# A Professional Career with Autism: Findings from a Literature Review in the Software Engineering Domain

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**Abstract.** Autistic individuals possess many unique skills that are beneficial to the workforce, especially the technology industry. However, research shows the unemployment rate is still considerably high among the autistic population compared to their neurotypical peers. It has been suggested that some autistic individuals may excel in software engineering roles. This paper presents a Multivocal Literature Review (MLR) to highlight the cognitive style and talents of individuals with Autism Spectrum Disorder (ASD). An analysis is carried out to fully understand the challenges faced by autistic individuals transitioning into the workplace while also highlighting the challenges faced in their day to day working life. These challenges include workplace environments as well as workplace ceremonies, including, for example, daily stand-up meetings. Many neurotypical software engineers, software engineering firms and academics can benefit from this information as they work towards a more inclusive and more effective software engineering community.

**Keywords:** Autism · Software engineering · Neurodiversity · Autism Spectrum Disorder

## 1 Introduction

Autism is a "complex lifelong developmental disability that typically appears during early childhood and can impact a person's social skills, communication, relationships and self-regulation", it is defined by a "certain set of behaviours and is a 'spectrum condition' that affects people differently and to varying degrees" [1]. Even though Autism Spectrum Disorder (ASD) can affect people of any age, gender, or ethnicity, much of the statistics available online relate to the diagnosis of children. According to the Centre for Disease Control, 1 in 54 children have been identified with ASD [2]. According to one


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source, "ASD is 4 times more common among boys than among girls" [2], but the gender position might not be well established at this time and its importance is not central to this research.

Recent unemployment statistics show that only 22% of autistic adults managed to secure employment [3]. Yet, many young adults with autism may, we suggest, envision transitioning from education into the workforce like many of their peers. However, individuals with ASD in their twenties were found to be less likely to be employed than their peers with other disabilities, including speech/ language impairment, emotional disturbance, intellectual disability and learning disabilities [4]. Strikingly, almost 42% of young adults on the autism spectrum either never worked, or worked and did not receive remuneration for that work during their early 20's.

There are many benefits that individuals with ASD can bring to a business that neurotypical individuals may not, including high levels of concentration and focus, reliability and dependability, attention to detail and accuracy, technical abilities such as coding and programming and factual knowledge and excellent memory [6]. These benefits may make individuals with ASD particularly suited to specific roles in the software engineering sector, and could outstrip the capability of neurotypical individuals in certain respects [7]. What programmer, tester or other IT professional, we ask, would not wish the skill of intensive concentration with their complex tasks? Specialisterne, a Danish consulting company, is a foundation that works to enable one million jobs for people with autism and similar challenges through social entrepreneurship, corporate sector engagement and a global change in mindset [8]. About 75% of the skilled employees at Specialisterne have some form of autism spectrum disorder [9]. The Danish company first introduced the autism hiring process and many more multinational companies such as SAP and Google are following suit. The work of Specialisterne and others is important, much needed and appreciated, the authors of this paper suggest that it helps to integrate peoples across the neurodiverse spectrum.

The purpose of this paper is to further develop the understanding of the cognitive abilities and characteristics of software engineers with ASD, the usability of technology and the transition into the workforce for individuals on the ASD spectrum, and the working environment for such individuals. Sect. 2 of the paper presents the methodology used and the related literature, Sect. 3 presents the analysis of literature focused on 3 areas: Cognitive Abilities and Characteristics of Autistic Software Engineers; The Usability of Technology for ASD Individuals; Transition into the Workforce for Individuals with ASD; and Adapting the Work Environment to Meet the Needs of Autistic Employees. Section 4 presents the limitations of the research conducted and plans for future work while Sect. 5 presents the conclusions of the research conducted to date.

## 2 Related Literature

### 2.1 Methodology

This research has been carried out using both grey and white literature, non-academic sources and peer reviewed papers, adopting Multivocal Literature Review [10]. The topic of Autism and Software Engineering was investigated under four key themes: Cognitive Abilities and Characteristics of Autistic Software Engineers; Usability of Technology;

and the Transition into the Workforce for Individuals on the Autism Spectrum; and Changing the Work Environment to Meet the Needs of Autistic Employees. These four themes were essential to bring a focus to the work and also to limit the research to a manageable scope.

The primary objective of the exercise was to research the topic in the allocated time frame and to present the findings in this research paper. Having defined the key themes, search strings were identified around each theme and they were executed in combination across Google Scholar, individual publisher digital archives, including IEEE Xplore, ScienceDirect, and Google. Limited time was available to the research team (further information on which is outlined in Sect. 4), the work was divided up around the themes and a period of parallel research was conducted individually. Finally, the researchers jointly synthesised their individual research findings to address the research objective. The team liaised weekly with the assessment supervisor in order to ensure the themes of research were suitable.

### 2.2 Inclusion/Exclusion Criteria

Academic sources were considered when they provided additional value to the topic or an interesting viewpoint of one of the key themes discussed. When researching grey literature, non-academic sources, the team questioned whether the source was reliable and valid before deciding to include the data. This process involved examining the origin and quality of the material, for example if it was from an online blog, moderation of the blog was sought. By utilising this process, the team gathered just over 30 sources which were deemed relevant to the key themes in question. The results of the findings are discussed in the analysis section of this paper.

## 3 Analysis

### 3.1 Cognitive Abilities and Characteristics of Autistic Software Engineers

Many individuals on the autism spectrum are deemed unemployable due to the social struggles and behavioural patterns which accompany ASD [11]. However, according to Austin and Sonne [9], many individuals with high-functioning autism (HFA) possess capabilities that are suitable for roles in the technology industry including software testing, quality control and security monitoring. HFA is often used to refer to individuals with ASD who have the ability to read, write, speak and manage life skills without much support [12]. According to the Diagnostic and Statistical Manual of Mental Disorders, HFA individuals make up half of the autistic population and are the fastest growing group of individuals on the spectrum [13]. These scholars also suggest that individuals with HFA are especially skilled at paying attention to detail, detecting error and orderly code [9].

For many years there's been a stigma attaching autism to "mental-illness" [14]. However, as autism is becoming more prevalent, autistic self-advocates chose to represent themselves through the term "neurodiversity" [2, 14]. These skilled individuals with autism are changing the stigma previously attached to the condition and are claiming

ownership while redefining the "powerful brain-based model" they possess [14]. In order for firms to expand their talent pool and utilise the skills and talents currently offered by individuals with HFA, they will need to meet the needs of employees with ASD and put more of an emphasis on job skills rather than social skills [14, 15].

Research shows that autistic individuals possess many of the analytical skills required by software developers including programming, math, problem-solving and debugging [9, 16]. Baron-Cohen et al. [16] suggest individuals with HFA possess the ability to "recognise repeating patterns in stimuli" and process a high amount of information in the style of systemising. This attention to detail is used to gain an overall understanding of a system and construct rule-based systems in the form of "if p then q" [16]. Per Baron-Cohen's hyper-systemising theory of autism, individuals have the ability to pay attention to detail in the context of complex systems which are characteristics especially important for programming and the technology industry [16].

Technology companies can benefit greatly from the unique abilities and characteristics autistic software developers possess such as attention to detail, finding comfort in repetitive behaviour and the ability to visualise problems [9]. Morris et al. [17] conducted a study in which six out of ten participants experiencing neurodiversity noted they were good at noticing patterns and mentally visualising information. In the same study, participants mentioned they had a good ability to mentally execute code in order to anticipate bugs and spot bugs in code by recognising patterns in the formatting [17]. Several participants also noted that they were skilled at achieving an intense state of focus on authoring a piece of code or completing a specific project [17]. Morris et al. also concluded that autistic developers were capable of developing "out-of-the-box solutions or making intuitive leaps that were valuable in their line of work" [17]. The research also distinguished that the code developed by these autistic developers was particularly clean and orderly, exemplifying strict adherence to the rules of coding style [17].

Studies show as individuals with autism possess a high level of interest and specialisation, are constantly eager to learn and have a great capacity to make judgements and decisions, they are further suited towards jobs in the software industry [15]. Although high functioning individuals with ASD possess unique cognitive abilities, they also experience challenges and stressors compared to their neurotypical co-workers. Baron-Cohen et al. explain that individuals with ASD often show little interest in other people, have a need for sameness and exhibit repetitive behaviours which can lead to challenges in coordination, teamwork, communication and leadership [16]. Morris et al. concluded that half of the individuals who self-identified as neurodiverse describe themselves as having poor interpersonal communication skills and that their lack of interpersonal intelligence caused challenges within their jobs [17]. This lack of interpersonal skills can in turn be a challenge to those with ASD trying to gain employment as a significant number of software development jobs require communication, collaboration and management skills [16]. Acuña et al. found that managers considered human attributes such as independence, stress tolerance, environmental orientation, empathy, and teamwork and cooperation and not just technical knowledge when making hiring decisions [18]. This is largely due to the fact that a lack of human attributes and capabilities often contribute to the high failure rate of IT projects [19].

Although HFA individuals often have unique talents especially with regard to attention to detail and systematic thinking, they often misunderstand or misinterpret social nuances and subtle cues [19]. Individuals may experience difficulty empathising with colleagues and as many autistic people have restricted or specialised interests, they may distract themselves during social interactions [17] making it difficult to build relationships among co-workers and peers. Morris et al. explain that individuals with autism experience difficulties interpreting co-workers' statements and emotions, coping with office politics and managing conflicts with peers [16]. These various social challenges can in turn induce stress and anxiety for those experiencing ASD, especially in the workplace.

As the demand for software talent continues to grow, companies are challenged to meet the demand with a diverse pool of individuals [9]. Mello and Rentsh [20] suggest that diverse teams outperform teams constructed of members with the highest-ability. Cognitive diversity leads to better problem solving and innovation which is especially necessary for software development teams and the complex, continuously-changing technology industry [9]. Diversity among individuals and the unique characteristics of those with autism may also encourage new perspectives in the workplace.

### 3.2 The Usability of Technology for ASD Individuals

When designing technology for users with ASD, usability and accessibility must be considered. Most of the time, web developers and designers are designing for neurotypical users and do not think of these two important aspects, this in turn leads to a lack in experience when working on technology for individuals with ASD [21]. To aid developers and designers when working on these technologies there are some, but not many, Human Computer Interface (HCI) guidelines available to them [22]. Since there are so few HCI guidelines available, McKenna et al. suggests "it is important for designers to understand the unique characteristics of the ASD population. Designers should then incorporate this knowledge into technology design and testing" [23].

The characteristics and needs of individuals with ASD should be considered from the very start of the design and specification process [24]. With these considerations in place right from the beginning of software development, it will allow for improved usability [25]. Many things can affect how individuals with ASD interact with and use a system such as primary and secondary attributes. Some of these attributes include mental maturity, motor skills, verbal comprehension, working memory, processing speed, gender, chronological age and experience using similar devices and software [23, 26]. With these attributes in mind, developers will better understand the characteristics of the population in which they are designing and developing for [23].

Individuals with ASD can face many challenges while using technology such as information processing, communication, and behavioural issues [23]. Regarding information processing, "ASD persons should be kept in mind when developing sensory components of a system" [23]. McKenna et al. explains that an individual with ASD experiencing hypersensitivity to light may be irritated or overwhelmed by a display's high contrast and brightness [23]. When designing web pages and applications a user's chronological age must be considered. This is not the case with ASD users as their chronological age may not match their mental age [23]. This is important in order to appropriately present

display information or instructions to someone within the ASD population [23]. Even though designers and developers may be working with neurotypical adult users in mind, there might be some benefit for ASD individuals if some design components preferred by children are incorporated [27]. Due to the nature of ASD, communication can be difficult for these individuals. Therefore, "communication tools and expression aids should be considered when designing multi-user systems to facilitate effective social exchanges and information sharing" [23]. A final usability challenge found during this research that is common to individuals with ASD is related to behaviour. Many individuals with ASD have decreased motor proficiency [23]. This decrease shows that these individuals display reduced motor precision when completing a job [23]. An example in the technology sector would be an individual with ASD trying to use certain devices like a mouse on a desktop or laptop.

In order to overcome some of the usability challenges for individuals with ASD, Britto and Pizzolato have conducted research that recommends a set of guidelines to design and develop websites and applications more suitable for those with ASD [22]. These proposed guidelines may help to improve usability for those individuals with ASD in the technology sector or those hoping to gain employment in the technology industry. There are ten proposed guidelines consisting of visual and textual vocabulary, customization, engagement, redundant representation, multimedia, feedback, affordance, navigability, system and status interaction with touch screen [22].

### 3.3 Transition into the Workforce for Individuals with ASD

Although people with ASD face usability challenges, they are still keen to be independent individuals and join the workforce. With this being said, finding appropriate employment may be a challenge as many people with ASD are either unemployed or underemployed [17]. A recent study found that only 58% of adults aged between 21 and 25 with ASD were employed [5]. Being employed can have a positive impact on the health and well-being of an individual with ASD [28]. However, adults with ASD often have trouble navigating traditional job interviews, complex work environments due to the social dynamics, varied communication requirements and need for flexibility [28].

Hedley et al. [28] conducted a study to gain a better understanding of the transition into work for individuals with ASD, including barriers and promoting workplace success. The participants that took part in the study by Hedley et al. were entered into a programme at Hewlett Packard Enterprise (HPE) [28]. During the study, participants identified many factors that facilitated success at work such as "organization support, advice from co-workers, supportive leadership and allowing environmental modification" [28]. Other individual factors that participants found helpful were being aware of upcoming work that was to be done and having the option to take breaks [28]. A part of the successful transition into work for those with ASD was making environmental changes to the workplace [28]. The transition into work not only relies on effort from the individual with ASD but also from the existing staff at companies. Some accommodations that can be adopted by existing staff to ease the transition include "inviting trainees to social events, providing extra time to adjust to the work environment, modifying work allocations, providing clear instructions, acceptance and awareness of individual differences and redirecting trainees if they become distracted" [28].

Participants in the Hedley et al. study also identified some challenges during the transition into the workforce. Participants faced challenges associated with the job tasks but also individual challenges. Job tasks which most affected the participants included "learning new processes and frustration associated with ongoing problems with the computer network which prevented them from completing their tasks" [28]. Individual challenges encountered by the participants included "time management, organisation problems and maintaining attention" [28]. One outcome of the study by Hedley et al. was related to the "quality of work" from the participants. It was noted by co-workers that participants had the ability to detect errors that had been previously missed [28].

Some careers that may be appropriate for individuals on the autism spectrum would be software engineer, website designer, computer programmer or computer graphics designer [29]. One thing that all these positions have in common is that there is the ability to have limited and structured social interaction which would appeal to individuals with ASD. Software testing is another career that would be well suited to an individual with ASD as it "is repetitive and detailed work for which most people have limited tolerance, and it is a job that needs to be done well" [9]. Software testing is a job that can be done alone and therefore is suited to ASD individuals as they struggle with social interaction [9]. The job of a software tester includes constant referencing back and forth between computer output and listings of the results that should have been generated by software [9]. The characteristics of this type of work are well suited to an individual with ASD as they have "an exceptional ability to focus and pay attention to detail and finding comfort in repetitive activities" [9].

### 3.4 Adapting the Work Environment to Meet the Needs of Autistic Employees

The environment in which people with ASD are working can significantly affect their ability to complete a task. Technology companies must be flexible and incorporate changes to how things are done to accommodate people with ASD. Many technology companies such as Specialisterne and SAP have found that people with autism have traits that can be well-suited to information technology roles, such as software testing as noted in Sect. 3.3 [9].

Since 2004, Specialisterne have recognised the positive impact that employing people with ASD can have for business and that these employees can be up to eight times more accurate at tasks, such as manual data entry, than neurotypical employees [30]. Specialisterne have altered the interview process to a more informal interaction, similar to a "hangout" [31]. This allows neurodiverse candidates to demonstrate their abilities to managers in a more casual setting [31]. Other technology companies have taken on a similar approach, for example, SAP have created a "soft skills" workshop to help neurodiverse candidates who have never worked within a professional environment before [31].

Although the rate of unemployment of people with autism is still relatively high, when SAP began its *autism at work* program they found many of their applicants held bachelor and/or master degrees, with some even holding dual degrees [31]. The number of Autistic students attending university is increasing. One US study of ASD Individuals at university reported that 34.31% undertook a major in STEM and of these 16.2%, the largest cohort, majored in computer science [32]. The STEM major rate was higher for

ASD individuals than 10 other disability categories and for the general population at 22.8%. Unsurprisingly, autistic people with these credentials do get hired and excel in their role [31].

Without changes to Human Resources (HR) and the interview process people with ASD will continue to be overlooked by firms. Following suit from Specialisterne, many companies such as SAP, HPE and Microsoft have transformed their HR process to discover neurodiverse talent [31]. Many firms have also moved away from the traditional interview process and come up with a more casual setting to recruit additional neurodiverse employees. James Mahoney, who directs the Autism at Work Program at JP Morgan Chase, has said that they have taken inspiration from Specialisterne and have created a separate autism recruiting program so people with ASD are not overlooked during the early stages of the recruitment process [14]. Individuals with ASD may be overlooked within a regular interview process due to their unique social skills. This can include poor eye contact, oversharing their weaknesses and rambling answers [14, 31].

Many managers are aware of the business benefits that diversity can bring to a company. However, they are not as aware of the benefits that neurodiverse employees can bring [31]. Companies that hire neurodiverse staff can bring different perspectives and gains, and as previously stated, cognitively diverse teams often outperform teams lacking diversity [31]. For example, it was a neurodiverse software tester, sensitive to disorder, that noticed and questioned a trend of crisis mode before a launch of a client's project [31]. This resulted in the company realizing it was too accepting of the chaos and resulted in a redesign of their launch processes [31]. The changing mindset of managers has become extremely beneficial to all employees and not just employees with ASD. Managers have become more aware of all their employee's talents and needs [31]. SAPs senior vice president of digital business services has said the initiative of getting "to know the person better, so you know how to manage them," has benefited him within his managerial role [31]. This initiative has helped him become a better manager to all of his staff, especially supervising individuals with ASD [31].

Another way firms can make their company more inclusive for people with ASD is to alter the way their teams are structured and operated. Employees with ASD may have difficulty identifying tone while communicating with colleagues and can be quite structured when it comes to rules or guidelines [17]. Therefore, it is important for firms to create a solid managerial role and team relationships [17]. Gobbo and Shmulsky, have suggested that holding one-on-one meetings to provide support and feedback can help individuals with ASD within a non-judgmental environment to feel more included [33]. Hala Annabi et al. also suggested that the training of managers and peers on characteristics of ASD is vital and that peer mentors can also be beneficial for employees with ASD to help them feel included [15]. People with ASD can also struggle with multitasking which may be particularly difficult during team meetings where employees must listen and contribute to the conversation [15]. Approaches to making meetings more autism-friendly can include audio-recording of meetings or having a designated note-taker in each meeting which can be then sent to everyone involved to ensure no one feels singled out [15].

Individuals with ASD can be sensitive to their surroundings which can cause challenges in their working day-to-day lives. In order to accommodate individuals with

ASD, companies must consider the diverse needs which may accompany those on the spectrum. When designing a typical office space, it is designed to meet all of the average persons' basic needs. Although a lot of the time, the designer does not consider the needs of a person with ASD. Design elements that are autism-friendly include an orderly workspace, simple design, indirect lighting, muted colour tones, quietness and escape rooms which can create a positive work environment and help limit the stress and anxiety triggers for individuals with ASD [19, 34]. Companies can also give employees with ASD the option to work or take a break in an escape room to help them complete their day-to-day tasks [34].

## 4 Research Limitations and Future Work

Although there is a considerable amount of information regarding autism friendly software engineering, there is an opportunity to further the understanding of the lack of employment among the autistic population. This is especially interesting as individuals with ASD offer unique talents in comparison to their neurotypical peers and large technology companies such as SAP, Microsoft and Google have indicated both the social impact and business benefits of hiring individuals with ASD. There is also an opportunity to further the understanding of the similarities between the characteristics of HFA and the skills required and desired for software development and the technology industry. Findings of such studies may potentially provide a connection between the talents autistic software engineers bring to software development and the rising demand for technology workers.

In the opinions of the authors, there is very little research addressing the unemployment of autistic individuals especially when their abilities are clearly aligned with characteristics desired by the growing technology industry. This research finds that autistic individuals are more likely to pursue STEM (Science, Technology, Engineering and Maths) related subjects in postsecondary education compared to non-STEM subjects. It is also clear that this interest in STEM subjects, combined with the success from companies such as SAP and Microsoft, highlights the potential business benefits of hiring autistic individuals. Furthermore, from the existing literature, it is clear that the cognitive style and characteristics of high functioning autistic individuals can be mapped to the skills relevant for software developers. This research finds that those working in technology with autism experienced challenges compared to their neurotypical peers due to the lack of understanding of the diversity talents of autistic individuals. Although, in order for companies to fully benefit from the unique talents of HFA individuals, they must adapt their hiring process, ways of working and ensure the technologies used are applicable to those with autism to both enable and further develop the talents which the autistic population possess.

The research was primarily conducted by a team of three final year undergraduate students, under the weekly supervision of an experienced academic and over a period of 7 weeks. The evidence from the research is that there is a large volume of published and grey material on the topic of autism and software engineering (and technology, more generally). Future work can target a more comprehensive review of the domain, and if undertaken over a longer time period and by more experienced researchers, this work can lead towards an important outline and classification of the field.

## 5 Conclusion

In recent years, the technology industry has become aware of the talents and competitive advantage of employing individuals with autism. The needs of potential employees with autism are being met within the employment process and the workplace. Companies and management have identified the benefit of team neurodiversity and potential benefit of expanding their talent pool, and some firms have gone to great lengths to alter and improve their HR and interview processes in order to effectively employ and onboard individuals with autism. Companies must also have appropriate technologies in place to meet the usability needs of autistic individuals and enable a smoother transition into the workplace.

However, even with the above protocols in place, individuals with ASD still face challenges associated with their lack of interpersonal skills and gaining employment. After analysing the literature, research shows people with ASD struggle to communicate with colleagues and with the interpretation of nuance, therefore, triggering stress and anxiety within the workplace. Although this research concludes that individuals with ASD possess skills suitable for roles in the technology industry, there is very little research regarding the lack of employment for individuals on the spectrum even though they hold the desired attributes, especially those of a software.

It is clear that autistic individuals possess unique talents such as attention to detail, systematic thinking, high level of focus, comfort with doing repetitive tasks and ability to visualise problems. These traits are well-aligned with the needs of software engineering roles, especially programming and testing. Our research shows that companies have started to seriously engage the autism-friendly software engineering space. There are many benefits for companies in doing so, including accesses to very talented individuals in a sector where talent is difficult to source, and the increased social capital that companies can acquire through socially integrative policies. While these benefits are important, perhaps most important of all is the trend towards software engineering firms welcoming new colleagues with autism and providing them with an environment to exercise their unique strengths in roles where they can excel; done correctly, this is win-win for employers and their ASD employees.

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