstrate better job performance and increased productivity. Effective communication not only improves the quality of code reviews but also facilitates giving feedback, which proved challenging for our interviewees. Our research also indicates a preference among many individuals with autism to work from home, highlighting the importance of supportive company policies and team awareness. These factors play a crucial role in helping individuals manage stress levels and develop coping mechanisms, ultimately enhancing productivity. Moreover, the work environment significantly influences self-identity and acceptance among individuals with autism. Feeling safe and accepted in their environment encourages them to share their diagnosis more comfortably. This increased openness encourages a sense of integration within the company and team, leading to a higher likelihood of receiving necessary accommodations and support. Improving code

comments and documentation significantly aids individuals with autism during code reviews, especially considering their challenges in understanding others' code. Despite not being confirmed by our evaluation survey, many interviewees highlighted the benefits of hyperfocus in programming and code reviews, attributing it to their ability to pinpoint errors and rectify them, which also helps reduce stress. These individual traits and preferences vary among individuals with autism, impacting their performance and interactions within the software development environment. However, not all individuals with autism exhibit these traits uniformly, highlighting the diverse nature of their experiences and abilities within the context of software engineering.

To evaluate the relevance of our theory across different groups, we conducted an online evaluation survey that included both autistic and non-autistic software engineers. A total of 49 participants completed the survey, including 5 autistic individuals. Geographically, the participants were primarily from Portugal, with additional participants from Belgium, the United States of America, Brazil, and Canada. The majority of participants fell within the 21-25 age range and held master's degrees. The survey encompassed 11 categories, each containing one to five questions, which we analyzed using statistical methods such as the *Mann-Whitney U* test, *Wilcoxon* rank-sum test, *Bonferroni* correction, and *Cronbach's* Alpha measure. Our analysis included generating Likert scale graphs for each category, comprising each question to provide a visual representation of the results. Many categories aligned well with our theoretical expectations, particularly in areas such as Social Skills, Code Reviews, Programming Skills, and Communication. However, we noted differences in the Focus category, where none of the statements confirmed our initial hypotheses.

9.1 Answering Research Questions

In Chapter 1 we laid out our research questions and having presented our theory and discussed it, we are now able to answer the research questions.

RQ1: How can we help individuals with [ASD](#) thrive in the field of Software Engineering?

Supporting individuals with Autism in Software Engineering involves implementing workplace accommodations such as physical adjustments and educational initiatives to raise awareness about autism among employees. Specific tool accommodations tailored to their needs and improvements in communication strategies are also essential for enabling an inclusive and supportive work environment.

RQ2: What strengths and challenges do individuals with [ASD](#) have when conducting code reviews?

When conducting code reviews, individuals with autism demonstrate notable strengths such as attention to detail, a drive for perfectionism, persistence in bug identification and resolution, hyperfocus, and logical thinking. However, they may encounter challenges related to communicating feedback effectively, grappling with disorganized code structures, and resistance to adopting new perspectives or methodologies.

RQ3: How can software development teams and companies leverage the skills of individuals with [ASD](#)?

The initial step involves hiring individuals with Autism and subsequently making workplace accommodations. Provide them with the freedom to ask questions, assign tasks that demand attention to detail, and identify their areas of interest as they tend to hyperfocus on them. Use their logical thinking abilities to design robust algorithms, facilitate code structures, and enhance software performance. Additionally, offer communication training to help them improve their skills and overall effectiveness within the team.

9.2 Future Work

Possible future work could be going more in-depth into what specific strengths autistic individuals have regarding code reviews. Although this was our initial objective, we faced some challenges in recruiting individuals with the requisite expertise for interviews. Exploring these strengths further could provide valuable insights into how neurodiversity can positively impact code review processes.

Moreover, there is an opportunity to develop software tools or plugins designed to support neurodivergent individuals during code reviews. These tools could improve communication, task organization, feedback processing, and code comprehension, thereby boosting overall productivity and inclusivity.

Additionally, research could focus on establishing simple guidelines for creating inclusive code review environments that meet the needs of neurodivergent individuals. This might involve adjusting current code review methods, creating new tools, or using techniques tailored to diverse cognitive styles, creating a more inclusive and productive workspace for everyone involved.

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INTERVIEWS' STRUCTURE

Demographic Questions:

1. What is your age?
2. What is your nationality?
3. What is your level of education?
4. If you're a student, what is your major?
5. If you have a job, what do you do? And what course did you take?
6. What is your diagnosis?
7. Who diagnosed you? A psychologist, a psychiatrist, etc.
8. At what age were you diagnosed?
9. How did you find out about this study?

Open Questions:

1. What programming languages do you use?
2. What IDE do you usually use?
3. In your experience, what are some common challenges you face while programming?
4. What type of bugs would you say are more difficult to detect?
5. Do you feel that the way errors are reported is useful?
6. How do you prioritize which bugs to fix first?
7. Do you do pair programming?
8. How do you feel when doing pair programming?

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9. How often do you do code reviews?
 10. In your experience, what are some common challenges you face during code reviews?
 11. Can you describe a specific example of a challenge you faced during a code review and how you overcame it?
 12. In your experience, what are some of the benefits and drawbacks of code reviews as a tool for software development?
 13. How do you think code review processes could be modified to better accommodate individuals with autism or other neurodivergent conditions?
 14. Have you encountered any situation where your autism has given you an advantage during a code review? And programming?
 15. What is your approach when reading and trying to understand new code?
 16. How do you prefer to receive feedback on your code?
 17. How do you feel about giving feedback on other people's code?
 18. Have you ever encountered any difficulties during code reviews that you believe were related to your diagnosis?
 19. What do you think about working in a team? Are there any specific aspects that you find particularly challenging?
 20. What strategies do you use to manage stress or anxiety that may arise during coding or code reviews?
 21. How do you deal with working with new IDEs or programming languages, and tools?
 22. How do you think the industry and workplace culture could better support individuals with your diagnosis in the field of software development?

B

CATEGORIES AND CODES

Categories	Codes	Quotes	Count
Communication	Preference for Written Communication	<p>I-02: The way the information arrives, if you tell me only by voice it can be forgotten, better a written thing also.</p> <p>I-05: it becomes much easier to understand the text.</p> <p>I-06: [I prefer] by message.</p> <p>I-07: I prefer the text because I can get back to it and I can read it again.</p> <p>I-09: I like more by text.</p> <p>I-12: There are times when it's verbal, a conversation, but no, I prefer written.</p> <p>I-15: I prefer by text even because I can read, I don't know, it is easier for me to communicate by text.</p>	7
	Preference for Verbal Communication	<p>I-01: (...) I always prefer to talk.</p> <p>I-04: It can be face to face...</p>	2
	Indifference for Type of Communication	<p>I-03: I leave guidance notes or suggestions and sometimes even call the person and talk to them.</p> <p>I-14: it can be spoken (...) but it can also be written.</p>	2
	Preference for Visual Communication	<p>I-01: The best way to communicate with an autistic person when they want them to program is with a drawing.</p> <p>I-10: It would be nice to have visual connectors.</p>	2

	Social Communication Challenges	<p>I-05: Trying to avoid offending others unintentionally + I try to get someone neurotypical to read [the feedback] before I send to avoid offending others unintentionally. + I have to think 3 or 4 times what I'm going to write + I don't write straight into the tool; I write in a separate notepad, and I see and review what I wrote before sending.</p> <p>I-08: Sometimes I get that fear of "offending," and I don't want to be misunderstood. I find myself writing the message and I think if this message can be mistaken or not.</p> <p>I-15: Sometimes there are people who don't get that much criticism, there are people who sometimes don't accept the criticism and sometimes you have to be a little more careful. But at the same time, sometimes I can't be so careful, or I think I'm being careful, sometimes that person doesn't take the criticism well.</p> <p>I-16: I have a difficulty of parameter, of filter even, sometimes I can say something, and the person feel offended, feel bad about what I said because I do not have a really very good notion of what can harm a person.</p>	4
	Need Clear Communication	<p>I-01: Ask for things to be clearer.</p> <p>I-09: I think mostly the feedbacks have to be very clear.</p> <p>I-14: Sometimes it [communication] is very abstract, not very well explained, sometimes not very objective.</p> <p>I-16: In code review we would need more accurate information (...) A clearer information of what we are doing would be very important for us to begin to understand the functioning of the code.</p>	4

APPENDIX B. CATEGORIES AND CODES

Social Skills	Social Challenges	<p>I-03: People don't have much sympathy for me, but they really like my technical collaboration.</p> <p>I-04: I've been working at a company where I've been bullied a lot because people don't have respect for.</p> <p>I-05: difficulty putting myself in the shoes of others.</p> <p>I-09: I have a hard time dealing with people.</p> <p>I-16: in a matter of soft skill, I have a lot of social disability.</p>	5
	Social Communication Challenges	<p>I-05: Trying to avoid offending others unintentionally + I try to get someone neurotypical to read [the feedback] before I send to avoid offending others unintentionally. + I have to think 3 or 4 times what I'm going to write + I don't write straight into the tool; I write in a separate notepad, and I see and review what I wrote before sending.</p> <p>I-08: Sometimes I get that fear of "offending," and I don't want to be misunderstood. I find myself writing the message and I think if this message can be mistaken or not.</p> <p>I-15: Sometimes there are people who don't get that much criticism, there are people who sometimes don't accept the criticism and sometimes you have to be a little more careful. But at the same time, sometimes I can't be so careful, or I think I'm being careful, sometimes that person doesn't take the criticism well.</p> <p>I-16: I have a difficulty of parameter, of filter even, sometimes I can say something, and the person feel offended, feel bad about what I said because I do not have a really very good notion of what can harm a person.</p>	4

	<p>I-05: Challenges with Facial Expressions</p>	<p>I have a very hard time understanding people's facial expressions.</p> <p>I-09: If I don't have a view of the person's body expression, and the phone doesn't allow that, I get all puzzled.</p> <p>I-14: with emoji, because this is important, it may not seem important, but it is because you are expressing some facial expression.</p> <p>I-16: Sometimes it's a facial expression that I have a hard time identifying a lot.</p>	4
Code Reviews and Programming Skills	Strengths in Code Reviewing	<p>I-04: I can avoid the errors very well because I go into a lot of detail.</p> <p>I-12: when it's time to do the code, when it's time to revise it, I often do a little faster.</p>	2
	Hyperfocus on Programming	<p>I-02: Given that programming has become the hyperfocus, I get a face of being in heaven and don't upset me.</p> <p>I-03: I said IT was my hyperfocus.</p> <p>I-06: I have an ability to hyper fixate on things.</p> <p>I-09: I have a hyperfocus on computers in general, not just programming so it's very easy for me to focus on coding. It's easy to spend hours coding.</p> <p>I-15: I think I can focus more than other people.</p> <p>I-16: We [autistics] have the matter of hyperfocus, we start doing one thing, and if we focus too much on this thing, we end up producing a lot. We have a great production because we are hyper-focused on what we are doing + in programming the hyperfocus also enters + I can give a much greater focus to a way of writing the code and the code is very coherent, it is very accurate, so I think that in this part in the programming itself helps a lot.</p>	6

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Focus	Hyperfocus on Programming	<p>I-02: Given that programming has become the hyperfocus, I get a face of being in heaven and don't upset me.</p> <p>I-03: I said IT was my hyperfocus.</p> <p>I-06: I have an ability to hyper fixate on things.</p> <p>I-09: I have a hyperfocus on computers in general, not just programming so it's very easy for me to focus on coding. It's easy to spend hours coding.</p> <p>I-15: I think I can focus more than other people.</p> <p>I-16: We [autistics] have the matter of hyperfocus, we start doing one thing, and if we focus too much on this thing, we end up producing a lot. We have a great production because we are hyper-focused on what we are doing + in programming the hyperfocus also enters + I can give a much greater focus to a way of writing the code and the code is very coherent, it is very accurate, so I think that in this part in the programming itself helps a lot.</p>	6
	Ambivalent Effects of Hyperfocus	<p>I-09: This hyperfocus I have, which can last for hours, it helps me somehow, but it also hinders me.</p> <p>I-10: have tunnel vision, start something a bit based on that kind of detail and then only stop when I'm too far into something.</p> <p>I-15: I feel that if I have a problem, I don't know, I sometimes stay in that, I can't stop thinking about it. I think at some point it ends up helping. When I have an interest in something, I end up focusing on it.</p>	3
	Focus Issue	<p>I-07: I consider myself someone who has a focus issue, and this is getting emphasized if the task is not well defined.</p>	3

		<p>I-15: sometimes I would unfocus a little + I make small mistakes also for lack of attention.</p> <p>I-16: difficulty focusing sometimes</p>	
Challenges in Programming and Code Reviews	Focus Issue	<p>I-07: I consider myself someone who has a focus issue, and this is getting emphasized if the task is not well defined.</p> <p>I-15: sometimes I would unfocus a little + I make small mistakes also for lack of attention.</p> <p>I-16: difficulty focusing sometimes</p>	3
	Feelings about the Code Reviewing Process	<p>I-16: The code review process ends up being very stressful for me because there's so much that's not adapted.</p>	1
	Challenges with Abstraction	<p>I-12: The biggest difficulty I find when programming, is to do the abstraction, the concepts are very abstract + if there is some abstraction and I have to understand the abstraction of the other person, then it is even more difficult + when I developed something more abstract, it gets more complicated.</p> <p>I-17: [difficulties with] some concepts like object orientation and some things that are more abstract.</p>	2
	Challenges with Detecting Syntax Errors	<p>I-01: syntax errors, for example when I have to close the curly braces or when I have to put the semicolons.</p> <p>I-02: lack of boring commas or those parentheses, or an extra space.</p> <p>I-10: of syntax, typos, and commas. I really hate that.</p> <p>I-13: Sometimes a letter, a comma, are little things that are more complicated.</p> <p>I-17: punctuation, sometimes it looks for a much more serious error and sometimes it's just a parenthesis, a comma, a quotation mark.</p>	5

APPENDIX B. CATEGORIES AND CODES

Challenges in Detecting Errors that seem Obvious	<p>I-06: Mistakes that sometimes seem obvious, but that to me are not.</p> <p>I-13: the things that are actually silliest for us to see.</p> <p>I-15: More these minor errors I think than the errors like these things more of lack of attention even.</p>	3
Challenges Keeping Up	<p>I-17: I think more slowly (...) But still sitting with colleagues and writing at the same time, I have difficulty. + the slowness that I said that I am slow sometimes.</p>	1
Challenges with Logical Thinking	<p>I-14: logical reasoning, that I need to figure out what I need to do to function (...) I think that's the main challenge for me.</p> <p>I-16: I think I have more difficulty with the logic part, (...) it catches me a lot in the development part.</p>	2
Challenges of Resuming Code	<p>I-02: My challenge may be when we're doing the code, then we pause and when I come back, I have to do the reasoning again.</p> <p>I-06: Sometimes I get lost a lot on things (...).</p> <p>I-15: I have a lot of trouble when they interrupt me, go back to doing what I was doing.</p>	3
Challenges with Switching	<p>I-07: if there are blockers, it's hard for me to switch to find the alternative solution.</p> <p>I-16: difficulty in letting go of my way of doing things.</p>	2
Ambivalent Effects of Hyperfocus	<p>I-09: this hyperfocus I have, which can last for hours, it helps me somehow, but it also hinders me.</p> <p>I-10: have tunnel vision, start something a bit based on that kind of detail and then only stop when I'm too far into something.</p>	3

		<p>I-15: I feel that if I have a problem, I don't know, I sometimes stay in that, I can't stop thinking about it. I think at some point it ends up helping. When I have an interest in something, I end up focusing on it</p>	
<p>Challenges in Adapting to New IDEs / Software</p>		<p>I-01: For me that [working with new software] is one of the most complicated things to do. Having to get used to a new text editor. He doesn't follow the same spacing as me, that's a big challenge for me.</p> <p>I-03: With a lot of resistance and against my will.</p> <p>I-05: I have some difficulty adapting to IDEs, but I solve it in a short time, a few hours, at most a day.</p> <p>I-08: But I have this big difficulty in moving between IDEs.</p> <p>I-10: The first week is tricky, it has a new environment, it has new shortcuts on the keyboard, it doesn't integrate in the same way and there's nothing like talking to someone who's already tried it and then going little by little and doing things a little bit more challenging.</p> <p>I-16: It's a disaster at first, because I'm used to something, (...), then a person brings me a new IDE, a new tool, I need to understand how that tool works, and it gives some problems, some bugs, that I had no idea existed (...) I'm already with the technology that I'm already used to so when it changes, I have a hard time adapting. I don't have as quick an adaptation to a new technology as people usually have. When they are already in the technological environment they can easily adapt to a new IDE, but I can't.</p>	<p>6</p>

APPENDIX B. CATEGORIES AND CODES

	Frustration with Un-organized Code	<p>I-01: If someone sends me a code to look at and the code is not organized in the way that is logical to me, the first thing I do is reorganize the whole code, which is extremely frustrating for me.</p> <p>I-08: I get upset if the code is not well formatted, but I understand that other people don't have that concern.</p>	2
	Resisting to Learning New Things	<p>I-01: I don't really like to start learning anything new and I always feel a lot of friction + I don't like to learn how to use something new, but that doesn't mean I don't learn. + if it's a new thing I'm doing, it's very difficult for me to start and create a routine to do that. After I create my own way of doing it, it's even more difficult to change. Even if I want to, there is a lot of irritability on my part.</p> <p>I-08: The process of changing to something else that for me is not very structured in my head, for me it's a process that can be a bit time consuming.</p> <p>I-17: Change is never easy for me, but it was a matter of adapting.</p>	3
	Challenges with Logical Thinking on Code Reviews	<p>I-05: [difficulty in code reviews a] Understanding the logic of who did it.</p> <p>I-17: Difficulties usually are understanding the logic if it is from someone else.</p>	2
Work Environment	Need for Flexible Schedule	<p>I-01: At the company level it would be much easier if there could be this freedom of choice of one's own schedule.</p> <p>I-06: For autistic people it is good to have hours, to be able to have all the breaks without colleagues noticing and commenting.</p> <p>I-15: have a more flexible schedule.</p>	3
	Need to Respect Individual Work Pace	<p>I-02: try to respect the rhythm of each one.</p>	7

	<p>I-03: It is necessary to leave the autistic be free and autistic. Produce what he has to produce in the way he feels most comfortable.</p> <p>I-04: You have to give the person space to be able to demonstrate all the flaws in the system.</p> <p>I-05: give us some freedom to be in our space.</p> <p>I-06: they should also be freer to make their stereotypes.</p> <p>I-08: People know that I have a harder time explaining myself or exposing myself and they give me that space to go recording some things or for me to ask some things asynchronously and not have to try to perceive them in a Zoom meeting, that freedom is quite important.</p> <p>I-09: there must also be a respect for the condition.</p>	
Preference for Remote Work	<p>I-02: Having the possibility to work alone or more at home than in the office.</p> <p>I-03: We work remotely which for me is an added value. I-03</p> <p>I-05: Teleworking is always preferable too. Comfort is greater, concentration too.</p> <p>I-06: if necessary be teleworking.</p> <p>I-08: working remotely helps a lot.</p> <p>I-09: I prefer to work from home.</p> <p>I-15: [the company] To give the option of home office, work from home.</p>	7
Fair Hiring Practices	<p>I-03: They treated me as if I was incapable, they gave me simple problems and did not let me participate in making more complex and technical decisions.</p>	2

APPENDIX B. CATEGORIES AND CODES

		I-16: As much as the company hires a person who is part of the spectrum, it hires more as if it were an obligation because it has a rule specifying that the company must have PWDs and everything else. So, I see that they hire more as a rule and not as an opportunity really for the person to show what skills they have.	
	Discomfort with Noise	I-09: A lot of people, same environment, noise, always with headphones, it's kind of complicated. I-15: one thing I didn't like very much was noise, people talking all the time, it got in my way. I-17: (...) a lot of people talking at the same time (...), I ended up losing focus.	3
Teamwork and Collaboration	Teamwork Benefits	I-14: learning and you can get more diverse opinions or have more people to do the consultation, that's the main advantage of working in a team.	1
	Teamwork Challenges	I-01: The communication part is where I feel the most difficulty. I-03: Yes, but I think it [working in a team is difficult] would be difficult for anyone, which is the lack of character. I-05: I had a lot of problems with the teams and isolated myself a lot and preferred to be alone. I-06: Communication is arguably the most difficult aspect when working in a group.	4
	Preference in Working Alone	I-05: I used to isolate myself a lot and I would rather be alone, even for hours on end, than have to deal with other people because my way of seeing things and theirs is completely different.	1
	Need for Feedback	I-09: I really need feedback. I need to receive more feedback than I need to give.	1
	Challenges in Giving Feedback	I-15: That [giving feedback] is already a little more complicated.	2

		I-16: God it is very complicated, I get very nervous when I need to do this + I have a really hard time when the feedback is focused on a matter more of soft skill than a technical of skill.	
	Challenges with Pair Programming	I-12: Usually I feel more pressured, it's harder. I-15: I found it harder to program with someone else than to program alone. I-16: it's not easy, for me it's quite complicated. I-17: At first, I had a lot of difficulty.	4
Individual Traits and Preferences	Problem-Solving Approach	I-03: I usually don't solve problems; I usually attack the root cause. If you solve the problem, it will happen again, it is not a matter of if, but when. But when you solve the root cause, it won't happen anymore, because you've solved the source of the problem.	1
	Comfort in Interacting with AI	I-03: I get to have a healthier conversation with artificial intelligence than with people. Today my main contributor is ChatGPT. I-03: ChatGPT could be a good tool to detect errors in the future. I-14: (...) now with ChatGPT and other bots people say it's talking to a robot and some people joke that they talk to me sometimes they say "(...) you behave like a robot, you think like a robot." I-17: Sometimes when I don't know what the error is, I go to google and now also ChatGPT, which also helps.	4
	Imposter Syndrome	I-08: Sometimes I feel like I have imposter syndrome before I send the code to the review process, sometimes I wonder if it is really good to be ready.	1

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	Preference for Creative Processes	I-09: But repetitive processes often mess me up. I prefer creative processes. (...) I can't live in a scenario of many repetitions of very repetitive tasks.	1
	Preference in Working Alone	I-05: I used to isolate myself a lot and I would rather be alone, even for hours on end, than have to deal with other people because my way of seeing things and theirs is completely different.	1
	Perfectionism	I-08: I want to be as thorough as possible, maybe sometimes it gets to a level of too much + I tend to be as thorough as possible. I-09: I am very thorough, the view I have of the code is quite interesting, I think I get a very interesting approach to the code. I-12: it is faster to pay attention to these smaller details. I-14: you can see the patterns of activities, it [autism] helps you at a certain point or even be aware of some detail of the code that is not making sense.	4
	Not Paying Attention to Details	I-15: I have problems with details, so really sometimes, in my case it's identifying things that are sometimes very, that are not very, I'm not a very detailed person, I can't sometimes find the details like that.	1
Autism Awareness and Acceptance	Need for Autism Education and Inclusion	I-04: Creation of specific programs for autistic people. I-05: Make peers who are working with us more aware of our issue. Explain to them why we are different and there is no reason for them to take us badly. I-12: in terms of inclusion, a lot of understanding for specific difficulties.	4

		I-16: I think offering information about the autistic spectrum for the whole team is very important. It can be a class, a call, like a workshop with the information of what is the autistic spectrum so that we can feel comfortable working with other people + making people in the company aware of what is the spectrum is very important for inclusion.	
	Need to be Heard	I-12: The people on the spectrum are very different so it ends up being interesting to just listen a little more, it would change a lot because in the place where I work there are other people in the spectrum and the experience varies a lot in the same company, according to the teams they are in. I-17: They could better understand how a person with autism works and how that colleague works too, because each autistic person is different from the other. Anywhere in the world, one will never be the same as the other. So, I think they could understand that colleague better, although they already do that.	2
	Lack of Autism Awareness in Teams	I-16: I see that the teams we work with have no idea what autism is. They have no idea I'm part of the spectrum, they have no idea what's going on.	1
Self-Identity and Acceptance	Difficulty in Defining Normal	I-16: I see that the teams we work with have no idea what autism is. They have no idea I'm part of the spectrum, they have no idea what's going on.	1
	Disclosure of Diagnosis	I-03: There was one company where I did [disclosed] (...) They treated me as if I was incapable, they gave me simple problems and did not let me participate in making more complex and technical decisions.	3

APPENDIX B. CATEGORIES AND CODES

		<p>I-05: I don't advertise it [the diagnosis], but when the team that is working with me asks me, I answer and I don't make a point of hiding, I answer openly.</p> <p>I-16: (...) I feel better when I know that people know that I am part of the spectrum. I don't see a need to explain myself all the time (...) I think it's important that people know, because anything can happen to me, (...) I can have a sensory crisis, (...) and I think it's important that they know about my diagnosis.</p>	
Stress Management and Coping Mechanism	Seek Support	<p>I-01: talk to someone who has done something similar to mine and throw all the information out there.</p> <p>I-06: Asking for help when I can't.</p> <p>I-12: I usually have to ask other people what the ideas were.</p> <p>I-14: I try to talk to someone else on my team.</p>	4
	Taking Breaks and Shifting Focus	<p>I-08: if I realize that some task is making me a little anxious or overwhelmed, I try to move on to another one and try to be more in control of myself, (...), and then I try to go back to that task that might be more difficult or that is not going well for me.</p> <p>I-09: I use some techniques like stopping for a while.</p> <p>I-10: If I'm feeling very frustrated, I usually stop, look at another ticket, then come back later.</p> <p>I-12: I usually get up and take a walk, or go to the toilet, drink water, walking back and forth.</p> <p>I-13: I get up and walk around the room a little bit.</p>	7

		<p>I-14: sometimes I will do the task the next day and I will focus on another activity because it can give me time to think (...) What I do is I leave one activity and go to the other.</p> <p>I-15: if I can't really find the problem, I'll do something else that I like to do and then come back or, you know, try to disconnect a little bit from that and come back later.</p>	
	Stress Management	<p>I-04: I stop, unplug, and try to give myself a reboot.</p> <p>I-09: It is complicated for me to manage anxiety when the code has many errors.</p> <p>I-16: I usually use some repetitive movement, some stimulus to be able to relieve my anxiety at that instance.</p>	3
Comments	Clarity in Code Comments	<p>I-02: It's important to comment the code to make sure other people will understand it as well.</p> <p>I-05: (...) The commented parts were simple and obvious but were not the right ones. It causes me discomfort, frustration even. + Better documentation of the code, with a brief explanation in each block saying what is intended to make.</p> <p>I-08: Another difficulty is if there is a lack of commentary. It is very difficult to work with lack of documentation.</p>	3

Table B.1: Categories and Codes



Quantitative Methods for Business Analytics

Dr. [Name] | Department of Business Analytics | [Institution]

Course Overview: This course covers the application of statistical and mathematical techniques to business data.

Key Topics: Regression Analysis, Time Series Forecasting, Decision Trees, and Data Mining.

Prerequisites: A solid foundation in statistics and calculus is recommended.

Learning Objectives: Students will learn to interpret data, build predictive models, and make data-driven decisions.

Assessment: The course includes assignments, a mid-term exam, and a final project.

Contact: [Email] | [Phone] | [Office Hours]