

**LEVERAGING AI AS ASSISTIVE TECHNOLOGY TO SUPPORT
NEURODIVERGENT USERS**

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ABSTRACT

Neurodivergent individuals, such as those with autism, face significant challenges in communication, social interaction, and executive functioning skills, often leading to social isolation and challenges navigating educational and employment settings. Assistive Technology is a powerful tool for supporting neurodivergent individuals across various aspects of life, from early childhood through adulthood. This research examines how AI-enabled assistive technology can support neurodivergent individuals throughout various life stages, focusing on two key domains: communication development and employment. We first address communication development with a study that explored Speech-Generation Devices (SGDs) as game controllers for an interactive digital coloring game. We found that all five participating autistic children (ages 3-5) engaged with our interactive coloring game, with two showing emerging joint attention with facilitators. Next, we address assistive technology in the employment domain. To study this, we conducted three studies: 1) an interview study with fifteen stakeholders which revealed the challenges experienced by autistic job seekers along the hiring pathway as well as the organizational tools, connectivity tools, and visual media tools used by autistic job seekers throughout the hiring process; 2) a formative study with autistic job seekers and job coaches exploring the use of ChatGPT as an interview coach, and 3) an explorative study of data annotation tasks with ten neurodivergent adults as a potential avenue for employment. Based on the results of these studies, we present ideas for the future design of engaging digital social learning contexts for SGD learning and practice, as well as AI-

enabled assistive tools to support neurodivergent users while job seeking. We conclude that as digitalization advances, designing inclusive AI-enabled assistive tools is critical for supporting neurodivergent individuals from early development through adulthood.

To my mother, whose spirit continues to guide me, your emphasis on the importance of education shaped my academic path. And to my father, who taught me the values of hard work and persistence. Together, you made this achievement possible and stands as a testament to your influence.

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CHAPTER 1

INTRODUCTION

Across their lifespan, neurodivergent individuals, such as those who identify as autistic, often struggle with communication, executive functioning, and social skills (American Psychological Association, 2013). When reaching adulthood, they often face barriers to employment, with labor statistics showing lower employment rates for neurodivergent individuals compared to neurotypical individuals (US Bureau of Labor Statistics, 2022).

To support communication, some neurodivergent individuals utilize technological solutions such as Speech Generating Devices (SGDs). Often, these devices are introduced at an early age (Lorah et al., 2022) but face barriers to adoption and motivation to use them by caregivers (Du et al., 2022; Du et al., 2023). As neurodivergent job seekers approach adulthood, they also often face job-seeking and maintaining employment challenges. Though some vocational resources are available (Wehman et al., 2016), little is known about the assistive technology they use during the job-seeking process and applications of digital technology while on the job.

These challenges offer opportunities to develop Artificial Intelligence (AI)-enabled assistive technological solutions. To study these opportunities, this thesis explores AI as an assistive technology solution across two key challenges within the lifespan of neurodivergent users: communication development in early childhood and employment support for adults.

1.1 Challenges for Neurodivergent Users: Communication

Autistic individuals often have difficulty communicating vocally, impeding their engagement with others (American Psychological Association, 2013). To alleviate these difficulties, autistic individuals sometimes require Augmentative and Alternative Communication (AAC) as a form of communication, which provides a way to communicate as an alternative to vocal speech (Lorah et al., 2022). Examples of augmentative and alternative communication include technological solutions such as speech-generating devices (SGDs), which offer applications to AAC users on personal devices such as tablets and smartphones. These applications often contain grid displays where the user selects icons on the grid, and the application outputs speech to match their selection (US Department of Health and Human Services, 2022). Despite this technology, the adoption of SGDs can be challenging for autistic individuals as it requires significant training for individual users and caregivers to use these devices, and this hurdle limits motivation for users and their caregivers to use this assistive technology (Du et al., 2022; Du et al., 2023).

One way to address these challenges is to combine AAC with Artificial Intelligence (AI)- enabled gamification. In this thesis, we present a study (Garrison et al., 2025) exploring the use of gamification to increase engagement with five autistic children who use SGDs. This work suggests future design ideas for developing AI-enabled gamification and SGDs.

1.2 Challenges for Neurodivergent Users: Employment

In addition to challenges with communication, autistic individuals face challenges in gaining employment. According to the US Bureau of Labor Statistics (2022),

individuals with disabilities face significantly higher rates of unemployment and being out of the labor force compared to those without disabilities (80% vs. 30%). Their employment rate is markedly lower, with only 21.3% employed compared to 65.4% among individuals without disabilities. Individuals with Autism Spectrum Disorder (ASD) often struggle with social interactions and executive functioning, presenting challenges in typical workplace environments. These difficulties can hinder their ability to maintain employment and adapt to new tasks or routines (Schall et al., 2020; Tomczak & Kulikowski, 2023). Existing systems designed to support employment among neurodivergent individuals face scalability, cost, and transportation challenges. These limitations reduce the accessibility supports in the workplace, illustrating the need for innovative, scalable solutions like assistive technologies and digital work environments (Gilson et al., 2021; Wehman et al., 2016).

In this thesis, we explore the use of assistive technology by neurodivergent job seekers during the job-seeking process: 1) where we explore the use of assistive technology to address the challenges that autistic individuals face during the hiring process, and 2) the use of an intelligent interview coach to support autistic job seekers with interview skills. In addition, to exploring the use of AI as assistive technology for neurodivergent workers while on the job, we present a study highlighting the performance and perspectives of neurodivergent users in a digital work environment (Garrison et al., 2023).

1.3. Structure and Thesis Statement

This thesis is organized as follows: first, as noted in Chapter 1, we introduce the challenges faced by neurodivergent users with communication and engagement as well as

employment, and introduce novel opportunities for assistive technology, particularly assistive technology that utilizes artificial intelligence, to support neurodivergent users with these challenges. We demonstrate this with four studies (Chapters 2-5) and conclude with a summary and discussion of thesis contributions (Chapter 6).

This thesis hypothesizes that leveraging AI as assistive technology, when designed with an understanding of neurodivergent users' perspectives and experiences, may address challenges that neurodivergent individuals face across their lifespan. Specifically, that AI-enabled gamification can enhance communication and engagement for autistic children using speech-generating devices, while AI-enabled job seeking preparation tools and AI-enabled assistive tools within digital workplace environments can improve the job-seeking experience and employment success for neurodivergent adults.

CHAPTER 2

EXPLORING ENGAGEMENT OPPORTUNITIES FOR AUTISTIC CHILDREN: USING AAC AS A CONTROLLER IN A WIZARD-OF-OZ COLORING GAME

2.1 Introduction

Autistic children often have difficulty communicating vocally and engaging socially with others (American Psychiatric Association, 2013). These difficulties may lead to social isolation from peers and members of their family (Dueñas et al., 2021). To mitigate these social and communication challenges, autistic children sometimes require Augmentative and Alternative Communication (AAC) as a form of communication, which provides a way to communicate as an alternative to vocal speech (Lorah et al., 2022; United States Society for Augmentative and Alternative Communication, 2022). AAC encompasses a wide range of communication methods, including both low technological and high technological options. Low technological AAC includes forms of communication that do not require electronic devices (Holyfield & Lorah, 2023). Examples include picture boards and communication books. These methods rely on symbols or pictures to facilitate communication. High technological AAC involves electronic devices, ranging from simple button-based devices to complex computer systems (Holyfield & Lorah, 2023). These include speech-generating devices (SGDs), specialized devices, and apps implemented on commodity hardware, such as tablets. SGDs often use a grid display, where symbols, pictures, or words (icons) are organized within a grid format and users select to construct messages. Grid displays range from a field of one to hundreds of icons (see Figure 2 for an example).

AAC is particularly relevant for autistic children for several reasons. Many autistic children have difficulties with verbal communication and struggle with social skills (American Psychiatric Association, 2013). Some autistic children may be non-verbal or have limited speech, making expressing their needs, thoughts, and feelings challenging. AAC can provide structured ways for them to engage in social interactions (Lorah et al., 2022). AAC tools such as SGDs can be tailored to the individual's needs and abilities, providing a personalized way for autistic children to communicate (Farzana et al., 2021). AAC can also reduce frustration from the inability to communicate effectively and help autistic children become more independent in communication, reducing their reliance on caregivers to interpret their needs and desires (Du et al., 2023; Laubscher et al., 2023; Lorah et al., 2022). AAC plays a vital role in supporting autistic children by providing them with tools to communicate, participate in social and educational activities, and more fully express themselves.

Despite the well-documented benefits of AAC, integrating it into daily routines often requires significant time and practice—a challenge for both caregivers and therapists (Du et al., 2023; Laubscher et al., 2023). This difficulty can restrict AAC's use to only supporting functional communication, rather than enabling rich, socially engaging experiences for autistic children, their caregivers, and peers. In supporting functional communication alone, this represents a missed opportunity to fully harness AAC's potential. In this paper, we propose re-purposing existing SGDs as game controllers. By leveraging the inherently motivating nature of play, this approach not only has the potential to foster deeper user engagement but also creates valuable opportunities for users to practice SGD use. Over time, it may facilitate meaningful social interaction

through multi-player games involving peers or caregivers, thereby broadening the scope of AAC to support both communication, social connection, and collaboration.

In examining previous research on gamification and AAC, studies have shown acceptance with therapists and caregivers of autistic children in using gamification to support in learning prerequisite skills for using SGDs, such as learning to press icons on a screen and orienting the child's attention to the device (Boster & McCarthy, 2018; Du et al., 2023; Wendt et al., 2020). However, these studies did not contain games that responded to the speech-generated output of a device. The use of SGD as an interactive game controller, to our knowledge, has not been studied before with those who use AAC. SGD as the game controller can serve as a tool to support the communication partnership between the child, their caregivers, siblings, peers, and therapists, within a socially situated practice, while playing the game.

To explore the use of the speech-generated output of SGD to control a game, we conducted an exploratory Wizard-of-Oz case study (Holyfield et al., 2024; Mulsby et al., 1993), with five autistic children. These were children who were 3-5 years of age, who use AAC, and participated within a university clinic setting. We incorporated a piggyback prototype using pre-existing digital platforms (Grevet & Gilbert, 2015). To observe our participants' engagement with the game and SGD, we designed a coloring game using Microsoft's Paint 3D and open-access coloring pages from Crayola. For this study, I acted as the 'game,' and responded to the speech-generated output of the participant's SGD by coloring items in the picture when the participant selected the color on their SGD. Participants accessed the game using Zoom's web conference platform

with the shared screen feature enabled to view the game, and were asked to ‘control’ the game using their SGD.

The main contribution of this work is to explore the novel use of the SGD as a game controller, providing insights for future design considerations of AAC-controlled games and for future work in exploring the use of such games to enhance social connection and collaboration between autistic children and their caregivers, siblings, peers, and therapists. With this study, we propose three design goals for future work in AAC-controlled games: 1) Use Existing SGDs by ensuring the design does not require a new device or application as new devices and applications can be costly and often require additional training (Du et al., 2022); 2) Foster Playful Use of SGDs as most SGDs are designed for functional communication, and by integrating play, users may get more practice with the device and be more likely to use it long-term (Du et al., 2023); and 3) Facilitate Social Interaction by creating opportunities for social interaction with peers, siblings, and caregivers, enhancing the social dimension of SGD use. These goals represent our vision for future AAC devices and applications. In this work, we model the use of Design Goal 1 with our piggyback prototype and Wizard-of-Oz method and begin the evaluation process using a case study for Design Goal 2 to determine its potential for engaging users. Our results also show instances of Design Goal 3 with two participants.

2.2. Related Work

2.2.1 Engagement Challenges for Autistic Children Who Use AAC

Effectively addressing the engagement challenges of autistic children using AAC involves a comprehensive strategy. This includes selecting appropriate and effective communication tools and creating socially engaging environments tailored to the child’s

interests (Koegel et al., 2012). One way that parents and therapists engage with autistic children is by using SGDs (see Figure 2 as an example). Research indicates that SGDs are particularly effective for autistic children, facilitating more frequent and spontaneous communication compared to other AAC methods like picture exchange systems or sign language (Lorah et al., 2022). This suggests that SGDs may be more user-friendly and engaging, encouraging autistic children to communicate more often using these tools. Research has also shown that aligning activities with the child's interests, such as games, significantly enhances their interaction with others (Koegel et al., 2012).

Despite the effectiveness of SGDs, particularly when paired with activities within the child's interests, there are still challenges in engaging autistic children to use AAC. Research with parents of autistic children highlights the challenges parents face in incorporating AAC into their daily routines (Du et al., 2023; Laubscher et al., 2023). For AAC to be effective, it must not only accommodate the diverse communication styles of autistic children but also seamlessly integrate into the family's daily life (Laubscher et al., 2023). Parents often spend an inordinate amount of time learning to operate and use SGDs within their child's daily routine and strongly desire to connect and engage with their children (Du et al., 2023; Laubscher et al., 2023). Parents also worry about the stigma that the SGD carries, as their child uses a different modality to communicate when compared with vocal peers (Laubscher et al., 2023).

One way to address these engagement challenges faced by autistic children who use SGDs is to incorporate gamification with the use of the SGD, allowing parents to engage with their child in preferred games, and also creating a tool for autistic children who use SGDs to connect with their vocal peers and siblings. For social engagement and

communication within games, previous research explored promoting teamwork (Gutwin et al., 2016) and aiding in language learning (Safi et al., 2018). Games that are controlled by speech generated by an SGD may increase opportunities for engaging social learning contexts. This study will explore the engagement of autistic children who use SGDs and their interaction with a coloring game that responds to SGD output.

2.2.2 Gamification for Autistic and AAC Users

For AAC users, previous studies have also examined the design and use of games to support users in learning how to use their SGDs. Studies have found the importance of adding visual and sound components, storytelling, and customization to game design to enhance engagement and learning (Camargo et al., 2019; Mubin & Poh, 2019). In addition, previous work has shown success in using immersive games and universal design teaching new skills to autistic children, indicating the potential of gamification for this population (Ramos Aguiar et al., 2023).

Within the design of AAC game applications, research has also highlighted the importance of incorporating user-friendly design features within AAC apps, such as including interactive elements (i.e. popping bubbles on a screen), and adding familiar characters in games (Boster & McCarthy, 2018; Wendt et al., 2020). These features can motivate learners and facilitate interaction with peers, demonstrating the importance of a user-centric approach in AAC technology. Integrating AAC into engaging and meaningful activities, such as games, increases the motivation of the AAC user to engage with their device and with others (Gough & Dutton, 2018). It is important to consider all of these recommendations when designing games to incorporate with the use of AAC. For our study, we selected a game that combined visual elements (coloring the picture)

with sound (verbal acknowledgement of the user's selection of the color), and selected coloring pages with familiar characters such as barnyard animals, pets, and underwater animals.

2.2.3 Interactive Game Controllers

Game controllers specifically designed for the game console, such as those used in PlayStation or Xbox consoles are a common way to interact with games. Games with consoles designed to interact with body movements, such as Nintendo's Wii or Microsoft's Kinect are also popular (Schlömer et al., 2008; Shirai et al., 2007), specifically when working with those with developmental disabilities (Chung et al., 2014; Vukićević et al., 2019) or with older adults (Agmon et al., 2011; Chao et al., 2015; Yang et al., 2020). In addition, the use of body movement as a game controller has shown to promote social engagement and movement with those in retirement communities (Lee et al., 2020) and with patients who are diagnosed with dementia (Unbehaun, Aal et al., 2018; Unbehaun, Vaziri et al., 2018).

Voice-controlled games have existed since 1973, and their development has largely been tied to the development of hardware and software to capture and process voice input and to incorporate it within game play (Allison et al., 2020). However, despite this long period of development, there is limited work on the use of voice-controlled games. Some research has shown that voice-controlled games can function as an accessibility feature for individuals with motor impairments (Allison et al., 2018). Previous studies have also evaluated the use of voice control compared to fine motor control of games and found that though gamers with fine motor control performed better in the game, the voice control features caused less fatigue for gamers with motor

impairments (Harada et al., 2011). An advantage of using voice control is that it may eliminate gaming errors that sometimes occur when using fine motor movements (Piotrowski et al., 2019). In addition, some autistic children have challenges with fine motor skills (Lloyd et al., 2013), and games that respond to voice output may provide another accessibility option for engagement with games.

For this study, we propose the use of a voice-controlled game, which uses SGD output as the voice controller. Previous studies have investigated the use of voice-controlled games, particularly regarding the design patterns that are present in such games currently on the market (Allison et al., 2018). Based on this research, one design pattern was particularly salient, the design pattern of unscripted conversation. In an unscripted conversation design pattern, the character in the game may follow a script with questions, but the player can respond in any way. Based on keyword recognition, the game then responds to the player. In our game, we incorporated this design pattern by asking the participants the colors they would like to color the animals in the pictures, providing an unscripted conversation component to the game.

2.3 System Overview

2.3.1 Game Implementation

A primary focus of the game's implementation was to be child-centered, incorporating participant preferences within the game (Currin et al., 2024). Since our participants did not have the communication skills necessary to communicate their preferences with researchers, we provided an initial screening form to the clinic's therapists, where we asked them about the activities they observed children engaging with more frequently in the clinic. The facilitators indicated that the children enjoyed

coloring, and for this reason, we selected coloring to be the game's activity. The children recruited for our study were familiar with selecting color icons on their SGDs.

Based on the feedback from the clinic's therapists, we designed a coloring game for participants using Microsoft's Paint 3D application and digital coloring pages available for open access on Crayola's website 2. The setup of the game followed a Wizard-of-Oz design format (Maulsby et al., 1993), where the I acted as the 'wizard,' running the game and responding to the speech-generated output of the SGD. The participants did not see the 'wizard' during the interaction with the game.

2.3.2 Game Implementation Rationale

The purpose of this study was not to study a coloring game, but rather, use the coloring game as an example of a game that could be integrated with SGDs, in order to promote the independent use of SGDs in a socially situated practice between the child who used the SGD, their peers, family members, and anyone else within their social network. We used the Wizard-of-Oz method to present the game to participants so that we could explore the game's feasibility, without needing to develop the actual software to play the game. In addition, this format allowed for flexibility, as we were working with young children, and we could respond to unpredictable behavioral responses. With consideration to our Design Goal 1 (outlined in the introduction of this work), it is important to note that different autistic children may use different SGDs. These devices are typically proprietary in nature meaning that they cannot be augmented or tinkered with. To circumvent this barrier, we devised a lightweight piggyback-prototype which required no modification to the existing SGDs. Piggy-back prototyping is a method of quickly assembling a new system prototype from an old system (Epstein et al., 2022).

Previous research has shown this method for use in proprietary social media systems (Grevet & Gilbert, 2015) as well as with plugins (Delcourt et al., 2023). For our implementation, we built the game from a pre-existing system of Microsoft Paint 3D, with a ‘wizard,’ who responded to the keywords generated from both SGD and vocal speech output.

When reflecting on Design Goal 2, we also considered that the participants might attempt to use the screen as a touchscreen to color the image in the game, rather than control the game with their SGD voice-generated output. Touchscreen coloring as a feature was not enabled on the game’s laptop as our primary purpose was to explore the connection between the use of the SGD as a game controller and engagement. For this reason, we only allowed vocal speech or SGD output to control the game. We allowed these communication modalities to function as the game controller to provide flexibility for participants who communicated with vocal speech as well as a SGD, while fostering engagement both with the SGD and the game.

2.3.3 Game Play

During the game process, in-person ‘game facilitators,’ familiar people and therapists assigned to work with the child in the clinic, supported the participant while playing the game. This Wizard- of-Oz Coloring Game involved four steps (see Figure 2.1). With the assistance of the game facilitator, the child logged into the Zoom session where I acted as the ‘wizard.’ Game facilitators were allowed to redirect participants to the SGD to select the color and to point to the game screen when the color changed but were instructed to provide minimal prompts to the child outside of this rule. This was to show the child that the SGD was controlling the game. The researcher turned their

camera off, with one side of the Zoom screen showing only the child on the video and the coloring page so that the researcher could observe and record how the participant and game facilitator were interacting with the game. With the researcher not visible on the screen, the child could interact with the ‘game’ rather than the researcher. The researcher also turned their microphone and speaker on to communicate with the participant and hear commands from the child’s SGD. On the participant side, their microphone and speaker were on to enable communication with ‘the game.’

The researcher started the game, asking the child to select a color using their SGD to color the animal on the screen. The child selected the color on their SGD, and it generated an output sound of the color selected. Finally, the researcher moved the paintbrush and colored the picture in the game based on the child’s selected color.

2.4 Wizard-Of-Oz Formative Case Study

2.4.1 Ethics Statement

An Institutional Review Board approved the study. Due to the fact that our participants were children under the age of 18, we followed the informed consent process approved by the Institutional Review Board, where the participant’s legal guardian consented to their inclusion in the study. However, we also included assent procedures (Flowers & Dawes, 2023) within our study, asking participants if they wanted to play the game with us before starting. If they moved towards the game, we started the game. As soon as the child moved away or indicated they were done playing the game, we ended the game session. Since the ‘wizard’ was operating remotely from a laptop, we required game facilitators to be present with the child. We also made our system portable, so that it could be incorporated within the typical clinic routine, familiar to the children.

2.4.2 Methods

2.4.2.1 Participants. We recruited five participants for the case study who participated in a university clinic. We used convenience sampling (Jager et al., 2017) to recruit our participants from one clinic where autistic children attended several days per week to learn to use their SGDs. We used this strategy for recruitment, as autistic children who use AAC can be a hard-to-reach population (Sadler et al., 2010) requiring an extensive professional network and legal guardian consent. We also recruited participants specifically who indicated a preference for coloring, through previous observations by clinic therapists, as an activity they were observed to spend time with in the clinic setting. The purpose of this study was to be an exploratory multiple case study, and one that did not require a large sample size, as is standard for these types of studies (Schoch, 2020). Participants ranged in age from 3-5 years, and all were diagnosed with Autism Spectrum Disorder, as shown in Table 2.1. All participants used SGDs to communicate, and were able to select at least one icon on a page using their SGD. Though participants demonstrated a range of proficiency with their SGD and speech capacity, at the time of the study none of the participants were using either speech or their SGD to fully meet their daily communication needs. All were using speech with low frequency and with a small number of words, and all communicated primarily through pre-linguistic means (e.g., pointing to things they wanted, pushing away things they didn't want, facial expressions, using nonspecific vocalizations). All participants used the SGD Proloquo2Go by Assistiveware (see Figure 2.2). Participant information is shown in Table 2.1.

2.4.2.2 Setting. We used the web conference platform Zoom to complete our study. Participants accessed Zoom through a laptop set up within the University clinic on a table, in an open area within the clinic. Participants also had their SGD present. The laptop was not a touchscreen-enabled laptop. This was so that only the voice output of the SGD could control the game, and a participant did not accidentally color the image using the touchscreen of the laptop. We enabled the Zoom screen share function, with the coloring page displayed on the screen in Microsoft Paint 3D, as well as audio and video recording functions (see Figure 2). In addition, we had an alternate video recording from another video recording device positioned toward the child and laptop screen to capture data that would not be collected from the Zoom recording, thus providing more information for future data analysis. For example, if the child chose to keep their AAC device lower than the laptop camera, the alternate video recording could capture this video instead of the Zoom video recording. Only the Zoom camera was used to help the ‘wizard’ operate the game. The second camera’s recording was not accessed by the ‘wizard’ during game play.

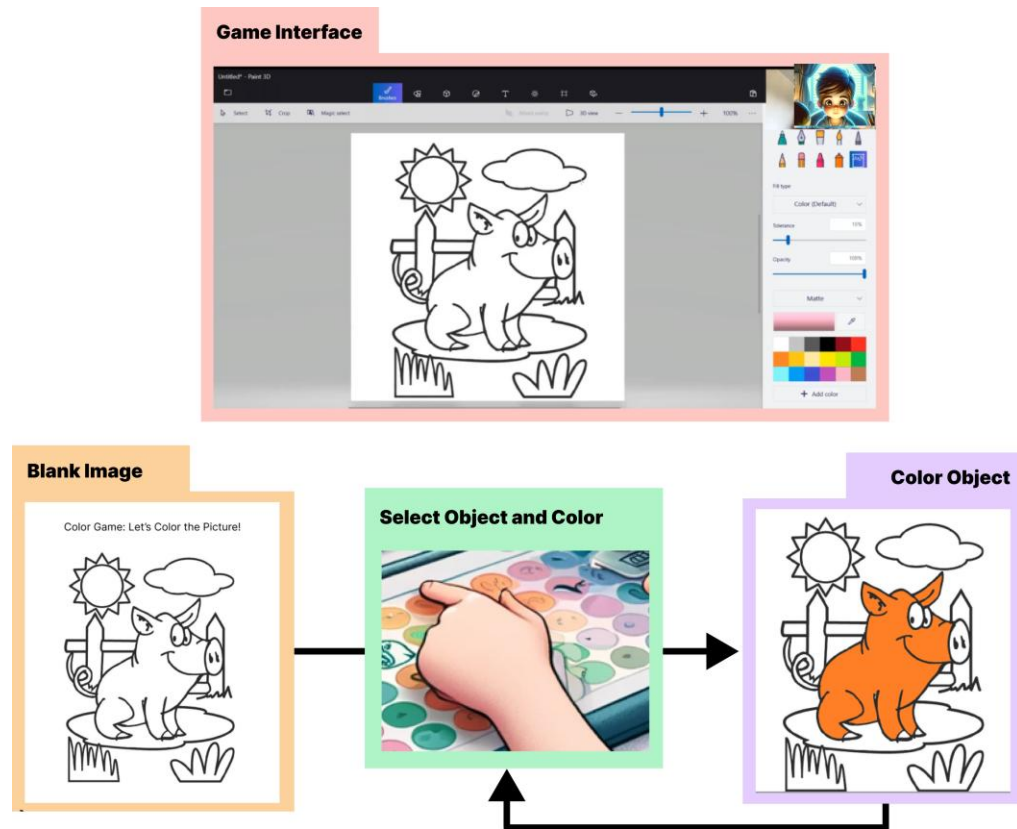


Figure 2.1. System Overview Setup. **Game Interface:** The child logs in to the zoom session with the Microsoft Paint 3D picture. **Blank Image:** The researcher, acting as the game starts the script “Let’s play a game! What color should we color the pig?” **Select Object and Color:** The child selects the color on their SGD, and the SGD broadcasts the sound of the word (eg.“orange”). **Color Object:** The researcher colors the pig in that color. The game continues with additional selection of colors per object.



Figure 2.2 Setting. Image of a participant logged in to the game and using an SGD with a grid display to play the color game.

2.4.2.3 Wizard-of-Oz Procedure. Participants accessed the game through the Zoom video conferencing web platform with the shared screen feature enabled. The ‘wizard’s’ computer shared the digital coloring pages on Microsoft’s Paint 3D program. The coloring pages were selected from the ‘Plants and Animals’ page, and we selected the first three pictures that showed common animals: barnyard, pets, and undersea creatures. These categories of animals were chosen due to higher levels of preference with these animals and children at this age group (Borgi & Cirulli, 2015).

Once the game facilitator logged the participant in to the Zoom web conference, the game began. The ‘wizard’ then began the game script as follows:

Hi, do you want to play a game?

[Wait for child to indicate ‘yes’]

Let’s go to your color page!

[Pause for navigation.]

We are going to color the picture!

[Pause for 5 seconds.]

Use your talker to tell me what color to color each animal!

What color should we color the pig?

For example, when the participant selected the color ‘pink’ on their SGD the speech generated output said Pink. I then moved the paintbrush and selected pink on the Zoom screen, coloring the picture of the pig pink on the screen (Figure 2.1). When moving to the next image in the picture, the ‘wizard’ stated to the participant the next image to color and asked what color to color the image (following the game script above). These game turns repeated until all the images on the page were colored. The ‘wizard’ asked the participant if they wanted to keep playing, and if they indicated yes, the ‘wizard’ pulled up the next coloring page. The ‘wizard’ followed this procedure until the participant indicated they were finished playing by saying “All done” using their SGD or by moving away from the screen.

2.4.2.4 Data Collection. Data were collected via the Zoom audio and video recording as well as with a second camera present in the room collecting video and audio data. We collected data using both viewpoints, so that we could get a good vantage point

of the child's interaction and engagement with the game. This allowed us to also reflect that a typical game would not be able to 'see' the player, and these observations would provide valuable information for designing future games for follow up studies.

Though there has not been an established definition of engagement in early childhood literature, some studies define engagement through behavioral observations (Ritoša et al., 2023), using duration of interaction as a form of measurement (Miller, 2015). For this study, we defined two behavioral dimensions for observation with our participants: 1) engagement with the game, defined as the length of time the participant was in front of the computer interacting with the game and 2) engagement with the SGD, defined as the length of time the participant interacted with the SGD through eye gaze or selection. Engagement onset was counted in seconds from the time the participant had their body oriented towards the computer or SGD with the offset when the participant looked or moved away from the computer or SGD. We also counted the number of turns the participant engaged with the game, and recorded any joint attention responses (where the participant made eye contact or oriented their body towards the game facilitator and to the game) (Murza et al., 2016).

In our data collection process, as previously noted, we had two cameras recording: the Zoom camera angle, which can be described as the 'Game View,' providing us with the vantage point of what an automated gaming system would 'see' when the player was playing the game; and the second camera recording the player from behind, defined as the 'Room View.' This participant observation data collection strategy (Kawulich, 2005) provided insights into user behaviors and experiences while the participant was interacting with the game. This approach was essential for us to collect

data, and to the proprietary nature of existing SGDs, we could not modify SGDs to gather data. By using this approach, we sought to capture user interactions with the SGD that might not be readily captured by the ‘Game View.’

Table 2.1. Participant Information. From our observations of participants, Proficiency with AAC is defined as the following: Beginning: the participant can select one icon on a single page; Emerging: the participant can select multiple icons on a page; the participant can navigate or scroll between two pages or fields. From our observations of participants, Speech Capacity is defined as follows: Non-vocal where the child did not emit any vocal words or word approximations; Partial vocal where the child emitted vocalizations but they were word approximations; and Vocal where the child emitted one or more full vocal words. Pictures are the number of pictures colored during the game. Game is defined as the seconds spent engaged in the game. AAC is defined as the seconds spent engaged with their SGD.

Id	Age	Gender	Proficiency with AAC	Speech Capacity	Pictures	Game	AAC
P1	4	F	Emerging	Non-vocal	2	360	360
P2	4	M	Beginning	Partial Vocal	2	46	141
P3	4	M	Beginning	Partial Vocal	1	20	5
P4	5	M	Beginning	Non-Vocal	1	13	7
P5	3	M	Emerging	Vocal	1	56	56

2.4.2.5 Data Analysis. Since our participants had limited communication to provide us with feedback on their user experience, data analysis for our case study involved an iterative and ethnographic approach, consisting of behavioral observations to gather information (Blomberg & Burrell, 2009). I maintained a journal to document observations and evolving thoughts about user experiences. Additionally, discussions were held with the University clinic’s behavior analyst and speech and language pathologist during the data analysis process to gain further insights into the child’s

experience and to contextualize observations. Serving as the 'wizard' I also engaged in a process of iterative sense-making during the data analysis process to develop a deeper understanding of each child's individual experience and to understand commonalities across participants. The other collaborators on this study also reviewed the video recordings independently, jotting down observations. All collaborators met to share observations, with weekly meetings occurring from December 2023-February, 2024. Furthermore, these regular meetings were held by the collaborators to reflect on potential biases or alternative explanations as part of the data analysis process. The data analysis process was iterative, and used this ethnographic approach to qualitatively code the observations. Thus, calculating inter-rater reliability would not be suitable (McDonald et al., 2019).

2.5 Results

In this section, we present the results as a case study with five participants interacting with the Wizard-of-Oz SGD-controlled coloring game within a clinic setting. We first share our observations of each participant's experience with the game, reflecting on the experience through the vantage points of the game view and room view videos. Next, we synthesize our observations into three themes: engagement with the game, engagement with the SGD, and game play opportunities for social interaction and collaboration. A summary of engagement results can be found in Table 2.1.

2.5.1 Participant Observations

P1 was a 4 year old female who had emerging proficiency with AAC and was largely non-vocal (did not emit vocal words or word approximations). She was able to

navigate her SGD, scrolling between two pages of icons, selecting an icon from a field of multiple icons on a page.

From the Game View video, the participant started the Zoom session with the shared screen feature enabled of the Microsoft 3D paint game. For the participant's initial selection, the 'game' was not able to hear the audio, and the facilitator vocally repeated the color the participant selected from the device. Once the initial object was colored, the participant moved forward in the game and continued pressing colors on their SGD to complete two coloring pages. We observed 5-second pauses between the question from the game 'What color do you want to color the picture?' and the selection of colors from the SGD. When the game script advanced to a new picture, the child continued to press colors. The game facilitator stated that the child wanted to color the previous picture in its entirety, including the background. At this point, the 'wizard' went back to the original picture so that the child could color the background of the image, before moving on to the second page. The game facilitator later shared after the game's conclusion that they knew they wanted to color the background based on previous experience with the participant and coloring. Following this observation, we can infer that an automated gaming system would switch pictures once all of the objects were colored, leaving the background uncolored. However, with this participant, the game, operated by myself as the 'wizard,' manually facilitated the continuation of coloring the current picture until all the white spaces in the background were filled. This should be a design consideration and challenge for future game design, as a child may become frustrated if they want the entire picture colored, including the background.

From the Room View video, there was more to see compared to the Game View presented. We observed that the participant initially wanted to use the screen as a touch screen; however, once they saw the connection between pressing an icon on their SGD and seeing the colors on the screen, they continued to select colors on their SGD, coloring the two different pictures. When transitioning from the second to the third picture, the game loaded a new image and the 'wizard' asked the participant to choose a color. The participant did not respond and was prompted by the game's facilitator, to choose a color. The participant, visibly frustrated, used their SGD to say, "all done," resulting in the termination of the game session.

During the game, the participant navigated between two pages on their SGD, each with a field of 12 options. The participant engaged with both the game and the SGD for 360 seconds each and colored two pages. For this participant, once the initial connection occurred between the selection of an icon from the SGD as a means to control the game, they consistently looked to the game, then to their device to select the color, and then back to the game for 13 turns. They also engaged in one joint attention response with the game facilitator (eye gaze from device to the game facilitator) when they needed help with the game, and the game was not responding to the initial touch screen selection.

P2 was a 4 year old male who had beginning proficiency with AAC. He was partially vocal, vocalizing some approximation of words during our session. His SGD had a single page with 4 icons of colors as choices.

In the Game View video for this participant, the session started with the participant being partially visible on the video, and making a vocal sound resembling "een," which led the game to color the first object in the picture green. There was a long

pause before the next selection of the SGD by the participant. We reflected that it was a challenge for the ‘wizard’ to understand what the child was doing without being able to see the participant, and the game continued to follow the script, repeating the prompt of What color do you want to color the pig? three times until the child selected a color from the SGD. Following the next selection, the game continued to respond to the color choices made by the participant using their SGD, coloring objects on the screen accordingly based on the audio input from the SGD. The ‘wizard’ noted that they could not see the participant on the video camera, and needed to rely on the audio output of the SGD to move forward in the game. This is similar to how an automated, rather than ‘wizard,’ SGD-controlled game would respond.

In the Room View video, again, we observed a different experience of the participant than from the Game View. The participant interacted with the game by attempting to press buttons on the laptop and using the screen as a touchscreen, which resulted in accidentally closing the game on the screen. The facilitator intervened by reloading the game onto the screen. After being redirected to select a color using the SGD by the facilitator, the participant proceeded to select colors on the device without looking at the game screen. It was observed that the participant was not looking at the game screen; however, it appeared as though they were responding to the audio of the game script as they would wait for the game to ask the question of What color...? and then would respond by selecting a color. The engagement times were recorded as 46 seconds with the game and 141 seconds with the SGD, during which the participant colored two pictures. They engaged with the game for seven turns. They did not have any joint attention responses with the game’s facilitator.

P3 was a 4 year old male who also had beginning proficiency with his SGD. He was partially vocal, and had some vocal word approximations during the observation. His SGD also contained a field of 4 colors.

From the Game View video, the participant took some time to interact with the game, and 50 seconds elapsed before they selected a single color on the SGD to color in the picture presented on the screen. After this selection, the facilitator shared that they walked away, and the game ended. For this participant, it was again a challenge for the ‘wizard’ to understand if they were attending to the prompt of What color do you want to color the pig? so the game repeated the prompt 5 times before they selected a color on the SGD.

The Room View video revealed that the participant stared at screen making mouth movements and some vocal sounds, looking around the room. For this participant, the SGD showed a field of 4 colors. The participant’s engagement with the game was brief, looking at the game screen for 20 seconds and interacting with the SGD for 5 seconds to make a color selection. They made a single color selection to color one object in the picture, for one turn. Despite this brief engagement, it was noted to the researchers by the game’s facilitator that this duration of engagement was the longest the participant had sat and attended compared to other clinic activities. Reflecting on this experience, we noted the participant needed a more explicit connection between selecting the color from the SGD and the game’s response, indicating a need for the facilitator to model the use of the device and then point to the corresponding action in the game. The participant did not have any joint attention responses with the game’s facilitator.

P4 was a 5 year old male who had beginning proficiency with his SGD. He was non-vocal and did not vocalize during the session. His SGD had a field of 4 icons representing the colors red, green, blue, and yellow.

For the Game View video, we observed the child interact with the SGD by first selecting two colors simultaneously, which presented a challenge for the ‘wizard,’ acting as the game, in isolating a single color’s audio to color the picture. As a result, the game repeated the question, “*What color do you want to color the pig?*” regarding color choice when this overlap occurred. The child selected ‘orange’ on their SGD, and the game colored the pig in the picture orange. As the ‘wizard,’ operating the game, we noted that we could see that the child moved away from the game and ended the game. For an automated gaming system, this would be a challenge to identify that the child was finished playing, and the game would continue to loop the prompt of “What color do you want to color the[insert name of object]?” if the child moved away and did not close the application.

For the Room View video, the child selected two colors simultaneously on their SGD. After the child was prompted to select one color instead of two, they selected ‘orange’ and then smiled at the screen when the pig was colored. Although there was a field of 4 colors available on the SGD, the child then desired a different color than what was present. They could not find the color on the field of 4, and then attempted to select it by touching the color on the game screen. This attempt was unsuccessful, leading to frustration, vocalized by yelling and walking away from the game. The child was engaged with the game for 13 seconds and with the SGD for 7 seconds. They engaged with two turns in the game. They did not engage with joint attention responses with the

game facilitator. Reflecting from this vantage point, it is possible that this participant would need more than four choices on their SGD to be visible when playing a color game.

P5 was a 3 year old male who had emerging proficiency with his SGD. He was vocal and vocalized words and word approximations as he selected icons on his SGD. His SGD contained a field of 4 icons of colors; however, he was able to scroll and move the field up and down to select from a display of new colors.

In the Game View video, the ‘wizard,’ operating as the game, initially could not hear the child’s vocal speech command to color the pig red. The facilitator intervened by repeating the color out loud, prompting the game to color the pig as requested. After coloring the pig, the child continued to use vocal speech and also select colors on their SGD to complete coloring the first picture. The game responded to both the vocal speech selection and SGD output as the purpose of the game was to respond to both types of speech. When the game transitioned to the second picture, the ‘wizard’ again could not hear the child’s color selection. The facilitator had to repeat the color choice, but in the delay, the game facilitator noted that the child had walked away from the game which was not visible to the ‘wizard’ operating the game.

From the Room View video, the child was seated at a table, and it was noted that other clinic children and therapists were present in the room off-camera. It was observed that the child had access to a field of four colors on their SGD and was actively scrolling between fields to select colors from different fields of 4 icons. The child used vocal speech and identified colors before making selections on the device. Their full attention was on the game once the first object was colored. However, the child walked away from

the game, when the game lagged and did not immediately color the picture with their color selection. The child was engaged with both the game and the SGD for 56 seconds each, coloring one picture with 5 turns of the game. This participant engaged in two joint attention responses with the game's facilitator, and one joint attention response with another child in the room when different colors appeared on the screen. Reflecting on this vantage point, to keep children engaged, game lags will need to be minimal between the selection of color from the SGD and coloring of the picture, and auditory issues with voice control of the game within noisy environments will need to be solved.

2.5.2 Case Study Synthesis

2.5.2.1 Engagement with the Game. We observed that emerging AAC users had a higher duration of engagement with the game. P3 and P4 spent more time engaged with the game than their SGD, looking at the screen and attempting to use the screen as a touchscreen to color the picture. P1, P2, and P5 all colored 2 pages of the game, while P3 and P4 colored 1 page before indicating they were finished playing by walking away or selecting "all done" on their SGD.

Vocal speech capacity did not seem to impact the engagement with the game for our participants, as P1 spent the longest time with the game and did not make any vocal word approximations. Once the initial connection was made between the SGD generation to control the coloring of the game, P1 and P5 consistently looked to the game, then to their device to select the color, and then back to the game for several turns.

2.5.2.2 Engagement with the SGD. We observed that for emerging AAC users, we again had a higher duration of engagement with their SGDs, with P1 engaging with their application for 360 seconds and P5 engaging with their SGD for 56 seconds; both of

these participants spent an equal amount of time engaged with the game and the SGD. P3 and P4 spent the least time with their SGD (5 and 7 seconds, respectively). P2 spent more time engaging with their SGD (141 seconds) than with the game (46 seconds). It should also be noted that P2, did respond to the game questions by selecting colors on their SGDs in response to game questions; however, their full attention was on their SGD rather than the game. This is an interesting finding as they were hearing and responding to the game instructions but not looking at the screen to see the color change.

For P5, our only vocal participant, we observed that they often vocally stated the color and then selected it on their SGD. The game responded to both the vocal selection and SGD-generated output, and this participant used both communication modalities consistently to interact with the game.

2.5.2.3 Game Play Interaction and Social Collaboration. All of the participants engaged with the game for at least one turn (Design Goal 2). P1 initially showed an inclination to use the screen as a touch interface; however, once the connection between using the application as the controller occurred, they consistently used their SGD to color the images. P1 also displayed a preference for coloring every object in the entire picture. The game attempted to move to another picture without coloring all of the objects, and this led to frustration when the game progressed to a new image without completing the coloring of the entire picture.

We observed that two of our participants (P1 and P5), engaged in joint attention responses between the game and the game's facilitator, who was a familiar therapist within their clinic setting (Design Goal 3). P1 looked to the facilitator when they needed help to navigate to an icon to interact with the game. P5 also engaged in one joint

attention response with a peer off of the camera screen when the color showed on the screen, and two joint attention responses with the game's facilitator when the game shifted to a new coloring page. This indicated emerging social collaboration between the participants, therapist, and peers during game play.

Observations also revealed situations where there was a need for social collaboration between the participant and game facilitator. P3 was observed making mouth movements and looking around the room, and P4 smiled when the pig was colored on the screen after they selected their first color, but showed frustration when they could not find the desired color shown in a field of four on their SGD and walked away from the game. These instances demonstrate a need for more collaboration from the game facilitator to show the connection between the SGD as the game controller and the game, and a natural learning opportunity to teach the child to navigate the fields of the SGD.

2.6 Discussion

2.6.1 Design Implications for AAC Voice Controlled Games

It is important to note that all participants engaged with both their SGD and the game for a brief duration, and all of the participants engaged with the game for at least one turn. For autistic children who are beginning communicators, even brief moments of engagement can be considered a success, as the executive functioning skills needed for engagement and joint attention between SGD and the game can be a challenge for this population (Corbett et al., 2009). Based on this finding, games may require better modifications to suit these early-stage communicators' needs and capabilities. Simplifying the game interface with fewer elements on the screen, incorporating more movement with child-friendly characters or avatars, and integrating more sounds could

enhance attention and engagement for beginning communicators. In addition, it is necessary to trial the game design with autistic children who have more established language skills, SGD use, and joint attention capabilities to determine if they may be a more suitable audience for these types of games. We observed frustration for some participants when the images were not completely colored (P1), when a color appeared as an option in the game but not on their field of view for the SGD (P4), and when there were lags in game responses (P5), indicating a need for flexibility and quick responsiveness of future gaming systems. For two of our participants (P2 and P3), having more guidance connecting the SGD as the game controller would be beneficial to address challenges with playing the game. These findings align with previous research suggesting that before engaging with an activity, the learner must engage with events of instruction (Gagne et al., 2005), indicating a need for scaffolding activities before initiating the game. Existing literature using gamification to teach prerequisite skills for AAC supports the use of a pre-game tutorial phase aimed at capturing the learner's attention and assessing prerequisite skills, such as attending to the game screen and navigation of their SGD (Wendt et al., 2020).

Within game design research, game tutorials reveal mixed results regarding their efficacy regarding gaming performance (Andersen et al., 2012; Cao & Liu, 2022). However, research in this field has shown that game tutorials, depending on the game type (Kao et al., 2021) or game's complexity (Andersen et al., 2012; Cao & Liu, 2022), may increase player time with a game, and guidance from in-game tutorials provide positive effects on learning to play the game and user flow for gamers (Morin et al., 2016; Passalacqua et al., 2020). Researchers have also noted that within actual games,

there can be several design features (such as The Personal Advisor, where a within-game agent can provide visual cues and advice for the player) that support the learning of the game for players outside of a standard tutorial (Poretski & Tang, 2022).

Notably, neurotypical adult gamers are the primary population of study for most game tutorial studies, and not autistic children, who may require direct instruction before learning a skill (Ganz & Flores, 2009). Autistic children sometimes have a low frustration tolerance (Mazefsky et al., 2013) and may hyper-focus on particular stimuli in their environment (Marsicano et al., 2023), both of which are considerations for game designers for this population. In particular, games that contain multi-sensory stimuli and features leading to frustration for a neurotypical gamer may be amplified and lead to game abandonment for autistic gamers. It is important that future SGD-controlled games are developed using a co-design process (Partogi & JafariNaimi, 2016) with autistic children, their therapists, and their caregivers, when developing future iterations of the game as well as game tutorials.

Research within game design has also shown that players learn game mechanics by exploring different components of games (Anderson et al., 2012), and may experience higher levels of enjoyment if these tutorials are modeled within the context of the game (Frommel et al., 2017). Game tutorials that are fun and engaging may also increase user adoption in playing the actual game (Zhiyong et al., 2021). In addition, observing others play games can be helpful for gamers (Li et al., 2014), and pre-game tutorials incorporating exploration and models of game play, as well as game facilitator guides for parents and game partners, may support autistic children who use SGDs to learn SGD-controlled games within a social and collaborative context. From this study, we learned

that using a piggyback prototyping method (Delcourt et al., 2023; Epstein et al., 2022; Grevet & Gilbert, 2015) was helpful for gathering information on the use of games and SGDs for autistic children. This method allowed us to incorporate the speech generation from different SGDs as well as vocal input with an already existing digital platform, saving us time and resources (Design Goal 1). If we had to develop a from scratch prototype with direct connectivity to an SGD to explore this idea with our participants, it would have presented challenges in navigating proprietary SGD software. In addition, using the Wizard-of-Oz method also allowed for flexibility within the game-play, so if the child exhibited frustration, rather than continue with the script presentation, the ‘game’ moved on to the following picture.

With that said, during game-play, we identified moments where the ‘wizard’ responded to the child differently than in an automated game system (e.g., instances when the audio was difficult to hear through Zoom and the facilitator repeated the speech-generated output), which is a key observation for the future design of SGD-controlled games. For our study, we had two cameras recording participants, the Zoom recording, and an in-room recording of the child’s interaction with their SGD and the game. When analyzing the results, there were moments where the in-room camera showed a different angle of the child interacting with the SGD and occasionally picked up on more auditory output from the device than the Zoom recording. Ultimately, the Zoom recording vantage point is what an automated game would ‘see’ while interacting with someone playing the game. Challenges identified from these recordings (audio capture, tracking the child’s attention to both the game and the device) provide insights for future design

considerations, such as adding an external microphone, as well as eye-gaze tracking software to incorporate within future AAC voice-controlled gaming systems.

2.6.2 SGD-Controlled Games for Supporting Social Connection and Collaboration

Previous research studies have noted children's frustration and lack of motivation in using AAC, often stemming from a disinterest in using a SGD as a communication tool (Laubscher et al., 2023). We observed two instances of this with our participants, with P3 taking 50 seconds to interact with their SGD, and P4 visibly showing frustration when they could not find the color they wanted on their grid display for the SGD.

Personalization of games to match individual interests, paired with SGD integration, may increase the frequency of independent SGD use.

In addition to their potential to provide increased opportunities for independent practice in AAC, games controlled by SGD output could also offer a new context for social interaction (Design Goal 3). Though participants in the current study interacted with the game individually, we did observe two participants demonstrating the emergent use of joint attention during the game (P1 and P5) with the game's facilitators (Murza et al., 2016). By allowing vocal speech and SGD output to control the game, this also sets up the opportunity for collaboration with AAC users and people who do not use AAC. One notable concern among parents is the stigma associated with AAC, when their children use AAC to communicate in primarily vocal settings (Laubscher et al., 2023), and the integration of AAC within games may motivate vocal peers to engage with autistic children who use AAC, thus facilitating social interaction and inclusion (Trottier et al., 2011).

By transforming the learning of the SGD from a passive to a shared experience, games can enhance engagement and social practice with the device and with others, including parents, siblings, and peers, particularly when engaging in play activities (Du et al., 2023). This is particularly relevant considering Broffenbrenner's Family Systems Theory, which emphasizes the inter-connectedness of children and families within larger social systems (Brofenbrenner, 2013; Laubscher et al., 2023). Games, therefore, can be designed to integrate seamlessly across these nested systems, encouraging participation from all members of the child's social network.

Within the child's social network at home, parents of children using SGDs often face the challenge of dedicating significant time and effort to learning and integrating SGDs into family routines, compounded by a general lack of external social support and training for SGD use (Du et al., 2023; Laubscher et al., 2023). This situation is further exacerbated when children lack regular access to therapy services or inclusive peer settings that could provide highly engaging social settings for AAC use. Games, in this context, offer a plug and play solution, potentially reducing the time and effort required by parents while simultaneously promoting social engagement with AAC activities. This approach aligns with recent research suggesting that games can be an effective practice tool outside therapy sessions, enhancing communication through play (Du et al., 2023). Gamification of AAC may foster connectivity and shared communication experiences between parents and their children, as well as between siblings, a desire strongly expressed by parents (Laubscher et al., 2023).

Within their larger social network, gamification may improve the engagement between autistic children, their SGDs, and with others as a collaborative tool. One

research study noted that autistic children and young adults reported that the social interactions within multi-player or team player video games were their primary source of social connection (Finke et al., 2018). Furthermore, previous research has shown that incorporating neurotypical, vocal peers in game-play with autistic children who use AAC, can increase contextually appropriate communication within the game, particularly between the AAC user and their peers (Trottier et al., 2011). Games that require teamwork or cooperative play can help children practice social skills like turn-taking, sharing, and collaboration towards common goals. SGDs as game controllers may be customized to prompt users to interact, perhaps by requiring players to press buttons in sequence or communicate choices.

2.7 Limitations and Future Work

The primary purpose of this case study was exploratory: to gather insights regarding the interaction of participants playing a coloring game, using their SGD as the game's controller. The use of SGDs as an interactive game controller, to our knowledge, has not been studied before with young autistic children, and thus, we needed insights gained from this study to guide future work in designing SGD-controlled games for children with autism. It is important to note that the purpose of this study was not to show generalization across age groups, nor was it meant to show any long-term effects or changes in the participants following the study, and the brief engagement periods demonstrated by participants are not an indicator of long-term effectiveness of the game.

Within AAC research, studies often focus on a single site with few participants (Ganz et al., 2012; Ganz et al., 2023; Light et al., 2021). In addition, we chose this research design and method due to the following challenges: we needed to find young

autistic children who use SGDs, a population that requires: 1) legal guardian approval to participate in research; and 2) one that requires an extensive professional network to find. Due to these challenges, our sample came from children already participating in a clinic setting within one geographic area, which is a limitation. Despite this limitation, the case study provided us with valuable information regarding the design of future studies for testing the game with a larger sample of participants of different age ranges from different geographic areas with different SGD proficiency levels, across several sessions so that we can study the effects of SGD-controlled games longitudinally.

This study used a Wizard-of-Oz method to test the game, which allowed for potentially more pauses or disruptions within the game's flow than an automatic system. To facilitate the Zoom recordings, we also used a laptop to play the game, and some participants tried to use the screen as a touch screen to play the game, when initially taking their first turn. Future studies should examine the use of a larger second screen as part of the game setup so that the user only sees the larger screen of the game and the SGD while playing the game. The sessions also took place in a clinic that had other children playing, so the noise level in the room sometimes made it challenging for the researcher to hear the SGD output. Future designs should look at universal microphone connectivity between the SGD and game.

Future studies should also examine adding additional prerequisite ‘game tutorials’ to teach the requirements for game play to the child prior to starting the game. These games can contain activities as levels or milestones presented as pre-game modules, following the research on events of instruction (Gagne et al., 2005) with the following milestones:

- Game Milestone 1: Attention to big screen and game. The child directs their eye gaze to the big screen showing the game, by following the movement of icons such as bubbles on a screen. This can be detected using eye gaze software.
- Game Milestone 2: Attention to SGD. The child selects icons on their SGD, responding to instructions from the ‘mini-game’ (i.e. “touch red,” “touch orange”). The game detects the selection based on the audio output of the SGD.
- Game Milestone 3: Practice with eye gaze to the game and selecting icons on their SGD. The child looks at the screen first, receives the instruction ‘touch red,’ and then selects the red icon on their SGD. The game tracks both movements with eye gaze detection and audio detection.

It is also important to observe the application of this work when evaluating engagement with AAC game play and additional groups of people. Examples of these additional game studies include:

- Studying the use of SGD game play with children who are more advanced communicators on the autism spectrum.
- Studying the use of art or coloring games with children who have significant motor impairments, including those who use SGDs. Children who do not have the motor skills necessary to draw often require others to create artwork for them. SGD Art Games could provide an opportunity for inclusion for that population.
- Studying the effects of games that respond to SGD output and engagement with multiple people within a larger collaboration system, evaluating multi-player use of SGD games, specifically with caregivers, peers, and siblings.

2.8 Conclusion

Overall, by using a Wizard-of-Oz coloring game guided by our three design goals, we gained valuable insights regarding how autistic children who use AAC may interact with a game that responds to SGD output as the game's controller. These include the impact the level of proficiency the child has with the SGD, the importance of preparatory activities for children at different stages of SGD familiarity, and ideas for future design iterations of an SGD-controlled game. As part of our study, we also observed with two participants, moments of social connection and collaboration through game play. These findings emphasize the need to explore new gaming approaches for autistic children who

use AAC. The observed variability in engagement also suggests a need for adaptable and personalized features within such games. In the future, we plan to conduct more in-depth studies on gaming prototypes for autistic children who use AAC.

CHAPTER 3

EXPLORING THE CHALLENGES AND ASSISTIVE TECHNOLOGY FOR AUTISTIC JOB SEEKERS ACROSS EMPLOYMENT PATHWAYS

3.1 Introduction

Transitioning from high school to the workforce is a pivotal period for young adults, moving from the structure and comfort of the high school environment toward the unknown world of employment. For autistic individuals this transition presents a unique set of challenges, as they may encounter new experiences of social interaction, as well as the need for more advanced executive functioning skills, both of which they may find to be difficult (American Psychiatric Association, 2013).

Previous research highlights three pathways for autistic job seekers: 1) University, defined as attending a 4-year University setting and/or graduate school; 2) Job Coaching, defined as attending a certificate program or vocational rehabilitation program; and 3) Self-Directed, defined as receiving a high school diploma and not enrolled in any vocational program or University (Davies et al., 2024). In a scoping review of 33 studies with 1640 autistic participants, Davies et al., found that 29.2% received job coaching, either through supported employment or certificate programs, 15.6% of participants were self-directed, and the largest group of participants came from the University pathway with 55.2% of participants attending a university setting. Previous research also highlights specialized employment programs for autistic job seekers that provide internship or practicum settings within the University pathway, and work closely with universities, requiring a University degree for ongoing employment. These companies recruit autistic individuals directly from university settings to work within their unique

work environment, providing on-the job training, support, and an inclusive coworking community (Solomon, 2020; Solomon et al., 2023).

Instead of attending a university setting, autistic job seekers may also take another pathway—job coaching. This pathway is funded through state vocational rehabilitation offices, and typically involves 1:1 or group coaching, where job coaches guide autistic job seekers to find employment within a workplace (referred to as competitive integrated employment, (Anderson et al., 2021). These programs are designed to provide individualized aid and vocational training to help autistic individuals achieve and maintain employment, with this ongoing support in facilitating workplace integration (Solomon, 2020; Anderson et al., 2021). A retrospective review with 65 autistic participants found that such programs have successfully helped autistic job seekers achieve competitive integrated employment (Wehman et al., 2016).

Autistic job seekers may also choose the self-directed pathway, where job seekers receive vocational support in high school, particularly through job skills training that equips them with practical skills for the workplace. Post-high school graduation, rather than attending a university or vocational rehabilitation program, job seekers within this pathway choose self-directed employment, where an individual will seek employment independently, without the support of a University or state rehabilitation agency (Zatz & Harrison, 2024; Wei et al., 2015).

3.1.1 Challenges Encountered by Autistic Job Seekers

Systemic issues such as high unemployment rates among autistic adults and a fragmented service system complicate access to competitive employment for autistic job seekers (Solomon et al., 2023). In addition, autistic job seekers are often matched to jobs

that are below their education level or are placed in jobs by vocational rehabilitation agencies that do not match their skillset (Davies et al., 2024).

Across all pathways, many autistic job seekers face challenges with social interactions, sensory sensitivities that affect focus and participation, and mental health issues such as anxiety and depression (Davies, et al. 2024). Furthermore, transitioning to novel environments, as encountered during the job seeking process, presents substantial hurdles in adaptation during the transition to competitive employment (Cage et al., 2020). Despite legislation and available programs, many individuals and their families report challenges in accessing these resources effectively (Anderson et al., 2021; Davies et al., 2024). These include acquiring essential skills such as interview techniques, which sometimes lead families to seek expensive private alternatives (Anderson et al., 2021).

For autistic job seekers, finding employment that is accommodating to their unique needs is also a challenge. A scoping review of 32 studies with 1,152 autistic job seekers, emphasized the importance of workplace accommodations, appropriate role alignment, and the role of family and community support networks in navigating employment challenges effectively (Southey et al., 2024). Challenges with social interactions, communication, flexibility, time management, and organization, may also autistic job seekers during the job seeking process (Bury et al, 2021).

3.1.2 Assistive Technology Within the Hiring Process

Assistive technology, which is defined as products, equipment, and systems that support learning and working (ATIA, n.d.) may support autistic job seekers with the challenges mentioned above, primarily with communication skills, social interactions, and challenges with time management and organization. To address the challenge of time

management and organization, the most used assistive technology across all three pathways are Personal Digital Assistant (PDA) applications, as these applications tend to be the most portable for employment settings (Wang & Jeon, 2023; Syriopoulou & Stefani, 2021; Walsh et al., 2017; Tincani et al., 2023; Kim et al., 2022). Previous research has also explored how off-the-shelf technologies such as smartphones and smartwatch applications assist autistic university students manage academic tasks supporting goal setting, self-monitoring, and receiving reminders (O'Neill & Smyth, 2024).

To address the challenges of communication and social interaction within the hiring process, Virtual Reality/Augmented Reality (VR/AR) applications are also used in developing job seeking skills tailored to the needs of autistic job seekers (Wang & Jeon, 2023). These technologies are deployed for skill development, particularly within job coaching contexts. This previous research highlights the use of VR and robotics for their role in rehearsing social interactions within a controlled, simulated environment that prepares individuals for real-world scenarios (Wang & Jeon, 2023; Kim et al., 2022; Syriopoulou & Stefani, 2021).

Despite the mention of PDA, VR/AR technology and robotics in previous research, most studies have evaluated assistive technology for autistic adults while already on the job (Walsh et al., 2017; Tincani et al., 2023). While this research is valuable, there is limited research regarding the use of assistive technology in the job seeking process, especially when transitioning from high school to employment across the three pathways (university, job coaching, and self-directed). Additional information is

needed to identify the challenges they may face during job seeking, as well as the opportunities for the use of assistive technology tools to address those challenges.

3.1.3 Aim

Within each pathway, during the hiring process, ‘checkpoints,’ defined as specific discrete actions taken by job seekers, must occur, such as submitting a resume or completing an interview. However, the literature does not converge on the definition of these checkpoints for job seekers. To learn more about the checkpoints autistic job seekers face, the challenges encountered within the hiring process for autistic job seekers, and the assistive technology used within each pathway, we conducted a need-finding study using semi-structured interviews with fifteen participants within the three hiring pathways: University, Job Coaching, and Self-Directed.

We address the following research questions:

- RQ1: What are the checkpoints that autistic job seekers encounter in each pathway in the job-seeking process?
- RQ2: What challenges do autistic job seekers encounter at each stage of the hiring process?
- RQ3: What assistive technology do autistic job seekers use to address those challenges within each checkpoint?

3.2 Method

In this section of the paper, we discuss our methodology for conducting the study.

3.2.1 Participants

An Institutional Review Board approved the study. We used purposeful sampling and snowball strategies to recruit participants, through the researchers' professional

network and social media platforms (Suri, 2011; Naderifar et al., 2017). All participants were offered compensation for their participation in the form of a \$25 gift card for an hour of their time.

We sought participants who met one of the following requirements: 1) those from Universities as well as internship coordinators who work at companies supporting autistic job seekers from University settings (University Pathway); 2) job coaches from state vocational rehabilitation agencies who support autistic job seekers in the hiring process (Job Coaching Pathway); and 3) autistic job seekers who have previously searched for jobs in the past through any of the three pathways, seeking at least one autistic job seeker per pathway. We chose these groups of stakeholders to recruit for the study, as these stakeholders were from the pathways identified in the literature (Davies et al, 2024; Wehman et al., 2016; Anderson et al., 2021). We had a total of fifteen participants respond to our recruiting efforts, and no participants withdrew from the study. Information regarding participants can be found in Table 3.1.

Table 3.1. Participant Information. This table shares the relevant participant information we collected as part of the screening process. Pathways are coded as U: University, Coach: Job coaching, and SD: Self-Directed.

Id	Type	Pathway	Description
S-1	Seeker	U/Coach	26 years old, Bachelors, looking for clinical work
S-2	Seeker	SD	19 years old, High School, looking for Food/Retail work
S-3	Seeker	Coach/SD	24 years old, High School, looking for Food/Retail work
S-4	Seeker	U	28 years old, Masters, looking for research work
S-5	Seeker	SD	27 years old, Certificate, looking for Food/Retail work
U-1	Assistant	U	Works for an Academic Success program at a University
U-2	Assistant	U	Works for an Academic Success program at a University
U-3	Assistant	U	Academic Transition Coordinator from a University
U-4	Assistant	U	Internship coordinator for a company in the technology sector recruiting autistic students
U-5	Assistant	U	Internship coordinator for a company in the technology sector recruiting autistic students
C-1	Assistant	Coach	32 years experience coaching in Office settings
C-2	Assistant	Coach	15 years experience coaching in Retail settings
C-3	Assistant	Coach	7 years experience coaching in Warehouse settings
C-4	Assistant	Coach	7 years experience coaching in Office settings
C-5	Assistant	Coach	18 years experience coaching in Retail settings

3.2.2 Procedure

All interviews took place via Zoom with audio and video recording enabled and transcribed using Zoom's built-in transcription software. Interviews took approximately one hour to complete. Researchers asked participants questions about their experiences in the hiring process for their individual pathways and questions regarding the assistive technology tools used within those pathways. Sample questions for autistic job seekers included the following: *1) Tell me about your experience in seeking employment.;* *2) What steps did you take to find a job?;* *3) What were the challenges you experienced while searching for a job?;* and *4) What assistive tools or technology do you use to help you during the job search process?*

3.2.3 Data Analysis

We downloaded the transcripts from the Zoom platform and prior to coding, cross-checked transcriptions with the video recording to verify the accuracy of the transcription. To code the transcripts, we used a thematic analysis process when reviewing transcripts from participant interviews by first identifying the checkpoints (as codes) found along each pathway in the hiring process and then identifying the challenges and assistive technology tools that were used within those checkpoints. We sorted these checkpoints and assistive technology tools into themes and sub-themes (Braun & Clarke, 2023; MacDonald et al., 2019). Myself and another collaborator separately reviewed the transcripts to identify the checkpoints, challenges, and assistive technology tools used by participants. Both researchers then met to review all the themes identified across three meetings, where they discussed their findings to establish a

consensus on the final set of themes for checkpoints and assistive technology. This final set was then reviewed with a collaborator for their agreement with the findings.

3.3 Results

This section shares the results of our semi-structured interviews with participants. We organize each section by the checkpoints discussed by participants along each pathway (RQ1). Within each of those checkpoints, we then discuss the challenges identified by autistic job seekers (RQ2). For each checkpoint, we also identify the assistive technology tools used by participants (RQ3).

3.3.1 Resume Building

The first checkpoint identified by participants in the job seeking process was *resume building*. In this checkpoint we identified the following challenges as themes: resume development support, advocacy, and accessibility as shown in Table 3.2. We also identified the following assistive technology as themes: organizational tools and visual media tools as shown in Figure 3.1.

Table 3.2. Challenges Noted by Participants as Themes Per Checkpoint

Checkpoint	Challenge	Participants
Resume	Development Support	Assistants
	Advocacy	Seekers
	Accessibility	Seekers
Networking	Engagement	Assistants
	Connection	Assistants
Job Search	Skill Matching	Assistants and Seekers
	Support/Needs Matching	Seekers
Job Application	Confidence	Assistants and Seekers
	Disclosure	Seekers
Interview	Anxiety	Assistants and Seekers
	Response Structuring	Assistants and Seekers
	Lack of Communication	Seekers

	Organizational Tools					Connectivity Tools		Visual Media Tools		
	Virtual Coaching Software	Grammar software	Digital Calendar	AI Assistant	Text/Auditory Messaging	Job Search Websites	Social Media Platforms	Visual Supports/Checklists	Digital Templates / Scripts	Video models
University/Academy Company	Resume	*	*					*		
	Networking	*					*	*		
	Job Search	*		*						
	Application							*		
	Interview	*				*			*	
Job Coaching	Resume								*	
	Networking									
	Job Search			*		*				
	Application									
	Interview	*				*		*	*	*
Self-Directed	Resume				*					
	Job Search					*				
	Application				*					
	Interview									

Figure 3.1. Assistive Technology Used per Checkpoint Per Pathway

3.3.1.1 Resume Challenges. With this theme, participants within the University and job coaching pathways identified areas of support needed for resume development, specifically by providing coaching services, illustrating that for autistic job seekers, knowing how to build a resume is a challenge. *“Our focus with autistic students is to review resumes and cover letters. For things like a resume, we coach on how to do a resume, how to format it, and how to write the bullets”*(U-1). U-3 also shared that: *“We work on the job process together with the students, but it depends on the student's goals. You're graduating, what's your plan? Would you want to spend our time together looking for jobs polishing resumes together”*(U-3)? Job coaches also support autistic job seekers with resume development by providing them with coaching on how to use it within the

hiring process to develop confidence: *“Number one, we work through getting their resume together, we talk through their resume so that they can speak on their experience. We make sure that it's something that they can read and feel confident discussing”* (C-4).

Self-directed participants shared that a challenge they encountered during resume building was in advocating their need for independence within the process. S-2 shared that: *“My mom has suggested I get a job coach to help me with doing my resume. But I didn't really do it. I wanted to learn from these experiences myself”* (S-2). S-3 also preferred to work without job coaching support for their resume: *“I did work with my state's Office of Vocational Rehabilitation for a few years. But I closed my file at the beginning of COVID, because I realized I got more done on my own”* (S-3). This also indicates a switch between pathways for S-3 from Coaching to Self-Directed.

Another challenge noted by job seekers was accessing accessible resume forms online. S-4 stated:

The other real thing I struggle with is the resume. I've made a resume and I can upload the pdf, and then they have another form online to fill out your entire resume in a text field. It's like do one or the other. That's extremely inaccessible to need to do it twice. (S-4)

3.3.1.2 Assistive Technology for Resume Building. For resume building, participants mentioned organizational and visual media tools to support in the resume building process. One organizational tool mentioned in participant interviews to address challenges encountered when filling out information on resumes was the use of software: *“Once they have, their resumes, we help them edit with grammar software”*(U-1).

University participants also use visual media tools such as visual supports and checklists to support the challenges encountered within the resume checkpoint. U-1 noted:

The first step for students is to break down this overwhelming process into concrete steps. So you know, making a list and saying, okay, you need to have your resume reviewed. There's so much content to cover about navigating the resume process and following up with recruiters. There's a checklist that we go through in the workshops with students. (U-1)

An additional visual media tool was the use of digital templates. When job coaches work with job seekers, they use digital templates to support in resume building. C-4 shared: *"I have an email template that I send out to them every single time we do a resume to help with organization" (C-4).*

3.3.2 Networking

The next theme we identified as a checkpoint in the job seeking process was *networking*, where job seekers and employers are connected either through in-person events, virtual events or digital messaging. In this checkpoint we identified the following challenges: engagement and connection (Table 3.2). We also identified the following assistive technology themes: organizational tools, connectivity tools, and visual media tools (Figure 3.1).

3.3.2.1 Networking Challenges. In reference to networking, U-5, an internship coordinator with a company that directly recruits autistic students from Universities, shared how they overcome connection challenges while networking: *"We partner with colleges and universities that have Career Centers that specifically target autistic students for networking" (U-5).* U-3 also shared: *"We're also trying to develop more relationships with the Career Center at the University. We are referring over to them all*

the time, because they do tons of great events” (U-3) U-4 found that working with Disability Resource Centers rather than Career Centers at Universities was more beneficial:

We connect with a lot of our students from Disability Resource Centers at Universities versus Career Services. Many students don't go to career services. So we target the Disability Resource Centers at Universities for our hiring pipeline. (U-4)

One challenge identified by University participants for this checkpoint is with engaging autistic job seekers in the networking process: *“A lot of students are actually hesitant to network with the alumni. And that's a big obstacle for them in the job search process” (U-1)*. Participants also shared, *“We also host job fair prep sessions specifically for autistic students” (U-1)*, and:

We're always trying every semester to require the students to participate in some sort of career development, whether it's by participating in a career fair, or those kinds of things. It's constant development with their time here with us. (U-3)

Job coaches did not explicitly mention networking as part of the hiring process in their interviews; however, they discussed supporting job seekers by connecting them directly with employers, and potentially eliminating the challenges that autistic job seekers may face when networking on their own. C-4 stated that:

During the job search process, we have very specific conversations about what they like to do for work and what they do not like to do for work, so that we can make sure that we find them the best fit possible. We help them contact people that we know are hiring, and where there might be a good fit. (C-4)

3.3.2.2 Assistive Technology for Networking. University assistants were the only pathway that mentioned using assistive technology as a resource for networking. Participants in this pathway used connectivity tools such as social media platforms to

support the challenges they encounter with connecting students within the networking checkpoint. They mentioned using websites such as Canvas and Handshake to aid students in networking. U-5 noted:

On social media we're very strategic in how we post. I get into groups where there are autistic students coming together as a community. I find better results when I'm networking within groups that have that common theme...where neurodiversity is viewed as an advantage and an identity and it's not something to be overcome as much as celebrated.(U-5)

Another resource Universities use to connect autistic job seekers in the networking process was a website called the Neurodiversity Career Connectorⁱ. U-4 shared: “So if you go to the Neurodiversity Career Connector, this is where there are over 100 jobs for autistic candidates in one spot. They upload their resume and they see all these jobs” (U-4).

3.3.3 Job Search

The third checkpoint identified by participants in the job seeking process is the *job search*. In this theme, we identify the following challenges: matching skills sets to job descriptions, and matching support or needs of autistic job seekers to job descriptions (Table 3.2). We also identify organizational and connectivity tools as assistive technology used within this checkpoint (Figure 3.1).

ⁱ <https://ndcc.simplifyhire.com/>

3.3.3.1 Job Search Challenges. One challenge noted by University participants, was helping autistic job seekers choose jobs to apply that match their interests and skill sets:

Some students know exactly what they want to do, and our job is to get them there. Some don't know what they want to do. We give them a wide range of options and then narrow it down, based on what would be a best fit for the student. We look at salary and job security and then give more specific recommendations for industries and specific employers that could be a good fit (U-1).

Matching the individual's interests to the job was also mentioned by job coaches:

“We look for jobs that are based on the individual’s interests. That could be anywhere from office work to grocery store, to a restaurant to a library” (C-3).

Self-directed participants noted that a challenge in the job search process is being able to find a job that matches their unique needs. S-5 shared: *“When searching I apply all the filters. Income, and if it's close to where I live, because I don't drive. I have a family member who drives me. So that's a major factor”*(S-5). Transportation needs were also a concern for S-2 who stated: *“When searching for jobs, the job has to be a little bit closer to me, because I don't really have a car yet. It has to be where I can ride my bike or walk”* (S-2).

Self-directed participants also shared that they searched for jobs on their own using job search websites or found employment when their parent/caregiver supported them in the job search. S-2 stated: *“I typically hear about jobs through Indeed or through my mom. Sometimes I go around seeing if people are hiring”* (S-2). while S-5 shared: *“Sometimes I find out about jobs by like word of mouth, from family members who saw job postings”* (S-5). Despite caregiver and job coach support in finding jobs, some job seekers continue to find difficulty in securing employment. S-3 shared that: *“I haven't*

had much luck with it, finding jobs, I'll be honest. It's hard figuring out what I want to do and finding something that fits” (S-3).

3.3.3.2 Assistive Technology for the Job Search. For the job search, participants discussed the use of organizational tools and connectivity tools. Organizational tools in the form of digital calendars were noted as being used in both the University/Academy and the Job Coaching Pathways, mainly for support with managing time during the job search. noted:

We recommend having a set block of time each week to work on the job search process because there's so many components to it. To have them set, let's say, on Friday, from 2-4pm, using their digital calendar, to look at jobs like browse on various websites and Thursdays for an hour. (U-1)

while C-1 stated: *“During sessions, I often would share my screen to show a strategy for managing time-blocking on their calendar” (C-1).*

Job coaches and job seekers also used connectivity tools such as job search websites in the job search process, to help with their challenges of matching skills with unique needs. They mentioned using Indeed as their primary method of online job search: *“My clients know how to look on Indeed, and then they know how to look on Google Maps to see what's close to their house” (C-4).* S-5 stated: *“Someone in my family recommended Indeed to me to use to search for jobs. For the most part I use Indeed, cause it's just a quick and easy way to find jobs that I want to do with my work experience” (S-5).*

3.3.4 Job Applications

The fourth checkpoint identified by participants across pathways was the *job application*. In this checkpoint we identify developing confidence and disclosure as

challenges (Table 3.1). We identify organizational tools and visual media tools as assistive technology used in the job application checkpoint (Figure 3.1).

3.3.4.1 Job Application Challenges. One challenge noted within the job application process was in helping autistic job seekers develop the confidence to fill out applications on their own. Universities support autistic students who are seeking employment with their job applications by reviewing and providing encouragement in the application process. U-2 stated: *“It tends to be students that work with us, and they're like, I've got an internship where I want to apply. What do I need to do”* (U-2)? U-3 shared challenges when caregivers are involved in the application process, due to privacy laws, also seeks to support the development of autonomy with students:

You know the parents are typically involved in the application process and following up on the material. But our expectation is that students will communicate to their parents. It's practice for the future, when you have to be in charge of all your own information. (U-3)

Job coaches also noted that one challenge they encounter in this checkpoint is working with their clients on developing confidence during the application process: *“So a lot of them will come in, and the first thing they want to say is, well, I might not be good at this, because I have a diagnosis, or because of this, I might do this. We try to kind help them present some more confidence as they are applying for jobs”* (C-5).

Job seekers found that the application process can be confusing when not knowing if they are qualified for the job, and not having the confidence that they are good enough for a job, with S-4 stating:

When applying for one internship, there's one where I applied that had a massive list of skills needed, listed in the application. With all these skills, I felt I'm not good enough for them, so I didn't want to waste my time. My mom kept pressuring me to apply though and I just did it, and then I ended up getting an offer. I was very confused by that. (S-4)

Another challenge noted by job seekers within the application process is whether or not to disclose on the application that they have autism. S-5 shared:

There have been some jobs that I've applied for, and they ask if you have a disability in there. Sometimes I have, sometimes I haven't. It just depends on how I felt disclosing it that early because I didn't necessarily want to be cut for disclosing. (S-5)

3.3.4.2 Assistive Technology for Job Applications. For the job application checkpoint, the use of assistive technology to address challenges was mentioned the least by participants, though there were organizational tools noted within the interviews.

Within the self-directed pathway, S-3 noted that they use an organizational tool in the form of an AI assistant to support them with both resumes and job applications in the hiring process: *“I've mainly used ChatGPT to proofread responses in text boxes” (S-3).*

Universities also use visual media tools within the job application process: *“After they ask us what to do, we provide them with some digital checklists to help them through the process” (U-2).*

3.3.5 Interview

The last checkpoint that participants identified as part of the hiring process is the *interview*. Within this checkpoint we identify the following challenges: overcoming anxiety, knowing how to structure responses, and lack of follow-up communication from employers (Table 3.2). Participants identified organizational and visual media tools as assistive technology used within this checkpoint (Figure 3.1).

3.3.5.1 Interview Challenges. Job seekers expressed that they experienced some challenges at this checkpoint. The first challenge noted was in overcoming anxiety and knowing how to answer interview questions from potential employers: *“I was a little bit nervous in interviews because I don't have that much work experience. And I was unsure*

if that would work against me.” (S-3), and “It is a challenge not understanding the questions that they were asking” (S-1. One jobseeker shared that they had previously received support from a job coach for the interview process, stating “I needed practice with what to tell people, because I didn't know what to tell people when talking to them” (S-1), but stopped working with their particular job coach because they: “didn't seem to understand what I needed”(S-1). Most of the self-directed job seeker participants reported that they go into interviews without support.

University pathway participants shared that they support autistic job seekers in overcoming anxiety by practicing with mock interviews. *“We have done mock interviews, one on one. We have also done practice panels in our meetings with them” (U-2). Job coaches also support autistic job seekers with mock interviews to help job seekers practice how to answer questions from potential employers. They use several strategies in this process, focusing on verbal and non-verbal cues: “With interviews we work on soft skills. Some could be eye contact, clarity with speech volume, turning your body to the person you're speaking to, and staying on topic”(C-2); and repetition: “When I teach interview skills, it's literally like we plan and practice an answer, for example, like what are your strengths, and then they learn how to answer it, and practice it over and over” (C-3).*

Job seekers also expressed frustration when employers do not provide them with the outcome of the interview. S-4 shared: *“I've gotten ghosted a lot. After the interview, they will say Oh, you're gonna hear from us in 2 weeks. We'll make a decision and let you know, even if you don't get it. Well it's been 4 years since one of those” (S-4). S-2 shared:*

“There's only been 3 or 4 times I've been offered a job after an interview. Most people don't get back to me”(S-2).

3.3.5.2 Assistive Technology Tools for Interviews. The interview checkpoint contained the largest number of assistive technology tools mentioned within participant interviews. One organizational tool identified was virtual coaching software to support the challenges within interview preparation. University participants also shared that they use software to help with interview coaching, supporting job seekers with answering questions during the interview process: *“We've trialed a platform called Big Interview, where there was sort of an avatar who would speak and allow students to practice” (U-1).* Job coaches also noted the benefit to using virtual coaching for individuals in areas where access to services is challenging:

I also see a lot of opportunity to generalize teaching these skills with some distance learning, or some outreach to rural areas for vocational training. If we could kind of send them the equipment, but still be able to monitor it, or or something like that, it might be useful. (C-5)

University and Job Coaches also used text or audio messaging in their work, particularly when supporting job seekers in interviews in addressing social anxiety. C-5 noted a new ‘bug in ear’ system, where job seekers had a Bluetooth headphone directly connected to the job coach’s microphone to practice interview skills: *“We use role play*

and feedback or in situ type of training. We also have a cool new bug-in-the ear system”

(C-5). U-5 shared that for autistic non-speakers, they will often conduct interviews

through text messaging applications:

We require candidates to communicate and collaborate through Slack. We don't require people to have cameras on, we don't even require you to speak aloud. We have non-speakers, with different ways of communicating. We will let candidates know if they would prefer a Google Meet or Zoom interview with or without a visual, that's fine. I've done entire interviews in the chat box for those that are non-speakers. (U-5)

Participants noted the visual media tools they use to address challenges within the interview process. C-4 stated: *“I'll print their questions out and bring them with me to the interview, so that they can read the notes that we wrote together about the company”* (C-4). University and Job Coaches also use another form of visual media, digital templates as assistive technology tools. *“We will provide or give homework. We will send emails with a template of interview questions”* (U-3). Another visual media tool mentioned within the interviews was the use of video models. C-5 stated that they use them primarily for interview practice: *“For teaching interview skills, we will use a job aid and I'll show some examples of how a successful interview might go with videos of people acting out a successful interview”*(C-5).

3.4. Discussion

In this study, we identified challenges found in each checkpoint, for each pathway along the hiring process for autistic job seekers and the assistive technology tools used within each of those checkpoints. We summarize the challenges faced by autistic job seekers and provide design suggestions for developing assistive technology tools to address the challenges encountered within each checkpoint.

3.4.1 Challenges Within the Hiring Pathways

This study highlights the checkpoints and assistive technology used by autistic job seekers when navigating employment pathways. From our interviews, we identified several concerns and frustrations that autistic job seekers face when navigating the checkpoints within the hiring process. Job seekers often need to decide how much personal and professional information to disclose, as identified by S-5 in the job application process, which can create a stressful experience (Ara et al., 2024) and potentially hinder their chances of employment (Raymaker et al., 2023; Vincent & Fabri, 2022).

Adding to this strain is the uncertainty job seekers experience when employers do not communicate the outcome of the interview (S-4). We discovered through our participant interviews that this lack of communication often leaves candidates uncertain, at a 'dead-end' along the pathway, where they need to determine whether they should continue waiting or explore other opportunities.

Using web-based platforms to apply for jobs can also frustrate job seekers and may be inaccessible, as mentioned by S-4. This is mainly because it requires them to upload a resume and re-enter the same information in a text form. S-4 also noted that they were hesitant to apply for jobs that contained a long list of skills required for the job. They were confused that after applying, they received a job offer despite lacking specific skills on the list. Employers should consider these viewpoints when posting jobs on websites, as this inefficiency may deter candidates from applying, limiting their job prospects and the employer's prospects for qualified candidates.

Our interviews indicate that networking, a checkpoint identified within the University and Job Coaching pathways, may be absent from the Self-Directed pathway. These pathways use different strategies when supporting networking, with universities and internship companies directing autistic job seekers to career fairs and collaborating with career and disability centers to connect with potential employees, whereas job coaches create the direct connection between autistic job seekers and potential employers that are hiring. Without networking, self-directed job seekers may be at a disadvantage, as networking is a significant factor in discovering job opportunities (Wanberg et al., 2020).

For job seekers in our study, we observed that most of our self-directed participants did not mention the use of assistive technology to support challenges within the job seeking process (Figure 3.1). Only two participants mentioned assistive technology available along the checkpoints, with the use of job search websites and generative AI tools (S-3 and S-5).

Some autistic job seekers rely on parent or caregiver support during the job search checkpoint, and this was a common theme discussed by University and Self-Directed participants in our study, corresponding with previous research in this space (Anderson et al., 2021). Given this information, mechanisms are needed to connect self-directed job seekers and their social network, such as parents/caregivers and peers, to available assistive technology tools.

3.4.2 Design Suggestions for Assistive Technology Within the Hiring Pathways

This study reveals significant opportunities for developing assistive technology tools and connecting self-directed autistic job seekers with assistive technology across

various checkpoints of the job-seeking process. We present the following suggestions for assistive technology that may help autistic job seekers along each checkpoint within their hiring pathway.

3.4.2.1 Networking and Collaboration Tools. Creating assistive tools for networking and collaboration is needed, especially for the self-directed pathways. Participants in the University Pathway mentioned resources such as the Neurodiversity Career Connector initiative to support networking. Technology that connects job seekers with potential employers can play an important role in bridging the employment gap (Ara et al., 2024). Some initiatives have started this process, within the United States, the Employer Assistance and Resource Network on Disability Inclusion (EARN)ⁱⁱ and the Workforce Recruitment Programⁱⁱⁱ; however, these resources require the employer to actively seek out resources and collaboration, rather than focusing on mutual connection and collaboration between job seekers and employers. Tools to create and facilitate connection and collaboration between employers and autistic job seekers are needed to support the job search process.

3.4.2.2 Assistive Tools for Resume Building. Uploading resumes to job sites is often cumbersome and repetitive. Developing assistive tools tailored for these tasks could significantly ease the job application process, not just for autistic job seekers but for all job applicants. With large language model (LLM) integration, as suggested by one of our self-directed job seekers, these tools can offer personalized suggestions for resume enhancement and automate the transfer of information from resumes to online job

ⁱⁱ <https://www.dol.gov/agencies/odep/resources/earn>

ⁱⁱⁱ <https://www.wrp.gov/wrp>

platforms, thereby saving time and reducing errors in applications (Ara et al., 2024). For example, a user may be able to provide the LLM with their resume, and then the LLM could provide suggestions for the user on how to better fit their resume and work experience to the job description. This is something future researchers should explore with autistic job seekers.

3.4.2.3 AI Virtual Assistants. There is also an opportunity to support job coaches and self-directed job seekers with AI virtual employment assistants across all checkpoints. These virtual assistants could provide consistent motivation and assistance with various tasks, starting from the job search and assisting with the job application. For networking and interview preparation, these AI Virtual Assistants could also act as intelligent conversational agents, practicing with the job seeker response structuring and conversation skills needed for networking and for interview preparation. In education, virtual assistants are used to support students in managing time and engagement with learning materials (Gubareva & Lopes, 2020), and the utility of AI virtual assistants can be extended to the job-seeking process.

3.4.2.4 Connecting Autistic Job Seekers with Assistive Technology. Perhaps the most critical need is for connecting autistic job seekers with assistive technology. In our interviews with participants, three out of the five job seekers did not mention assistive technology used in the job-seeking process, outside of traditional job searching websites. We learned that self-directed participants often need to find resources on their own and may only be aware of the resources available if a parent, friend, or caregiver has shared information with them during the job seeking process (Solomon et al., 2023). Using connectivity tools such as social media (Instagram or TikTok videos) could

support in connecting autistic job seekers with assistive technology that can be used to support in the job seeking process.

3.5. Limitations and Future Work

As a need-finding study, this study had a small interview sample, and we did not have more than five autistic job seekers respond to our recruitment efforts. Due to this small sample size, our results should not be generalized. However, through this study, we gained valuable insights regarding the challenges faced along the checkpoints along the road to hiring, the assistive technology used by autistic job seekers to address those challenges, and design considerations for developing assistive technology for autistic job seekers to guide expansion studies.

Future research should also evaluate the efficacy of different types of assistive technology, such as AI platforms, in supporting job seekers, particularly those following a self-directed path. Additionally, incorporating networking and collaboration tools within the Self-Directed pathway requires further investigation. It is essential to consider ways to connect self-directed autistic job seekers with assistive tools to aid them in the hiring process, affording them similar support as individuals within the University and Job Coaching pathways.

3.6. Conclusion

This study highlights the challenges autistic job seekers face across the University, Job Coaching, and Self-Directed pathways to employment. Our findings discuss the role of assistive technology in addressing these challenges, particularly in the checkpoints of resume building, networking, job search, job application, and interviews. Our findings also show that self-directed autistic job seekers may be underutilizing these

tools, requiring a need to connect autistic job seekers in this pathway with assistive technology resources. From this study, we conclude that there are several opportunities for the design of assistive technology solutions to support autistic job seekers navigating the employment process.

CHAPTER 4

TOWARDS DESIGNING AN INTELLIGENT INTERVIEW COACH FOR AUTISTIC JOB SEEKERS

4.1 Introduction

Navigating the job interview process and communicating job-related skills effectively is intimidating for most job seekers (Bublitz et al., 2017; Constantin et al., 2021). Job seekers may be unprepared for an interviewer's questions, which may increase anxiety during the interview process (Langer et al., 2016). Unfortunately, previous studies reveal that job seekers' anxiety can negatively impact ratings and recommendations for hire by interviewers (Powell et al., 2018). Specifically for autistic job seekers, job interviews can be particularly daunting as it can be challenging for them to respond and interpret verbal and non-verbal cues from interviewers (Bublitz et al., 2017), and they may have difficulty with being able to speak on their experiences related to the job when interacting with an interviewer (LaRue et al., 2022). Successful interviews also require navigating social interactions and adapting to unpredictable questions from potential employers (Bublitz et al., 2017). Due to these social challenges, job interviews can lead to disadvantages for autistic job seekers, resulting in lower employment rates and fewer job offers (Whelpley & May, 2023).

Given these challenges, it is essential to alleviate the difficulties that autistic job seekers may encounter during the interview process (Bublitz et al., 2017; Kumazaki et al., 2019; Smith et al., 2021). Providing autistic job seekers with personalized vocational coaching may help them navigate the interview process and make the interview process more accessible and supportive (Hall et al., 2024; Schall et al., 2020; Wehman et al.,

2020). In the United States, vocational coaches provide support in job finding and skill training to autistic job seekers while on the job, which can require many hours of 1:1 support (LaRue et al., 2022). However, a major challenge with personalized human vocational coaching is that it is resource intensive and difficult to scale to the number of autistic job seekers that may seek out this form of support (Lorenz et al., 2016). One way to address this difficulty of scaling the role of personalized human vocational coaches is to explore the use of personalized intelligent interview coaching.

Previous research examined the use of virtual conversational agents and chatbots for helping autistic individuals practice *conversation skills*. These studies found that autistic participants appreciated the feedback provided by these systems, valued the opportunity to practice conversation skills privately, and felt that they benefited from the safe environment these chatbots provided for learning and expressing emotions during the learning process (Ali et al., 2020; Cha et al., 2021; Xygekou et al., 2024). Previous studies with neurotypical users have also shown that chatbots and virtual interviewing agents have the potential to reduce anxiety surrounding job interviews, teach users how to respond using dialogic feedback, and when rationalized feedback was delivered, view the virtual interviewing agent as trustworthy (Daryanto et al., 2024; Takeuchi & Koda, 2021; Thakkar et al., 2022). However, it is important to note that none of these previous studies evaluated the use of an intelligent interview coaching chatbot with autistic job seekers. Although these previous studies show the potential value of intelligent conversational agents for every job seeker, it is important to note that autistic job seekers experience unique challenges in communication, and that this might impact how intelligent interview coaches should be designed.

In this study, we explore the design of an intelligent interview coach chatbot for autistic job seekers by asking the following research questions:

- RQ1: What are the unique challenges autistic job seekers face during the interview process?
- RQ2: What are the recommendations of vocational coaches and autistic job seekers regarding the design of an intelligent interview coach?
- RQ3: What are the perspectives of vocational coaches and autistic job seekers regarding the use of an intelligent interview coach?

To answer these questions, we conducted an exploratory study. We interviewed five vocational coaches and five autistic job seekers to gather insights about their personal experience related to the job interview process (RQ1). In order to study RQ2 and RQ3, we showed participants an example of a sample intelligent interview coach based on ChatGPT. Participants were allowed to briefly interact with the sample interview coach. Following this interaction, we gathered their recommendations for the future design, and their perspectives on the use of an intelligent interview coach. Following these interviews, we identified four different design considerations when developing intelligent interview coaches, as well as ideas for the use of an intelligent interview coach as a collaborative assistant for autistic job seekers and vocational coaches.

With this exploratory study, we add to the previous discussions and open research questions in the field of HCI regarding the design of technology to support

neurodivergent and autistic job seekers in the process of obtaining employment (Ara et al., 2024; Hall et al., 2024; Jang et al., 2024), and contribute the following:

- Empirical observations from autistic job seekers and vocational coaches regarding their experience preparing for job interviews, and the unique strategies they use to overcome challenges within the interview process.
- Empirical observations regarding perspectives from autistic job seekers and vocational coaches on the design considerations and use of future intelligent interview coach chatbots, as collaborative assistants, to prepare autistic job seekers for behavioral interviews.

We also discuss further challenges, limitations, and future work related to this study.

4.2 Related Work

In this section, we review the relevant literature and previous methods related to the following: behavioral interview questions, interview challenges for autistic job seekers, and designing intelligent chatbot systems to support interview preparation.

4.2.1 The Behavioral Interview

Behavioral interviews have become increasingly prevalent in the hiring process as a means for employers to assess candidates based on the candidate's past experiences and behaviors (Ralston et al., 2003). These interview questions emphasize storytelling, where candidates are expected to chronologically narrate what they did in a specific situation in a previous workplace scenario and the outcome of their actions (Lin, 2010; Ralston et al., 2003). For example, a job seeker may be asked "Tell me about a time that you dealt with an unsatisfied customer?" This storytelling element has become critical to an applicant's success, as it allows the interviewer to evaluate how the candidate's past behavior aligns

with the role's requirements (Bangerter et al., 2014). One of the major differences between behavioral interviews and traditional interviews is their structure and focus. While traditional interviews may prioritize credentials and technical skills, behavioral interviews emphasize competencies and past behaviors as indicators of future performance (Doll, 2018; Lin, 2010; Swider et al., 2016).

For job candidates in behavioral interviews, storytelling is not just a skill but a major requirement for performing well. Studies have shown that it is not just the content of the stories, but also *how* they are told that significantly influences interview outcomes (Bangerter et al., 2014). Descriptions that do not follow a narrative structure tend to decrease hiring recommendations by recruiters when behavioral questions are asked, highlighting the significant influence of storytelling on interview outcomes. Recent research has also explored the effectiveness of storytelling in interviews and how training can enhance a candidate's ability to construct interesting narratives (Lin-Stephens et al., 2022). Findings from this research indicate that training in storytelling significantly improved the quality of candidates' stories (Lin-Stephens et al., 2022). Examples of training and coaching interventions that aim to improve storytelling are as follows: 1) train on narrative elements, 2) offer feedback, and 3) conduct practice sessions (Bangerter et al., 2023; Lin, 2010). Previous research has highlighted the STAR method as a useful tool for interview preparation. The STAR method uses the mnemonic "Situation, Task, Action, and Result" to help interviewees structure their responses in behavioral interviews. Studies have found this approach to be beneficial for framing responses among neurotypical job seekers (Bangerter et al., 2023), and it has also been shown to support autistic job seekers in navigating behavioral interviews (Strickland et al., 2013).

4.2.2. Challenges Faced by Autistic Job Seekers in Interviews

Interviews can be daunting for any job seeker, as they involve interacting with unfamiliar people and responding to potentially unexpected questions (Constantin et al., 2021). However, for autistic job seekers, these social challenges often require specialized preparation and support to navigate the complex nuances of communication and social cues encountered during the interview process, particularly during behavioral interviews (Strickland et al., 2013). Previous research with college students revealed that autistic students, when compared to neurotypical peers regarding communication styles, exhibit different social patterns, such as variability in the length of their statements, increased pauses when responding to questions, and challenges when discussing questions regarding team collaboration (Bublitz et al., 2017). As noted, behavioral interviews have recently become an important part of the interview process (Ralston et al., 2003). For autistic job seekers, previous research has evaluated using a web-based training intervention to increase communication skills within the behavioral interview (Strickland et al., 2013). Though this research found that the web-based intervention was effective in establishing more verbal content with autistic youth, the researchers did not directly interview the participants about the intervention or the design of the web-based training program prior to implementing the intervention.

In addition to the increased social and communication challenges with autistic job seekers, some interviewers may form unfavorable impressions of autistic candidates, often due to a lack of understanding of autism-specific traits, and can lead to lower hiring rates for autistic individuals, even when they are qualified for the job (Whelpley & May, 2023). Autistic job seekers often struggle with disclosing whether or not they have autism

during the job-seeking process due to these concerns (Davies et al., 2023). They often mask their identity as autistic or hide 'autistic traits or behaviors' in the workplace due to these fears (Miller et al., 2021; Pryke-Hobbes et al., 2023). Though masking and disclosure are noted in these previous studies within the workplace and in the job-seeking process as a whole, the specific challenges within the interview process for autistic job seekers is still an open research question that we explore in this study.

4.2.3 Intelligent Interview Coaches

Recent research has shown an interest in studying the use of intelligent interview coaches for interview preparation for neurotypical users (Daryanto et al., 2024; Takeuchi & Koda, 2021). In these studies, researchers focused on the feedback delivery of the intelligent interview coach. One study explored the different aspects of an intelligent interview coach's role in interview training, examining the influence of rationalized feedback from virtual coaches during interview practice with intelligent interview coaches. In this study, participants expressed higher trust and perceived reliability when the feedback included quantitative data, showcasing the potential of these intelligent systems to provide structured and data-backed guidance (Takeuchi & Koda, 2021). Another study examined the use of dialogic feedback by an intelligent interview coach, and found that dialogic feedback promoted continuous learning (Daryanto et al., 2024).

Though limited, some studies have examined the use of intelligent conversational coaches and their potential to support autistic adolescents and adults in practicing communication and emotional expression (Cha et al., 2021; Xygekou et al., 2024). In one study, participants felt these agents provided a judgment-free space to practice dialogue strategies and reflect on their social interaction in conversation (Cha et al., 2021). Further

research also analyzed interactions between autistic and neurotypical adults with an intelligent conversational coach (Xyngkou et al., 2024) finding that autistic users sought more social connection from the intelligent coach than their neurotypical counterparts. However, they often felt disappointed when their emotional needs were not fully met.

Though intelligent conversational coaches have been studied to develop social and communication skills with autistic adolescents and adults, there has been limited research on applying such intelligent coaches to job interview preparation. One study evaluated a Virtual Reality (VR) Interview Training program designed for autistic transition-age youth (Smith et al., 2021). With this program, participants interacted with virtual avatars and selected their responses to the avatars using a pre-programmed field of responses within the software. Researchers found that this VR training program showed improvement in participants with learning job interview skills, reduced anxiety, and, with the skills learned, provided greater employment opportunities for the autistic adolescents enrolled in their program (Smith et al., 2021). However, this study did not evaluate conversation during an interview with an intelligent interview coach, as participants in the study selected how to respond to interview questions from the pre-programmed field of responses, and were not able to type responses to the avatars in the program.

4.3 Methods

4.3.1 Study Context and Researcher Positionality Statement

This study took place within the United States and recruited participants from the United States. It is also important to consider my history, and its influence on theme development. Though I do not identify as autistic, I have experience in autism research and extensive professional experience working directly with autistic individuals in

educational coaching and advocacy support settings. Our team's background shaped the thematic analysis coding approach in two distinct ways. First, our familiarity with autism supported the identification of themes that are particularly relevant to autistic job seekers and vocational coaches working in the field. These themes included social and vocational challenges, particularly as it relates to interviewing skills. Second, interdisciplinary insights from the fields of human-computer interaction, as well as psychology and education, supported the analysis of data, incorporating ideas and theories from these different fields within the thematic analysis process.

4.3.2 Study Environment

The study took place on Zoom with audio and video recording enabled. Following each interview, we downloaded the transcripts from the Zoom platform, and cross-checked transcriptions with the recording to verify accuracy of the transcription, correcting transcription errors prior to coding.

Participants interacted with the demo ChatGPT Interview Coach using the shared screen and remote function through Zoom, accessing the ChatGPT interface with the demo Interview Coach, on my computer. This allowed us to save their interactions with the ChatGPT interface environment.

4.3.3 Participants

For the study, we used purposeful sampling (Suri, 2011) to recruit participants, targeting stakeholders who are domain experts in supporting autistic job seekers as well as autistic job seekers. We recruited participants from local high school transition coordination agencies, US-based vocational coaching agencies, state vocational rehabilitation agencies, and through the US-based professional network of researchers.

Institutional Review Board Name Redacted approved recruitment and consent procedures. We compensated vocational coaches and autistic job seekers \$25 each. The study took place from June 2023-early January 2024, and each interview took approximately one hour to complete.

By the end of the study, we recruited 10 participants to interview: 5 autistic job seekers, and 5 vocational coaches. We selected autistic job seekers who had previously searched for employment and had been on at least one interview. Vocational coaches were selected based on the criteria that they had experience supporting autistic job seekers in the interview process as noted in Table 4.1. The vocational coaches came from a range of industries, with varied years experience and education levels. The number of years of experience ranged from 2-32 years. Three vocational coaches came from administrative industries, one vocational coach came from higher education, and one vocational coach was from warehouse and manufacturing. Two vocational coaches had bachelor's degrees, and three had advanced graduate degrees (Table 4.1). We started our thematic analysis process as soon as the first interview was completed, and iterated throughout the following interviews. We completed our recruitment of participants once we had reached saturation in theme development during the thematic analysis process (Braun & Clarke, 2021; Guest et al., 2006; Guest et al., 2020), by calculating the number of codes generated by base size (the number of data collection events), the run length (the number of interviews where we gathered new codes), and the new information threshold where there was less than 5% of new codes developed (Guest et al., 2020).

Table 4.1 Participants

Id	Type	Participant Information
S1	Seeker	Administrative, Bachelor’s Degree, 26 years old
S2	Seeker	Food/Retail, High School, 19 years old
S3	Seeker	Food/Retail, High School, 24 years old
S4	Seeker	Higher Education, Master’s Degree, 28 years old
S5	Seeker	Food/Retail/Childcare, Associate’s Degree, 27 years old
C1	Coach	Administrative, Bachelor’s Degree, 7 years working with autistic job seekers
C2	Coach	Administrative, Bachelor’s Degree, 7 years working with autistic job seekers
C3	Coach	Higher Education, Master’s Degree, 2 years working with autistic job seekers
C4	Coach	Warehouse/Manufacturing, PhD, 18 years working with autistic job seekers
C5	Coach	Administrative, PhD, 32 years working with autistic job seekers

4.3.4 Demo ChatGPT Interview Coach

To demonstrate the use of a intelligent Interview Coach for participants, we used OpenAI’s ChatGPT interface (GPT-4 since at the time of the study, GPT 4-o was not available) with a simple system prompt to provide an example of a chatbot. We used the following system prompt:

Marta is a job coach who helps people learn interview skills. When coaching others in interview skills, she first teaches them to come up with examples of questions in behavioral interviews, and then teaches them to tell their experience using the STAR (situation, task, action, result) method. Example of feedback for correct response: Excellent work! You did a great job explaining the situation. Feedback for incorrect response: Let’s work on this a bit more [provide example of what was incorrect and how to fix it]. Let’s practice interviewing. I will be the user and you will be Marta. Please provide one question at a time. You should use short sentences to provide feedback and answer questions.

The purpose of using a demonstration of an intelligent interview coach interaction was twofold: first, so that participants could interact with and experience an intelligent interview coach chatbot; and second, to gather design considerations and recommendations for the use of an intelligent interview coach chatbot.

As shared in the prompt above, we provided ChatGPT with a 'persona' of Marta, an interview skills job coach. When instructing the user, we asked Marta to use the STAR method (situation, task, action, result) as a framework for providing feedback to participant responses to behavioral interview questions. We also provided for 'Marta' an example of feedback delivery for a correct response and incorrect response. We incorporated these instructions within the prompt because both the STAR method and structured feedback delivery were noted within the literature as effective interventions for developing storytelling within the behavioral interview (Bangerter et al., 2023; Daryanto et al., 2024), and noted in research with autistic job seekers (Strickland et al., 2013). We tested the prompt, editing our grammar and wording of sentences, until it reliably provided the desired response. For example, when testing the first iteration of the prompt, ChatGPT provided several questions at once to the user. We went back to the prompt to provide an additional instruction for Marta: "Provide questions one at a time and wait for the user's response before giving feedback." A sample example of an interaction between ChatGPT and a user is shown in Figure 4.1.

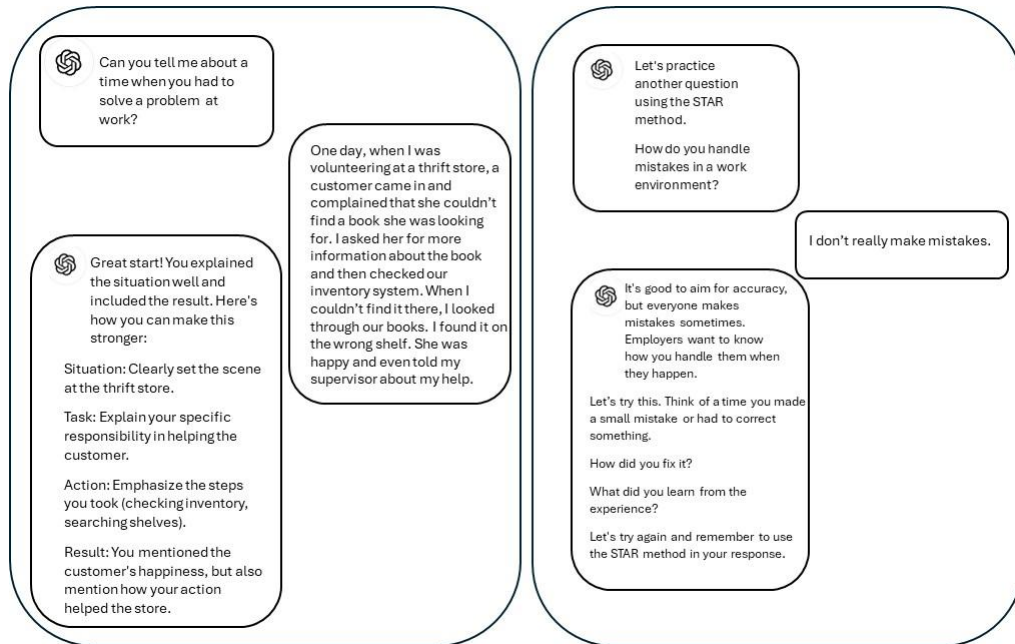


Figure 4.1. Sample interaction Between Participant and ChatGPT Interview Coach

4.3.5 Procedure

We met with each participant for approximately one hour via Zoom. First, participants were asked to share their personal experiences with the interview process, or when coaching others during the interview process. We asked autistic job seekers the following questions: 'Did you have to go through a job interview to get the job? Tell me about that experience.'; 'What were some challenges you experienced when interviewing for jobs?' and 'Did you receive any coaching or support in the interview process? If so, what was that experience like?' Examples of questions asked during this first part of the interview for vocational coaches were: 'What does a typical session look like with a client?'; 'Have you ever coached clients in interviewing? What was your experience in this? How did you teach them?' and 'What typical challenges are you facing with clients

when teaching interview skills? How did you overcome them?' These questions were guided by *RQ1: What are the experiences of autistic job seekers and vocational coaches who support autistic job seekers while preparing for job interviews?* examining the interview preparation experience from two different viewpoints.

Following the first part of the interview exploring the participant's experience in the interview preparation process, participants were shown an example of a chatbot using ChatGPT (GPT-4) of a virtual interview coach (Figure 4.1), and asked to interact with the interview coach for a few turns by typing responses to the chatbot's questions in the ChatGPT interface remotely accessed on the my computer. I conducted these sessions with participants, and when participants had a noticeable pause in their interaction, I asked if they wanted to continue, or move on in the interview. If the participant indicated they wanted to move on, they were then asked questions about their perspectives on the use of the intelligent interview coach and their design recommendations for future iterations of the coach. Examples of these questions included (for autistic job seekers and vocational coaches): 'Regarding the ChatGPT Interview Coach, what are your general thoughts about the coaching interaction?'; 'What are some positives and negatives about the interaction?' 'Is there anything you would change if you were the intelligent interview coach?'; and 'Would something like this help you? Why or why not?'

These open ended questions were guided by *RQ2: What are the recommendations of vocational coaches and autistic job seekers regarding the design of an intelligent interview coach chatbot during the interview preparation process?* and *RQ3: What are the perspectives of vocational coaches and autistic job seekers regarding the use of an intelligent interview coach chatbot?*

4.3.6 Data Analysis

Following each interview, we obtained the transcripts from the Zoom platform. These transcriptions were cross-checked with the recording to verify accuracy of the transcription, and we corrected transcription errors prior to coding. We used a thematic analysis when reviewing transcripts from participant interviews, a qualitative research method used to identify patterns (themes) within narrative data by first identifying initial codes, then sorting these codes into common themes (Braun & Clarke, 2012; Trainor & Bundon, 2021). Myself and a collaborator met to identify the codes and themes. Once the theme was identified, all collaborators discussed and reviewed the findings together, coming to a consensus.

This thematic analysis process was iterative, with five rounds of discussion each following 1-3 interviews held, where I calculated the saturation measurement as outlined in Section 3.3. As part of our analysis, we used a reflexive process to identify our themes, based upon our experiences working with autistic job seekers. For this type of process, inter-rater reliability would not be suitable to calculate (McDonald et al., 2019; Trainor & Bundon, 2021). We worked through this process, until we hit saturation with the themes identified, and we felt we sufficiently answered our research questions (Braun & Clarke, 2021; Guest et al., 2006; Guest et al., 2020).

4.4 Results

During the interviews, we first asked participants questions about their personal experiences while interviewing and strategies for providing support during the interview process (RQ1). In the data analysis process, we identified three salient themes: *social anxiety*, *masking*, and *disclosure*. Following interaction, with the demo ChatGPT

interview coach, we asked participants their feedback regarding the design of future intelligent interview coach chatbots (RQ2). During this phase of the interview, we identified three themes for design considerations for future intelligent interview coaches: *response structure, feedback delivery, and strategies for procedural scaffolding*. Participants also shared their perspectives on the use of intelligent interview coach chatbots in the interview preparation process (RQ3), converging on three themes for the use of an intelligent coach chatbot: *collaborative assistance, confidence builder, and intelligent chatbot concerns*. This section outlines the themes and salient supporting statements we found during the interviews with participants. An aggregate analysis of themes identified across participants can be found in Table 4.2.

Table 4.2. Overall Themes Identified in Participant Interviews

	RQ1			RQ2			RQ3		
Id	Social	Masking	Disclosure	Response	Feedback	Procedural	Collaborative	Confidence	Intelligent Coach
	Anxiety			Structure	Delivery	Scaffolding	Assistant	Builder	Concern
S1	x	x	x	x	x		x	x	x
S2	x		x		x			x	
S3	x	x	x	x	x		x	x	
S4	x	x	x	x	x	x		x	x
S5	x	x	x	x	x	x	x	x	x
C1	x			x	x	x	x	x	x
C2	x			x	x	x	x	x	
C3	x	x	x	x	x	x	x	x	
C4	x	x		x	x	x	x	x	x
C5	x			x	x	x	x	x	

4.4.1 RQ1: What are the unique challenges autistic job seekers face during the interview process?

4.4.1.1 Social Anxiety. All of our participants expressed that social anxiety can be a challenge for autistic job seekers during the interview process. Social anxiety is something that most job seekers experience in the interview process; however, the autistic job seekers in our study shared their own unique challenges with social anxiety during interviews. S3 stated: *"I'd say, anxiety is a big challenge, like when I start out interviewing. I freeze and am not able to speak when I'm trying not to mess up. I have that same reaction when it comes to like building relationships too"* (S3). Sometimes this 'freezing' occurs when autistic job seekers need additional processing time.

When I am nervous and I don't understand the questions that they are asking, sometimes I need a second to respond. I understand what you're saying, but I'm nervous and sometimes it takes me a minute to process what you're asking me, and then for me to give a response. (S1)

S2 also described their social anxiety in interviews by saying: *"it is a little awkward, I don't really know that person too much so I don't know what to say, especially when the vibe is not really the greatest"* (S2).

Maintaining eye contact in interviews was also noted as a challenge by job seekers. S1 shared: *"I would say, making eye contact is a struggle"* (S1). S3 also stated: *"I have a tendency to avoid eye contact when I get really nervous. So that is another issue, but I can usually catch myself most of the time"* (S3).

Practice and rehearsal are well-established strategies for managing social anxiety (Hendriksen, 2018). Vocational coaches shared these and other strategies for supporting

autistic job seekers with social anxiety by coaching them through the storytelling process during the interview, using repeated practice and their resume as a visual aid.

Number one, we work through getting their resume together. We talk through their resume so that they can speak on their experience. If they get nervous, they can look at their resume and read it so they feel comfortable reading it to express their experience. This practice is to make sure that they feel confident, like pitching themselves, because that's a big deal in the interviews. (C2)

C4 also shared: *"We give them lots of practice. Give them opportunities to rehearse, first with the coach, then with a peer, and then hopefully with some feedback in a more realistic setting" (C4).*

Vocational coaches mentioned that autistic job seekers sometimes struggle to generalize skills from practice sessions to actual interviews, potentially due to social anxiety in the real-life setting, *"They tend to master the questions in our sessions. But then they still really struggle in the actual environment when they get nervous" (C5).*

They also noted that when they are coaching, teaching too rigidly can potentially create more social anxiety with the person they are coaching:

For a lot of my particular clients, these social interactions can be very emotional. If we teach too strictly to the 'rules', then they can't adjust to the variation that they're going to see in conversation, whereas if we teach them more generally, then they feel lost and get really frustrated. So, finding that balance between how much structure and instruction and generalization. (C4)

4.4.1.2 Masking. As noted in Table 4.2, masking was a theme more commonly noted from job seekers. Four out of five of the job seekers in the study shared their strategies for *masking*, which is defined as the process of hiding aspects of your identity or mannerisms to avoid harm (Miller et al., 2021). Job seekers shared that this is something they often do during job interviews: *"I mean, I can spoof eye contact because my trick is I can do it consciously. But I end up being like a few degrees off from the eyes.*

But it's close, something no one can notice" (S4). For autistic job seekers, masking is something that eases the interview process, and has been learned through therapy and coaching:

In the past I would say, social skills were very hard for me. Like interacting, understanding people, and reading their facial expressions. Things like that. But I've been lucky enough to have gone through speech therapy to where I have learned how to do those things, and it's made my life so much easier. (S1)

Job seekers also shared that when they are in situations such as an interview, they view the interview more as something to be memorized, rather than as socializing with others.

I'm pretty good at interviews. At least from what other people say, even the people who have rejected me for jobs. They say I interview well. I don't know. I've always been better at public speaking than socializing. I'm not perfect, but public speaking is just something I haven't really like inordinately struggled with. You can plan for it more. It's a single thing. It's more one-sided, rather than the social interaction. You can memorize what to say. (S4)

Two vocational coaches also mentioned supporting autistic job seekers with masking during interview preparation: *"I'll coach them around, you know, making sure you have good posture and smiling. Having eye contact. Memorizing an elevator pitch and what to include in that elevator pitch" (C3).* However, they also noted their own personal struggle with supporting masking when coaching:

You know, it's how to deliver information in a way that society feels like is relevant and needed. So it stinks, because they have to bend themselves to create these soft skills. However, it also helps them in the long run to advance in their career, and also advocate for themselves in a way where neurotypical people will actually listen to them. (C2)

4.4.1.3 Disclosure. One job coach noted disclosure as an issue in the interview process (Table 4.2). However, for all of the autistic job seekers in our study, disclosing that they are autistic to employers is a major decision point in an interview.

I was kind of nervous in the interview, because that was my first actual job. And since then I have had trouble interviewing because I don't know if I tell them I have autism ahead of time, if they'll keep me on. I struggle with disclosing the disability because I don't want to be left out just because I handle things differently. (S5)

S1 shared that:

Interviewing was hard because I didn't know what was expected out of me. Like when they asked questions, what are your strengths, and what are your weaknesses like? Do I be honest? You know, because you don't want to make yourself look bad, and talk yourself out of the job. So I struggle with that. (S1)

One vocational coach also noted issues when autistic job seekers disclose in the interview:

In an interview a lot of them will come in, and the first thing they want to say is, well, I might not be good at this, because I have a diagnosis, or because of this, I might do this. It is a challenge, because I think as an employer when you're looking at hiring somebody, disclosing can be a pretty big red flag or a situation where we're gonna cross you off the list, and move on to the next candidate moment. (C4)

4.4.2. RQ2: What are the recommendations of vocational coaches and autistic job seekers regarding the design of an intelligent interview coach?

4.4.2.1 Response Structure. All of the job coaches in the study referenced response structure, while four out of five job seekers noted response structure of ChatGPT (Table 4.2). Job seekers in our study, appreciated the concise responses from ChatGPT, as it outlined sample situations and offered an example for improvement without overwhelming them with information. S3 noted a preference for this approach: *"I like how it gave me an example of how I could have better articulated the task and the actions I took without overloading me with information. It gives me things that I need to improve on"* (S3). One job coach also noted the structured response delivery: *"I like the structured responses. It described what the expectation is, and then debriefed after the*

practice with feedback about how they did, and giving praise where they got it right. So I thought that was really cool" (C5).

Job seekers also appreciated the structured presentation of the STAR method (Situation, Task, Action, Result) (Brumm et al., 2005) to support their narrative, outlined by ChatGPT in the demo (see Figure 4.1), but they expressed a need for more explicit expectations of what it means and more examples before and after the method's introduction.

I liked how it mentioned the STAR method, but then it didn't tell me what it was wanting in my answer. Be more explicit. I think that would be helpful. Because if I know what's expected out of me, clearly, I can give you a really good answer. (S1)

Participants also suggested integrating individualized elements, such as being able to input their resume, to make the instruction more relevant and personal. *"I feel like tying it to your resume like asking questions about a previous internship, or your previous job, or something that you did in your resume that you're proud of is another thing that could help in responding" (S4).*

All of the vocational coaches in the study shared suggestions for improvement for the response structure from the interview coach chatbot. They discussed the need for simplifying and visually organizing the response structure to enhance comprehension for autistic job seekers. This included suggestions for using short and clear text with larger fonts. *"I know, a lot of my clients would really benefit from something like this. However, because of the wording in it it's going to be very hard for them to read the bigger words and blocks of text" (C2).* They suggested decomposing the chatbot's responses: *"I think some of my clients would have trouble taking in as much information in the response given by the chatbot. It might need to be broken down into smaller segments" (C4).* For

vocational coaches it is also important to provide customization when responding, *"making sure that you are providing the response to the client, at their language level"* (C4). and *"it needs to more simple and matched to the person when responding"* (C1).

This personalized approach ensures the intelligent interview coach's responses are relevant to each user's unique communication abilities and preferences.

One advantage discussed by vocational coaches in the chatbot's response structure was the consistency in responses. C4 noted:

It's very consistent with the language, and tying it back to the person's answers every time. I think that that's a really strong way to provide responses, even when the task itself varies from question to question.(C4)

4.4.2.2. Feedback Delivery. All of the participants in study noted feedback delivery as a theme (Table 4.2), and all of the job seekers in our study expressed a desire for more detailed, constructive feedback. S3 suggested that the chatbot could offer more context when correcting their responses: *"Maybe go into a little bit more detail about where I or the person using this went wrong. That's probably the big thing because I need context too. Make sure I'm answering the question as correctly as I can"* (S3). This feedback aligns with the need for more examples. S1 felt that the chatbot needed to communicate its expectation: *"I didn't like how it didn't tell me what it was wanting. It needs more examples. So again, I didn't know what was expected out of me"* (S1).

The format of the feedback was also a point of discussion. S4 observed that a text block was less accessible, suggesting a more structured layout with a clear separation of the assessment parts:

Doing it as a block of text is probably less accessible. My eyes gravitate towards the capitalizations of the technical terms and the parentheses. I think having it as an overall assessment, the S, T, A, R and then the conclusion as separate lines would be a lot better. (S4)

Job seekers noted that the chatbot also provided positive feedback for responses that followed the STAR process. S1, in particular, liked the praise incorporated into the feedback:

Like, the praise? Like I really liked that. It made me feel good. I liked that it was multiple things. It was kinda like sandwiched in. That's how I received feedback the best. (S1)

S2 also noted, *"It is teaching you a method, and is like, yeah, you did these things right. And you know, you forgot to mention these things. I think it was pretty straightforward about how you did"* (S2). This indicates the importance of balancing constructive feedback with positive reinforcement when providing feedback.

Despite these benefits, S5 and S4 noted that feedback from a chatbot might differ from that of a human coach: *"It's less personal. You know, you're working with a computer or a machine. So you may not necessarily get the kind of feedback you think you are from, like from a person"* (S5)? S4 noted that human coaches could provide deeper analysis and context to responses from the practice with the chatbot:

With a human coach I would want to go into these sections and analyze them a little closer. Just like just identifying a match isn't really helpful. But that's where a human coach could add a lot more context to that like, oh, this is the kind of situation that you should be talking about to an interviewer. (S4)

All of the vocational coaches appreciated the feedback delivery with the interview coach chatbot. C5 noted the structured nature of feedback delivery, particularly highlighting the feedback's behavioral skills training components, a method of training that involves instruction, model, rehearsal, and feedback (Kirkpatrick et al., 2019; Miltenberger et al., 2017).

I like that it has components of behavioral skills training built-in: giving some examples and then asking them to practice, and then debriefing after the practice with the feedback about how they did, and giving praise where they got it right, and some supportive prompting or feedback where they might need to do something differently. (C5)

C3 and C5 described their use of role-play within behavioral skills training in their own coaching practice, including modeling successful interviews and providing practice opportunities. *"We provide some instructions, maybe a job aid, and show them some examples of how a successful interview might go. Sometimes we'll also do the non-examples too" (C3).* and *"I use behavioral skills training. Lots of modeling, either with me modeling or with video models. And then lots of practice opportunities" (C5).* C4 echoed the appreciation for the structured feedback, suggesting its similarity to a rubric:

I really like how structured the feedback is and how it's consistent and not confusing. Being able to identify those pieces of his answer and place them back in that STAR format. It's almost like following a rubric or a rating scale (C4).

4.4.2.3 Procedural Scaffolding. All of the job coaches in the study discussed strategies they use for procedural scaffolding, linking it to ChatGPT interview coach (Table 4.2). Two job seekers noted the need for more procedural scaffolding, a process to break down complex steps into smaller components and providing structured support as the learner masters the skill (Liu & Adams, 2017; Smith & Ragan, 2004), by the intelligent interview coach. S4 mentioned the benefit of providing explanations for what they were doing, prior to starting the task, an example of procedural scaffolding: *"I think it'd be a lot more useful if I knew what the STAR method was ahead of time" (S4)*

Participants suggested using the chatbot as part of a scaffolding process, transitioning from text-based interactions to real-world practice.

Instead of getting like a list of reminders like, this is kind of more like that hands-on practice before getting to the next step. The step before this would be: here's what the STAR method is, and here is why you might like it. The step after this is a practice with a real person. Before we get there, this lets me experiment and understand in a more actualized way than just telling someone about the situation. (S4)

Another example of the need for procedural scaffolding was shared by S5, noting that the chatbot could be improved by being more structured and straightforward: *"It was not as necessarily structured in the beginning. They didn't necessarily start off by mentioning the STAR method, and they just asked a question. They should mention certain ways to handle a situation, perhaps with more examples"* (S5). One vocational coach revealed that they also use the STAR method as a framework to provide procedural scaffolding in their own practice to teach autistic job seekers to answer questions in interviews. C3 noted: *"So for answering interview questions, we also use the STAR method, explaining situation, task, action, and result, walking through each of those components and then giving them an example"* (C3). C2 also appreciated how well the chatbot made use of the STAR method to guide individuals in their responses:

The STAR method, I think, is a really good idea, because it can get them to start thinking about those situations. It'll get them to start using it when they do answer questions. It's very clear, and it is a great way to get those answers. (C2)
C2 also emphasized that this is especially beneficial for the autistic job seekers.

"A lot of them will tell me, what do you want me to do? Just tell me what to do, and I will do it. So, the fact that it's spelled out this way very clearly is good" (C2).

To support in this procedural scaffolding, vocational coaches also suggested:

I think it'd be helpful in the very beginning to give an example of a STAR response. So, ask a commonly asked interview question, giving an example of what a response might be. Then they have a better picture. (C3)

In general, all of the vocational coaches highlighted other forms of procedural scaffolding they use in the interview preparation process with autistic job seekers that could be added to future intelligent interview coaches. Vocational coaches often practice questions with autistic job seekers ahead of time: *"So, I would have a form I would coach them from, and I would sit down and just go over, okay, what do we say to this answer? What do we say to this answer?" (C1)*, but also noted the risk of going too far with providing scripts during practice: *"There's no guarantee they're going to ask you any of the questions I give them from a script, but it's still good to practice" (C2)*.

The intelligent interview coach chatbot provided additional scaffolding benefits in the form of repetition and practice, as noted by vocational coaches in the study. C1 emphasized the importance of repeated practice, noting that: *"I think this would help a lot. They can practice and do it multiple times and over and over until they get the skill" (C1)*.

4.4.3. RQ3: What are the perspectives of vocational coaches and autistic job seekers regarding the use of an intelligent interview coach?

4.4.3.1 Collaborative Assistant to Human Vocational Coaching. All of the vocational coaches in the study noted that the ability to practice and receive feedback without the constant presence of a human coach can significantly enhance the learning process (Table 4.2). C4 discussed the intelligent interview coach's potential in terms of productivity.

This would be amazing, because instead of me role playing this 45 times, I could have them do it a couple of times, maybe even see the results. They could send them to me, and then I can structure that really valuable one-on-one time in a more productive way. (C4)

Cost was also noted: *"You could give someone more opportunities to work on this skill without having to make them pay for more coach hours"* (C4). An intelligent interview coach chatbot may reduce the financial burden of paying for additional coaching hours, and allows for more productive use of one-on-one coaching sessions.

Vocational coaches also highlighted that the intelligent interview coach can be used with job seekers' in collaboration with their larger social network outside of the vocational coaching session. C2 highlighted the integration of natural supports, such as family members, into the training process:

But we also lean on natural support when needed. If I have somebody who has a mom that wants to be involved. I'm all about it! I will give you guys homework to do together. Go on with the virtual coach and do 3 simulations. I want to know what the questions were so screenshot it for me for our next session. (C2)

It is important to note that vocational coaches were clear in the intelligent interview coach's role as a *collaborative assistant*, rather than a replacement, for traditional human vocational coaching. C3 stated that the chatbot offers additional practice opportunities due to the limited availability of coaches and the high anxiety levels associated with job interviews.

They come in with so much anxiety around the job interview. I can see this as an assistant, but not as a replacement to human coaching. So let's say, if a student, you know, meets with the coach like once a week, or once every 2 weeks, but they want more practice than that because of the bandwidth of coaches. I could see this being a supplement to that. (C3)

This may be particularly beneficial for autistic job seekers requiring more frequent practice than their coaching schedule allows as noted by C5:

I think that technology like this could help people that were highly motivated. So I have a limited amount of time with my job coach. But if I have access to this like while I'm riding the bus, or in my downtime, I can practice on my own. (C5)

For autistic job seekers, they often need to find their own support if human coaching is unavailable. S3 shared:

I did work with my state's office vocational rehabilitation for a few years. But I closed my file at the beginning of COVID, because I realize they weren't really that helpful to me. I realized I got more done on my own. So I've been doing my own thing for like the last 3 going on 4 years. This could give me some techniques in the interview to keep it manageable. (S3)

C3 stated: "a tool like this could be beneficial for people who are on the job market who are not necessarily at a University anymore, who want that additional practice" (C3).

4.4.3.2 Confidence Building. All of the job seekers and vocational coaches in the study highlighted the potential of the chatbots' impact on social anxiety, a theme identified in RQ1 (Table 4.2) and confidence. S5 noted that practicing with the interview coach could develop their confidence during the interview preparation process:

I've never had any kind of coaching. But it could help just because of how I'm a naturally anxious person, and it takes me longer to get to the speed where everyone else is at. So just getting up to pace with everybody else, you know. Get to where they need me to be. (S5)

S1 also mentioned that it reduces the power dynamic in actual interviews, allowing for more relaxed and thoughtful responses:

I find interviews hard. I'm so worked up that I'm going to mess up, and my anxiety kicks in. And then my oxygen goes into overdrive. And I don't have to worry about that. If it's like something like this, because I'm not having to face that new social interaction, I'm able to calmly think about it and like, take as long as I need not have to worry about, you know, giving a response within a certain amount of acceptable time. And I can just write and answer those questions. (S1)

Practicing various responses with the chatbot without fear of judgment was also valued. This fear of judgment was also noted previously by participants in RQ1 as part of their discussion regarding masking and disclosure challenges. "You know, like if you get

multiple opportunities to practice until you feel comfortable enough to go into an actual interview" (S1). S3 also stated: "I feel less judged by interview software than from a human" (S3). S4 pointed out the freedom to experiment with responses might be too direct for a traditional interview setting.

I would never be that blunt with a human like with a potential employer. I would never criticize a question from another human because that would probably cost me the job interview as correct as it would be. But I'm more comfortable doing that with ChatGPT. (S4)

For autistic job seekers, the chatbot also could function as a communication support system to alleviate social anxiety:

Something like this could provide a barrier between me and the employer to where I would have a third party communicator when I was struggling to communicate, like when I had a human job coach. It also gives you like, realistic experience to practice with what kind of questions that you're going to be asked. (S1)

All of the vocational coaches mentioned that an intelligent interview coach could help build confidence for their coaching clients. *"So I think for students because they come in with so much anxiety around interviewing. This could be what they need to build their confidence and supplement coaching."* (C3) Vocational coaches suggested that there may be a reduction in anxiety that can be present in traditional job interviews. C5 pointed out: *"With the use of the chatbot, it allows for increased repetition to decrease the anxiety produced by human-to-human social interactions in job interviews"* (C5).

4.4.3.3. Intelligent Interview Coach Concerns. Three job seeker participants and two vocational coaches (Table 4.2) noted some concerns with designing an intelligent interview coach chatbot system. First, some participants brought up concerns regarding the chatbot's knowledge base, and its familiarity with autism. S1 shared:

Yes I could benefit from coaching for interview skills. But I would like to clarify. It would need it to understand autism. I'd be looking for something that has understanding of, like the social challenges and communication struggles of autism. It's like, if you're gonna help people with autism, you should know about autism. (S1)

Second, the interview coach chatbot's consistency in providing responses was also a concern for participants. *"I think big AI scares me right like, what if it goes off track, and I'm not sitting there watching it? And now they've practiced a bunch of non-examples. How much variability is there? How can we control for that "(C4)?*

Participants had concerns with the intelligent interview coach chatbot's generalization to real-life experiences: *"Something negative about this is that it is not how a real job interview is going to be. In a real job interview it would be a human asking you questions" (S1)*. When conversing with a human, participants noted that humans will pick up on non-verbal and contextual cues that an intelligent interview coach may not be able to respond to. For example, S4 noted: *"It just doesn't have a human intuition like when interviewing with a human in a real life job interview. I think it could be a little pedantic" (S4)* and S5 stated: *"It's less personal. You know, you're working with a computer or a machine. So you may not necessarily get the kind of feedback you think you are from, like from a person? Right? You know, it's not gonna be the same" (S5)*. Vocational coaches also worried about the interview coach chatbot being able to coach soft skills: *"Another downside is that you wouldn't be able to coach those soft skills. So the language might be there. But how is the person delivering these responses" (C4)?*

4.5. Discussion

In this study, we used an exploratory approach to identify the experiences of autistic job seekers in the interview process, as well as considerations for the design and

use of intelligent interview coaches for autistic job seekers during interview preparation.

In summary, we identified three common issues that autistic job seekers experience while preparing for job interviews: social anxiety, masking, and disclosure concerns.

Participants also identified the following design considerations for future intelligent interview coach chatbots: response structure, feedback delivery, and procedural scaffolding. Participants shared that they saw the use of an intelligent interview coach chatbot as being a collaborative assistant for autistic job seekers, vocational coaches, and the larger social network of autistic job seekers, such as caregivers and friends. They also expressed that an intelligent interview coach may support autistic job seekers in developing confidence while preparing for job interviews. During the interviews, participants shared their concerns about the intelligent interview coach, specifically regarding generalization to real-life job interviews with a human interviewer, and the knowledge base an intelligent interview coach would have regarding the nuances of working with autistic job seekers.

4.5.1 Design Considerations for Developing Intelligent Interview Coaches for Autistic Job Seekers

Based on the interviews with participants, we propose the following design considerations, incorporating procedural scaffolding (Liu & Adams, 2017; Smith & Ragan, 2004) within the intelligent interview coach chatbot. We suggest the following considerations: 1) *cues* for the learner to understand the task and procedure; 2) *multiple opportunities* for the learner to practice; and 3) *specific feedback* delivered to the learner following the learning opportunity (Block et al., 1971; Chargois, 2013). In addition, adding personalization to learning, with targeted materials and individual, customized

spacing of instruction is also a design consideration for future intelligent interview coach chatbots (Betts et al., 2021; Keller, 1974).

4.5.1.1 Including Cues for the Learner. The first procedural scaffolding component we suggest as a design consideration for intelligent interview coach chatbots is to provide cues for the learner to understand the expectation within instruction (Block et al., 1971; Chargois, 2013; Smith & Ragan, 2004). Within our participant interviews, we identified two strategies to cue the learner within the interview preparation process: the *STAR process* and *including visuals*.

- *STAR Process.* Vocational coaches and job seekers (S1, S4, S5, and C3) noted that using the STAR process as a mnemonic cue was a beneficial way to frame interview questions, and should continue to be used. The STAR process can be seen as one way to mitigate some challenges with the the interview process, by providing a framework to structure responses to interview questions (Bangerter et al., 2023; Brumm et al., 2005). By using this as a framework, each part of mnemonic "S-T-A-R" (Situation, Task, Action, and Result) provides guidance for the job seeker in structuring their narrative in the storytelling process of the interview.

- *Visuals.* Autistic job seekers (S4) also expressed that adding visuals, would make practicing interview skills feel less 'pedantic' when using the intelligent interview coach. They also suggested incorporating different fonts and bullet points to break up the text and allow for visualization of responses from the chatbot. One job coach (C2) explicitly mentioned using the job seeker's resume as a visual aid within their own coaching practice, which is consistent with previous research suggesting that the use of visuals is beneficial to autistic individuals when learning new skills (Rutherford et al., 2020).

4.5.1.2. Multiple Exemplar Training Opportunities. Another procedural scaffolding design consideration for an intelligent interview coach chatbot is to provide the learner with multiple practice opportunities. This is relayed in Variation Theory, which outlines a process where learning occurs when a learner is presented with multiple examples and non-examples during the learning process (Guo et al., 2012; Marton, 1997). Job seekers (S2, S4) and vocational coaches (C4) in the study expressed that they needed more examples of the use of the STAR process for answering job interview questions than the single example provided by intelligent interview coach chatbots. Research also suggests that multiple exemplar training improves generalization of social skills for autistic learners (Erhard et al., 2022).

4.5.1.3. Structured Feedback Delivery. The third design consideration which incorporates procedural scaffolding for an intelligent interview coach chatbot is to provide specific and structured feedback delivery. In our study, autistic job seekers (S1-4) requested clearer feedback with examples of what was correct and incorrect in responses. Vocational coaches (C3 and C5) suggested the use of behavior skills training as

something to include in the feedback delivery process, where a learner is provided explicit instructions, a model, and the chance to rehearse the skill with feedback (Miltenberger et al., 2017), and has shown to be effective for autistic job seekers (Lerman et al., 2015). One vocational coach (C4) also suggested the use of a rubric or rating system linked directly to the STAR method as part of the feedback delivery. It is possible that a behaviorally anchored rating scale, a form of feedback delivery that provides a score based on specific behavior exhibited by the learner, could be a way to provide this feedback (Schwab et al., 1975). The use of such rating scales with autistic adults has not been well studied, and is an open research question.

4.5.1.4 Personalizing Instruction. The use of personalized instruction (Betts et al., 2021; Keller, 1974) is another design consideration for an intelligent interview coach chatbot. Vocational coaches (C2 and C4) wanted the response structure to be personalized to the autistic job seeker's communication ability, and autistic job seekers (S4) also suggested that their resume could be provided to the intelligent interview coach, to tailor questions and responses to their own personal job experience. Recent research in personalized, intelligent tutoring systems have shown promise in developing mathematics and reading skills for autistic students (Mazon et al., 2023; Mondragon et al., 2017). Future intelligent interview coaches could provide contextually relevant examples and adapt instruction for autistic job seekers based on the job seeker's interviewing abilities and skill development (Judy et al., 2012).

4.5.1.5. Summary of Design Considerations. From the recommendations of autistic job seekers and vocational coaches during our interviews, we can imagine developing a new intelligent interview coach that incorporates procedural scaffolding, with cues,

multiple practice opportunities, and structured feedback delivery, and personalized instruction. For this interview coach, we can add additional components to the initial prompt (See 3.4) based on feedback from participants, as summarized in Table 4.3.

Table 4.3. Design Considerations Outlined by Participants

Participant Id	Design Consideration
S1, S4, S5, C3	Provide explicit instructions of what is expected of user, and provide example of the STAR method before asking the first question (<i>Cue</i>).
S4, C1, C2, C4	Break feedback down into small segments, using bullet points and different font colors for outlining the STAR method. Use images and videos as part of the chatbot conversation to model the skill. (<i>Cue</i>).
S2, S4, C4	Provide an example of what the user did well and other examples of how this could be answered in a future interview. Have the user practice the questions again. (<i>Multiple Practice Opportunities</i>).
S1, S2, S3, S4, C4, C5	Provide an example of what the user did not do well and how to improve the response (<i>Structured Feedback Delivery</i>).
S4, C2, C4	Ask the user about previous job history. Tailor the wording to the communication style of the user. (<i>Personalization</i>).

4.5.2. Intelligent Chatbots as Collaborative Assistants

We learned from vocational coaches and autistic job seekers that the use of an intelligent interview coach chatbot provides collaborative benefits, such as assisting in alleviating socio-emotional barriers people face when seeking feedback (Foong et al., 2017; Hou et al., 2024), and how the use of an intelligent coach could potentially support in communication between autistic job seekers and employers, as reflected in previous HCI research (Choi et al., 2024; Jang et al., 2024). Specifically, we learned from our interviews with autistic job seekers (S1) that the use of an intelligent interview coach chatbot may bridge communication difficulties job seekers face when interviewing with

employers. For autistic job seekers, working with an intelligent coach, can help develop their storytelling responses to behavioral interview questions during interviews.

Practicing with the intelligent interview coach allows for interview practice in a space free of human judgment (S4), echoing previous research findings comparing digital and human interactions within instant messaging exchanges (Hill et al., 2015), and computer mediated communication tools (Burke et al., 2010). Intelligent coaches powered by Large Language Models (LLMs) provide answers to questions with immediate feedback and create an environment for multiple practice opportunities which is essential for building confidence and reducing social anxiety in autistic job seekers (Wong et al., 2015).

Reducing anxiety can also lead to self-confidence, which may increase social engagement within interviews (Smith et al., 2014).

Vocational coaches shared that an intelligent interview coach could support with procedural scaffolding when teaching interview skills, allowing autistic job seekers collaborate and practice interview skills with others in their social network (such as caregivers or friends). Interviews with autistic job seekers also revealed that practice with an intelligent interview coach may enhance learning sessions between vocational coaches and job seekers, allowing for supplementation of vocational coaching services, when more practice is needed. In the field of HCI, specifically for autistic job seekers, the use of LLMs and other intelligent systems have explored areas of collaboration between the system, user, and their larger social network (employers, support personnel, and coworkers). For the job seeking process, these systems could support collaboration with executive planning, networking, and communication between an autistic job seeker and future employer (Ara et al., 2024). While on the job, these systems may also support the

collaboration between neurotypical coworkers and autistic workers by mitigating potential social and communication challenges faced by autistic workers when interacting in the workplace (Jang et al., 2024).

4.6 Limitations and Future Research

It is important to note the limitations of this research. First, we address our small sample size. Our study ran from June 2023 to January 2024, and for every vocational coach we recruited, it required approximately 1.5 months to recruit one autistic job seeker. We note that our study's sample size of autistic job seekers aligns with other recent studies published in HCI research, with a sample range of 5-11 autistic participants (Ara et al., 2024; Jang et al., 2024; Kim et al., 2023). While our sample is aligned with prior work, it introduces some limitations. First, we are unable to generalize our findings to all autistic job seekers and this was not our goal. The purpose of this study was exploratory, to gather information on the challenges autistic job seekers face, their recommendations for the future design of intelligent interview coaches, and their perspectives on the use of intelligent interview coaches. While sample size and statistical significance are key measures of research quality in positivist work, we followed best practices in qualitative research which included reaching code saturation (Braun & Clarke, 2021; Guest et al., 2006; Guest et al., 2020), where with our last participants, no new themes were discovered with autistic job seekers or vocational coaches in our interviews.

In addition, the purpose of this study was not to evaluate or compare any one method or delivery of structuring responses. We used the STAR method in the study because we needed a sample to provide to our participants to explore their perspectives

on the use of an intelligent interview coach. We selected the STAR method to incorporate within our system prompt, because it has been established in the literature as a way to structure responses during interviews (Lin, 2010). Future research should evaluate other approaches, or conduct studies comparing other approaches to the STAR method when structuring responses within the system prompt.

Using ChatGPT as an intelligent interview coach also has some limitations. As pointed out by S4 and S5 in the interviews, ChatGPT's lack of genuine emotional intelligence can be a challenge with user interaction. While it can mimic empathetic responses, it cannot fully understand or react appropriately to emotional complexities or contextual information often present in interviews. Additionally, ChatGPT contains a limited knowledge base, which may not include socially valid information regarding autism, the latest industry trends, or specific job requirements, potentially limiting the relevance and timeliness of its advice during interview training for autistic job seekers (Cheng et al., 2023). Another limitation is ChatGPT's inability to provide feedback on non-verbal cues, such as body language, which are vital in interview settings (Loconte et al., 2023). Despite these limitations, the participants felt ChatGPT or a similar intelligent interview coach chatbot, would be helpful to support interview skills coaching for autistic job seekers. Participants also indicated in their interviews that while on the job, human vocational coaches often help to facilitate communication between autistic employees and employers. It is possible that intelligent chatbots could also function as third-party facilitators in interview training as well as in developing communication strategies for autistic employees and their employers (Jang et al., 2024; Yang et al., 2023). This is something that should be studied further in future research.

In our study, we found that job seekers often mask their autistic identity to future employers, especially during the interview process, and vocational coaches, though sometimes hesitant to do so, support this practice. Disclosure concerns were also a common theme in our interviews. Future studies should look at the challenges of masking and disclosure for autistic job seekers as areas of study, perhaps also including employers within the discussion.

Future studies should also explore the design considerations we included in our discussion for potential user studies, incorporating participatory and co-design methodologies with autistic job seekers. During this exploratory study, we uncovered several open research questions that could be examined through such studies with an intelligent interview coach chatbot, such as examining the use of behaviorally anchored rating scales to provide feedback, incorporating visual supports and cues, and evaluating opportunities for multiple exemplar training. The pedagogical methods used by the intelligent interview coach for autistic job seekers is also an open question as it is unclear if a personalized system of direct instruction (Keller, 1974) or perhaps another methodology, such as inquiry based learning, where a learner gains the skill through questions and independent discovery during the learning process (Chiappetta & Adams, 2004), would be preferred by autistic job seekers.

4.7 Conclusion

This research explored the challenges experienced by autistic job seekers in interviews (RQ1). By conducting semi-structured interviews with participants, we gained valuable insights regarding the design considerations for intelligent interview coach chatbots (RQ2). We also discussed the potential of using intelligent chatbots as a

collaborative assistant to support autistic job seekers in interview preparation (RQ3). In the future, we plan to conduct more in-depth user studies regarding the open research questions generated from this exploratory study, which will be required to evaluate the feasibility of intelligent interview coaches to support autistic job seekers when pursuing employment opportunities.

CHAPTER 5

UNDERSTANDING THE EXPERIENCE OF NEURODIVERGENT WORKERS IN IMAGE AND TEXT DATA ANNOTATION

5.1 Introduction

Neurodivergent individuals, such as those diagnosed with autism spectrum disorder (ASD) and attention deficit and hyperactivity disorder (ADHD), face numerous challenges associated with participation in the workforce. Data from the National Longitudinal Transition Study-2 (NLTS-2), the largest comprehensive post-graduation survey of youth with disabilities in the U.S., showed that only 37% of young adults with ASD within the study were employed up to eight years after graduating from high school and that 34.9% reported never holding a job since high school (Wagner et al, 2006; Shattuck et al, 2012). It is important to highlight that this study did not include any breakdown by ASD severity and any comorbidities, so it is likely that for some segments of the ASD population the statistics are even more discouraging. A systematic review of research on the transition of youth diagnosed with ADHD (Gordon and Fabiano, 2019), also found that teenagers and young adults with ADHD had lower occupational attainment and demonstrated job instability. These difficulties for neurodivergent individuals to obtain and maintain employment may be due to challenges in obtaining transportation, challenges with communication, relating to others' experience, and maintaining flexibility and focus with rapid changes in tasks presented in the workplace (Schall and McDonough, 2010; Schall et. al, 2020; Woods et al., 2002; Yaneva et al., 2015; Tomzcak and Kulikowski, 2023).

To address these challenges, crowd work provides an interesting opportunity for neurodivergent workers. Crowd work often involves data annotation in micro-tasks, such as those found within Amazon’s Mechanical Turk (AMT) within a remote and digital work environment, where the “worker” can work from the comfort of their own home and choose tasks to complete for payment. These digital work environments may provide a path to employment and highlight the strengths of neurodivergent workers (Hara and Bingham, 2015; Zyskowski et al., 2015). With an increased emphasis on building fair AI models (Gao et. al, 2022; Park et. al., 2021), particularly in reducing the bias that currently exists for neurodivergent individuals (Guo et al, 2020; and You et al., 2022), it is also important to obtain datasets annotated by neurodivergent workers to aid in building fair, inclusive AI systems. To study this, however, we must first learn from the experience of neurodivergent workers on data annotation tasks within these digital work environments.

Because little academic research addresses neurodiverse workers (LeFevre-Levy et al., 2023), an inductive approach may be an appropriate beginning. The objective of our exploratory study was to gain insights into the feasibility of data annotation work for neurodivergent workers. We studied the feasibility along two dimensions--the task performance and perspectives of participants. To study these dimensions, we recruited ten self-identified neurodivergent participants who were 18-30 years of age. We built a custom web platform that presented 3 types of text and image annotation tasks with 20 questions for each task. These were tasks that were common representations of objective and subjective tasks typically found in platforms such as AMT. Upon completion of each task, we conducted semi-structured interviews and a survey to gain insight into the

experience of neurodivergent workers regarding the tasks presented in the platform. In addition to the interview, we also encouraged our users to “talk aloud” during the completion of the tasks to share their experience interacting with the interface and completing tasks.

During our study, we faced challenges in gathering information from our participants despite our efforts to present multimodal questions during the interviews. We found that neurodivergent participants did not prefer to “talk aloud” while working on the tasks. From this experience, we suggest that researchers be mindful of different communication preferences, such as vocal or written communication, when interviewing neurodivergent participants. Based on the observations of individual task completion and the experience of our participants, we provide suggestions for potential employers of neurodivergent workers regarding the design of tasks in digital work environments.

5.2 Related Work

There is a small but growing body of research studying how neurodivergent workers experience crowd work (Hara et al., 2019; Hara and Bingham, 2017; Uzor et al., 2021; Zyskowski et al., 2015). Crowd work, specifically in work involving data annotation, often involves significant attention to detail and detail processing. Some neurodivergent workers may have strengths in memory ability, information processing, and may have a strong interest in digital technology (Murray, 2018). Tomzcak and Kulikowski (2023) discuss these strengths, citing research from authors that specifically evaluated perspectives of those with ASD. They propose that compared to neurotypical people, if work is paired with these strengths, it could reduce burnout (Tomzcak and Kulikowski, 2023). Additionally, in an interview with crowd workers and job coaches

with disabilities, which included a subgroup that identified as neurodivergent, Zyskowski et al. (2015) found that both job coaches and workers regard crowd work as a viable source of employment and that neurodivergent workers currently participate as remote crowd workers.

Zyskowski (2015) also highlighted the concerns of workers regarding pay in crowd work settings. The workers reported that their main concerns with crowd work were user design, pay, and performance ratings, and, to a lesser extent, the lack of socialization opportunities (Zyskowski et al., 2015). It was estimated that most crowd workers make less than minimum wage (Hara et al., 2018; Hara et al., 2019; Hornuf and Vrankar, 2022), and neurodivergent workers are often underemployed, which leads to fewer chances for financial independence (Khalifa et al., 2020). Additional studies analyzed payment issues within the micro-task economy, noticing that crowd workers often spend a significant amount of time working on tasks without pay – searching for tasks, working on rejected tasks, or starting work without completing tasks (Uzor et al., 2021). Uzor et al. (2021) completed a survey of 600 participants identified as having various disabilities to gain insight into the accessibility challenges of crowd work platforms such as Amazon Mechanical Turk. They observed that 43% of the participants struggled with the time required to complete micro-tasks, there was insufficient time to complete the tasks to their satisfaction, and some participants reported higher levels of anxiety and depression due to these time limits.

The challenges identified in these previous studies highlight the pressing need for changes within digital work platforms for data annotation. However, when developing these digital work environments to be favorable for neurodivergent workers in

employment, we must also understand the experience of neurodivergent workers— their responses and perspectives regarding data annotation tasks (Praslova, Bernard, Fox, & Legatt, 2023). Given the potential of these digital work environments as an avenue to reduce unemployment in the neurodivergent population, our study aims to provide insights into the opportunities and obstacles in reaching that goal, such as identifying task challenges and suggestions for digital work features.

5.3 Methods

For the study, we recruited neurodivergent participants, and built a custom web platform that presented 3 types of text and image annotation tasks that were common representations of objective and subjective tasks typically found in platforms such as AMT. Upon the completion of each task, we conducted a semi-structured interview and survey to gain insight into the experience of our participants regarding the tasks presented within the platform. This section outlines the methodology of our exploratory study.

5.3.1 Participants

We recruited 10 self-identified neurodivergent participants between the ages of 18-30, through social media postings and emails to local agencies supporting neurodivergent individuals in employment (Table 5.2). Following recruitment, we asked participants to take part in an informed consent meeting to explain the study and answer any questions they had about their participation. All screened participants consented to participate. An Institutional Review Board approved all procedures.

5.3.2 Custom Platform and Tasks

We chose to build a custom platform to tailor data collection and perform our study remotely through Zoom using features such as the share screen and the participant

control screen function in the Zoom platform. This was for two reasons. First, we were able to log a wider range of worker behavior than is possible using AMT, such as recording response latency, and participant duration per question. Second, using our platform, we could interact with the workers remotely through Zoom and could record the work sessions for analysis, which is not enabled by AMT. AMT restrictions prevented performing such a user study on the AMT platform using Zoom. Remote interaction with Zoom was a necessity, because due to COVID-19 restrictions, we were not able to have in person contact with participants. We created the tasks to closely resemble common tasks at AMT and followed previous research suggestions in design regarding the task design (Pavlov, 2014; Sarhan, 2019) and task instructions (Manam and Quinn, 2018). Within each task, we also implemented a “Skip” feature that allowed users to skip questions and explain their reasons for skipping a question. The platform measured time spent on a task and logged cursor movements, keyboard strokes, response latency, and mouse button clicks. We used a Latin square design (Gao, 2005) for the presentation of tasks and randomly ordered our questions within each task, to reduce the likelihood of ordering effects on participant responses (Cai et al., 2016). Access to the platform will be available upon request.

We studied three different tasks: receipt transcription, picture analysis, and movie reviews. These tasks were representative of some image and text annotation tasks found in AMT, with 20 questions per task, randomly selected from each of the datasets per task in our custom platform. We also designed our tasks to be similar to those used in

previous research (Hara and Bingham, 2017). The summary of the tasks is shown in Table 5.1.

Table 5.1. Summary of Tasks

Task	Dataset	Description
Receipt Transcription	ExpressExpense Sample Receipt Database (Janík, n.d).	Participants were asked to fill out the information for the shown receipt from an image of a restaurant receipt
Movie Reviews	IMDB movie review dataset (Maas et al., 2011),	Participants were asked to: “guess the rating that the reviewer entered (1=Bad, 10=Great)” by selecting the number of stars. In addition, participants were asked “why did you choose this rating” to provide insight into their answers.
Picture Description	Visual Genome (Krishna et al., 2017).	Participants were asked to “write five descriptive words for the image” and “write a sentence to describe the image using at least 10 words.” Five separate text boxes were provided for the keywords and one text box for the sentence.

5.3.3. Data Collection

Following the consent meeting, participants met with the researchers for separate “work sessions” via Zoom. We gave participants access to the web platform through a computer dedicated to the study in the research lab and Zoom’s remote function. With participant consent, all sessions were recorded and transcribed by Zoom. Some participants required more time to complete tasks and were asked to return for a second

and even third “work sessions” to complete the tasks. Most sessions lasted around 60 minutes. Following each task during each “work session,” participants were asked if they needed time for a break.

Each task started with two practice questions. We used the first question to model for the participant how to use the web platform to respond to questions, as well as how to use the skip and submit buttons featured on each question page. The second question allowed the participant to practice. We provided help only if the participant had issues or questions about interacting with the platform. As this was an exploratory study, to study the participants’ behavior and experiences, we did not provide direct feedback on their responses in the platform while answering questions. We also modeled for participants how to “talk-aloud” (Laffal et al., 1985) while working on the tasks. This was in the form of narrating the selection of responses and why they were selecting the response.

Following the two practice questions, participants worked independently on the remaining 18 questions. During this time, we muted the microphone and turned the camera off. We designed this protocol to measure how participants interacted with the tasks. If participants asked questions during the tasks, we unmuted the microphone and turned on the video camera to respond. If the participant asked for feedback about their responses, such as if they were correct or incorrect, we responded with “Do your best,” and did not provide feedback on the response. If the participant asked a technical question (e.g., mouse battery needed changing), or for a break, we responded to their question.

Following each task, we asked participants questions from NASA-TLX, a reliable and valid tool that measures subjective workload assessment in tasks (Xiao et. al. 2005;

Hart, 2006). Participants were asked to rate on a scale of one through five (one being strongly disagree and five being strongly agree) the following questions: “Was the task complex?” (Mental work), “Was the physical activity strenuous?” (Physical work), “Did you work hard to accomplish your level of responding” (Effort), “Did you feel your pace completing the task was fast?” (Pace), “Did you feel successful?” (Success), “Did you feel frustrated?” (Frustration). We asked each participant why they selected their response to the survey questions, and we also asked additional open-ended interview questions to gather more information regarding the participant’s experience, such as “Did you experience any challenges, and if yes, what were they?”, “Is there anything you would want to change about the tasks?”, and “Is there anything in addition that you would like to share about your experience while completing the tasks?”

5.3.4 Data Analysis

To answer research questions about task completion and the experience of the participants, we used a different data analysis approach for each task, as each task presented varied data analysis challenges. For tasks where we had a ground truth annotation (receipt transcription and movie review), we calculated accuracy and mean absolute error. For subjective annotation tasks (picture description), we classified responses into common categories, following suggestions for subjective data annotation analysis from previous research (Alm, 2011; and Hube et al., 2019). To understand the experience of our participants, we collected data from the survey and open-ended interview questions from the NASA-TLX (Hart, 2006; Hong et al., 2018; and Yan et al., 2022).

5.4 Analysis and Results

5.4.1 Analysis of Responses

For the receipt transcription task, we determined the ground truth answers by examining each receipt. We then manually compared the answers provided by each participant with the ground truth. We ignored questions that participants skipped when using the skip button. For each participant, we calculated the percentage of correct entries in text boxes. We deemed the answer incorrect if the answer was different from the ground truth, ignoring minor spelling mistakes and capitalization.

The Receipt column in Table 5.2 reports the accuracy for each participant. One participant reached an accuracy of 96%. Six participants had an accuracy over 90%. We noticed that some participants made consistent errors, such as entering incomplete street names (P02).

The dataset contained ground truth labels (on a scale of 1-10; with 1 being bad and 10 being excellent) about the movie review. We calculated the mean absolute error (MAE) as the average absolute difference between the response and ground truth. Bias scores were calculated as the average difference between the responses and ground truth.

We observe from the MAE column in Table 5.2 seven of the participants (all self-identified as having ASD) had scores greater than a MAE of 2.0. When examining the properties for this task, we find that this task required attention, focus, and emotion recognition, which may be challenging for individuals with ASD (Baron-Cohen, 2000; Brewer et al., 2016; Schall and McDonough, 2010). All three participants with MAE less than 2.0 self-identified with ADHD. Though they have challenges in attention and focus,

individuals with ADHD do not necessarily experience challenges with emotion recognition (Woods et al., 2002).

We also asked participants to explain why they selected each sentiment to understand their reasoning behind the answers. As shown in Table 5.2, we coded the explanations into three categories: 1) explaining the tweet (Desc), 2) out of context (OOC; off topic or did not match the context of the tweet), and 3) personal association (Assoc). An example of a personal association is the comment “I love the Guardians of the Galaxy movie,” when justifying their rating selection that mentioned the movie “Guardians of the Galaxy.” Six out of seven participants with ASD (P01, P02, P06, and P09) often used out of context or personal associations for their justifications. It is important to note that this was a subjective task, and these responses are not necessarily “incorrect” but were different and not directly related to the movie review.

Picture Description. In this task, despite the Visual Genome dataset containing a specific set of attributes and object labels per picture, questions to the participants were open ended. To analyze the five keywords entered to describe each picture, we manually categorized the entered keywords into six coding classes: 1) objects (e.g. labeling actual items in the picture), 2) setting (e.g. labeling where the picture appeared to be located, such as a “city” or “forest”), 3) actions (e.g. labeling what someone was doing in the picture), 4) emotions (e.g. labeling how someone may be feeling such as “happy,” or “sad”), 5) attributes (e.g. labeling colors, shapes, or textures), 6) associations (e.g. labeling a personal connection to the picture, such as the name of something they were reminded of in the image, but not present in the picture).

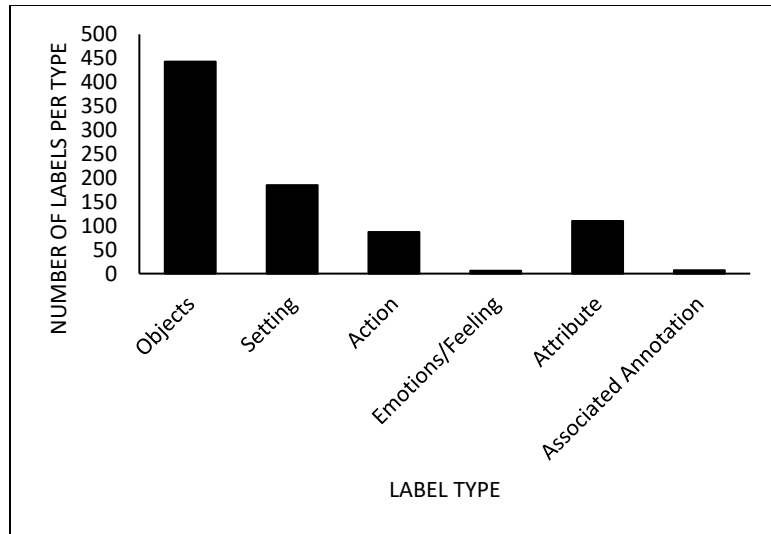


Figure 5.1. Distribution of number of label types for the picture description task.

We counted the distribution of keyword categories for participants as shown in Figure 5.1. Overall, the most common keywords were in the object category, followed by setting, attributes, and actions. Emotion and associations were used very rarely. Some of the associative annotations entered by participants related to their own personal experience rather than a description of the picture. For example, one participant entered the name of the resort they visited when shown a beach picture.

Table 5.2. Results. a) Participant id, b) participant self-identified diagnosis, c) total skips, d) average duration in seconds per question per task, e) mean accuracy for receipt transcription, f) mean absolute error movie review tasks, g) mean bias per participant in movie reviews, and h-j) and justification categories for movie review tasks (Description, Out of Context, and Association).

Id	Dx	Skips	Duration	Receipt	Movie				
				Accuracy	MAE	Bias	Desc	OOC	Assoc
P01	ASD	9	94.2	92%	3.5	-1.28	0	3	15
P02	ASD	1	78.6	78%	2.72	1.28	6	8	4
P03	ASD	2	62.2	94%	2.06	0.28	17	0	0
P04	ADHD	4	68.2	96%	1.17	0.61	18	0	0
P05	ASD, ADHD	0	130.4	93%	1.39	-0.06	18	0	0
P06	ASD	7	204.0	89%	3.89	0.11	3	9	2
P07	ASD	9	105.6	74%	2.94	-2.39	9	0	4
P08	ADHD	1	68.5	91%	1.39	-1.06	15	0	3
P09	ASD	22	61.7	61%	3.5	0.94	1	15	2
P10	ASD	0	79.7	93%	2.06	0.06	14	0	4
Avg		5.5	95.3	86%	2.46	-0.15	10.1	3.5	3.4

5.4.2 Analysis of Work Completion

Work completion is important in data annotation, as skipped responses lead to missing data, which is undesirable for employers in data annotation work. We measured work completion by counting how often participants did not answer parts of questions or when they skipped whole questions. As shown in the Skip column in Table 5.2, four participants had 5 or more skipped questions, and these participants self-identified as

having ASD. We observed that the picture description and movie review tasks caused the largest number of incomplete or skipped questions. These tasks required the participant to read long passages, and type novel responses based on what was provided, as compared to the receipt transcription task which involved transcribing what was in the image.

5.4.3 Analysis of Time Per Question

Speed is an important component of work. Crowd workers are typically paid a flat fee to complete a task, and the time to complete a task directly influences the hourly rate for crowd work. The time column in Table 3 shows the mean time in seconds per question across all tasks. P05 and P06 took the longest per question (Table 5.2), and we noticed that they spent more time with movie reviews which involved reading long paragraphs of text. Upon inspection of Zoom sessions, we observed that P05 was working on a second screen in parallel with our tasks (presumably on other activities) which may have affected their time per question.

5.4.4 Analysis of Effective Hourly Pay

Worker payment for data annotation tasks, as previous research notes, is a major issue in crowdwork (Hara et al, 2018; Uzor et al., 2021). A study by Hara et. al in 2018 estimated that the hourly wage for crowd workers on AMT ranged from \$4.80 to \$6.19 per hour (Hara et. al., 2018). In this section we wanted to compare the pay potential for participants in our study. To make it easier to follow the results, we assumed that the hourly pay (*HP*) of an average successful worker in our participant group is \$10 per hour ($HP = \10). Let us denote as t the time a particular worker needs to complete a task. We define a successful worker as a worker who answered all questions in a particular task, regardless of the time needed for them to answer the questions and regardless of the

accuracy of the answers. Let us denote as $avg(t_{EX})$ as the average time our successful participants needed to complete a task. We calculate the effective hourly pay (EHP) (5.1) for a particular worker on a task as:

$$EHP = HP \cdot avg(t_{EX})/t. \quad (5.1)$$

For example, if the average time on a task of successful workers was 10 minutes, and a particular successful worker needed 20 minutes to complete it, that worker's EHP would be \$5 per hour.

However, because our platform allows workers to skip questions (and this is a common feature on most crowdsourcing platforms), we assumed that such workers should not be paid for skipped questions. Thus, we calculated the fraction of answered questions on a task f for each worker ($f = 1$ if the worker answered all the questions). Then, the EHP (5.2) is calculated as:

$$EHP = HP \cdot f \cdot avg(t_{EX})/t \quad (5.2)$$

For example, if the worker from the previous example who spent 20 minutes on the task answered only 50% of the questions, that worker's EHP would be only \$2.50 per hour.

From this, we calculated the EHP for all participants in our study on each of the three tasks and show the results in Table 5.3. We observe that the average EHP for our participant group was \$10.18 for the movie task, \$9.59 for the picture task (less than our set hourly pay); and \$13.07 for the receipt task. The lowest paid worker (P09) on the picture analysis task, would earn only \$1.95.

It is also worth noting that task requesters for crowd work are likely to refuse payment if the answer quality is not satisfactory. In addition, they might even refuse to pay if there are many skipped questions or if the work is not finished fast enough. Given

this, we observe that the participants that skipped many questions (i.e. P06 and P09) would risk not getting paid at all for their work.

Table 5.3. Effective hourly wage per task.

Id	Movies	Picture Analysis	Receipts	Average per participant
P01	\$5.52	\$7.83	\$18.38	\$10.58
P02	\$12.50	\$8.26	\$9.60	\$10.12
P03	\$12.75	12.61	\$25.64	\$17.00
P04	\$10.04	\$14.02	\$22.34	\$15.47
P05	\$5.33	\$7.99	\$8.08	\$7.13
P06	\$2.05	\$9.24	\$4.86	\$5.38
P07	\$14.39	\$11.43	\$3.69	\$9.83
P08	\$12.77	\$9.86	\$18.93	\$13.86
P09	\$15.22	\$1.95	\$11.37	\$9.51
P10	\$11.26	\$12.66	\$7.82	\$10.58
Average per task	\$10.18	\$9.59	\$13.07	

5.4.5 Analysis of Participant Experience

To gain insight on participant experience regarding the tasks, we asked participants to rate six NASA-TLX questions (Mental work, Physical work, Effort, Pace, Success, Frustration) (Hart, 2006) on a 5-point Likert scale. When comparing individual responses and their experiences, we observed some interesting insights. P02, P06, and P10 rated effort as being very high (giving it 5 ratings). It is noteworthy that P02 and P10 never skipped more than one question, while P06 spent the longest time on the tasks.

P09 reported the highest level of frustration across tasks (average of 3, compared to the other participants' average of 1) and this participant had the most skipped questions.

We also asked participants open-ended interview questions regarding their experience as they were going through the tasks, and encouraged them to “talk aloud,” while going through the tasks. Despite having a model of “talk aloud” at the beginning of each task, participants chose not to talk aloud during their work on tasks. This is consistent with the previous literature stating neurodivergent participants, particularly those with ASD, may have difficulty in with vocal communication (Schall and McDonough, 2010). Thus, gathering qualitative information using this method presented a challenge.

When asking our open-ended interview questions of participants, we provided the option for participants to type in Zoom’s chat feature or vocalize their responses to these questions, and we found that two participants, P02 and P09, preferred to type some of their responses. In reviewing the transcripts from interviews, we can group the responses from participants into three themes regarding the tasks: task preferences, challenges with tasks, and suggested features for digital work environments and tasks.

5.4.5.1 Task Preferences. Overall, most participants found the tasks to be enjoyable. Regarding the receipt task, participants found this task to be easy because: *“It was very straightforward” (P04)*, and *“I was really good at this because the information for the addresses and phone numbers were right there” (P10)*. For the picture analysis task, P07 noted, *“It was easy because I could easily find things in the picture. It's a fun assignment to get paid for” (P07)* and P05 stated, *“There's really no wrong answers unless you're just describing something that's not there” (P05)*. Several participants

enjoyed the movie review task because, *“movies make me happy”*(P06), and *“that's my thing. I love movies! It was fun!”* (P08). It was interesting to observe that P03 and P04 both chose to write sentences before providing the descriptive words for the picture analysis task, working directionally from the bottom to the top of the page. When asked about this preference, P04 stated: *“Creating the sentence is easy to do first because you are making an outline for yourself to come up with the five words”* (P04).

5.4.5.2 Challenges with Tasks. All participants reported challenges with deciding annotations for the subjective tasks. For the picture analysis task, P01 stated: *“It's kind of hard to decide on a descriptive word. Some of the images do not have many details”* (P01), and P05 stated: *“Some pictures I felt like I had a lot to work with in terms of describing it, and then there were some where it felt like I couldn't really say a lot without repeating myself”* (P05). For the movie review task, P02 stated that *“I worked slowly because I was reading the sentences. It took a while. These questions were hard”* (P02), while P03 reported that: *“It was hard to determine the rating based on what they said”* (P03). P07 also reported that working alone on the tasks without the researcher present caused some anxiety. They said: *“My anxiety takes over when I have to work by myself. What if I accidentally type in the wrong information”* (P07). For receipt transcription, participants reported challenges with handling missing information: *“Typing and finding the state on the receipt was hard. It was also hard when the phone number wasn't there”* (P02). We did provide participants with written instructions to skip missing information; however, participants still reported this as a challenge. In addition to handling missing information on the receipt transcription task, participants reported

trouble reading the receipts. P05 reported: *“Some of them were small and hard to read from the screen” (P05).*

5.4.5.3 Suggested Features for Digital Work Environments. Participants also provided suggestions for setting up inclusive and accessible digital work environments in data annotation for neurodivergent workers. Participants suggested that requesters provide clear instructions for tasks with visual examples, visual and auditory stimuli, accessible keyboard functions, word counters, and screen readers. For auditory and visual stimuli, participants requested auditory and visual stimuli to provide feedback and backgrounds on the screen to help them focus. P05 stated, *“It would be nice to have something to help focus after each question, either a sound or an image” (P05).* Specifically in the movie task where participants had to read long passages of text, P08 stated *“The reading kind slowed me down; it would be good to have something to read the text for me” (P08).*

5.5 Discussion and Conclusion

Based on the responses and experience of participants in this study, our findings have implications for designing tasks in digital work environments that highlight the strengths of neurodivergent workers. We found that in our study, participants had a higher quality of responses on objective tasks such as receipt transcription. Thus, digital work environments containing more objective tasks may be preferable for some neurodivergent workers. It is important to note, however, that neurodivergent workers may not effectively identify preferable tasks unless they have access to the needed information to make these decisions. Previous related research developed a browser plugin that aggregates data from AMT, enabling crowd workers to self-identify tasks that

yielded higher wages (Callison-Burch, 2014), thus reducing the penalty that “invisible labor” (Toxtli et al, 2021) may pose for neurodivergent workers. Our findings from the use of our custom platform, could inform the development of similar tools within real world data annotation platforms to enable neurodivergent workers to select tasks that best match their skill sets and are more likely to yield higher wages and increase job satisfaction.

Incorporating individual preferences and matching unique skill sets to the task can also help workers perform better and decrease pay discrepancies caused by skipped or incomplete responses (Uzor et al., 2021; Walsh et al., 2020; Zyskowski et al., 2015). This would also benefit requesters or employers of such tasks; in that they would get higher quality data annotations. Though we echo previous findings that worker-job matching while providing assistive, inclusive technology is important when recruiting neurodivergent participants for tasks in digital work environments (Hara and Bingham, 2017; Tavanapour and Bittner, 2019), further study is needed to evaluate employer perspectives regarding incorporating task preference, designing tasks and task instructions within digital work environments. In our study, we designed our tasks within our custom platform with instructions based on suggestions in design regarding the task design (Pavlov, 2014; Sarhan, 2019) and task instructions (Manam and Quinn, 2018). Task requesters on platforms such as AMT often post tasks with unclear or ambiguous directions (Manam and Quinn, 2018), which may frustrate or confuse both neurodivergent and non-neurodivergent workers. Developing assistive and inclusive tools to support in the learning of these tasks and reducing frustration may be beneficial for all data annotation workers.

Based on our observations on the individual responses of our participants within our platform, it is possible to envision building customized virtual coaching and support systems for some participants within current data annotation platforms such as AMT, perhaps through the use of generative AI language and computer vision models. For one participant (P09) we observed that they skipped many questions within the tasks. Mechanisms such as auditory or visual prompts built into the digital work platform may reduce skipped responses for this participant. While such assistive tools are difficult to add to AMT, they may be implemented through browser plug-ins. Companies that provide in-house labeling on custom platforms could also integrate these tools into their current systems. Participants P06 and P07 required more time to complete tasks. Matching these participants to tasks that do not require timed responses would prevent penalties (loss of wages) for the slower pace. Regarding working independently, in a digital work environment setting, P05 stated: *"I did find myself putting something on to listen to on my other monitor here. Because I don't like it when there's just silence, and I have no external stimuli when doing repetitive tasks like this."* Providing a built-in system with background music or visual stimuli for this worker may be beneficial. On the other hand, related research found that too many stimuli may distract some workers in a digital work environment (Das et al., 2021). Thus, such environments need to be customized to individual worker preferences.

In addition to developing tools for support, researchers should be aware of the preferred communication methods of neurodivergent study participants. For example, we observed for two of our participants, typing into a text box was preferred in comparison to vocal communication. By incorporating the preferred communication method by

neurodivergent participants, as researchers, we were able to gather more information on participant experience. This would, in turn, facilitate the inclusion of diverse viewpoints in design studies. We echo the statements of previous researchers supporting the inclusion of neurodivergent participants on research teams, so that study design is better informed by their experience (Motti, 2019; Spiel et al., 2020; and Sam and Hillman, 2022).

Another critical challenge for future research is to understand if crowd work can be an entry point for long-term positions, such as work in data entry, medical billing, and office administration. While many tools have been developed for workers who are blind, or who have low vision (Kacorri et al., 2017; Medina et al., 2022), very few studies have focused on developing tools for neurodivergent workers (Motti, 2019; Rapp et al., 2019). There has been some research on framing micro-tasks as internship opportunities for crowd workers (Suzuki et al., 2016). However, more research is needed in this space to study the link between micro-tasks in digital work environments and long-term employment outcomes. Future studies could investigate training neurodivergent workers using real world data annotation platforms such as AMT and evaluating if the skills in training generalize to other data entry settings in accounting and medical offices.

An obvious limitation was the small sample size of the study. With ten participants, it was hard to generalize our observation of responses to a larger neurodivergent population on data annotation tasks, especially when considering the diverse subgroups of our participants, where seven participants self-identified as having an ASD, and two self-identified as having ADHD. One participant identified as having both ASD and ADHD. For this reason, we did not have enough statistical power to make

general conclusions about ASD and ADHD subgroups. Another limitation is that this paper targeted neurodivergent participants rather than neurodivergent and non-neurodivergent participants. The purpose of the study was to highlight the experiences of neurodivergent workers when completing data annotation tasks, rather than a comparison of their responses to a different group of participants. Regardless, we believe that these results provide helpful information that may inform follow-up studies, such as an experimental comparison of neurodivergent and non-neurodivergent worker responses on “real-world” tasks found in AMT or other platforms. Future studies could investigate the similarities and differences between subgroups of neurodivergent workers and responses in data annotation tasks.

It is important to note that another limitation is in the types of tasks selected for the study. For this study, we evaluated three different tasks, that were inspired from real world AMT tasks. These three tasks were chosen to provide a representation of various image and text annotation tasks, but there are many more types of tasks on platforms such as AMT, such as image annotation, object recognition, and audio transcription tasks. Future studies should evaluate the responses and experiences of neurodivergent workers across all of the different types of tasks found in platforms such as AMT, in order to gain more insight into task preferences and challenges.

In conclusion, the results from this exploratory study provide some insight regarding task completion, effective pay, and the experiences of neurodivergent workers when completing image and text-based data annotation tasks. These results suggest that some micro- tasks may be a good match for the unique skill sets of some neurodivergent workers. As a byproduct of our results, we also observed potential issues with wages for

our participants in different micro-tasks. Based on this information, our team is working on future studies evaluating the task design and instruction preferences of neurodivergent workers, as well as studies to develop and evaluate generative AI prototypes that provide individualized coaching and support in data annotation tasks within real world digital work environments. These future studies may reduce wage inequality and frustration found in current data annotation tasks, supporting an entry-level avenue for full time data entry jobs for neurodivergent workers.

CHAPTER 6

SUMMARY, CONTRIBUTIONS, AND FUTURE RESEARCH

6.1 Overall Summary

This thesis outlines the potential use of AI as assistive technology across the lifespan of neurodivergent users within two domains: communication and employment. In Chapter 2, we explored the use of an SGD-controlled game. In this study, we discovered that all five participants engaged in some capacity with the SGD and the game, and two participants engaged in moments of joint attention with the game's facilitators. We present design implications for using AI in future game design in pre-game tutorials, personalization of use, and development of these games to facilitate turn-taking and social interaction between autistic children, their caregivers, siblings, and peers.

Chapters 3-4 explored the use of assistive technology with autistic job seekers as they navigate the hiring process. We discovered that stakeholders in our exploratory study of assistive technology in Chapter 3 did not mention the use of AI for most of the checkpoints along the hiring pathway and that self-directed job seekers mentioned assistive technology the least across the three pathways to employment (University, Job Coaching, and Self-Directed). In Chapter 4, when introducing an AI intervention as assistive technology (ChatGPT Interview Coach), we discovered design recommendations and the perspectives of autistic job seekers and job coaches towards building a new AI interview coach prototype. Finally, in Chapter 5, we explored a digital work environment with neurodivergent users, observing their responses to the

environment and learning about their perspectives on working within a digital work environment.

This thesis hypothesized that leveraging AI as assistive technology, when designed with an understanding of neurodivergent users' perspectives and experiences, may address challenges that neurodivergent individuals face across their lifespans. The studies' findings support this hypothesis, with some limitations. First, each study identified concrete ways in which AI could address challenges faced by neurodivergent individuals, with the first study supporting communication and engagement through SGD-controlled games and our remaining studies identifying moments of AI as assistive technology when supporting job-seeking preparation and workplace task completion. Through these formative studies, we discovered that our participants' perspectives and experiences revealed the need for more research in AI-enabled assistive technology. Specific design opportunities for AI-enabled assistive technologies were also identified across all studies, providing a foundation for future development and testing.

Despite these findings, our research did have some limitations. Our studies did not test the effectiveness of the proposed AI solutions in real-world settings over time. While future directions for design were identified, their actual impact still needs to be empirically validated. In addition, no single AI approach will address all the needs of neurodivergent users, and future studies will need to explore personalized solutions that can adapt to individual preferences and strengths. The research, particularly within our game study, also revealed that technological solutions must be integrated within supportive social frameworks to be effective (Garrison et al., 2025).

6.2 Contributions

This thesis makes several contributions to human-computer interaction, assistive technology, and neurodiversity research. Regarding theoretical contributions, the first study establishes a framework for designing AI assistive technologies for autistic children who cannot communicate their experience with researchers. Empirically, identifying moments of joint attention between autistic children and facilitators during SGD-controlled gameplay also provides evidence of such technologies' potential to enhance communication.

Within the employment domain, our identification of four checkpoints in the hiring process experienced by autistic job seekers provides a structured approach for understanding where and how technological interventions might be most beneficial, and the discussion of challenges faced by autistic job seekers during the hiring process provides grounding for future research. Additionally, the research on using an intelligent interview coach showed that autistic job seekers and job coaches may view AI tools as collaborative assistants during the hiring process. The research also showed specific challenges we observed by neurodivergent individuals in digital work environments, creating a foundation for future research studying AI tools as assistive technology in these environments.

From a design perspective, the research establishes preliminary design recommendations for SGD-controlled games to enhance communication and engagement for autistic children. The study of the AI interview coach led to specific guidelines for prompt engineering when designing the next iteration of the AI interview coach. Our

digital workplace study also identified moments where designers can explore using AI as assistive technology to support neurodivergent workers in a digital work environment.

6.3 Future Research Directions

As exploratory studies, our sample sizes were small and were not generalizable. Future research should expand to include more participants with varied neurodevelopmental conditions, cultural backgrounds, and geographical locations to ensure that the use of AI as assistive technology can truly address the challenges experienced by neurodivergent individuals. While this exploratory approach was appropriate for the initial investigation of these topics, future work should include controlled studies to test the effectiveness of AI-enabled assistive technology.

Additionally, the research captured perspectives and interactions at single points in time rather than tracking outcomes over extended periods. Longitudinal studies would provide insight into how AI assistive technologies might impact neurodivergent individuals' development of skills over time across different domains.

Building on the contributions and limitations of this dissertation, several directions for future research emerge. Future work should examine caregivers' perspectives for designing AI assistive technology within the communication and employment domain. Additionally, future work should focus on collaborative design methodologies that involve neurodivergent individuals as co-designers rather than simply participants, particularly for the AI employment tools identified in this research. Research exploring how AI assistive technologies might function across support networks, such as within educational services and vocational rehabilitative services, could also provide a more holistic approach when evaluating the use of AI as assistive technology for

neurodivergent individuals throughout their lifespan. As AI advances, it will be exciting to see how this technology can support the inclusion and skill development of neurodivergent users as assistive technology.

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