

# The Workplace Playbook VR: Exploring the Design Space of Virtual Reality to Foster Understanding of and Support for Autistic People

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A growing number of organizations are hiring autistic individuals as they start to recognize the value of a neurodiverse workforce. Despite this trend, the lack of support for autistic employees in workplaces complicates their employment. However, little is known about how people around autistic individuals can support them to create pleasant employment experiences. In this work, we develop the concept of the *Workplace Playbook VR* to investigate how virtual reality (VR) can help autistic people develop their work-related social communication skills in partnership with people in their support network. Using a video prototype to present the concept, we interviewed 28 participants, including 10 autistic people and 18 members of their support networks, which included family members and professionals. Our interviews revealed that the *Workplace Playbook VR* program can provide common ground for autistic people and members of their support network to participate in more empathetic communication regarding workplace challenges. Despite the benefits, we identified the potential misuse of social communication skills training features of the VR program to correct the personal characteristics of autistic individuals. Furthermore, to cultivate inclusive workplace environments, we found the needs of VR development not only for autistic people but also for neurotypical employees to promote their understanding of autism and empathy toward autistic employees. We suggest VR designs that promote a sense of agency and self-advocacy for autistic employees, and autism awareness and acceptance training for neurotypical employees.

CCS Concepts: • **Human-centered computing** → **Collaborative and social computing**.

Additional Key Words and Phrases: Autism, Neurodiversity workforce, Virtual Reality (VR)

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## 1 INTRODUCTION

There is a growing interest in building inclusive workplaces as organizations begin to recognize the value of a neurodiverse workforce. An increasing number of companies are making endeavors to hire autistic people<sup>1</sup> as the strengths, values, and talents of this population gain wider recognition. However, the employment rate of autistic people is only 15%—much lower than the 54% employment rate of people with other types of disabilities [19, 85]. Studies have shown that a lack of support and accommodations regarding the challenges autistic people encounter at work—such as social communication skills—complicates their successful employment [33, 65]. Moreover, the lack of appropriate understanding about autism among employers and co-workers is identified as one of the most common barriers preventing autistic people from finding and retaining employment [22, 54].

Virtual reality (VR) has been studied as an effective medium to provide vocational support for autistic people, for instance through training in social communication skills for job interviews [89] or job tasks (e.g., money management) [14]. Simulated reality provides an interactive learning environment that enables autistic people to practice skills multiple times in various scenarios [23, 92]. Moreover, sensing technologies that measure the behavioral and physiological signals of autistic individuals during VR interactions can personalize VR experiences and provide helpful insight and feedback about their behaviors [13, 55]. This rich body of past work, although not specific to work-related settings, has also shown the effectiveness of VR interventions in increasing autistic people's vocational skills [16, 41].

Despite the potential of VR to mitigate the challenges that autistic people may face at work, little is known about how VR technology can be deployed in contexts where autistic people actually interact with others to improve their work experiences. Moreover, to establish inclusive workplace environments where autistic employees can fully realize their potential while being well-respected, neurotypical employees should learn how to understand, appreciate, and respect autistic co-workers. However, most published studies focus on how VR interventions can increase autistic people's job-related skills [14, 21] and do not address interventions that target neurotypical employees. Few studies have investigated the design spaces of VR technology in promoting understanding and empathy of neurodiversity in the workforce. One study that featured a commercial company called Equal Reality showed that VR training programs that allow people to walk through various virtual social situations from the perspective of others of a different race, gender, or personality can promote empathy and inclusion in a work environment [25]; similar training programs may help develop empathy between neurotypical and neurodiverse employees. However, we have a limited understanding of how VR designs can better facilitate communication and understanding between autistic people and the community around them.

This study aims to uncover design spaces in VR where autistic people and members of their support networks can utilize VR technology to enhance the work experiences of autistic individuals. We define a support network as the people to whom autistic individuals might reach out to discuss their work-related issues, including family, friends, and professionals (e.g., special education teachers, therapists, or work managers)<sup>2</sup>. To investigate this idea, we created a video prototype that presents a VR system concept called *Workplace Playbook VR*. The prototype presents *Workplace Playbook VR* with a story of an autistic individual who virtually experiences job-related social

<sup>1</sup>We use identity-first language due to a reported preference of autistic people [44] and recent movement in academia [10].

<sup>2</sup>Professionals are defined as people who have expertise in challenges that autistic people face at work.

situations while wearing a head-mounted VR device<sup>3</sup>. After the experience, the individual reviews practiced behaviors together with a member of their support network using a tablet. The reflection process is facilitated by the interface, which visualizes the behavior and physiological features of the autistic individual such as turn-taking, eye contact, and heart rate, which are collected during the VR practice. To elicit feedback about *Workplace Playbook VR*, we conducted semi-structured interviews with 10 autistic people, seven family members of autistic people, and 11 professionals.

This work offers the following contributions:

- First, we propose and evaluate a conceptual VR system called *Workplace Playbook VR* that is designed to address the challenges of autistic adults. This fills a gap in the existing literature as most autism technology research focuses on children and adolescents.
- Second, our work contributes to the under-researched area of autism technology by adopting a socio-ecological lens of autism instead of a medically focused orientation. We uncover a potential danger of VR system designs that focus on training social communication skills as this can force socio-normative behaviors on autistic people. Thus, we suggest VR designs that promote a sense of agency and develop autistic people's self-advocacy skills.
- Third, our work responds to calls to involve autistic people in the early stages of technology design. We show how our inclusive design methodology effectively engaged autistic participants in the study and elicited rich feedback.
- Finally, we discover the design space for interventions targeting neurotypical employees and managers to develop understanding and appreciation of autistic employees.

## 2 RELATED WORK

### 2.1 Neurodiversity in the Workplace

Recent efforts have been made to create an inclusive workplace environment where every employee feels valued while their differences and contributions are recognized [35, 65]. Increasingly many IT companies (e.g. SAP and Microsoft) run diversity and inclusion divisions to support the work lives of neurodiverse people [4, 69]. In these programs, the strengths of neurodiverse people such as attention to detail and intense focus [88] are leveraged to the company's best advantage, such as by assigning IT product Quality Assurance (QA) to autistic employees. Workplace inclusion programs also provide opportunities to improve autistic employees' work experiences [28, 69, 95]; for instance, Cornell University's Yang-Tan Institute offers an Autism at Work program to educate human resource professionals about how to actively hire autistic individuals and foster an inclusive workplace culture [95].

Despite such efforts to develop inclusive workplace environments, barriers experienced by autistic individuals at work persist [33]. Communication and social difficulties are often identified as challenges to engaging in interactions with co-workers and supervisors [18, 45, 65, 96]. In addition, the negative attitudes of employers, managers, and co-workers often discourage autistic people and heighten their social anxiety [18, 83, 90]. A lack of individualized workplace training opportunities such as social skills and self-advocacy instruction hinders the successful employment of autistic people [29, 36].

On a more positive note, research has shown that having a group of supportive and understanding people around autistic individuals can facilitate their employment [33]. A support network that includes family, friends, co-workers, and support staff who are familiar with the individual characteristics, strengths, and weaknesses of an autistic person can provide personalized and practical support in unexpected and challenging situations [39, 66, 99]. Several approaches for facilitating workplace collaboration between neurotypical and autistic employees have been reported such as

<sup>3</sup>Our concept targets VR technology that offers a simulated immersive experience through a head-mounted VR device.

mentoring or coaching for autistic employees [76] and autism awareness training for neurotypical workers [28]. For instance, a recent study examined the co-work experience of eight autistic individuals and neurotypical colleagues across a three-month internship period [76]. For this study, autistic interns were assigned neurotypical “buddies” (i.e., mentors) and guided to email their buddies if they had work-related questions. Through this individualized support, autistic interns reported feeling accepted within the workplace. More importantly, managers reported the importance of identifying the needs, strengths, and weaknesses of autistic employees for successful collaboration, and suggested that modifications such as giving very specific instructions, communicating in writing, or addressing sensory issues could help.

Despite the important role of a supportive community in helping autistic people have pleasant work experiences, we still have only a limited understanding of how such training programs can be better designed and situated to support successful work experiences for autistic individuals at scale. This study explores design opportunities of a work-related social skills training VR program that can uncover the individualized characteristics of autistic people and consider how this program can promote understanding and support from community members around them.

## 2.2 VR for Autistic People

VR has the benefit of providing a safe, controlled environment for autistic individuals to practice social skills without worrying about the negative consequences of making common mistakes associated with face-to-face interactions [1, 6, 13, 16, 24]. Furthermore, the flexible and scalable nature of VR can manipulate environments and interactions tailored to autistic people to provide personalized interventions for people with various levels of cognition, language, and social skills [62]. Based on these advantages, VR-based interventions can be applied to a range of domains such as socio-emotional skills [24], safety skills [40, 81, 82], adaptive skills [49], and communication [24, 43].

Despite the promising results of previous studies, limitations on VR interventions for autistic people have also been reported [30, 47, 68]. While previous studies found VR intervention to be effective when acquiring daily living skills [47, 63, 78], a recent meta-review study pointed out that VR had moderate effects on improving communication skills and emotion regulation skills, perhaps due to the complicated and nuanced nature of these skills [47]. Regarding methodological rigor, results of VR intervention studies are often difficult to validate and generalize due to substantial variations among autistic individuals [40, 43, 68]. Furthermore, the lack of sufficient precedent and theoretical guidance for VR intervention design and the fact that actual users were not sufficiently involved in the design process were pointed out as limitations [30, 68]. This critical view emphasized the importance of understanding the characteristics, needs, and preferences of autistic individuals and stakeholders when designing VR experiences for them [68]. Thus, our research aims to improve the understanding of how VR experiences should be designed to enhance social and communication skills by involving autistic people and members of their support networks in the early stages of VR design. Our work seeks to perform the inclusive, participatory design of VR experiences with and for autistic adults who currently face various challenges in the workplace.

*2.2.1 VR to train employment skills.* Several researchers have investigated how VR technologies support autistic individuals to acquire employment skills [14, 21]. Employment skills can be divided into two broad categories: job-specific skills called hard skills (e.g., folding, photocopying, and sweeping), and more generic employment-related skills called soft skills (e.g., time management, social skills, and interview skills) [98]. Prior technology-related studies focused more on hard skills rather than soft skills [15], even though autistic people often experience more challenges at work due to their soft skills [33]. Social situations that may arise at work (e.g., working with

co-workers, managing conflict, dealing with office politics) have been identified as major challenges that autistic people face in the workplace [65]. Although some studies investigate the use of VR to develop autistic people's soft skills, many focus on learning skills for job interviews such as how to properly communicate and respond in interview situations (e.g., emotional regulatory strategies and self-advocacy methods), use non-verbal communication (e.g., eye contact) when interviewing, and manage attire or hygiene when preparing for an interview [41, 64, 89, 93], rather than on skills related to navigating social situations associated with ongoing employment (e.g., having lunch with co-workers and working with customers). While interview skills are important for obtaining employment, more contextualized and practical support for the everyday social encounters of autistic people in workplaces would further advance their work experience, satisfaction, and success. In this work, we investigate how VR technology designed to emulate various social situations that may arise in the workplace can help autistic people and their supportive community better prepare for more pleasant and inclusive work experiences.

*2.2.2 VR to promote shared understanding and communication.* Beyond its effectiveness in the acquisition of job-related skills, it has been found that immersive VR can be an effective medium for building empathy—the ability to share and understand others' emotions by taking someone else's perspective [8, 26, 46]. Previous research on VR and empathy has shown that people who underwent a virtual reality experience simulating life events such as becoming homeless were likely to have a positive attitude toward the homeless and present pro-social behaviors (e.g., sign petitions) [37]. Empathy-building among family, professionals, and co-workers is also critical for autistic people to have pleasant work experiences [33].

Building on the previous research, we investigate how VR systems can be designed to successfully mediate communication between autistic people and members of their support network, who can help address whatever issues and concerns autistic individuals may have regarding workplace social situations. Only a few studies have examined the use of VR technologies to facilitate functional communication between autistic people and caregivers (e.g., teachers, family members, and therapists). For example, studies have used a monitoring module that allows caregivers to observe a learner's VR situations in real-time and adjust task levels and scenarios accordingly to provide appropriate feedback [60, 75]. In another study, a therapist directly participated in a VR situation as a peer character, providing responses and feedback tailored to the behaviors of autistic people [24].

To foster understanding of an autistic individual, it is important to acquire a wide range of the individual's behavioral data, which can provide a foundation for collaborative reflections between the individual and members of their support network [71, 86]. Recent studies have proposed the exploitation of sensors integrated with VR platforms (e.g., eye-trackers and motion trackers) to detect users' affective states in real-time [74, 97]. Previous studies examining sensor integration have focused on collecting behavioral and physiological data in VR-based data-driven interventions. For example, vrSocial's use of visualization of proximity, voice volume, and speech duration of autistic children in real-time within virtual spaces was an effective way for the children to better regulate their proximity in VR [13]. Another VR-based system correlated children's physiological signals with their affective states while participating in given social tasks, which resulted in a VR-based system that was adaptive to participants' performance [48]. With VR, user data such as voice volume or affective state can be collected while they interact in the virtual environments, while stakeholders (e.g., caregivers, professionals, co-workers) can contribute to the learning process [5, 57–59]. Thus, such user-generated data could facilitate information sharing, perspective-taking, and communication among both autistic people and other stakeholders [77].

Extending this body of research, we examine how VR could mediate interactions and promote understanding between autistic people and their support network to build positive work experiences for autistic individuals.

### 3 DESIGN PROCESS AND THE RATIONALE OF THE WORKPLACE PLAYBOOK VR

We developed the concept of the *Workplace Playbook VR* to elicit concrete feedback about how VR could be designed to help autistic individuals and members of their support network address the challenges that autistic people might face in their current or future workplaces. To present the concept, we created a video prototype of the *Workplace Playbook VR*. The concept presented in the video prototype primarily targeted autistic people to support their work-related social and communication skills. We made this design decision because VR has been shown to be effective for training the social and communication skills of autistic individuals [41]. Those skills are known to be some of the most pressing challenges that autistic people face in workplaces [18, 33, 65]. However, as we will report in the findings section, our study revealed that such social and communication skills training VR programs have the potential to enforce “normative behaviors” on autistic people rather than respect their values and diversity. Moreover, to advance the positive work experiences of autistic employees in workplaces, we found the importance of practicing design interventions not only for neurodiverse people but also for neurotypical co-workers and employees. Therefore, this work ultimately offers VR design spaces of workplace environments for two target groups—autistic people and members of their community and their neurotypical coworkers.

This section describes the design process and rationale of the *Workplace Playbook VR* concept focusing on two components: (1) simulated scenario experiences in the workplace context targeting autistic individuals as primary users and (2) the data-driven reflection based on the collected behavioral and physiological data of autistic people during the VR experience. In the data-driven reflection, autistic people can discuss their practiced behaviors with members of their support network.

#### 3.1 The Simulated Scenario Experience

We developed the *Workplace Playbook VR* scenario inspired by Social Stories™, a narrative-based social skills intervention for autistic people [32]. The intervention provides sequential stories that illustrate certain situations and problems related to events in the lives of autistic people to help them learn how they should deal with the situations. To create a realistic social scenario that closely resembles real-world workplace situations and challenges, we involved our stakeholders in the early stages of developing VR scenarios. We employed a two-stage iterative design approach. In the first step, we interviewed two managers working at a company in South Korea with more than 200 neurodiverse employees to understand the wide range of challenges that autistic employees face at work. The managers shared the workplace social skills and etiquette that they walked through with all of their employees in every morning meeting. These included communication skills between managers and employees (e.g., asking for help with a problem, notifying a manager of a schedule change, or how to respond to corrective task feedback), communication between coworkers (e.g., responding to bullying and talking politely), and etiquette in public spaces (e.g., elevators and restrooms). They further noted that practicing these skills can be more challenging when autistic employees face unexpected situations. Based on the suggestions, we have developed three social scenario exemplars of unexpected situations that could happen at work, including when an autistic employee has to leave work early due to an unexpected matter, when an assigned task does not go as planned, or when a customer does not follow the rules at the store. Then, we discussed these scenarios with a clinician, family members, and an autistic individual to verify their ecological validity (whether they appropriately represented a real work environment and situation for autistic

employees). For the purpose of a video prototype, we chose a scenario in which an autistic employee has to leave work early and needs to elaborate on their situation at the morning team meeting. The scenario was chosen because the team meeting is one of the most common situations that autistic employees experience at work regardless of their occupation, which can help users better immerse themselves in the scenario. We describe the scenario in more detail in Section 4.1. In the video prototype, note that we simulated VR with low-poly avatars. Carter et al. found that the complexity of the avatar appearance made no significant difference in autistic people's social interaction behaviors [20]. Therefore, we chose low-poly over more realistic high-poly avatars since their development was more cost-effective.

### 3.2 Data-driven Reflection

One of our goals with *Workplace Playbook VR* is to understand how a VR system can serve as a communication medium between autistic people and their support network. To accomplish this, *Workplace Playbook VR* provides a reflection interface that plays a recorded video of an autistic person practicing the VR scenario with a visual summary of the social and communication patterns that emerged from their practice. This concept of practicing social communication skills by reviewing their own practiced behaviors was adopted from the video self-modeling [7]. Video self-modeling supports autistic individuals to learn social skills by allowing them to observe themselves successfully performing target skills on video. Although our approach does not directly show a successful case of self-practice, we follow the spirit of video self-modeling by offering a convenient environment in which to learn desired behaviors while watching their own self-practice video repeatedly.

For the purpose of the video prototype, we visualized turn-taking [67], voice volume [13, 67], eye contact [6, 42, 84], and use of language [11] in the reflection interface, as they have been identified as essential social skills for autistic people [94]. Furthermore, we included physiological sensing data—heart rate (HR) and electrodermal activity (EDA)<sup>4</sup>—in the reflection interface to highlight situations where users experienced physical correlates of anxiety.

The overall reflection interface (Fig. 1) offers a chance to investigate the VR experience of the primary user (i.e., an autistic individual) with members of their support network. We presented the visualized data (Fig. 1-2) with a video player that replays the user's VR experience (Fig. 1-1) to better support users to make sense of the behavioral and physiological data by watching the synced video together. The upper-right corner of the reflection interface contains a comprehensive assessment based on behavioral and physiological data (Fig. 1-3). The bottom-right corner contains a virtual coach who helps with the reflection process (Fig. 1-4). The coach provides messages based on the video played through the interface. For example, the coach guides users on which social communication skills were noted in the scenario and which specific skills can be further discussed with others. Below, we explain how the reflection interface presents each data type.

**3.2.1 Turn-taking.** The turn-taking reflection screen visualizes speakers' speech activity based on three elements: pauses, gaps, and overlaps (see Fig. 2-A), which are commonly used to model conversations [34]. To better highlight the overlaps and gaps in speech, we marked these sections on the timeline (Fig. 1-2) with a box and an exclamation mark. The system also displays a message when overlaps or inappropriate gaps occur as an icon overlaid on the video so that users can notice it while reviewing videos.

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<sup>4</sup>EDA measures the electrical conductance across the skin in-situ, within the context of daily activities [72]. EDA can be indicative of emotional arousal in children with communication challenges [2] or of sense of presence [3, 31, 61]; thus, it offers advantages in understanding and communicating with autistic individuals.

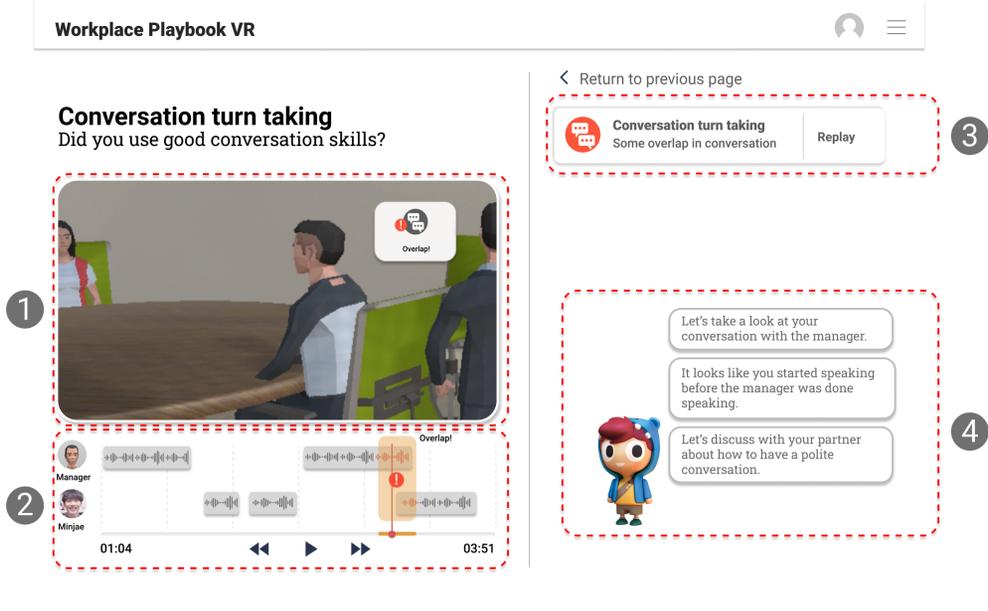


Fig. 1. The *Workplace Playbook VR* reflection interface: (1) a video player that replays the user's VR experience, (2) a reflection module that can review physiological/behavior information according to the video being played, (3) a comprehensive assessment module, and (4) a virtual coach with messages according to the video played in the interface.

**3.2.2 Voice volume.** The voice volume section in the reflection interface is designed with a visual gauge so that users can compare their volume to the desired level (see Fig. 2-B). A summarized message (e.g., "Too loud") and icon graphics are displayed on the gauge to help the user to recognize their voice volume at the highlighted time. Our design elements (a bar-shaped gauge and icons) were inspired by previous work, which evaluated the feasibility of voice volume feedback in a VR environment for autistic people [13].

**3.2.3 Eye contact.** The eye-contact section in the reflection interface allows users to examine where their gaze was pointing during the VR experience. We implemented a modified heat map [90] method that made the place where the user's gaze remained more transparent than other areas (Fig. 2-C).

**3.2.4 Language use.** The language-use interface provides general guidelines about appropriate language use in the given VR situation (Fig. 2-D). We designed the contents by referencing the existing programs for social skills training (e.g., PEERS) [50] and the workplace manual for neurodiverse people [70]. The social skill goals (e.g., initiating conversation and responding to questions) provide a checklist of expected interactions to be aware of in the conversation.

**3.2.5 Anxiety level.** Our interface provides information on the user's level of anxiety in a VR experience based on the HR and EDA data (Fig. 2-E). The anxiety indicator overlaid on the video shows the anxiety level metaphorically using heart, sweat, and facial expression images. The

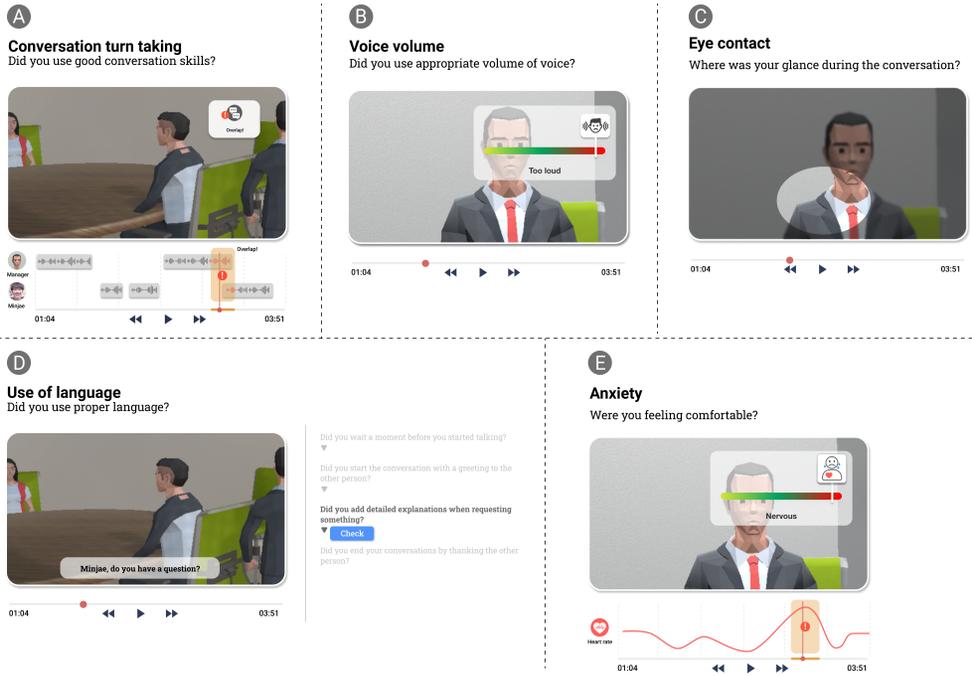


Fig. 2. The reflection interface screens for each physiological/behavioral data category: (A) conversational turn-taking, (B) voice volume, (C) eye contact, (D) use of language, and (E) anxiety (heart rate and EDA).

interface highlights the section where elevated HR was detected using a box marked with an exclamation mark.

#### 4 STUDY DESIGN

To better elicit feedback on how the *Workplace Playbook VR* concept may or may fail to address the needs of autistic people and their support networks, we conducted semi-structured interviews with 28 participants in South Korea (See Table 1). We recruited participants by distributing flyers to various autism-related organizations, clinics, and companies that hire autistic people. Our inclusion criteria for autistic participants were those aged 16 or older, diagnosed with autism by a medical professional, and able to verbally articulate their thoughts, feelings, and experiences. The participants included 10 autistic people aged 17–32 years (average = 23 years, SD = 5.4) who were either employed or preparing for employment, six family members of autistic participants, one family member of an employed autistic person, and 11 professionals who have expertise in the characteristics of autistic people and their employment experiences. Our autistic participant profiles were most consistent with a Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) Autism Spectrum Disorder (ASD) Level 1 label ("requiring support" in social communication and interactions despite their ability to speak in full sentences). The professionals included special education teachers, therapists, and current or former managers of companies employing autistic people. During the interviews, we showed participants a video prototype, discussed how they would use such a system in real practice, and what benefits and concerns they might foresee when using the system. Below, we described the video prototype content, interview process, and data analysis in greater detail.

Table 1. Participants Demographics

| Group                | Code | Gender | Age | Self or Child Job Description                                    |
|----------------------|------|--------|-----|--|
| Autistic Individuals | A1   | Male   | 20  | A college student; interested in becoming a traffic officer.     |
|                      | A2   | Male   | 19  | A college student; interested in career paths in finance.        |
|                      | A3   | Male   | 31  | A public assistant librarian.                                    |
|                      | A4   | Male   | 23  | An office assistant who takes and delivers documents.            |
|                      | A5   | Male   | 32  | An office worker.  |
|                      | A6   | Male   | 17  | A high-school student who wants to become a designer.            |
|                      | A7   | Female | 21  | A college student who wants to become a journalist.              |
|                      | A8   | Male   | 19  | A high-school student.   |
|                      | A9   | Male   | 20  | A kitchen assistant who washes dishes and prepares milkshakes.   |
|                      | A10  | Female | 28  | A public librarian who organizes and manages resources.          |
| Family Members       | F1   | Male   | 52  | Parent of A1   |
|                      | F2   | Female | 45  | Parent of A2   |
|                      | F3   | Female | 47  | Parent of A3   |
|                      | F4   | Female | 46  | Parent of A4   |
|                      | F5   | Female | 42  | Aunt of A6   |
|                      | F6   | Female | 60  | Parent of an autistic employee who makes and packages rice cakes |
|                      | F7   | Female | 50  | Parent of A8   |
| Professionals        | P1   | Female | 30  | Behavioral therapist   |
|                      | P2   | Female | 37  | Director of social innovation company                            |
|                      | P3   | Male   | 45  | Special education teacher  |
|                      | P4   | Female | 50  | Café manager   |
|                      | P5   | Female | 25  | Special education teacher  |
|                      | P6   | Female | 30  | Special education teacher  |
|                      | P7   | Male   | 46  | Former manager of a company with autistic employees              |
|                      | P8   | Female | 48  | Director of a Welfare Center for people with disabilities        |
|                      | P9   | Male   | 34  | Child and adolescent psychiatrist                                |
|                      | P10  | Female | 37  | Special education teacher  |
|                      | P11  | Female | 54  | Special education teacher  |

#### 4.1 Video Prototype

The video starts with a story of Minjae, an autistic senior high-school student who has been learning skills for employment but who still has many concerns about interacting with managers, co-workers, and customers. Minjae visits the vocational training center to experience various scenarios that he could face in his future workplace through the *Workplace Playbook VR* program. He puts on a VR headset and a wearable sensor. The system collects behavioral data from the VR headsets—eye contact, voice volume, language use, and turn-taking. The wearable sensor collects physiological HR and EDA data. In the VR program, he experiences a situation where he needs to ask a manager a question about leaving work early. On the VR screen, Minjae participated in a team meeting, during which he receives a text message from his mom asking whether he can leave work early due to an urgent matter at home. After checking the text message, the prompt asked Minjae to talk to a manager about this issue. In the first trial, Minjae said "I need to leave work early today" without explaining his reason for the request or making proper eye contact with his manager. After the trial, he took off the VR headset and reviewed his experience with a vocational trainer by watching the reflection interface together. After a discussion with his vocational trainer, he tried the VR program again and made an improvement in the skills discussed.

#### 4.2 Semi-structured Interviews with a Video Prototype

We elicited feedback on the video prototype through semi-structured interviews with the three participant groups. Our interview consisted of two parts. First, we asked about what challenges autistic people face in the workplace or in their everyday lives, who they share these challenges with, and how the individuals overcome them. After watching a video prototype, we asked more specific questions about the potential benefits and challenges of using the presented VR system in practice. Below, we describe how those questions were tailored for each individual group to better elicit their personal experience and feedback.

For autistic individuals, we first asked about what social and communication challenges they have experienced in workplaces or concerns they had about preparing for employment. After showing the video prototype, we asked how they would respond to the scenario if they had tried the VR program, which social situations they might want to experience more in the VR, and how the feedback presented based on the collected data could help them better practice their job-related social skills. Finally, we asked if they had any concerns about sharing the reflection interface with others.

Family members were asked about the performance of their child's social and communication skills and their experiences helping them practice those skills. After watching the video, family members were asked about the potential efficacy of our program for their child from the caregiver's perspective and how the system would or would not help them communicate with their child about their challenges.

Professionals were first asked about their experience teaching social skills to autistic people, and to reflect on what challenges they observed that autistic people often face in their workplaces or while preparing for employment. We then asked how they might use this system to benefit autistic people, how the VR system design could better incorporate the social skill training strategies they use, and the potential benefits and challenges of using VR to understand autistic individuals.

### 4.3 Data Analysis

We analyzed the interview data by conducting open coding with thematic analysis [17]. All interview recordings were transcribed for analysis. Three researchers individually read the interview transcripts and generated open codes using NVivo [56]; these open codes were then discussed among the whole research team to resolve disagreements and identify patterns. Then, we generated themes from these open codes. We identified statements that revealed both existing social communication challenges in the workplace and all expectations and concerns about using VR programs to support autistic people. Then, we structured the themes around understanding 1) how to use VR to improve autistic people's social skills, 2) how to use VR to support autistic peoples' communication, and 3) what data autistic people wanted to share.

## 5 RESULTS

In our interviews, we found two major contexts in which the *Workplace Playbook VR* concept could potentially be situated to provide benefits for both autistic people and the community of which they are a part. The first context is a personal setting where autistic people directly interact with their support network (e.g., family, counselors, and therapists). The second context is a workplace setting where neurotypical employees at work could use VR to better understand their autistic colleagues. In both cases, we illustrate how the *Workplace Playbook VR* can promote understanding and communication between stakeholders.

### 5.1 Personal Use of the VR to Facilitate Communication with Support Network Members about Challenges at Work

This section starts by describing the challenges that autistic people and their support network members face when seeking and providing social support for difficulties at work, and the potential use of VR to address these issues. Then, we explain how the concept of the *Workplace Playbook VR* can help autistic people have more pleasant work experiences and provide opportunities for members of their support network to provide constructive, collaborative, and empathetic feedback.

*5.1.1 Promoting understanding and establishing common ground for communication.* Participants expressed that the VR programs could help members of an individual's support network better

understand the existing or potential challenges of autistic people in the workplace and start conversations to address these challenges. Lack of communication between support network members and autistic people about everyday work occurrences sometimes resulted in identifying an individual's challenges too late. By going through the VR scenarios together, the support network members and autistic people hoped to have more frequent conversations about life at work. By watching the specific work-related situations with which autistic individuals have difficulties, family and professional participants wanted to become more understanding and empathetic regarding the struggles that autistic individuals might face at work. Some family participants noted that it had previously been difficult for them to fully understand what situations their autistic family members experienced at work because they could not observe actual situations. However, the virtual scenarios provided by the *Workplace Playbook VR* allowed them to deeply immerse themselves in the situation. They perceived that seeing the specific scenarios alongside their autistic loved ones could help them have more in-depth conversations about why each situation was challenging for the individual or what could be done better instead of giving one-sided directions, which they often reported doing in real-life. *"F1: It's important for parents to know the kind of program in which their kids are participating in. As their understanding of their kids grows, parents could alleviate various feelings they may have toward their kids. It would be nice if parents could also experience the program because then they would be able to know what their kids are doing and how best to help them."*

Autistic participants who were preparing for employment had some fears about various social situations they might face at work, such as getting scolded by a manager or bullied by co-workers. The lack of opportunity to experience possible situations at work increased their concerns about these situations. Family and professional participants also discussed how their autistic family members or clients often struggle to adjust to new environments. However, little information was available regarding what they could expect and prepare for before starting work. They hoped that VR could give them an opportunity to experience concrete social scenarios that autistic people might experience in daily work settings, thus allowing them to better prepare to adjust to new environments and overcome their fear of the unknown. *"A8: Wouldn't it be possible to relieve anxiety by finding a way to cope with the situation? You don't know when a difficult situation will happen, which makes me anxious. As I said before, I try to avoid the situation itself. If I have trained for such a situation, I think that it would reduce my fear when facing the situation in reality."*

Both the family and professional participants appreciated the possibility of using the *Workplace Playbook VR* to help them better understand the behaviors of autistic people with the collected behavioral and physiological data. The physiological data was perceived to be especially helpful for understanding the autistic person more deeply. While most family members and professionals were familiar with an individual's visible behavioral challenges, the VR system could help them recognize the invisible emotional states of the autistic individual, such as anxiety, leading to an awareness of more subtle aspects about the individual's emotional state. They hoped to get more context and clues about the individual's behaviors by observing the physiological data responses of autistic individuals to different scenarios. *"F7: It would be helpful to know some quantified information. I can't always see how anxious my child is under different circumstances. There are many situations where I can't check and I think we could have a conversation about the circumstances if I knew more. For example, we could discuss why he was feeling nervous, what his thoughts were, and how he reacted. Then, we could talk about ways of improving it together. It's usually difficult to know about these circumstances even if it happens in a school setting."*

**5.1.2 Clarifying target goals and skills to build pleasant work experiences.** Autistic participants reported strong desires to be successful at work. We found two major desires or goals they aspired to accomplish in the workplace—recognition of work abilities and development of interpersonal

bonds with co-workers and managers. The *Workplace Playbook VR* feature that allows autistic people to review and practice behaviors in various workplace scenarios was perceived as helpful at identifying areas for growth to help them achieve their goals. For example, A5 said that he required a lot of trial-and-error to develop his skills learning to report his assigned tasks to a manager more succinctly, appropriately, and persuasively. However, with the *Workplace Playbook VR*, he felt that autistic people could better identify and equip themselves with the requisite skills to achieve their goals because it would give them opportunities to see how they behave in certain situations more objectively. A2 further added, “[*Areas in which I am interested are:*] ‘*Checking areas where I can improve*’ and ‘*Checking situations where I am nervous*’. *I want to know myself better and improve my shortcomings because fear and confidence are, in some ways, psychological. I want to get to know myself better and develop my conversational skills proactively.*”

To achieve the goals and self-images that autistic participants wanted to establish at work, they discussed specific skills they would or would not like to practice using the *Workplace Playbook VR*. For example, using conversational turn-taking. Autistic participants wanted to practice appropriate timings to chime in to conversations so that they can signal their interest in a topic to others. Moreover, they wanted to check whether they were dominating conversations or interrupting frequently to ensure that they give others the impression that they are polite and mindful. In terms of eye contact, they hoped that by making frequent and appropriate eye contact, others would perceive their engagement and interest in the conversation. They also wanted to signal that they care for others by controlling their voice volume level and thus speaking at an appropriate volume in public spaces. On the other hand, A8 pointed out his desire to maintain his conversation characteristics. “*Sometimes, I wonder if I really need to correct this. [...] I’m sure that the volume of my voice is important, but I think that this can all be a part of my personality too.*” This finding points to an important design implication of technology, which is giving autistic people a choice to determine which skills they want to develop to achieve their personal values, goals, and desired images, rather than blindly suggesting that individuals follow “normative behavior.”

Autistic participants wanted to share their VR practices with people they trust, respect, and admire such as close friends, family members, or teachers who will understand their behavioral characteristics as they are rather than “correcting their behaviors.” Thus, about half of the autistic participants did not want to share their data with parents due to concerns about parents nagging or scolding them about their behaviors. Rather, they expressed a desire to share it with professionals or close friends who could listen to their challenges and offer constructive feedback. Further, our family and professional participants warned us about the possibility of using VR to point out behaviors of autistic people based on the standards of neurotypical society. The important role of support network members is to closely listen to autistic people, encourage them to choose their own goals, and then decide on what skills to work on to achieve these goals so that they feel empowered, appreciated, and respected.

In addition to developing communication skills for the purpose of work and socialization in the workplace, developing skills to advocate for autistic employees’ rights, workplace fairness, and work accommodations was emphasized in interviews. For example, F6 shared a story about her son who was struck by a coworker in the workplace. Since her son did not immediately report the incident, she found out about it much later. She hoped that the *Workplace Playbook VR* could include various scenarios regarding any unfair treatment autistic employees might face in workplaces and help them speak up about them. “*I hope that the VR scenarios could include situations where my son can speak up or say something like, ‘Mom, I’m upset because something like this happened,’ when he is mistreated at work. If the scenario ends with a ‘happy ending’ after he speaks up, he might speak up again when he faces a similar situation at work because he knows how to advocate for himself to resolve such situations.*” However, there can be many barriers to reporting negative events despite strong

communication skills. F6's son was concerned about his co-worker getting in trouble if he spoke out about the incident. Some autistic participants said that their past experiences of speaking up about their intensive workload or the negative attitudes of other employees were ignored. Therefore, as F6 mentioned, VR scenarios should be developed with consideration of the various reasons that autistic employees might refrain from advocating for themselves. Furthermore, it is important to establish a work environment in which neurodiverse voices can be heard. We discuss this in the next section.

## 5.2 The Extended Use of the VR to Promote Inclusive Work Environments

We initially came up with the *Workplace Playbook VR* concept to facilitate communication and understanding between autistic people and members of their support network in a casual setting. Expanding on this, our interviews revealed the extended role of the VR system in educating neurotypical employees, such as managers and colleagues, on the characteristics of autistic people, thereby encouraging a better understanding of autistic employees and how to embrace diversity in the workplace. In this section, we report on how the *Workplace Playbook VR* can facilitate understanding at work.

*5.2.1 Developing VR to build empathy in the workplace.* Autistic participants discussed the need to incorporate this VR tool into the workplace environment so that other employees could better understand their struggles and be more understanding toward them at work. A5 said, *"It would be nice if this [the Workplace Playbook VR program] could be deployed in the company. If the employers could make the program applicable to their workplace environment, they could use it to provide good feedback [to their neurotypical employees]."*

Autistic participants described how immediate corrective feedback will likely put them into a negative spiral, especially when they already feel nervous at work. Specifically, one of our autistic participants mentioned his characteristics of speaking slowly and lowering his head whenever he is nervous. However, others at work often pointed these characteristics out and urged him to correct them. Pushing him to change his behaviors when he is nervous often made him feel more intimidated, and resulted in more negative consequences. He wanted his managers to understand his behavioral signals so they could respond to him in a more appropriate and understanding manner. Other participants also shared their personal experiences of engaging in negative spirals and suggested the use of the VR system to better promote others' understanding of them at work. *"A3: I think that it would be nice to know information like, 'This style of autistic people can be like this or that'. [...] For example, with the unstable eye-contact results, it would be nice to tell the communication partner that we felt anxious at that moment instead of telling us that we should have stared at our partner [...]."* Moreover, one of our autistic participants added that the VR system can help co-workers understand autistic employees by *"knowing that there are people like me around them and embracing diversity."*

We found some misunderstandings that neurotypical employees had about autistic employees due to their limited knowledge and experience. For example, neurotypical employees, who often expect flexibility in working (e.g., changing work hours or assigned tasks), have conflicts with autistic employees who prefer to strictly follow the rules. In such cases, some neurotypical employees viewed autistic employees as too stubborn and rigid. Furthermore, a neurotypical manager participant reported a case in which an autistic employee sometimes interrupted conversations between the manager and customers because the autistic employee wanted to report her completion of a duty. This happened because the autistic employee focused solely on reporting her task to a manager; however, her behavior was sometimes perceived as rude or inconsiderate. To address these misunderstandings, VR could allow neurotypical employees to experience those situations

from the perspective of an autistic employee. By experiencing how autistic employees might think and perceive, neurotypical employees could better understand and empathize with autistic employees. *“P4: For us, we can wonder why they are not able to do something that comes naturally. But for professionals who work with autistic people, we understand that these things don’t come naturally to them. Even buttoning up a shirt may take a lot of time and effort to learn and still be a challenge but this may be hard for the neurotypicals to understand. Seeing this process in VR can help people understand [autistic people] better and maybe even help change their perspectives.”*

*5.2.2 Leveraging VR to cultivate inclusive workplace environments.* We found several different areas in the workplace—management strategies building and autism awareness training—where empathy-building VR could be used to cultivate inclusive work environments. Some of our autistic participants said that although they desired to get along with their co-workers, they struggled to even initiate conversations due to concerns about others’ negative reactions. Their past negative experiences with co-workers discouraged them from asking questions or engaging in small talk. *A4: “I feel that my co-workers may not respond favorably to my questions or requests.”* This finding denotes the importance of changing the attitudes and behaviors of neurotypical employees toward autistic employees to promote an inclusive atmosphere.

The first potential use of VR for promoting an inclusive workplace culture is building effective and considerate management skills that consider the characteristics of autistic employees. For example, one manager reminisced about her struggles when she first worked with autistic employees. Since every employee’s characteristics were different, it took her a while to understand their uniqueness and learn how to respond to them professionally and appropriately. She envisioned using the VR system to better help managers quickly identify the behavioral characteristics of each autistic employee to effectively find appropriate ways of responding to them. A manager shared a story of an autistic employee who significantly slows down his behaviors whenever he feels perplexed. One day, a customer came to complain to the manager because the employee had made a mistake. The manager purposefully did not tell the employee about his mistake immediately because she knew it would slow down his behavior and many customers were waiting. Although such adaptive skills are critical for managers to effectively work with autistic employees, developing them takes time. Observing how autistic employees actually behave in various simulated social situations in VR could help managers and co-workers better understand the characteristics of autistic individuals and be more mindful of their interactions.

Furthermore, the tendency of autistic employees to prefer to strictly follow instructions is often advantageous at work. However, we found that vague instructions from managers or co-workers can block their potential. For example, an autistic employee who worked at a café struggled to use a nozzle in a milk steamer although others at work typically learn how to control it by experience. The autistic employee found the flexibility of controlling the nozzle by experience without a specific instruction especially challenging. However, after a manager gave her a step-by-step instruction to use it, the autistic employee developed the most expertise in using the nozzle among all employees at the store. This example highlights the importance of neurotypical managers improving their understanding and applying knowledge about autistic people’s characteristics in their management strategies.

Finally, VR can be designed for autism awareness and acceptance training in workplaces. New managers or employees are usually trained either officially or unofficially via verbal instructions such as hearing about the characteristics of each autistic employee. However, with verbal explanations, it can be difficult to understand how serious behaviors are, in what specific context behaviors occur, and when is the appropriate time for managers to intervene. With a VR system, employees can observe the behaviors of autistic employees in the actual work setting. Managers also expressed

that this VR training experience could significantly alleviate their training effort. “P8: *There are people who joined the company—like our manager—without knowing about autism but who now have a better understanding. In the beginning, they would wonder why autistic people behaved a certain way, but openly discussing and hearing about autism and the spectrum of behaviors helped them develop a better understanding.*”

## 6 DISCUSSION

Our initial intention in developing the concept of *Workplace Playbook VR* was to help autistic people practice requisite skills for a variety of social situations that could arise in the workplace and discuss challenges and successes together with members of their support network. The spirit of this design was aligned with the findings of past research that have shown the efficacy of VR in training functional skills for autistic individuals [14, 16, 41, 89]. Despite our intended goal, we found that VR technology designed to develop the social and communication skills of autistic people has the potential to be misused to correct their characteristics and enforce normative behaviors from the perspective of a neurotypical society. This finding reveals important design implications that HCI researchers should consider when designing technology to develop autistic people’s social communication skills. In Section 6.1, we discuss how such VR systems should be designed to avoid enforcing normative behaviors and promote autistic individuals’ self-advocacy and sense of agency in workplaces.

Furthermore, our interviews revealed the potential for VR to promote neurotypical employees’ understanding of autistic employees, and potential applications of VR to cultivate inclusive workplace environments. Although the efforts of neurotypical employees are critical for developing an inclusive workforce, a large body of VR research mostly focuses on building the competencies of autistic employees through training in target skills [16, 41, 89]. Therefore, we aim to take a step toward investigating how VR designs can better facilitate the understanding of autistic employees at work and ignite a discussion about changing attitudes and policies at work.

### 6.1 Design Recommendations of Inclusive VR Design for Autistic People

This work responds to a recent call to conduct more inclusive design approaches when developing technology for autistic people [91]. Our inclusive design methodology of including voices of autistic people in the design process of VR could serve as an exemplar that incorporates the autistic perspective into designing VR systems. Below, we articulate three major design guidelines in the inclusive VR design approach that were successful in our study at eliciting active participation and feedback from autistic participants.

First, we put significant effort into developing a VR scenario that could represent realistic workplace environments and challenges that autistic people could face. We conducted a two-stage iterative design process with two managers, a clinician, two family members, and an autistic individual. Co-designing the scenario with stakeholders enabled our autistic participants to better relate to the scenario’s situation. For example, A2 said, “*it [the video] was touching because I could empathize with Minje. Seeing his struggles also reminded me of times I had difficulty expressing my thoughts in words.*” Their engagement with the scenario may have helped them better recall their own challenges at work and be more open about their struggles. Therefore, we suggest that future researchers put efforts into creating a VR scenario to which autistic people can closely relate and empathize.

Second, our video prototype that presents the background story of a user called Minje and shows the concrete context of using the VR system (e.g., showing Minje wearing a VR head-mounted display and a physiological sensor and watching his VR practice with a professional after the VR experience) clearly communicated the purpose of our system to autistic participants. We found

the video prototype particularly useful for autistic people who have strengths in understanding concepts with visual support. Further, in a situation like the COVID-19 pandemic where remote studies are more commonly practiced, researchers should devise effective ways to engage autistic participants in studies. We uncovered that the video prototype could serve as an effective medium in such a situation to better catch the attention of autistic participants, promote engagement, and increase understanding about the prototype concept.

Third, to elicit specific feedback on each design choice, we created PowerPoint slides that referred back to each interface design presented in a video (see Fig. 2). This communication strategy gave autistic participants an opportunity to better understand the purpose of each design, envision how each feature could or could not provide useful information personalized specifically to them, or how it could be redesigned to better support their needs.

## 6.2 VR to Promote Self-advocacy and Sense of Agency for Autistic Employees

Bolte et al. [9] called for future research to push the importance of rethinking the way autism is perceived, thus emphasizing the use of words that promote respect and an accurate understanding of autistic people. Researchers have re-conceptualized autism as neurodiversity [27, 87], contesting the understanding of independent living or the concept of autonomy. A central premise of neurodiversity is to support self-advocacy and personal autonomy in autistic individuals, allowing them to exert more control over their own lives [51]. To achieve autonomy, one must have functional communication, so any intervention promoting neurodiversity should provide opportunities to express agency and—more importantly—build effective and respectful communication between autistic persons and others in their environment [51]. The concept of agency can be used as an effective framework to understand the social interactions between neurodiverse communication facilitators [79].

Our interviews revealed the potential danger of social communication skills training features of VR in enforcing normative behaviors on autistic people. Spiel et al. also criticized existing technological interventions that make autistic people adopt strategies defined by neurotypical society [91]. Furthermore, they suggested the need to develop technologies that can respect autistic people's unique characteristics and further enhance their agency by enabling features that respect users' autonomy, such as by utilizing self-guided interaction. On a similar note, our autistic participants showed agency by defining their own internal goals and what self-image they desired to cultivate at work and determining which skills presented in the VR simulation might or might not be suitable for helping them achieve those goals. This sense of agency should be encouraged in the design of VR systems by allowing autistic people to set their own goals and determine which skills will help them achieve their goals prior to beginning practice. Aligned with the spirit of agency, we suggest giving autistic people complete control over deciding the members of their support network with whom they would want to share and discuss their VR practice. Furthermore, giving autistic people agency in terms of data sharing is especially important because the data collected with this system includes physiological sensor signals that could be sensitive when shared with others. The system should inform autistic people of the potential dangers and benefits of sharing the bio-sensor data with others so that they can make informed decisions. When discussing practice sessions, we should focus on scaffolding skills rather than correcting behaviors to support autistic people's priorities and interests. By discussing how and why they want to achieve goals, we can respect the agency of autistic people in determining their own goals and skills.

Further, we identified that VR could promote the agency of autistic individuals by empowering them to proactively prepare for potential situations that could happen in their workplaces and learn how to advocate for themselves. This preparation can be particularly helpful for autistic people who have fears about the unknown or who worry about unplanned events that may occur in various

situations they might encounter at work. Furthermore, we found that experiencing these scenarios in simulated reality can open up opportunities to discuss their struggles with others and how they might advocate for their rights, workplace fairness, and work accommodations. Future research should investigate more scenarios that deal with various situations in which autistic employees can practice self-advocacy. For example, scenario should encourage self-advocacy behaviors, especially regarding being bullied or unfair treatment. When designing the scenarios, as our findings indicated, we should consider and address various reasons that autistic people might not report negative events in the workplace, such as concerns about other people getting in trouble or past discouragement. The scenario could guide autistic individuals to understand the importance of standing up for themselves, communicating in their own way to stop unfair treatment, speaking up to prevent it from happening again in the workplace, and presenting the positive results of advocacy such as improvements in the workplace culture.

### 6.3 VR to Cultivate Inclusive Workplace Culture for Neurotypical Employees

We uncovered the potential impact of designing *Workplace Playbook VR* for training neurotypical employees that can promote their understanding of autistic employees. For example, our interviews revealed the *Workplace Playbook VR* feature that allows other people to watch the VR practice of autistic people has the potential to help neurotypical employees to better understand the exact situations in which autistic individuals struggle, how the individuals respond to situations, and how neurotypical employees can or should intervene situations. A growing number of research practices emphasize the importance of holding diversity and inclusion training in workplaces to engender a more inclusive workplace culture [22, 54]. However, we have limited understanding regarding technological design opportunities for effective and collaborative diversity training to promote empathy and inclusion in the workplace environment, particularly for the autistic population.

Our findings revealed some occasional misunderstandings among neurotypical employees about autistic employees at work, such as perceiving inadequate eye contact as rude or strict rule adherence as stubborn. Misunderstanding and conflicts can happen because of a lack of understanding about autism [22, 54] and autistic people's different ways of thinking and perceiving situations are often invisible [73]. Therefore, we suggest VR designs that allow neurotypical employees to experience invisible differences of autistic employees. Past research has shown that perspective-taking, the act of perceiving situations from the other's perspective, is effective at eliciting empathy, personal distress, and in turn, maximizing motivation to help [38, 80]. Therefore, we suggest an immersive and interactive VR simulation that can help neurotypical employees experience their autistic co-workers' various challenges. Using such VR, neurotypical employees could imagine how neurodiverse co-workers would feel in the simulated situation. The various sensing effects, such as distorting the VR screen to simulate dizziness or visualizing fast heartbeats on a VR screen may further help neurotypical employees experience how autistic people might feel differently in specific situations. When designing and implementing VR, researchers should investigate ways of co-designing it with autistic employees to reflect how they actually feel in specific social situations, and how VR can best reflect their thoughts and feelings.

Leveraging empathy-building VR, employers could spur an organization-wide discussion around how neurotypical employees' behaviors and attitudes should be changed, and how work manuals and management styles could be transformed to better accommodate autistic employees' needs. Developing VR scenarios that reflect the characteristics of autistic people in diverse workplace situations is critical to the success of this endeavor. For autism awareness and acceptance training, the general and representative characteristics of autism may foster the overall understanding of autistic employees. On the other hand, when developing detailed work manuals and supportive management strategies, the specific characteristics of autistic people working in the company may

be better addressed in VR. Therefore, VR designs should be flexible and customizable to incorporate both general representative and specific individual characteristics of autism. Future research should actively involve autistic employees to honor their thoughts regarding what kinds of behaviors they would prefer to include in the VR scenario and what kind of work instruction and management practices may be effective for them, and how their experiences can be faithfully represented to neurotypical employees.

## 7 FUTURE WORK & LIMITATIONS

One major contribution of this research is that it incorporates the voices of autistic people into the VR design process and suggests VR technology concept and methodology that respects the agency of autistic people. For our future work, we will implement a working VR system based on the design guidelines identified in this work. In this section, we discuss the potential challenges in developing and deploying the proposed VR system.

First, we expect difficulties in assessing the appropriateness of communication using voice volume, turn-taking, and anxiety. Technically, when measuring voice volume or biosignals, the system may be susceptible to false positives that arise from background noises in the physical environment or hardware differences between the microphone and physiological sensors. Moreover, deciding appropriate thresholds for voice volume and turn-taking can be challenging since communication norms could vary in given social and cultural contexts.

Second, generalizability is a well-known challenge in VR research [30, 68]. In the real world, there will be more unexpected interruptions and nuanced social situations than what can be covered in VR scenarios. Therefore, generalizing the skills adopted in the VR system to the real world can be especially difficult for the autistic population. To better support generalization, future research should investigate ways of generating a wide variety of flexible social scripts that are worth experiencing in the VR environment.

The *Workplace Playbook VR* is designed to target the autistic population who can understand and interact with others within social situations offered in VR. As mentioned in the study design section, the targeted population can verbally express their thoughts and feelings. Future research should investigate VR system designs for autistic people who require higher levels of support in social and communication interaction because the challenges of this group in workplaces might differ from those who have strong communication skills. For groups who need more support, the VR system may more sensitively address communication challenges and/or difficulties in coping with change.

Finally, when designing a VR system to support autistic individuals, it is important to connect technology to the practices and values of the culture [12]. Our study reflects the workplace experience of autistic and neurotypical employees in the Korean cultural context. Given the hierarchical nature of the Korean culture based on Confucianism, the power and managerial decision-making tends to be centralized with an emphasis on respect for seniority and leadership [53]. In addition, like many other Asian countries, collectivism influences the social etiquette and workplace norms, requiring individuals to work for the interests of their team and for their company's overall benefit rather than for their personal interest [52]. As such, future work should focus on the cultural context and its characteristics when designing VR scenarios and implement systems based on our findings.

## 8 CONCLUSION

This study investigated how VR can be situated in contexts where autistic people and members of their support network can work together to improve the work experiences of autistic employees. Using a video prototype of the *Workplace Playbook VR*, we uncovered that VR technology can

facilitate support for and understanding of autistic people in two major environments, personal and workplace settings. In the personal setting, we found that the *Workplace Playbook VR* has the potential to develop the necessary social and communication competencies for workplace success by facilitating data-driven reflections between autistic people and members of their support network. Here, we suggest VR designs that can promote self-advocacy and the sense of agency for autistic people in workplaces while avoiding the danger of enforcing normative behaviors or correcting their unique characteristics. In the workplace setting, we identified many challenges that emerge due to neurotypical employees' lack of understanding about autistic people, and workplace culture and policies focused on neurotypical perspectives. We suggest that empathy-building VR can establish a more neurodiverse workplace culture by igniting discussions around building inclusive management strategies, work manuals, and autism awareness and acceptance training. Through this work, we hope to support a neurodiverse workforce by emphasizing that more research and technical interventions should be developed to promote neurotypical employees' understanding of autistic employees to cultivate workplace cultures where autistic employees are accepted, respected, and valued.

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