

Understanding the Challenges Faced by Neurodiverse Software Engineering Employees: Towards a More Inclusive and Productive Technical Workforce

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ABSTRACT

Technology workers are often stereotyped as being socially awkward or having difficulty communicating, often with humorous intent; however, for many technology workers with atypical cognitive profiles, such issues are no laughing matter. In this paper, we explore the hidden lives of neurodiverse technology workers, e.g., those with autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), and/or other learning disabilities, such as dyslexia. We present findings from interviews with 10 neurodiverse technology workers, identifying the challenges that impede these employees from fully realizing their potential in the workplace. Based on the interview findings, we developed a survey that was taken by 846 engineers at a large software company. In this paper, we reflect on the differences between the neurotypical ($N = 781$) and neurodiverse ($N = 59$) respondents. Technology companies struggle to attract, develop, and retain talented software developers; our findings offer insight into how employers can better support the needs of this important worker constituency.

Author Keywords

Software development; neurodiversity; autism spectrum disorder; attention deficit hyperactivity disorder.

INTRODUCTION

Autism Spectrum Disorders (ASDs) are an increasingly prevalent societal issue. Recent reports from the U.S. CDC indicate that as many as 1 in 68 children aged 8 and under are on the autism spectrum [9]. The autism spectrum covers a broad variety of symptoms and abilities; some people may be non-verbal and entirely reliant upon their caretakers even in adulthood, while others face milder (though still substantial) challenges, such as difficulty in forming social

bonds with others, difficulty interpreting or conveying emotions, difficulty making eye contact, and/or difficulties maintaining mental focus on certain tasks, among others [1].

For adults with milder forms of ASD (such as Asperger's Syndrome), finding appropriate employment may be a challenge; many people with ASD are unemployed or underemployed [5], or face discrimination within their workplace [4]. Matching people with autism to jobs appropriate for their skills, interests, and personalities is an increasingly important societal issue; a good match can result in benefit not only for the autistic individual and his family, but also for employers who may value some individuals' unique skills, such as attention to small details [10].

Many people with autism have an interest in and affinity for technology [23]. Famed autism advocate Temple Grandin (who is herself autistic) specifically suggests that parents of children with autism consider preparing them for careers in computer programming [12]. Popular culture suggests that many members of the technology industry already may be "closeted" or undiagnosed autistics [31], though no numbers exist to confirm or deny such rumors. Recently, several companies, such as SAP and Microsoft, have publicly announced intentions to hire computer professionals with ASD, both as a matter of social justice and to take advantage of affinities between the profile of some individuals with ASD and the job requirements of the technology industry [13, 30, 33]. Advocacy groups such as AccessComputing provide bridge programs, advice, and other resources to make computing careers more accessible for people with disabilities, including people with ASD [7, 8].

In this paper, we present the first study of neurodiverse software developers, via interview and survey data. Understanding the perspectives and experiences of technology workers with ASD and other cognitive differences is important – if, as popular cultural suggests, the ranks of Silicon Valley contain many people with undisclosed cases of Asperger's Syndrome, or if more companies wish to follow the lead of SAP and Microsoft and actively recruit people known to have ASD into their workforce, it is important to understand whether such employees face unique challenges in achieving success in computing careers. After describing the methodology and findings of our interviews and surveys, we reflect on how

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these findings might translate into changes in software development workplace and workflow practices that can better support the success of technologists with ASD and more effectively leverage the unique skills and perspectives that they may bring to their jobs.

RELATED WORK

Much autism research focuses on children (such as developing technologies for children with ASD, their parents, or their caregivers, e.g., [15, 18, 26]). This emphasis on youth is understandable in light of the evidence that appropriate interventions at a young age are particularly valuable in the treatment of ASD [24]. In this paper, however, we focus on adults with autism, and particularly on the experiences of those adults in the technology workforce. Two relatively recent reviews of the literature on adults and ASD begin by describing how little research there is on the topic, compared to the amount of research on children with ASD [2, 16]. Hendricks' meta-analysis estimates the unemployment rate among adults with ASD as 50-70% [16].

Given the comparatively little published work there is on adults with ASD and the high rate of unemployment among this population, little attention has been paid to the workplace experiences of adults with ASD. Even less attention has been given to adults on the "high-functioning" end of the spectrum [2, 28], and less still to those who work in technical fields. In fact, the only study we know of that describes the experiences of a number of tech workers with ASD is Rebholz's dissertation, *Life in the Uncanny Valley: Workplace Issues for Knowledge Workers on the Autism Spectrum* [27]. In it, Rebholz describes and analyzes interviews with nine employees, seven of whom hold "computer-related jobs."

The goals of Rebholz's study were different than ours. Rebholz sought to describe the "issues encountered by high-functioning people on the autism spectrum who are in the top quartile of American wage earners" [27, p.1]; that study's inclusion of tech workers was not an explicit goal, but a virtue of the fact that it pulled its participants from the Seattle area. By contrast, our study focuses explicitly on tech workers. As a result, the two studies are complementary: Rebholz's covers a more general range of work experience than ours and asks questions about employment law and family background; ours covers a more general range of cognitive function.

Our findings echo and bolster many of the experiences of Rebholz's participants, including the benefits of employing someone with high-functioning autism, the ability to visualize problems, the importance of explicit communication from co-workers and managers, receiving a diagnosis as an adult, the personal nature of disclosing a diagnosis and the reluctance to do so, the negative effects of corporate restructuring, distracting and open work environments, and experience with accommodations. Furthermore, our participants place many of issues in the context of technical work, specifically of writing and testing

code or managing people who do. Our study also compares the experience of neurodiverse tech workers with those of neurotypical tech workers, an area that Rebholz identified as important future work.

Much of the other literature about adults on the spectrum concentrate on pre-vocational interventions [3, 21] or environmental factors [20] that influenced the employment experiences or quality of life for adults on the spectrum. Many studies (e.g., [14]) report on adults' continued struggle to maintain full-time employment.

Two studies are tangentially related: a study by Parr, et al. on leadership and ASD [25] and a study by Hurlbutt and Chalmers on Asperger's and employment [19]. The Parr et al. study investigates how a particular leadership theory affects employees with ASD [25]. In particular, how does adherence to a particular leadership style affect an employee's anxiety, and how does the employee's anxiety affect their commitment to their organization and their perception of their job performance? The researchers interviewed 52 employees (27 women; 25 men) with ASD, employed as "human service workers, research support staff, or cleaning and support staff." Employees rated their anxiety, commitment to their organization, and perception of their own performance, according to standard scales. The results showed that some leadership theories increase anxiety and negatively affect employees with ASD, even though studies have found the opposite effects in neurotypical employees.

Hurlbutt and Chalmers interviewed six adults with Asperger Syndrome and asked them questions about employment [19]. The goal of the study was to illuminate issues related to Asperger's and employment, in general, rather than the issues of people with Asperger's in a particular field. Participants were recruited at an autism conference or via social networks. Most participants had not worked in the areas in which they obtained their degrees and none were software engineers (although one participant was trained and worked as a library/information scientist). The researchers interviewed participants and asked many questions that were similar to ours, including how their diagnosis has affected them and their jobs, whether the participant had disclosed their diagnosis, and what accommodations, if any, they had received. The researchers coded the results and uncovered general employment themes that we also saw in our study: a reluctance to disclose diagnosis and the difficulties presented by social skills, environmental, and sensory factors.

INTERVIEWS: METHODOLOGY

We advertised our study via email to a distribution list within Microsoft comprised of employees who have autism themselves or who have family members with autism who have decided on their own to join that email discussion community (the names of members of the email list, and even the total number of members, were not available to us, as part of Microsoft's effort to preserve employee privacy). Although the list targets employees who are concerned about those on the autism spectrum, sometimes people with other

ID	Age	Approximate Age at Diagnosis	Gender	Country	Most Recent Job Role	Diagnosis
P1	43	Late thirties	Male	USA	Software developer	ASD
P2	51	Early forties	Male	U.K.	Technology consultant	Asperger's*
P3	23	21	Male	USA	Software developer	ASD
P4	45	Early forties	Male	USA	Website architect	PDD-NOS
P5	30	30	Male	USA	Software tester	ADHD
P6	46	Early thirties	Male	U.K.	Technology consultant	Asperger's
P7	46	Thirties or early forties	Male	U.K.	Technology consultant	Asperger's*
P8	49	Thirties or early forties	Female	USA	Software developer	Asperger's*
P9	34	3	Male	USA	Software tester	ASD
P10	52	49	Male	USA	Database administration	ASD

Table 1. Demographic details of interview participants. A * in the “Diagnosis” column indicates a self-diagnosis rather than a professional diagnosis. Participants P8, P9, and P10 worked in the software industry, but were not current employees of Microsoft.

diagnoses join the list. For example, one of the participants who responded to our call had ADHD, but did not identify as having ASD. While the majority of Microsoft’s employees are based in the USA, a substantial number are also located in other countries (3 of our study participants were based in the U.K.).

Our email advertisement described our research team’s interest in understanding the perspectives of neurodiverse software developers in order to help make software careers more inclusive. We offered a payment of \$50 (or a donation of \$50 to an autism-related charity such as Autism Speaks) for a one hour interview. Our call made it clear that all interviews would be confidential (no data would be reported to the participant’s manager or anyone else in their organization), held outside the employee’s regular workspace, and contained a calendar appointment whose title only let on that it was a meeting about software engineering. We also informed the participants that any data appearing in reports such as this would be anonymized.

Our email also indicated that recipients were welcome to share the study information with colleagues employed in the software industry at other companies; at least one reader apparently did this. We were contacted by a few software professionals who either worked for other companies or were otherwise employed, and included them in our sample (3 of our participants, P8, P9, and P10, did not currently work for Microsoft).

Interviews lasted between 45 minutes and 1 hour, and were conducted in-person for the six participants working near the researchers and via Skype for the four remote participants. We employed a semi-structured interview approach, starting with a set of core questions, but sometimes adding or removing questions based on a particular interviewee’s background, interests, and responses. Interviewees were also welcome to decline to answer any questions they found uncomfortable. All interviews were audio recorded with participants’ permission and the interviewers also took detailed notes. Table 1 summarizes key details about the ten interviewees.

INTERVIEWS: FINDINGS

After the ten interviews were complete, three researchers used open coding techniques to iteratively identify common themes that emerged across the interviews. We discuss those themes in the following sub-sections.

Diagnosis

A preponderance of articles on autism focus on diagnosis rates in children [2] and emphasize the importance of early diagnosis and early intervention [24]; consequently, we were surprised that with only one exception (P9), our participants did not learn that they were not neurotypical until adulthood.

Seven participants received formal diagnoses from medical professionals, while three (P2, P7, P8) diagnosed themselves. It may be the case that participants who self-diagnosed, rather than receiving a professional evaluation, may be incorrect in their labeling of their condition; however, we believe our role as researchers is to convey the experiences and perceptions of our participants, not to pass judgment on whether their diagnosis is “official” – our self-diagnosed participants had extensive knowledge of ASD (typically with other family members having formal diagnoses), and described experiences and issues highly similar to those of the participants with formal diagnoses.

Having one’s children receive a formal diagnosis of ASD was a common prompt for adulthood diagnosis (or self-diagnosis), as parents recognized in themselves many of their children’s traits. P2, P4, P7, and P8 noted that an autism diagnosis in one or more of their children prompted the realization that they were also on the spectrum. P9, our only participant who had himself been diagnosed in childhood (and received specialized education and therapies), also mentioned having children who were diagnosed as autistic.

Receiving a poor performance review at work was another prompt for diagnosis, i.e., if serious conflicts with a manager or other co-workers resulted in a need to consult with a mental health professional. P5, who differed from the other interviewees in having a diagnosis of ADHD rather than ASD, learned of his diagnosis by seeking professional help after receiving a bad performance review from his manager.

Interviewees found diagnosis beneficial, as it provided them with the basis for creating a plan of behavioral and sometimes medical strategies for addressing issues that interfered with their workplace success. P8 noted that having a diagnosis was a relief because, “it explains so much that I didn't understand.”

There are many possible reasons for the prevalence of adulthood diagnoses in this group, including that adults from earlier generations grew up in a time when autism awareness and diagnosis was less common, that some interviewees were born overseas in countries or cultures where autism awareness and diagnosis are less common, or that many milder cases of these conditions may be less noticeable or confused with other issues.

Disclosure

We asked participants whether they had disclosed their diagnosis to either their manager or a human resources representative in their workplace. Half of the participants (P1, P4, P6, P7, P8) had chosen not to disclose (we do not know if the participants' managers suspect that their employees have ASD or ADHD). The primary motivators for non-disclosure were concerns about being judged negatively by colleagues and of possible workplace discrimination. For example, P6 said that he was “wary of outing myself,” and noted that being neurodiverse is “where race, sex, and sexuality were [a few decades ago, as a civil rights issue]... autistic spectrum conditions are maybe similar, I think to that... years ago, gay people didn't feel comfortable coming out... people on the autistic spectrum are not yet comfortable about coming out.” P7 explained his choice of non-disclosure by saying, “I don't think our business [computing] is mature enough around its understanding of autistic spectrum conditions at the moment.” P8 noted, “I think I have a lot of skills, and I would like to be judged on my skills and not have to worry about a diagnosis.” Such concerns seem well-founded; P2, who decided to disclose to his manager, revealed that his manager told him that perhaps he should consider leaving his current role, and noted that, “people could and often [do] jump to conclusions.”

For the participants who did choose to disclose their diagnosis to management, a personal connection was often the prompt. For example, P3 decided to disclose his condition after hearing his manager describe how his own children had been diagnosed with ASD. P9 felt a close social/friendship relationship existed with his manager, and disclosed his own diagnosis to him as part of a larger discussion of his children's medical situation.

Software Development Challenges

Participants described a variety of challenges they faced as neurodiverse people working in the field of software development.

P1 and P6 reflected that they were often quite rigid in their interpretation of rules or in their desire for structure, i.e.,

becoming upset if colleagues' code didn't adhere strictly to style guidelines or if an Agile development meeting didn't follow all of the official rules described by the Agile programming movement (P1 noted, “Structure is good. That's why I like [Agile method]...”).

P3, P4, and P7 discussed how they had difficulty committing to or focusing on tasks that they perceived as mundane, though they felt they excelled and displayed unusual levels of focus for tasks they found particularly compelling. P10 specifically found the task of testing code (to make sure it is bug free) problematic, as the idea that end users would use the code in the “wrong way” and that he would need to anticipate this was extremely frustrating to him. P7 noted, “one of the things I hate is being bored... if I get bored I can disengage really quickly.”

P2, P8, and P10 identified that they sometimes expressed inappropriate emotions at work (and that they often were not aware of having done so unless a coworker informed them). P7 noted that code reviews, in which co-workers examine his code before committing it to the shared code repository, “can be quite confrontational,” though he did not identify this reaction as being inappropriate, per se. P2 mentioned that he would “blow up” at people who critiqued his code, and didn't realize that this reaction was considered unprofessional until a colleague explained it to him.

Interpersonal and Workplace Challenges

Half of the interviewees (P1, P6, P7, P8, P10) volunteered that they knew they had poor interpersonal communication skills. This led to many workplace challenges, including difficulty interpreting nuance in the meaning of coworkers' statements, difficulty interpreting coworkers' emotions, difficulty dealing with office politics, and difficulty handling conflicts with co-workers. Team meetings were cited as being a particular cause of stress, as was the process of interviewing to get a job; for instance, P10 reflected that he had done poorly on several job interviews because he did not make eye contact with the interviewers, which he concluded resulted in their viewing him as untrustworthy. P8 suspected that she was fired from a position because of her challenges with the social aspects of her job, “I think I can block it out [the social stuff] and focus on the stuff that needs to get done... that might be part of why I was let go... I don't know... I think I didn't have the social skills for people to want me to be on.” She went on to note, “It would be nice to be with a company where the social structure wasn't so complicated.”

Participants also described challenges with various types of communications, including face-to-face conversations, phone calls, and even e-mail (particularly interpreting emotion or nuance in e-mail). P8 said, “sometimes in an IM they [colleagues] would say, it would look like they were in agreement, but then I'd find out later that they were not, which was very confusing... I preferred to ask people what they could do for me in person, because there were more clues as to what they really meant.” P10, in contrast,

preferred electronic correspondence such as email because he “can do it more slowly, [and he] can think about what [he’s] saying.” Selecting which medium would be most appropriate for communicating with colleagues was also a source of confusion for participants.

Some participants had opportunities to try a management role at some point in their career, and management of other people often proved challenging – P1, P4, P7, and P8 reflected on these difficulties. P8 described that she felt she had been a good manager to other employees, and expressed confusion that the employees who reported to her didn’t seem to feel the same way, noting, “two of the people that I had working under me won’t talk to me anymore, I don’t understand why they won’t talk to me anymore... they both dumped me on Facebook... I don’t understand.” P1 noted that people with strong technical skills who were not well-suited to management had difficulty advancing within Microsoft, where promotions were often tied to moving into a managerial role. Note, however, that some interviewees had more positive experiences in management roles, and P6 mentioned aspiring to try out management in the future.

Environmental distractions, such as noisy work spaces or software-based distractions (e.g., notifications of incoming messages from email or other programs), were particularly problematic for participants. P1, P2, P3, P8, and P10 raised this as an issue. P1 noted that open plan offices, which are quite popular in technology companies [17], were a particularly distracting environment. P3 mentioned that he wore headphones and listened to music while working to help mitigate environmental distractions. Time management and task prioritization were difficult for P1, P5, and P10.

Frequent changes in organizational structure within Microsoft were called out as problematic by P1 and P7, who found having to adapt to new sets of managers and teammates particularly stressful and anxiety-inducing.

Accommodations

We asked interviewees to describe any accommodations they had requested in the workplace (if they had chosen to disclose their status), or what accommodations they might want to ask for if they were to feel comfortable disclosing or asking.

P2 and P6 both identified business travel as an area in which employees with ASD might require accommodations. Although Microsoft’s policy mandated hotel-room sharing among team members travelling to conferences to defray costs, P2 requested a private hotel room. He justified his request, explaining that after a long day of having to interact with other people at the conference, he felt that he couldn’t handle the need for additional social interactions at the hotel. He needed time to “chill out and just be on my own... and get my social battery filled up.” He also often requests to skip work-related social functions (such as team dinners), explaining that “it’s either fun or work, I can’t do both at the same time.” P6, who had not disclosed his diagnosis to

management, wanted to request dispensation against Microsoft’s policy that employees fly in economy class during business trips, because the stress of having so many people so close to him during travel was amplified by his ASD.

P5, who had disclosed his ADHD, made several accommodations requests at the suggestion of his therapist. He requested that his manager allow him to audio record team meetings to help him remember work items assigned to him. He found that taking notes while paying attention to verbal conversations at the same time was quite difficult. He also requested that key expectations and instructions be sent to him in written form so that he could re-read the information multiple times if needed. P7 also mentioned that he would find it helpful if he could request that key expectations from his manager be conveyed in written form, though he did not disclose his diagnosis and therefore did not make this request.

P5 requested an additional private weekly meeting with his manager in order to correct any potential misunderstandings in what he was working on and make sure his work stayed on track. He also requested that his manager be more attentive to providing more detail in any conversations and emails with him, as he found any ambiguities to be very difficult to interpret and resolve.

P3, who achieved “hyperfocus” on projects of interest to him but had difficulty working on projects he found mundane, was able to reach an agreement with his manager to have greater autonomy in selecting what aspects of the system he would code. P3 was also considering requesting a treadmill desk, as he felt that exercise might alleviate anxiety that he felt during the workday.

P8 and P10 both desired the flexibility to work from home and attend fewer meetings so that they could spend their time focusing on their strengths (writing code) and have less time (and stress) devoted to interpersonal interactions. P1 and P8 noted that a private office, perhaps even soundproofed, would help mitigate the distracting and stressful effects of working in open plan offices for people with ASD.

Greater awareness and sensitivity from colleagues to the needs of neurodiverse co-workers was something all participants hoped for, though this was difficult for people to balance with the perceived risks of disclosure. P8, who had not disclosed her ASD status to colleagues, noted that one potential benefit of disclosure may simply be greater empathy from colleagues, “if people didn’t get whatever social stuff they need from me, maybe they would be more understanding and explain what they need [more clearly].”

Finally, P10, who was among the half of our interviewees whose children also had ASD, observed that better health insurance coverage for caring for children with ASD would likely be valued by many employees on the spectrum, since their children were more likely than the children of neurotypical employees to have ASD.

Strengths

Despite the many challenges associated with ASD, ADHD, and related conditions, nearly all participants felt that being neurodiverse also provided them with advantages in their chosen careers relating to software development. P6 specifically emphasized that he preferred the term “Autistic Spectrum Condition” to “Autistic Spectrum Disorder,” because he felt that the disorder terminology implied that there were no positive aspects involved in being neurodiverse, an assertion with which he disagreed.

Six participants (P2, P3, P6, P7, P8, P10) perceived that they were particularly gifted in noticing patterns in information and mentally visualizing information. P6 mentioned an ability to “execute the code in my head” in order to anticipate bugs. P2 described an ability to spot bugs in code by recognizing patterns in the formatting (indentation of lines, etc.). P8 said that “finding the patterns” was her favorite aspect of programming, noting, “I can’t help myself, I look for patterns, that’s clearly an obsession of mine, patterns, and programming is really just a huge pattern.”

Several interviewees (P2, P3, P6, P7, P8, P9) noted that they were skilled at achieving a very high state of focus on authoring a piece of code or completing a specific project. P6 noted, “Aspies are very good at things like software testing... they’re very good at thinking things through and excluding other thoughts from their work.” P7 said, “I tend to be quite focused... I’ll find something of interest to me, I’ll be incredibly focused on that for a period of time, until I reach a point where I feel I personally understand it... and then I can very quickly lose interest in it.” P8 explained that her ability for intense focus was “such a benefit” for her job in programming: “I love it when I can just work and not have anything else, just being focused... is very satisfying.” P3 described enjoying experiencing a state of “hyperfocus” when working on certain programming projects.

P2, P6, and P9 noted that the code they authored was particularly clean and orderly, exemplifying strict adherence to rules of coding style, when compared to that of their colleagues. For example, P6 noted that colleagues who wrote “untidy code” irritated him, and attributed bugs to “nonautistic people developing the code and not thinking about boundary conditions... tidy code doesn’t have those sort of problems.” P2 noted that even before the advent of software development environments that would automatically indent code and support other aspects of coding style, “I would write my code in such a way that it would have that [nice formatting].”

P5 and P7 described strengths in tangential thinking – developing out-of-the-box solutions or making intuitive leaps that were valuable in their line of work. For instance, P7 noted, “I can be very insightful... I can make leaps that... quite often other people don’t.”

SURVEY: METHODOLOGY

To explore whether the themes that emerged from the interviews were distinct to software developers with cognitive differences or were also issues that resonated with neurotypical employees, we designed a survey to reach a larger audience.

We created an online survey using the SurveyGizmo service. The survey contained 32 questions, though some of these questions were shown only conditionally depending on prior answers (e.g., if respondents indicated they were neurotypical, they were not shown the subset of questions relating to their experiences as a neurodiverse software developer). In consideration of the sensitive nature of the survey topic, all questions were optional so that respondents uncomfortable with a particular question were free to leave it unanswered. Time-tracking software embedded in the survey indicates that participants spent a median of 6.4 minutes to complete the survey.

We sent the survey to 2,600 U.S.-based employees of Microsoft whose title indicated they were a software developer or software tester; specific employees meeting these criteria were chosen at random from the employee database to receive an email invitation to the online survey. The survey was administered during the last two weeks of October 2014. Survey participation was optional and anonymous; participants were told we would contribute \$1 to the Autism Speaks charitable organization for each completed survey we received (our team donated \$846 on November 3, 2014, an amount that was also matched by Microsoft’s matching charitable gifts policy).

The email invitation told participants that our survey was about “Software Developer Perspectives,” and explained, “Our goal is to broaden participation in software careers by people with varied cognitive profiles, including, but not limited to ASD (autism spectrum disorder), ADHD (attention deficit hyperactivity disorder), and dyslexia. Your response is important to us, even if you do not identify with any of these cognitive profiles.” We decided to broaden the survey call to include ADHD and other cognitive differences since our initial interviews indicated that some people with ADHD (like P5) identified informally with employees on the autism spectrum because they felt many of their challenges were similar, and because a large proportion of our other interviewees had co-occurring challenges such as ADHD.

SURVEY: FINDINGS

Demographics

846 people completed our survey (a 32.5% response rate). 718 (84.9%) of respondents identified as male, 107 (12.6%) as female, and the remaining 2.5% chose not to specify a gender. This preponderance of male respondents is roughly in line with the demographics at software companies (for instance, Microsoft and Google each recently reported that 17% of their technical employees are female [11, 22]). 91.8% of respondents reported their age; these respondents’ ages

ranged from 21 to 71 years old, with a median age of 32. Although respondents all worked in the U.S., they came from diverse backgrounds, with the majority having been born abroad. 34.8% were born in the U.S., 21.2% in India, and 10.2% in China. The remainder hailed from a variety of countries, particularly locations in Europe and Asia.

50.2% reported having a Bachelor's degree in computer science, and 25.7% reported having a bachelor's degree in another field related to computing (math, electrical engineering, information science, etc.). 3.5% reported having a graduate degree (Master's or Ph.D.) in computer science, and 11.2% reported having a graduate degree in a field related to computing. 6.5% of respondents indicated that they did not hold any undergraduate or graduate degrees in a computing-related field.

Respondents reported having worked in the field of software development for a median of 9 years (min 1 year, max 40 years), and having worked at Microsoft for a median of 5 years (min 1 year, max 25 years). 73.4% reported having a software engineering role, 23.4% reported having a software testing role, with the others reporting related roles such as "Data Architect," "Electrical Engineering," "Data Center Management," etc. Respondents reported being in their current role for a median of 3 years. 9.5% reported that they currently directly managed one or more employees (including interns and/or contractors), and 42.9% reported having directly managed one or more employees at some point in the past (either at Microsoft or at a prior job).

Neurodiversity

11 respondents (1.3%) identified as having an autism spectrum disorder (including Asperger Syndrome or PDD-NOS). 38 (4.5%) identified as having attention deficit disorder (including ADD, ADHD, and ADHD-PI). 16 (1.9%) identified as having dyslexia or another learning disability. Note that 7 of these respondents identified as having more than one of these conditions (e.g., ADD and ADHD); in total, 59 of the respondents (7.0% identified as having at least one of the aforementioned conditions, while 91.6% of respondents indicated that they did not identify as having any of the conditions (additionally, 6 respondents chose not to answer the question about their cognitive profile). The 59 respondents who identified with one or more of the cognitive differences were asked to respond to a set of survey questions specific to their experiences with that condition; the following sub-sections describe these participants' responses.

Diagnosis

42.4% of the 59 neurodiverse respondents reported being self-diagnosed, while 66.1% reported receiving a formal diagnosis of their condition by a professional (one person chose not to answer the question about diagnosis type). The age of diagnosis ranged from 4 to 50 years old, with a median of 23 (mean 22.5).

Responding to a multiple choice question asking whether any of several situations prompted the respondents' diagnosis, 15.3% indicated that they were diagnosed after one of their biological children had been diagnosed with a similar condition, 20.3% were diagnosed after one or more family members (other than their children) were diagnosed with a similar condition, 15.3% were diagnosed after a challenging situation at work (e.g., conflict with another employee, poor performance review), and 6.8% were diagnosed at the suggestion of a co-worker.

When asked whether they had changed aspects of their work after receiving their diagnosis, few respondents indicated they had, with two reporting having changed companies, two having changed roles, one having changed projects, and two having changed other aspects of their work situation such as their "day to day work style."

Disclosure

We asked what categories of people respondents had disclosed their condition to. Relatively few had disclosed their condition to co-workers: 20.3% had disclosed to their manager, 3.4% (2 respondents) had disclosed to a skip-level or higher manager, 1.7% (1 respondent) had disclosed to direct reports, 22.0% to co-workers on their team (peers in the company hierarchy), and none had disclosed to HR. In contrast, 32.2% reported having disclosed their condition to friends at Microsoft who were not members of their work team, and 76.3% reported having disclosed their condition to friends or family outside of Microsoft. 16.9% had not disclosed their condition to any of these groups of people.

Discrimination

We also asked these 59 respondents whether they had ever experienced workplace discrimination related to their condition, either at Microsoft or previous employers. 58 chose to answer this question, and the majority (52, 89.7%) reported that they had not experienced discrimination. The 6 who answered affirmatively were asked to briefly describe the discriminatory incidents; not all chose to provide descriptions. One, having attention deficit disorder, noted, "There is often intolerance and sometimes outright antagonism by smart people at [Microsoft] towards people that approach tasks and work situations differently compared to their natural viewpoint." Another, also having attention deficit disorder, said, "I often receive feedback that I'm 'odd,' and that it's limiting my career advancement." Another, with dyslexia, wrote, "It takes me longer to read things, so I get left behind and have to catch up."

Accommodations

Of the 17 employees who had disclosed their condition to management or HR, we asked whether they had requested or received any workplace accommodations; 94.1% said they had not. The one employee who had requested accommodations, a developer with attention deficit disorder, had requested a "good seat in [the] team room."

We also asked all 59 neurodiverse respondents whether there were any workplace accommodations they were not currently receiving that they thought might be beneficial, such as changes to policies or practices, to equipment or software, or to their working environment. 58 chose to answer this question; 15.5% indicated they would find some accommodations helpful. Suggestions included changes to the performance evaluation process (“Despite excellent technical performance, I’m often given average reviews for reasons directly related to my ADD symptoms.”) and hiring processes (“The interview process here is not geared toward people with disabilities. I also have Tourettes [sic] so I can get nervous and lock up. I will pass 40% of interviews and fail 60%.”). The most common suggestion was to change workplace arrangements: “I work in a cube environment where bright lighting and noise is common. I would much rather work in an office for parts of the day where I need to be focused.” (from an employee with ASD); “A more quiet environment” (from an employee with attention deficit disorder); “Private office space.” (from an employee with attention deficit disorder); “Not being forced into a [sic] open floor-plan ‘shared space’” (from an employee with ASD).

On-the-job Experiences

We asked all 846 respondents to describe their level of skill at various activities related to their jobs. In the following analyses, we exclude the 6 participants who did not respond to the question about their cognitive profile, since it is unclear whether they would fall into the neurotypical or neurodiverse group.

Respondents used a five-point scale (1 = significantly below average, 5 = significantly above average) to rate their level of skill at a list of several software development activities (Figure 1). Participants whose jobs did not require these activities could choose N/A or leave an item blank. We compared responses from neurotypical employees to those identifying as having ASD, ADHD, or dyslexia using Mann-Whitney *U* tests, and found no significant difference in self-rated skill for “finding bugs” ($p = .30$) or “visualizing the solution to a problem” ($p = .10$). There was a marginally significant difference in perceived skill at “employing good coding style” (neurotypical = 4.0, **others** = 4.1, $p = .06$). Neurodiverse employees rated themselves as significantly more skilled at “detecting patterns in code” (neurotypical = 3.9, **others** = 4.2, $p < .01$), while they rated themselves as significantly less skilled at “focusing on a particular task” (**neurotypical** = 3.8, others = 3.2, $p < .001$), “writing test cases” (**neurotypical** = 3.6, others = 3.3, $p = .04$), “requesting code reviews for your own code” (**neurotypical** = 3.8, others = 3.2, $p < .001$), and “reviewing other peoples’ code” (**neurotypical** = 3.5, others = 3.1, $p < .01$).

Respondents also used a five-point scale (1 = very uncomfortable, 5 = very comfortable) to indicate their level of comfort at communicating with colleagues using several types of media (Figure 2). There was no significant difference in comfort level for e-mail ($p = .17$), with social

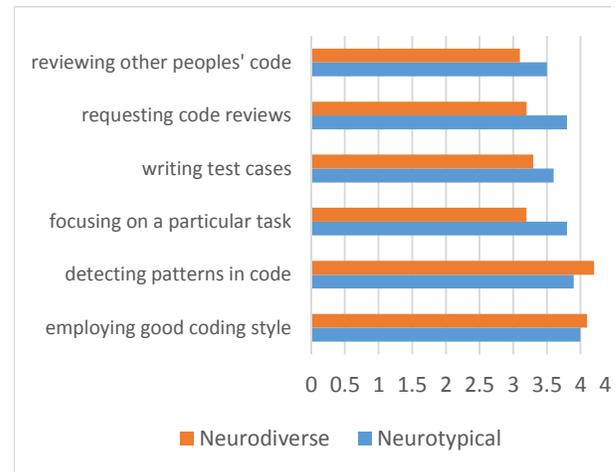


Figure 1. Software developers’ self-rated skill at software development activities (ratings use a five-point scale, with five representing the highest level of skill). Only items for which neurodiverse and neurotypical employees had statistically significant differences in their ratings are shown in this chart.

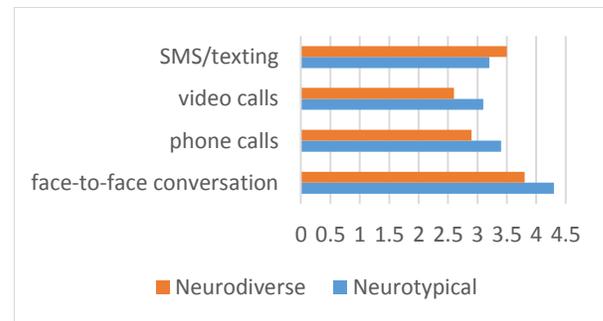


Figure 2. Software developers’ self-rated comfort with various forms of communication with colleagues (ratings use a five-point scale, with five representing the highest level of comfort). Only items for which neurodiverse and neurotypical employees had statistically significant differences in their ratings are shown in this chart.

media (e.g., Yammer) ($p = .36$), with instant messaging ($p = .10$), or with the use of communications mechanisms within software development tools such as source control systems ($p = .45$). Neurodiverse employees rated themselves as significantly less comfortable communicating with co-workers via face-to-face conversations (**neurotypical** = 4.3, other = 3.8, $p < .01$), phone calls (**neurotypical** = 3.4, other = 2.9, $p < .01$), and video calls (e.g., Skype) (**neurotypical** = 3.1, other = 2.6, $p < .01$). Neurodiverse employees rated themselves at significantly more comfortable communicating via SMS/text messaging (neurotypical = 3.2, **other** = 3.5, $p = .03$).

Next, respondents were asked to use a five-point scale to rate how challenging they find each of several work-related situations (1 = very easy to handle, 5 = very challenging)

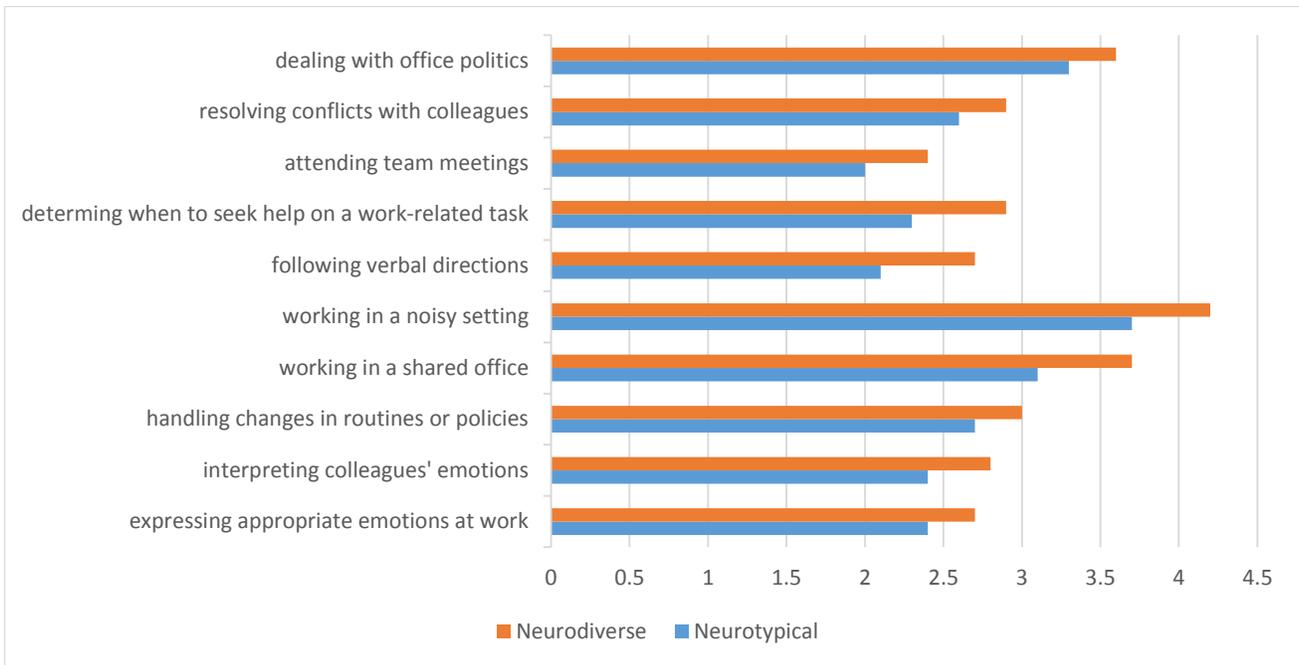


Figure 3. Software developers' self-rated level of challenge for various workplace situations (ratings use a five-point scale, with five representing the highest level of challenge). Only items for which neurodiverse and neurotypical employees had statistically significant differences in their ratings are shown in this chart.

(Figure 3). There was no significant difference in perceived level of challenge in having 1:1 meetings with one's manager ($p = .47$), handling reorganizations ($p = .35$), following written directions ($p = .12$), or resolving ambiguity in an assignment ($p = .16$). There was a marginally significant difference in level of challenge with expressing appropriate emotions at work (neurotypical = 2.4, **other** = 2.7, $p = .08$) and in interpreting colleagues' emotions (neurotypical = 2.4, **other** = 2.8, $p = .06$), with neurodiverse employees reporting both of these as larger areas of challenge than neurotypicals. Neurodiverse employees reported significantly higher perceived levels of challenge at handling changes in routines or policies (neurotypical = 2.7, **other** = 3.0, $p = .04$), working in a shared office (neurotypical = 3.1, **other** = 3.7, $p < .001$), working in a noisy setting (neurotypical = 3.7, **other** = 4.2, $p = .001$), following verbal directions (neurotypical = 2.1, **other** = 2.7, $p < .001$), determining when to seek help on a work-related task (neurotypical = 2.3, **other** = 2.9, $p < .001$), attending team meetings (neurotypical = 2.0, **other** = 2.4, $p < .01$), resolving conflicts with colleagues (neurotypical = 2.6, **other** = 2.9, $p = .04$), and dealing with office politics (neurotypical = 3.3, **other** = 3.6, $p = .03$).

Respondents used a five point scale (1 = strongly disagree, 5 = strongly agree) to rate their level of agreement with statements about their working style. There was no difference in responses to the statements "I enjoy working on projects as part of a team" ($p = .48$) or "I prefer to work from my own home" ($p = .42$). However, there was a difference in level of agreement with the statement "I enjoy working on solo projects," with neurodiverse employees preferring this

type of work more strongly than neurotypicals (neurotypical = 3.8, **other** = 4.1, $p = .02$).

Respondents used a five point scale (1 = strongly disagree, 5 = strongly agree) to rate their level of agreement with statements about their relationships with their co-workers. The only significant difference was in reactions to the statement "I enjoy(ed) having a management role" (which was only shown to those who indicated having ever been a manager in an earlier survey question), with neurotypicals more likely to agree (**neurotypical** = 3.7, other = 3.1, $p = .02$). There were, however, no significant differences in response to other statements related to management, "My personality and/or skills are well-suited for a management role" ($p = .95$) and "I am (was) successful in my management role(s)" ($p = .83$).

DISCUSSION

Our survey findings lend confidence that most of the challenges reported by our interviewees are indeed more salient issues for neurodiverse employees than for neurotypical ones. As with our ten interviewees, the fifty-nine neurodiverse respondents tended to be diagnosed in adulthood, and the majority did not disclose this diagnosis to management or their human resources (HR) department. Our survey findings also reinforce the suggestion of our interviewees that neurodiverse software developers perceive themselves as more skillful at focusing intensely on tasks and noticing patterns in code than neurotypical employees. Our survey also reinforces the interviewees' opinions that working in shared or open plan offices and dealing with the

people skills aspects of software development were more problematic for neurodiverse employees.

In addition to validating trends from our interviews, the survey also highlighted some additional differences between neurotypical and neurodiverse software development employees, such as the finding that neurodiverse employees reported significantly less comfort with synchronous forms of communication than their neurotypical peers; we hypothesize this may be because asynchronous tools allow them more time to review and reflect on messages and prepare considered responses; further study to investigate this issue is warranted.

Implications for Employers

Our findings suggest that a not-insubstantial minority of software development employees at Microsoft have neurodiverse cognitive profiles. Companies like Microsoft may underestimate the pervasiveness of these issues because most impacted individuals are unlikely to disclose their status to HR or management for fear of judgment or discrimination. Further, many affected employees may not even realize the nature of their condition until many years after joining a company, as adulthood diagnosis was quite common.

Creating an environment that educates all employees about conditions such as ASD and ADHD may be beneficial, both for helping affected-yet-undiagnosed individuals achieve insight into their mental state that may enable them to receive needed assistance and in creating a climate of understanding and empathy within the workplace that may increase workers' comfort in revealing their neurodiverse status. As P8 noted, "I wouldn't feel comfortable telling managers or HR... but that might have helped [me]."

Open plan offices have become particularly prevalent at tech companies [17], but our findings indicate this working arrangement may negatively impact this sub-group of employees; the most commonly requested accommodation from our respondents was to rethink this trend, or make alternative work arrangements available for employees who need it.

Limitations

Both our interviews and survey rely on self-report data, whose drawbacks include the possibility of participants intentionally or unintentionally misrepresenting their experiences. Surveys may be problematic for neurodiverse participants to complete accurately, since it is not possible to request clarification of a question's intent [25]. Additionally, there may be sampling biases – for example, the people who chose to respond to our requests for interviews may have chosen to do so because they have experiences that are much more positive or much more negative than is typical. We attempted to mitigate this by randomly sampling from Microsoft's employee list for our survey invitations, but there may be self-selection in who ultimately completed the

survey as well. We combined interviews with surveys as one way to mitigate the limitations of each individual technique.

Our interviews and survey include neurodiverse respondents with a range of diagnoses, covering varying points on the autism spectrum, as well as conditions such as attention-deficit disorder and learning challenges; some participants had multiple of these diagnoses, which may not be surprising given that characteristics of ASD and ADHD co-occur in a significant portion of the affected population [29]. Our sample size did not allow us the statistical power to tease apart nuances in the differential challenges that people with different diagnoses may experience – in addition to sample size, the co-occurrence of diagnoses within a single participant and/or the variability in the specifics or severity of a diagnosis across participants makes such analyses quite challenging, though they certainly have import and merit, and are a recommended avenue for further work.

All of the survey participants and all but three interview participants were employees of Microsoft; it may be that their experiences are not generalizable to the tech industry more broadly, but may be specific artifacts of the culture at Microsoft. However, we found that the experiences of the three employees who worked at other companies were quite similar to the others', suggesting that some amount of generalization is probable.

We also acknowledge that, while our findings indicate that there is hidden neurodiversity within the technology industry, the range of neurodiversity present in our study does not represent the range of neurodiversity in society. We recognize that a substantial number of people with ASD and other conditions may not be able to live independently in adulthood and that they and their caregivers may be concerned with a very different set of employment-related issues than the issues impacting the participants in this study.

Future Work

While this research is the first to shed light on issues related to neurodiversity among technology employees, it should not be the final word on the matter. Our survey results begin to give a sense of the extent to which software developers may represent various cognitive profiles, but more systematic sampling extending beyond a single company may be important for allowing the technology industry to better understand the need to take steps to support neurodiverse employees by providing data on the pervasiveness of these issues within and beyond Microsoft; such data may also help reduce the stigma associated with being neurodiverse by illustrating the extent to which it is a common phenomenon, as well as providing initial metrics against which further progress in diverse recruiting, hiring, and retention practices can be measured.

Interviews with managers and/or co-workers of neurodiverse employees would also add valuable information and perspective to this work. In this particular case, interviewing managers and co-workers was not possible, due to the

confidential nature of the interviews and the fact that most of the employees had not officially disclosed their neurodiversity. However, the growth of formal hiring initiatives for employees with ASD at companies such as Microsoft may make manager and peer interviews possible in the future for employees whose status has already been disclosed through such programs.

The knowledge that many technology employees may have profiles such as ASD also merits related research on improving software development tools and practices to better support and leverage these employees. From a software engineering research or HCI perspective, pertinent research questions may include whether there are benefits to pairing up neurotypical and neurodiverse employees for pair programming tasks, or having them review each other's code, since each may notice different types of bugs. Perhaps there are changes that should be made to scrum or other types of software development processes to better support participation by neurodiverse employees. It also seems important to investigate whether communications tools such as email or IM can be adapted to better support neurodiverse employees by providing assistance at interpreting affect or nuance within messages or by encouraging neurotypical authors to clarify points identified as potentially problematic. We look forward to addressing these topics in future work.

CONCLUSION

Although the media often speculates that the technology industry includes many people with autism spectrum disorders [31], and although some autism experts suggest that individuals on the spectrum consider technology as a career choice [12], and although some technology companies have announced goals of recruiting neurodiverse employees [33], there is almost no research that explores the experiences of neurodiverse tech workers and no research that we know of that compares their experiences to those of neurotypical tech workers. In this paper, we presented the findings of interviews with ten neurodiverse individuals in careers related to software development, as well as survey results describing the experiences and opinions of 846 software developers and testers, 59 of whom identified as being neurodiverse.

Our findings revealed that many technology workers receive their diagnosis in adulthood, often as a result of life events such as a child's diagnosis or poor job performance. Most do not disclose their diagnosis to HR or management, despite the fact that a variety of accommodations, such as changes in workplace layout or modes of communication, may be desired and beneficial. Neurodiverse employees also reported different cognitive styles, such as sensitivity to details and patterns, which may be an asset to their career if nurtured and recognized by employers. We hope that these findings help inspire employers and employees to effect workplace changes that help all employees better reach their potential.

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