Exploring the Use of a Voice-based Conversational Agent to Empower Adolescents with Autism Spectrum Disorder

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ABSTRACT

Voice-based Conversational Agents (VCA) have served as personal assistants that support individuals with special needs. Adolescents with Autism Spectrum Disorder (ASD) may also benefit from VCAs to deal with their everyday needs and challenges, ranging from self-care to social communications. In this study, we explored how VCAs could encourage adolescents with ASD in navigating various aspects of their daily lives through the two-week use of VCAs and a series of participatory design workshops. Our findings demonstrated that VCAs could be an engaging, empowering, emancipating tool that supports adolescents with ASD to address their needs, personalities, and expectations, such as promoting self-care skills, regulating negative emotions, and practicing conversational skills. We propose implications of using off-the-shelf technologies as a personal assistant to ASD users in Assistive Technology design. We suggest design implications for promoting positive opportunities while mitigating the remaining challenges of VCAs for adolescents with ASD.

CCS CONCEPTS

• **Social and professional topics → People with disabilities**.

KEYWORDS

Adolescents with Autism Spectrum Disorder, Voice-based Conversational Agent, Participatory Design Workshop

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1 INTRODUCTION

Voice-based Conversational Agent (VCA) is a type of an intelligent personal agent which offers various features such as searching news, personalized recommendation, weather forecasting through a voice-based conversational interface. VCAs are increasingly being served in multiple forms, such as standalone Artificial Intelligent (AI) speakers (e.g., Amazon Echo dot) and embedded agents in smartphone applications (e.g., Apple's Siri, Samsung's Bixby). In particular, VCAs provide personalized services that can assist users in their daily lives, reflecting personal preferences and lifestyle. Recently, researchers have investigated how VCAs for individuals with special needs can improve their quality of life and lead independent lives [47]. Research in this space suggests that VCAs can work as an Assistive Technology(AT) not only for individuals with mobility issues, such as people with multiple sclerosis [73] but also for individuals with chronic mental conditions in promoting social activities [2, 60].

Autism[1] is a life-long condition and known as a 'spectrum' disorder because the symptoms vary from person to person; however, there is consensus among clinicians that the core traits related to ASD are difficulties in social interaction due to restricted interests and repetitive behaviors [36, 57]. Such behaviors and limitations of interests to specific matters by people with ASD[2] are typically regarded as negative traits requiring clinical treatment. Furthermore, various ATs have been devised for the purpose of rehabilitation (e.g., employment and everyday life) of individuals with ASD [34, 40]. In contrast to the prior perspective that considered users with ASD as

[1] One of the authors of this paper is a psychiatrist who suggests use a medically accurate term. In that 'there is no one type of autism, but many [71]', authors agree with the use of the term 'ASD' to emphasize the concept of spectrum, but recognize that naming ASD as a disorder is criticized for being deficit-focused concept [80].

[2] Rather than revealing ideological preferences for choosing one of the two technical terminology, this paper uses both 'people with ASD' and 'ASD people' to underpin to understand the disability as a social context and recognition of personal identity, reflecting implications of the two arguments to describing disability [4, 26].

individuals who need treatment and assistance, researchers in the HCI and accessibility fields have recently attempted to view disability from a different perspective [4, 46, 70, 80]. Recent studies state that disability is not a limitation or deficiency, but an individual characteristic [7, 10]. Thus, living with a disability is considered another diverse aspect of life, not necessarily something in need of treatment or special assistance [47, 70, 81]. In particular, the recent trend of designing AT for people with ASD is also augmenting their abilities and supporting the unique characteristics instead of trying to correct or remove their autistic behaviors. Such an approach focuses on empowering individuals with ASD to express their personalities and explore their unique way of utilizing AT [72, 79, 81]. The self-help group who have children with ASD has recently become interested in the newly developed voice interface. For example, Judith Newman, a mother of a 13-year-old son with ASD, reported that her son was able to establish a bond with VCAs by expressing emotions or asking what he wanted to know using Apple's Siri. [55].

However, although several studies and articles have discussed the potential benefits of incorporating VCAs into the daily lives of individuals with ASD from caregivers or therapists' perspectives [20, 21, 54, 60], few studies have included the voices of individuals with ASD. In this study, we aimed to focus on adolescents' lived experiences using VCAs in their daily lives for two weeks and identifying their expectations towards the future design of VCAs through a series of design workshops.

This study aims to investigate the possibility that technology can contribute to promoting the daily life of people with disabilities in the direction of helping disabled parties to make their own decisions and choices following a social model, which means what makes people with disabilities is the attitudes and structures of society, not just their medical conditions. It is different from traditional perspectives defining disabilities personally, which excludes them from full participation in the society [1, 67]. Our work underpins the way people with disabilities can be independent and equal in our society, with self-determination and control over their own lives. Especially, a VCA is not a newly designed technology for disability. Still, it is worth finding out what possibilities are available in the process of expressing and applying personal characteristics to adolescents with ASDs who have various attributes of each person by using VCAs popularly distributed in our daily lives. In the current study, we set out to explore how VCAs could serve as an empowering AT for adolescents with ASD in navigating their daily lives and personal characteristics. Seven Korean adolescents with ASD participated in this study involving participatory design workshops, individual interviews, and the use of off-the-shelf VCAs for two weeks in their daily lives. The findings suggest that VCAs provided ways to express adolescents' unique interests through personalized features and helped them address their emotional and social challenges in their daily lives. Based on the findings, we discuss this technology's implications as a new way of AT and the design implications for utilizing VCAs in their daily lives.

The primary research questions of this study include:

- What roles can a VCA perform for adolescents with ASD in providing supports in their everyday life?
- What are the opportunities and challenges of one-to-one interaction between adolescents with ASD and a VCA for practicing daily living skills (e.g., turn-taking practice, self-management skills, weather checking)?
- What are the design implications for adolescents with ASD to use a VCA in their everyday life context?

2 RELATED WORKS

2.1 A VCA as a personal assistant for underserved populations

Researchers are increasingly interested in applying VCAs to promote people's quality of lives with physical disabilities [73], blind people [17, 60], the elderly [18, 84], or children [23, 29] who may be less accessible to technology. In particular, researchers have been interested in applying VCAs to help disabled people enhance independent lives [59]. For example, Pradhan et al. examined that VCAs could help blind users solve everyday tasks such as listening to music or checking the time through a voice interface and playing a control tower's role by integrating and managing assistive devices at home [60]. Balasuriya et al. showed that voice-based interfaces could help people with intellectual disabilities struggle with spelling or reminding GUI-based systems [2].

Not only could VCAs provide functional support, but could it play a role as a social companion. Users tend to build relationships with VCAs as if it were a person by adding persona, background story, or considering output modalities (e.g., voice interface, graphic interface) to articulate their emotions [43, 61, 62, 66]. In particular, VCAs could serve as a learning companion for children. Druga et al. showed that when children interacted with VCAs for learning, they expected VCAs to play various roles like a companion, friend, or tutor for fostering their learning activities [23]. The researchers also identified the potential of fostering social interactions by including other individuals in the learning activities with VCAs [29].

As voice interfaces have recently begun to be applied to everyday life, the ASD community is also keenly interested in how VCAs can support their daily life and enhance communication skills. Pradhan et al. suggested that the use of VCAs can serve as an opportunity for caregivers to observe the speech improvement in their children with ASD. However, previous studies have predominantly focused on caregivers' or therapists' perspectives instead involving the voices of individuals with ASD [60]. In this study, we investigated the lived experience of using VCAs by actively involving adolescents with ASD as design partners.

2.2 Empowering individuals with ASD with digital technologies

Traditionally, disability tended to be understood within the framework of intervention models in medicine and welfare. Recently, the change in the definition and concept of disability is not to understand disability at the individual level and define it as a problem, but to emphasize the importance of the environment, transform it into a social model, and understand it in a complicated way [4]. The most distinct trend of change is the emphasis on the self-determination and choice of the disabled party. According to these trends, recent studies in the AT domain have suggested design considerations

for digital devices to leverage people with disabilities' capabilities [37, 47, 58]. Research in this space focuses on their capabilities, instead of deficiencies, and suggests assistance based on the capabilities. Similarly, the ability-based design emphasizes acknowledging every individual's abilities instead of controlling or correcting what they do. From this perspective, designing user-adaptable interfaces is essential, rather than designing tools based on assumptions of pre-defined skills or rules [68], by examining the users' unique capabilities and contexts [11, 80].

Burke et al. identified how computer-mediated communication (CMC) can support autistic people to connect with others and foster supportive relationships. Individuals with ASD, who tend to have strong preferences in specific topics, often display their interests in their CMC profiles. It helps them create an interest-based online group to initiate supportive relationships [12]. Ringland et al. investigated how people with ASD construct their virtual world to interact with others through Minecraft [64]. They showed that children with ASD felt safer and more comfortable socializing with others in virtual environments than face-to-face interactions in real-world settings. The researchers had people with ASD and their families participate in a channel called Aucraft, a social community in the game, and experienced social connection through this, and became an opportunity to regulate themselves or express emotions through inputs in the game. In addition, these experiences led to opportunities to apply to the real world through rules or knowledge among people who have learned in the game world [64]. Based on the findings, they argued that AT for individuals with ASD should be designed in a way that their uniqueness can be incorporated into the system through appropriations and adjustments of existing systems.

Artificial intelligence-based a VCA has been spotlighted as it can be customized to users by learning about individual interests and characteristics. Such personalization features the potential to support autistic individuals to demonstrate their traits and strengths through digital technology [22, 53]. Inspired by prior work, in this study, we explored how adolescents' unique characteristics with ASD impact their interaction with VCAs to inform the future design of personalized VCAs systems for them.

2.3 Including people with ASD as design partners for appropriating existing technologies

Traditional approaches to AT for individuals with disabilities concentrated on designing technologies distinct from general population technologies [24, 63]. However, the increasing number of studies in this space have proposed that mainstream products for the general population could suit special needs based on 'appropriation' by individuals with special needs [6, 22, 64]. Appropriation refers to the users' act of repurposing products or systems regardless of the designer's intention [22]. As a way to facilitate appropriating mainstream technologies to function as AT, numerous studies adopted participatory design (PD) approaches involving individuals with special needs as active design partners [3, 48]. The approach is mainly used for focusing on non-experts people's opinions participating in the design process as co-designers [65]. The purpose of PD is to listen and reflect participants' voices that provide a rich space for designers to explore [25, 27, 32, 38].

Research has demonstrated that specific considerations are needed when including people with ASD as design partners through a PD approach due to the prevalent challenges they experience in communication. First, providing appropriate support is critical to facilitate participation in PD activities. Benton et al. proposed a way for children with ASD to collaborate as a design team; the researchers suggested that suitable prompts such as using visual materials and individualized, one-on-one support, are needed to facilitate the active participation and communication in the design process. One-to-one support of adults helped children concentrate on individual tasks and also encouraged disengaged children to bring into the group discussion [3]. Notably, using appropriate visual materials is vital due to the sensitivity to visual stimuli that individuals with ASD have [33, 69, 80]. Second, participating in the workshop itself should be positive, socializing experiences for children with ASD. Outside The Box project is aimed at exploring an alternative role of technology for children with ASD. The researchers emphasized the researcher's role as a person who keeps the participants' safety and provides opportunities for children to express their opinions freely [28]. Third, keeping a balance between flexible and organized is critical when it comes to planning for PD workshops for children with ASD who have diverse characteristics. As a way to deal with such a challenge, Wilson et al. proposed that having 'structured flexibility' is essential [79]. Informed by the considerations from the relevant research, we explored the potential of VCAs for adolescents with ASD through a PD approach by 1) providing various scaffoldings, including visual materials, to support them appropriate their usage of VCAs, 2) encouraging them to be flexible when using VCAs to suit their individual needs, and 3) provide socializing opportunities to interact with peers and researchers through workshops.

3 METHOD

3.1 The VCA used for this study

Before exploring the VCA use of adolescents with ASD, we conducted a benchmark study on three commercial VCAs - Kakao Mini© (Kakao, Seoul, Korea), Google Home© (Google, California, USA), NUGU CANDLE© (SK Telecom, Seoul, Korea) that are widely used in Korea. The purpose of the benchmark study was to determine the system that can 1) best support Korean speech recognition, 2) provide various user experience, 3) offer users a casual conversation experience with daily content and feelings (e.g. "How are you today?", "How's your feeling?"). Based on the study, we decided to use NUGU CANDLE [75], which supports a unique conversational feature that provides users with emotional reactions than two other VCAs. NUGU CANDLE provides five categories of functions; 1) music and audio (e.g., music streaming, ASMR (Autonomous sensory meridian response), radio, Podcast), 2) convenience features (e.g., mood light, alarm, wake-up call, calculator), 3) real-time information (e.g., news, weather forecast, fortune telling, movie or food recommendation, baseball game results, recipes, KO-EN dictionary), 4) making phone calls, and 5) emotional conversation. (The function was designed to give comfort to users through simple conversations such as "I love you," "Goodbye" and "Hungry" with a VCA, according to the company that created the NUGU.))

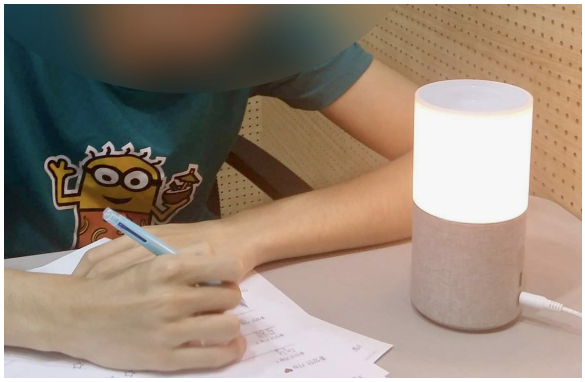


Figure 1: Appearance of NUGU Candle.

Table 1: Participants Demographics. All participant names were pseudonyms. ID refers to Intellectual disability and ADHD refers to Attention Deficit Hyperactivity Disorder.

Name	Gender	Age	Diagnosis
Paul	M	16	ASD
Fred	M	18	ASD,ID
Lisa	F	19	ASD
Brian	M	19	ASD
Daniel	M	17	ASD
Nick	M	17	ASD, ADHD
Ben	M	16	ASD
Tom	M	16	ASD

3.2 Recruitment

We recruited eight adolescents, whose ages ranged from 16 to 19 and are capable of communicating with others (Table. 1). We confirmed that the participants have the technical proficiency to potentially use VCAs on their own through a preliminary interview with their caregivers. Except for Brian, a college student, all eight of the participants are in high school. Each adolescent received a 20-dollar gift card to complete the two-week use of VCA at home and participate in the three workshops. The participants' caregivers were also compensated with 30-dollar for observing their children's use of VCAs and participating in the interview.

3.3 Ethical Considerations

Our study was approved by the Institutional Review Board (IRB No.B-1908/558-301). We obtained informed consent for participation from all participants. The adolescents' caregivers were also fully explained for the study, and they were agreed to participate in the study and the guardian interview. We informed the instructions about this study to our participants and their caregivers: 1) This study is not clinically validated therapy, 2) the participants could ask questions comfortably if they have any questions, and 3) there is no disadvantage even if the participants quit in the middle because the participation is entirely voluntary. As individuals with ASD can be embarrassed and anxious about unpredictable situations, we have told participants about the limitations of VCAs such as imperfect speech recognition. For example,if VCA had trouble understanding the speech, we told them that it was not because of the user, but the major problem could be with speech recognition technology. Thus, we suggested them repeat the call or call it another expression to get the VCA work better.

3.4 Study Procedure

To acquire in-depth opinions from each individual, we designed the study based on a participatory design approach. Participatory design (PD) is known as an effective communication approach to elicit feedback of users with special needs [3]. We organized four groups with each, including two or three adolescents with ASD, to share their experiences comfortably in a small group setting; however, one participant, Daniel, proceeded alone because his parents do not want Daniel to interact with other adolescents. Throughout the study, we conducted three participatory study sessions (Figure 2): (1) Session 1 - introduction and tutorial of using a VCA, (2) Session 2 - making a one-week use plan of a VCA, and (3) Session 3 - co-designing a personal VCA. We used the worksheets (Figure 3(a) 3(b) 3(c)) to help participants to express their feelings and introduce their user experience by answering 1) use plan, 2) which functions of the VCA they used, 3) descriptions of the situations where the VCA was used, 4) evaluations for the functions they used. With the worksheets, participants recorded what kind of conversations they had with the VCA, which functions they used, and how they reflected their experiences.

3.4.1 Session 1: Introductory and Tutorial Session. The first session's goal was to investigate ways of appropriating VCAs and creating personalized VCA experiences for adolescents with VCAs. We started the first session by introducing such a goal and various ways AI speakers can use examples in their daily lives. Next, we taught our participants how to use NUGU CANDLE, including installing and activating the system and initiating various functions through the tutorial.

In the first period of the study, we asked participants to try out the various functions of VCAs. To do this, participants made a plan with researchers on using a VCA three times a day, trying out all VCA functions in every five categories during the first three days, and then using the functions as they wanted(Figure 3(a)). Lastly, we requested adolescents to write a diary while using VCAs, including the followings: 1) the situation when they used a VCA, 2) what kind of conversations they had, 3) which functions they used, 4) how they evaluation of the features they used, and 5) how the VCA can be improved. It was used to make it easier to think about the experience of using the VCA in everyday life in workshops, refer to the diary contents that have been written, and communicate the experience of use to researchers. We used worksheets from left to third in Figure 3(a) 3(b)). In workshops, and the following two sheets are parts of the diary(Figure 3(c)), which were used for the use of VCA in their daily life for recording the experience of use. We asked them to film a video clip when they experience difficulty in writing a diary. Some participants said that writing a diary made them feel that they should write down all the conversation contents due to their obsessive characteristics. In that case, we asked them to take a video that captures the situation using a cell phone instead of a diary they wrote. After the first workshop, In case the adolescents

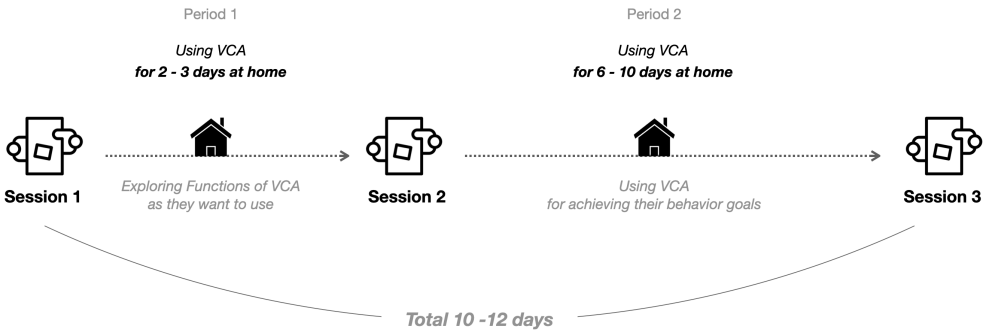


Figure 2: Study Process Diagram.

have difficulty or fail to install a VCA, we also guide caregivers on how to install and use a VCA.

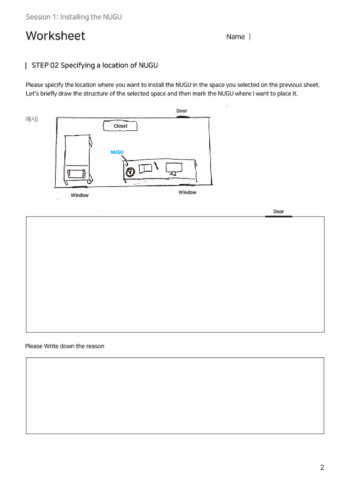
3.4.2 Session 2: Review the first period's usage and revising a plan of using VCA for the second period. In the second session, we collaboratively reviewed our participants' experiences with VCAs during the first period of at-home usage. We reviewed the diary entries and usage videos with all group participants consisting of two to three persons. In contrast, those who did not want to share the data with other participants reviewed their data during the individual interview. While sharing videos containing the process of use, we, as a group, discussed the difficulties and concerns that they experienced using VCAs.

Based on the collaborative reflection, each participant devised the plan for using the VCA over the following period (i.e. the 6-10 days of at-home use (Figure. 2)). Before devising plans, we had our participants work on the scaffolded worksheets(Figure. 3(b)) related to 1) which VCA features that they were most satisfied with, 2) which VCA features they were most disappointed with, 3) where they used the VCA, and 4) what the VCA experience was like with their family members. After filling out the worksheets, we encouraged them to discuss the contents of sheets with the researchers and other participants. Next, the adolescents participated in an activity to create their specific plans for utilizing VCAs. All participants planned the functions to be used according to their chosen behavior goals. The selected goals consisted of what they wanted for different areas of their life (Table.2). We presented four behavioral categories with examples related to their daily lives: 1) self-understanding and self-management skills, 2) communication skills, 3) interests, 4) and hobbies. We guided them to write which categories they are most interested in. We provided some guidelines so that participants can use the VCA continuously in their daily lives; for example, tasks should be related to their usual life patterns, and there should be no additional cost or burden for carrying out the tasks. Participants selected three behavioral goals considering their priorities and types of VCA functions that they are interested in. For example, Lisa's goal was to listen and understand the stories of others. She aimed to write down dialog with the VCA for enhancing concentration on a conversation with others. According to her goal, she made plans

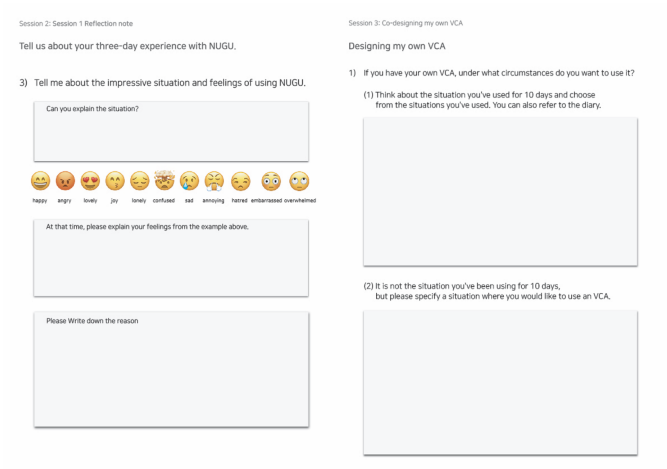
Table 2: Participants Behavior Goals and use plan.

Name	Behavior Goals	Functions that they used
Paul	Expressing feeling to VCA	Emotional Conversation, Radio, News, Reporting the results of a baseball game, Movie Recommendation
	Obtaining information that fits my interests	
Fred	Sleeping and getting up regularly	Wake-up call, Mood Light, Alarm, News
	Getting things done	
Lisa	Understanding the context of a conversation (Expressing my feelings to VCA & Listening to VCA's words carefully)	Wake-up call, Mood Light, Alarm, News
Brian	Tidying up, Getting up by using wake-up call, Doing things in order (e.g., shaving, washing hair, having breakfast, etc.)	Alarm, Music, Fortune-telling, News(sports, entertainment)
	Obtaining information from the news	
Daniel	Relieving stress	Emotional Conversation, Music, ASMR, Fortune-telling
Nick	Managing stress	Mood Light, Wake-up call, Fortune-telling, Music, Movie Recommendation
Ben	Managing stress	Mood Light, Reporting the results of a baseball game, Fortune-telling,
Tom	Trying to Strat a conversation	Music, Emotional Conversation, Food Recommendation, NUGU Encylopedia
	Practice to have an active attitude	

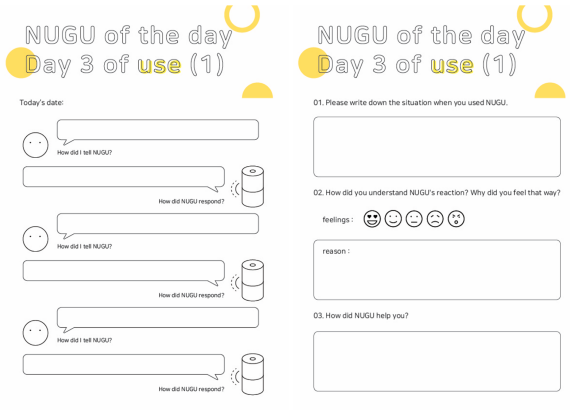
to use features such as "emotional conversation," "weather forecast," and "fortune-telling" of the VCA. Lastly, we guided the adolescents to create a diary related to their VCA usage for the following period. We instructed them to write a diary after using VCAs in the morning and evening, describing 1) the conversations with the VCA in the diary, 2) how the VCA helped them, 3) what they felt about the VCA's response. Also, the participants wrote down 1) what features they used during the day and how those features were helpful 2) give a score of NUGU functions (0 to 100 points) 3) Self-assessment of achievement of behavioral goals. They also took side notes on how the NUGU can be improved. We advised participants to record easily either through a diary or a video. After Session 2, individual



(a) A Worksheet used in Session 1.



(b) Worksheets used in Session 2.



(c) Diary Sheets.

Figure 3: The worksheets and diaries used during workshop sessions

interviews were conducted to fully understand the intentions and contexts of an individual's behaviors.

3.4.3 Session 3: Co-designing a personal VCA. The goal of the last workshop is to examine overall two-week experiences of using the VCA in autistic adolescents' everyday context and what kinds of expectations they had towards the future design of VCAs(Figure. 4). Due to the difficulties in communication that individuals with ASD have and lack of prior experiences in participating in the design workshops of our participants, we organized the workshop session in a way that we could gradually deepen the future VCAs ideas that each participant proposed.

First, participants and researchers reviewed the diary entries and usage videos from period 2 in a similar way through which we reviewed data in session 2. Next, we discussed the following questions through the worksheets(Figure. 5): 1) Self-assessment of achievement of behavioral goals 2) satisfaction level with the VCA functions they used, 3) extraordinary situations, and 4) suggestions for improving VCAs' functions.

Second, we asked participants to design an imaginary VCA that they would like to have in their daily lives based on the previous experience. We first requested them to describe the following two situations: 1) situations where they used the VCA based on their usage experience, and 2) situations where they would like to use a VCA in the future even though they have not had a chance to use it in such a way. When brainstorming, we instructed them not to take the current technical constraints into account, but to imagine whatever they would like for a future VCA. Then, they selected one situation and listed which personality and functions of VCA would fit best in the situation they chose. We provided some examples in the form of cards(Figure. 5) , which contained

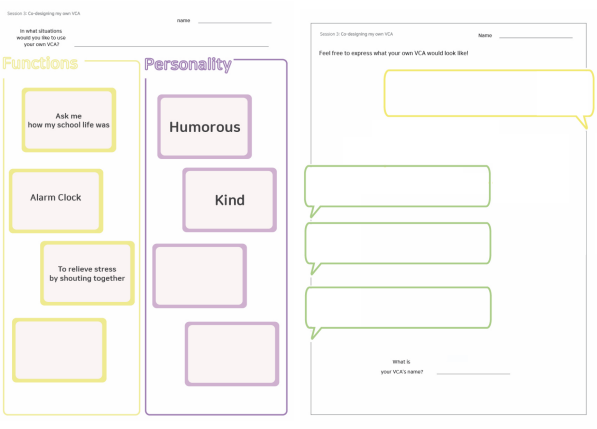


Figure 4: The cards and worksheets used in Session 3.

some example functions and personality traits to help them come up with ideas. The worksheets (Figure. 3(b)) are designed with the following questions: "In what situations would you like to use your own VCA?", "Please assign functions and personality of VCAs," "Feel free to express what your own VCA would look like!" and "What is your VCA's name?" They also drew the ideal VCAs' appearance (Figure. 6) that they think, gave a name to it, and introduced their design of VCAs to other participants [49, 50, 82].

Lastly, we asked participants to create usage scenarios to understand the features of their VCA designs clearly(Figure. 5). We then guided the participants to choose between the two scenes they developed and created fictional dialogue scripts with the VCA they designed. Then, each participant was asked to read the scripts reflecting the personality of the VCA. After the third session, we conducted one-to-one interviews to listen to individual's opinions that they might not want to share in group settings and asked participants' opinions about the VCA they had designed.

Figure 5: Capturing the moments during workshops.

3.5 Expert and Parent Interviews

Before conducting workshops, we conducted individual interviews with four ASD experts, including counselors, therapists, and clinicians who have experiences with adolescents with ASD for more than five years, to obtain feedback on the overall design of the research, the type of VCA to be used, and the structure of the workshops. The experts' feedback helped us provide ASD adolescents with specific and appropriate guidelines throughout the study.

After the workshops, we conducted one-on-one interviews with caregivers to better understand how adolescents with ASD used VCAs in their daily lives. Through parent interviews, we aimed to identify the adolescents' unique characteristics that could impact their usage of VCA. To this end, we asked what the parents had observed regarding their children's usage of VCA and what their opinions were. Also, we explained the results of session 2 and 3 to parents to better contextualize each participant's usage and design by listening to their parents' opinions. While other caregivers' interviews were conducted via phone, we had a face-to-face interview with the caregiver, who also participated in the experts' interview. We were not able to conduct interviews with Nick and Ben's caregivers due to their hectic schedules. Each interview lasted for 45 to 70 minutes.

3.6 Data Analysis

All interviews from group workshops, individual interviews with the adolescents, experts, and parents were audio-recorded and transcribed. The data analysis subjects included the transcripts, worksheets, and cards from the workshops, and the pictures depicting the ideal VCA's appearance. A thematic analysis was conducted to analyze the qualitative data from participatory design workshops and individual interviews. Through this method, we focus on examining themes in usage patterns and meanings of usage behaviors. Two researchers conducted an initial coding of the data through open-coding, while the other two researchers reviewed each coding process.

4 FINDINGS

4.1 Sharing Specific Interests with Personal VCAs

Throughout the study, using VCAs provided an excellent opportunity for our participants to express their specific personal interests. Restricted interests are common in people with ASD and often understood as a typical trait that must be fixed or removed. Having a specific interest is not necessarily bad [14]. Instead, it can provide a chance to interact with others through interests or an opportunity for people to understand themselves better. In this study, some participants felt an attachment to VCAs, and they shared their interests with VCAs and used them to obtain information about their interests.

> "I listened to sounds of animals and birds, [...] such as ASMR, and Melon (a popular music streaming application in Korea) [...] I'm so delighted when I can listen to that kind of sound [...] That sound is cheerful and exciting. (While introducing one of his favorite songs, which he listened to via VCAs) Listen, it sounds like a

> beast. It is a scratching sound, and I cannot even hear the lyrics. That sound might not be good for others, but I really like it." (Daniel)

Such personal interests also affected our participants' VCA designs. Daniel expected a VCA to fully understand his interests, actively provide information he was interested in, such as quantum mechanics, and mediate between him and others to have conversations. Fred, who loved using YouTube to listen to calm and relaxing music, felt that it was a shame that VCAs do not support music streaming through YouTube. The first few times, he listened to music from the music streaming service that NUGU provided. However, he found it difficult to find his favorite type of song through the application, so he barely used the VCA for listening to music after the first three days. Consequently, in the last design workshop, he decided to design his own VCA called tube, which featured a YouTube logo. This VCA was specifically designed for using the YouTube service (Figure. 6). He set up his favorite VCA functions (e.g., listening to music) and the additional function of YouTube. To utilize this function, he made the personality of VCA that he felt comfortable with and tried to use it to help him keep a regular life.

> "(Explaining his VCA idea) It should have a peaceful and quiet personality. (His VCA works for playing music that suits his tastes) I think it'll be disturbing to hear loud music in the morning." (Fred)

Specific interests are common traits in people with ASD. The specific interests could be a trigger for using the VCA, which has functions that can help these users maintain and develop their interests.

4.2 Enhancing Self-Care Skills in the Daily Context

We found that our participants used VCAs to manage their daily lives using features such as morning alarms, weather forecasts, and schedule management (Table. 2). Not only do VCAs have useful functions for self-management, but their kind personas and tone of voice have helped adolescents with ASD to perform actions independently. This can be helpful in that it motivates participants and induces them to plan and perform actions, unlike existing self-management apps, which focus on checking whether users have implemented what they planned. For example, Brian, a college student, realized the VCA could help him with his morning and bedtime routines after navigating different functions of VCA for the first three days of the study.

> "I called Aria this morning, and it said good morning. It made me feel like I was with Aria. It helped me listen to songs before I went to bed that made me feel relaxed [...] I had a deep sleep." (Brian)

This insight led him to use the VCA to improve his self-care skills such as schedule management and hygiene (e.g., washing his hair and body, shaving his beard), which had been his family members' concerns for a long time. Accordingly, using the VCA, he planned his morning routine, such as checking the weather forecast, eating breakfast, and taking a shower.

> "Well, I guess [...] it was helpful to keep my daily routine, such as helping me get up early! It was not that hard to use it in my daily life and it didn't disturb my daily routine." (Fred)

Specifically, our participants hoped that VCAs could offer customized and personalized assistance in their daily lives based on detailed knowledge of their daily context. For instance, Daniel, who had a keen interest in voices, hoped that he could customize a VCA's voice tone as he liked when gathering various kinds of information he needed for a day (e.g., weather forecast, bus arrival information, studying English) based on the types of information for each situation. Similarly, Tom hoped that VCAs could automatically detect his status and offer personalized assistance. For example, he wanted his VCAs to help him fall asleep using sensors by identifying if he was tired, playing calm music, and turning on a mood light.

In addition, the adolescents sought advice that could assist their daily lives through the VCA's "fortune-telling" function, a feature that provides a motivational message or general advice on attitude. Although fortune-telling is not a primary feature of the VCA, its advice, even in this form (e.g., making a concrete plan and sticking to a schedule), was more likely to be treated with seriousness by our users than advice from their parents or caregivers because adolescents are more independent, making it difficult for caregivers and therapists to intervene. Surprisingly, this minor, supplementary feature could have a persuasive effect on users' behavioral change.

> "One day, the VCA said I should be very careful today, but I didn't listen carefully. Then, my mother yelled and told me to stop using the computer because I was using it too much. [...] After that, I realized I should listen to advice from the VCA." (Ben)

Five out of seven participants used this feature throughout the study, and most of them were very satisfied with this function. It seemed they often perceived the advice that they received through this function as meaningful (e.g., "Thinking carefully before you talk will help you avoid making mistakes," "Be cautious. You could make a big mistake tomorrow."). In addition, Lisa's mother expected a VCA to continuously and actively advise adolescents on tasks such as scheduling and hygiene management.

4.3 Practicing Conversational Skills with VCAs

The two-week use of VCAs allowed our participants to learn about their communication (e.g., difficulties in understanding the context of dialogue, inaccurate pronunciation) and developed their dialogue strategies through various VCA functions. Lisa utilized the VCA to solve the difficulties she faced in conversations. She said that she often experienced difficulties understanding the structure of sentences and generating proper sentences while talking to others. Therefore, this participant set a goal to write down what the VCA said for a week. In addition, using VCAs provided an opportunity for our participants to improve their inaccurate pronunciation, which is one of the critical factors for effective communication. We found out that four out of eight participants experienced difficulties in having conversations with the VCA due to their pronunciation issues. Specifically, Tom repeatedly experienced difficulties activating the VCA due to his inaccurate pronunciation until Session 2; he often found himself unable to activate the VCA even after trying three or four times. However, after much practice throughout the study, he reported that his pronunciation improved, and he was

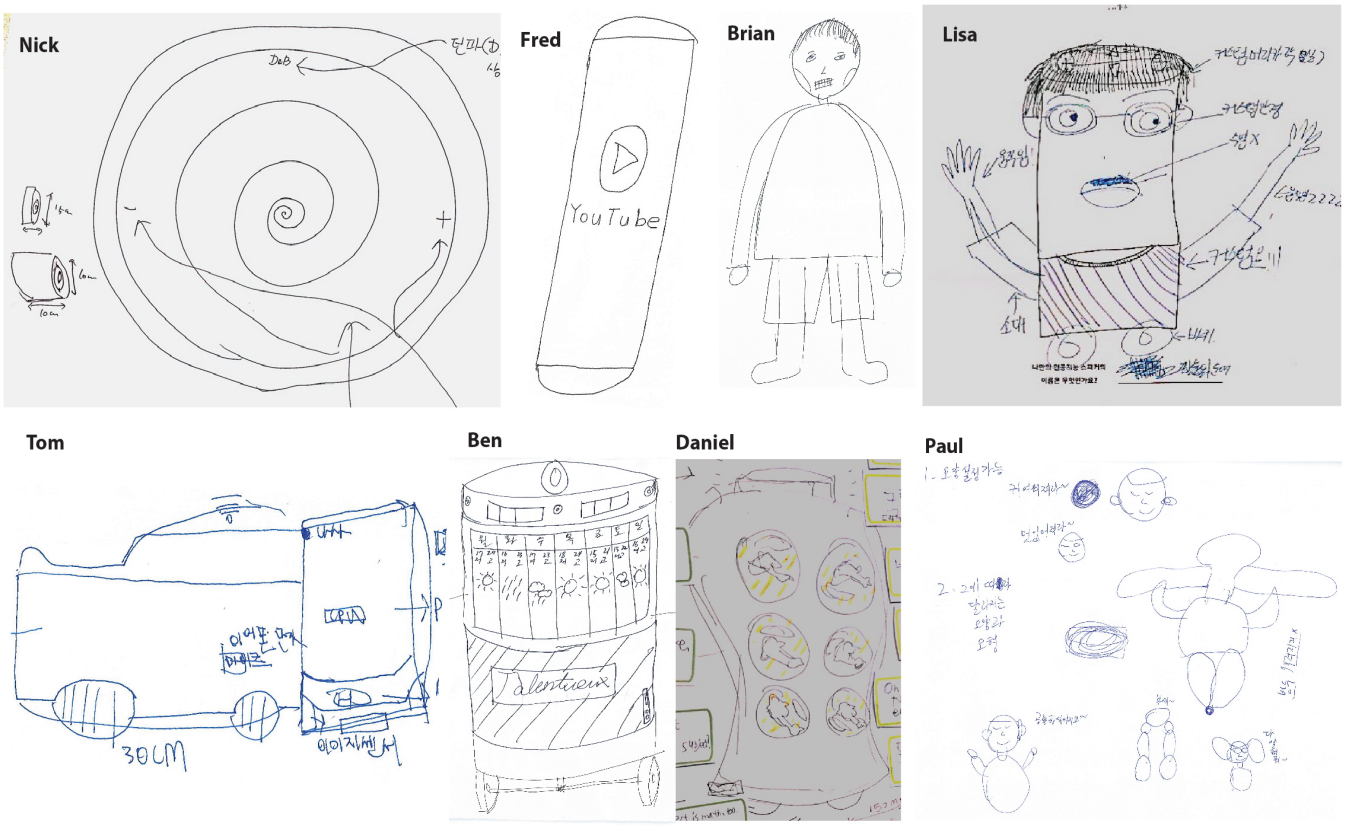


Figure 6: Drawing outcomes from session 3. Brain, Lisa and Paul expected to get advices on everyday life or spend their spare time together. Therefore they drew a VCA with a similar appearance. Nick, Fred, and Ben described their VCAs in cylinder shapes similar to the exterior of the VCA used in the study. Daniel and Tom described the appearance of VCA using their favorite objects, such as bus and china.

able to activate the VCAs right away. Tom got the hang of using a VCA for better speech recognition and shared this with other participants and researchers through the design workshop.

> "I had better pronunciation after using the VCA. By using the VCA, I learned how to use it. When I use the VCA, I need to clarify my pronunciation and pause between words." (Tom)

When designing the future design of VCAs, our participants developed various creative ideas about how VCAs could help them improve on communication skills in formal and casual communication contexts. Paul said he would like to simulate a presentation with a VCA and receive feedback from it when he needs to prepare for an important presentation. Meanwhile, Tom, who often found it challenging to have casual conversations with others, hoped that he could use a VCA for practicing such conversations. Therefore, throughout the study, he often initiated conversations with the VCA and expressed his emotions and thoughts. Such VCA properties enable users with ASD to practice speech and conversational strategies without temporal and spatial constraints. VCAs can therefore serve as an easily accessible conversational partner without fear of judgment.

On the other hand, adolescents also suggested simulating conversations in very personal contexts. Lisa, whose recent interest was a romantic relationship, hoped that she could have better conversations with the person for whom she had feelings by practicing with VCA. Therefore, when designing her own VCA, she suggested a proxy for a romantic partner by projecting the characteristics (e.g., timid, sweet) and tone (e.g., dark) that matched the person for whom she had feelings. Through a dialogue simulation with the VCA, she hoped to gain hints regarding when she needs to tell him about her feelings. A VCA can be a medium for adolescents with ASD to understand their emotional status and practice emotional expression. This shows that it can help ASD adolescents who have difficulty establishing and maintaining relationships with others to plan strategies for face-to-face communication in advance.

4.4 Expressing Their Own Emotions and Feelings Toward VCAs

Adolescents with ASD are usually not accustomed to sharing their personal stories with others. However, in this study, they expressed their thoughts and feelings to the VCA. Because it is a machine and therefore not human, it cannot express its feelings to users, making

it easier for the adolescents to express feelings and reveal their own emotions.

> "By the way, I think I can get my own thoughts off my heart because the machine can't read my emotions, and it does not have feelings. Machines are not human beings, so I can do so." (Paul)

We also investigated whether expressing emotions towards VCAs can help users regulate their emotions and manage stress by themselves. Tom stated that using the VCA to express his feelings helped him understand and manage his emotions.

> "When I talk to the AI speaker, I can understand how to express my feelings a little bit [...] I knew to release or relax my emotions once I used it. And, uh [...] sometimes, I think music from the speaker helped to calm me [...]." (Tom)

Experts who advised our research said that adolescents with ASD typically have few opportunities to express their emotions and are less skilled at doing so. Therefore, expressing their thoughts in words through conversations with VCA is an opportunity for ASD adolescents to practice how to express their emotions properly and think about the meaning of certain expressions by listening to the VCA's expressions.

> "ASD children find it difficult to talk to people, tend to have no close friends, and have difficulty expressing their feelings to others. VCAs have many restrictions. However, VCAs can help children express their feelings through their own speech. I think it helps ASD teenagers express their feelings in various ways and better understand expressions that they do not understand well." (Therapist 1)

4.5 Challenges of Using VCAs

Our study's findings indicated that using VCAs in daily life could result in positive effects for adolescents with ASD, such as improved management of their daily lives, regulation of negative emotions, and practice using communication skills. However, we also discovered some concerns about using VCAs in the daily lives of adolescents with ASD. First, we observed several instances in which the adolescents yelled, used improper language, and even hit the VCA when they were frustrated because it did not recognize their words correctly or did not support the type of service they wanted.

Second, we found that using VCAs could undermine autistic adolescents' self-esteem. One of our participants, Fred, talked about the frustration he experienced when talking with the VCA.

> "I felt that I'm not better than this machine because it talks much better than me [...] I usually needed some time to answer questions, but it did not wait for me to finish the answer and moved to another conversation [...] I had no idea how to talk with it." (Fred)

In addition, participants were concerned about privacy issues and other people's interference with their use when sharing the device with family members.

> "Next time, I would like to use NUGU without others' presence. When there were other people (family members) around me, I felt uncomfortable because I felt they were making fun of me." (Ben)

Through this, we identified that we needed to consult with other users about ensuring they had the proper authority and environment to use VCAs.

5 DISCUSSION

In this study, we examined the opportunities and possibilities that ASD adolescents face in conversations and interactions with VCAs. We found that VCAs could be engaging, empowering, emancipating tools that support adolescents with ASD by addressing their needs, personalities, and expectations, such as promoting self-care skills, regulating negative emotions, and practicing conversational skills. This section investigates the possibility of leveraging a commercial VCA to empower users with ASD by augmenting their personalities and characteristics rather than developing specialized prototypes designed to address the specific difficulties and challenges such users face in everyday life.

5.1 How Could Off-the-Shelf Products Become Empowering Tools for Adolescents with ASD?

The traditional AT approach was developed to help users adapt to inflexible systems and programs and make it possible for those with disabilities to do things they cannot do without assistance. However, following the recent AT research trend, we propose a holistic approach as an analysis framework for understanding disability as lived experience and personal well-being, not impairment, by building upon a prior study that suggested using the interactive model to emphasize that the disabled experience is multifaceted [28]. Wobbrock et al. [81] also defined *ability-based design* and argued that systems should be designed to accommodate users' abilities to suit individual traits [3]. In developing technology for people with ASD, this flexible and holistic approach is also needed, as Wobbrock et al. suggested. Frauenberger et al. [28] reported that technologies for those with ASD mainly fall under two categories: those supporting specific difficulties faced in daily life and those devising new effective ways of enhancing learning interventions. Even though ASD is understood as a spectrum of conditions, these specific categories ignore the rich and complex life-worlds of those with ASD as an opportunity space for design, strengthening a narrow conception of the possible roles that technologies might play in everyday life [26, 39]. Therefore, the authors state that it may be time to design beyond assistance and intervention and to employ a more holistic approach that helps those with ASD experience self-expression and self-empowerment rather than helping ASD users better accommodate technology [77].

A VCA has clear advantages of being appropriately customized to reflect individual interests or goals through various functions and manifest their strengths or unique characteristics. We suggest using a VCA as an empowering tool aimed at supporting individuals with ASD by reflecting their characteristics and catering to their daily needs. In this study, we found that users with ASD preferred to fully cater to their specific interests in using such technology comfortably and continuously [12]. In addition, adolescent users could share their personal stories with VCAs, accept responses or advice given

by VCAs, or reflect through the use of VCAs. In particular, the fact that adolescents did not feel burdened by proposals provided by VCAs shows that such advice or information is valued at certain times, which could reduce caregivers' and therapists' involvement in such individuals' daily lives [30, 45, 74, 76].

Interestingly, although the behaviors, habits and thinking processes of individuals with ASD are considered unique characteristics in our study, participants reported that they wanted to improve particular behaviors and habits that could affect the quality of conversations (e.g., language use, expressions, voice tone, turn-taking). Turn-taking with VCAs can be used to think about speech strategies used in communicating with and listening to the devices, naturally exposing users to the language habits and culture of the outside world. As a result, a VCA can serve as a conversational partner that allows many adolescents with ASD who have relatively few opportunities for conversation to rehearse various aspects of conversations without experiencing burden. Lisa, who is often asked to speak louder, reported that she noticed that her voice was louder when she spoke to the VCA and that she was able to adjust her voice level even when she spoke to others. Fred's father, who is also a psychological counselor, said that the fact that VCAs can be used easily in everyday spaces is a great advantage compared to weekly meetings with a therapist. Moreover, clinical experts highlight that VCAs have the potential to serve as instrumental applications that deliver intervening content aimed at enhancing social skills (e.g., PEERS [83]) which requires repetitive practice with conversational partners not only in a clinical setting, but also in everyday life. The experts predict that VCAs will allow individuals with ASD to practice what they have learned in previous instructional or clinical settings.

5.2 How Could We Design VCAs to Support Daily Tasks Management?

In the study, the participants exploited VCAs to manage their self-care tasks, discussed their difficulties with and views of VCAs, and listened to advice provided through VCAs. Participants also showed emotional attachment toward the personalized VCA as it provided tailored experience. We present design implications necessary to promote positive experiences with VCAs while stressing the importance of adaptability and customization. Additionally, we suggest ways to mitigate challenges of VCA use.

5.2.1 Design Implication 1: Providing initial moments and scaffolded approaches to developing strategies for using VCAs. During our workshops, the participants spent time 1) independently exploring what a VCA can do, 2) using the VCA's functions in their everyday contexts, and 3) forming expectations about the VCA's role. We were interested in exploring the use of VCAs by users with ASD in an open-ended way. Therefore, we helped users navigate their own VCA usage goals, but we did not guide or change their behaviors through the VCA. This required us to avoid providing users with a common and specific behavioral goal. We highlight this methodological consideration, which is to support users in exploring their own VCA usage corresponding to their abilities and difficulties by guiding them regarding how to plan and check their VCA use independently. By discussing and planning how to use VCAs with the researchers multiple times, the participants acquired a sound understanding of what functions VCAs have, how to interact with VCAs, and how to use VCAs. Based on this, they developed their own strategies for using certain functions of VCAs to suit their own context. As described in our findings, the participants' purposes for using VCAs and the roles they expected VCAs to play were varied. The participants wanted to customize the diverse functions of VCAs in accordance with their own goals rather than using them as one-size-fits-all devices. Overall, we perceive a need to design VCAs that enable users with ASD to spend enough time to initially and independently test out the functions of a VCA, identifying its roles and capabilities, and develop their own strategies for using and appropriating the VCA's functions. Such a need for a phase of gradual exploration of device's roles echoes the findings in [41, 51]. Although providing detailed guidelines exceeds the scope of our work, a VCA might support such exploration by scaffolding its capabilities, such as what it can and cannot do, as suggested by [52].

5.2.2 Design Implication 2: Personalizing the conversation styles and experiences. What relationships between users and VCAs and how they communicate can affect participants being felt VCAs as being personalized. We examine whether human-like conversational elements work effectively in building emotional bonds between VCAs and users. In previous VCAs studies, human-like features such as the rate of speech, voice, and persona were considered to foster a parasocial relationship with VCAs [17, 19, 43, 56, 61, 78]. In this study, participants expected conversations with VCAs to mimic what can be experienced through human communication such as emotional connection. The tone and attitude of the persona used for VCAs communication had the greatest impact. The participants wanted fine-tuning of specific conversational features (e.g., tone and personality). The submissive and honorific expressions from the VCA helped Tom converse, but in Nick and Fred's case, these traits were a barrier to conversation. For VCAs to be suitable for ASD adolescents with distinct behavioral characteristics, it is necessary to allow adolescents to select the VCA elements such as voice, tone, and personality.

The participants believed that VCAs' voice and tone could be used to reflect adolescents' specific preferences for desired conversation partners. All of our participants are native Korean speakers. The Korean language has two levels: high politeness and low politeness. Koreans use honorific languages to show respect for listeners. It is common to see younger people use honorific words with elders. The other form is not used out of disrespect. Instead, it can indicate intimacy and closeness in a relationship. When the VCA in this study continually used honorific words, some participants became uncomfortable. "If you talk to it using casual words, it should respond with casual words..." Participants expecting a friendly relationship with VCAs wanted to program such language style preferences. The adolescents wanted to control speech, voice, and persona traits to reflect features of their ideal and most natural conversation partner.

The participants expected VCAs to act proactively or make recommendations at times. They expected a three-dimensional VCA persona that appropriately changes in personality according to functions used or the user's situation. The participants also expected a

VCA to reveal their own feelings or thoughts on situations rather than always adapting to and accepting their requests.

Participants expected to build effective and natural relationships with VCAs. Participants expected VCAs to gradually share information to users or actively express feelings as experienced in communication with other people. For example, Lisa reported feeling embarrassed by the fact that VCAs can only share the user's information without disclosing its own information. Currently, VCA technologies can only execute and respond to the user's requests. It will be necessary to develop design elements that can facilitate long-term relationships based on the disclosure of VCA's information from public to private content over time.

5.2.3 Design Implication 3: System Guidance for mitigating improper requests or behaviors. As we describe above, users may misbehave by swearing or damaging the device. This often occurs when VCAs respond inappropriately to a user's needs or provide the wrong answer. When improper use continues, usage may trigger problematic or negative behaviors. Therefore, design elements should establish proper relationships with VCAs by devising systemic measures or guides.

Studies involving social robots are exploring how robots can best respond to users [8]. In particular, for robots operating in everyday environments rather than in refined experimental settings, studies have explored how robots should respond to users' adverse reactions [35]. Robots express emotions and provide responses to users' requests mainly through speech [9], facial expressions [13, 44], and nonverbal expressions [5]. According to such studies it is considered unnatural for robots to convey emotions or states through facial expressions [8] while emotional states are best expressed directly on the device's exterior using colors or lights or through movement or voice expression [42].

As ASD is sensitive to audiovisual cues, the system can allow users to control their inappropriate behaviors through audiovisual features such as visual signals, tactile feedback, or voice cues. Specifically, in an expression study of appearance-constrained robots performed by Kim et al.[42], nonverbal communication was adopted by initiating imagery of skin color changes or bruising in robots when users swore. Similar approaches may be used to address instances of VCA damage or cursing through device surface color changes to respond to such occurrences. Inappropriate actions can then be instantly controlled through indirect notification. In addition to changes in appearance, especially in cases of communication with media such as VCAs or chatbots, it is important to introduce human characteristics [15, 31] so that users can feel empathy for robots as a means to cope with aggressive behaviors rather than merely responding by expressing anger [85].

Recently, studies have examined which conversation strategies are most appropriate when users make inappropriate requests or swear [16]. If VCAs were to alert users to their improper behaviors in conversation, established personas or conversation strategies should be developed organically.

6 LIMITATIONS & FUTURE WORK

In this work, VCAs were proposed as a conversation partner for ASD adolescents; however, VCAs were not a fully turn-taking device due to technological limitations. If a conversation model capable of full turn-taking is introduced through technological improvement, users must investigate perceptions and expectations of conversation continuously and gradually develop machines. The study was also conducted on participants in a single country; thus, cultural factors may have influenced the study results. It will be necessary to consider how design elements can be tailored to specific languages and cultures, and such features should be considered when establishing design guides or application concepts. In addition, this study focused on daily contexts of home environments; thus, work on how VCAs can be utilized in various other settings such as schools and clinics must be conducted.

7 CONCLUSION

In this study, we explored the possibility of leveraging a VCA as a personal assistant in everyday life by including the voices of adolescents with ASD. The participants adopted VCAs as a tool to share their interests, support their self-care, and practice conversational skills or expression of emotions. It provides opportunities for using a VCA to empower adolescents to manage their daily routines by themselves and emancipate them by providing information about their interests and getting emotional connections. Based on findings, we investigated the value of appropriating an off-the-shelf technology to a personal assistant for individuals with VCA. Also, we proposed the design implications of VCA in order to utilize better in the daily life of adolescents with ASD.

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