

Candidate number: 10149

An overview of Conversational Agents as support tools for people with Autism - perspectives on user experience: a scoping review

Bachelor's thesis in Psychology

Supervisor: Lucas Bietti

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Preface

This bachelor's thesis was an individual project with the goal to write a scoping review on a modern and relevant topic for psychology such as conversational agents.

In the process, I carried out a literature search on bibliographical databases online and, after selecting relevant studies, analyzed and extracted data from the literature.

The methodological part of the scoping review was outlined with assistance from the supervisor and four other students with a similar project. I would like to thank all of them for their support and their contributions which helped shape this review.

Abstract

Mental health issues continue to be a health concern for many people across the globe that drain resources and negatively affect the lives of those suffering from the disorder but also their families and friends. This scoping review introduces conversational agents, also known as chatbots, as a possible solution for this issue. More specifically, as a support for people with Autism Spectrum Disorder. The aim of this scoping review is to give an overview of the existing literature on conversational agents for people with ASD, with a focus on aspects relating to user experience.

Seven online bibliographical databases were used to retrieve relevant documents. This resulted in 14 studies being selected and examined using thematic analysis. Five themes connected to user experience were analyzed. Four of them determined a priori: satisfaction, utility, usability, and independence, and one emerging from the studies: personalization. The thematic analyses revealed that all the themes were covered in the studies, though to different degrees. A further analysis and discussion of the themes suggests that the themes are addressed insufficiently in relation to each other in the literature. More holistic approaches to user experience might be beneficial.

The world is currently living through a crisis of mental disorders. Mental conditions are on the rise which is putting stress on economies, individuals, and health systems (Murray et al., 2012) The World health organization estimates a shortfall of 10 million health workers by 2030, mostly in low- and middle-income countries (World health organization, n.d.). This means that societies have to find new ways to treat people with mental disorders. Conversational agents (CAs), also known as chatbots or virtual agents, present an opportunity to provide treatment and support for many at a time.

These systems can converse and interact with humans using spoken, written, and visual languages, and are currently being developed to support people with different issues like depression and anxiety (Abd-Alrazaq et al., 2019). Developing cheap and accessible conversational agents may be the solution to many of the problems that we are facing both in high- and low-income countries.

This scoping review will attempt to connect conversational agents to a disorder that is still not fully understood to us: Autism.

Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a neurodevelopmental disorder, meaning it is part of a group of conditions which typically manifest early in development, and which are characterized by “developmental deficits or differences in brain processes that produce impairments of personal, social, academic, or occupational functioning” (American Psychiatric Association, 2013, p.36). More specifically, ASD is characterized by deficits in social communication and social interaction across multiple contexts as well as restricted, repetitive patterns of behavior, interests, or activities. These can take the form of deficits in social-emotional reciprocity, in comprehension of body language and eye contact, or in development and maintenance of social relationships, also like

stereotyped and repetitive motor movements, ritualized patterns of behavior, or abnormally intense fixation on certain interests (American Psychiatric Association, 2013).

Screening and prevalence

ASD poses a challenge to the affected, their families, and society as it is a lifelong disorder that has its onset in childhood. Its prevalence appears to be on the rise likely due to conceptual changes in the understanding of the disorder, as illustrated in the changes from DSM-IV to DSM-V (American Psychiatric Association, 2013) but also due to increased awareness of ASD and improved screening tools (Masi et al., 2017; Maenner et al., 2023; Sanchez-Garcia et al., 2019). An increase in attention to different ethnic groups, social classes, and genders have also contributed to an increase in estimated prevalence (Maenner et al., Elsabbagh et al., 2012; Green et al., 2019). The increase in prevalence can be observed in the US in the reports made by The Centers for Disease Control and Prevention (CDC), which provide estimates of prevalence of ASD among children aged 8 years in the US. The last two reports, for example, show an increase in the prevalence of ASD from 1 in 44 children to 1 in 36 (Maenner et al., 2021; Maenner et al., 2023). Worldwide estimates are more difficult to calculate reliably. Elsabbagh et al. (2012) produced, however, a systematic review analyzing studies from Europe, Western Pacific, Southeast Asia, the Eastern Mediterranean, America, and Africa estimating the prevalence of ASD to 1 in 161 people worldwide.

The increase in prevalence warrants attention considering the substantial cost of ASD for individuals, families, and societies; upwards of 1.4 million dollars per individual according to a study by Buescher et al. (2014). Raising awareness and developing screening tools, interventions, and policies to detect and treat ASD early and effectively, might help reduce the economic as well as the psychological burden derived from ASD.

Universal screening of young children has been proposed as a way to identify individuals with ASD and initiate interventions early on that might improve the developmental course and outcomes of these children. This idea has been supported by the American Academy of Pediatrics (Johnson et al., 2007) and by newer studies like the meta-analysis by Sanchez-Garcia et al. (2019) which supports the idea that current screening tools are accurate at detecting the presence of ASD in children between 14-36 months, and Gabbay-Dizdar and colleagues' (2021) longitudinal study on 131 children which shows greater improvements in ASD symptoms in children diagnosed before 2.5 years compared to those diagnosed later. Nonetheless, arguments against universal screening have also been laid out by the U.S. Preventive Services Task Force (Siu, 2016).

Indeed, screening poses a challenge as the time at which ASD may become visible is dependent on the severity of the symptoms. Severe cases may be diagnosed by age 2-3, e.g., children with co-occurring intellectual impairment and less than 70 IQ are often evaluated before 36 months (Maenner et al., 2021), while milder cases may go undiagnosed until 6-7 years and, in some cases, symptoms might even go unnoticed until adulthood (Au et al., 2021). Early screening and diagnosis enable earlier interventions which may improve the life of the children (Au et al., 2021, Gabbay-Dizdar et al., 2021) and may be crucial, among other reasons, to protect children with less severe ASD that might go unnoticed.

Comorbidity

Screening is challenging in part due to individual variations in the expression of ASD; the same is true for diagnosis and treatment. The heterogeneity of the disorder stretches in multiple directions. Different degrees of severity and functioning and a myriad of co-occurring medical and psychological impairments must be accounted for.

Comorbidity of disorders is an especially hindering problem when it comes to ASD. When diagnosing ASD, DSM-V guides clinicians to specify whether there is an accompanying

intellectual and/or language impairment as well as any genetic disorders, medical conditions, or mental disorders (American Psychiatric Association, 2013). These specifiers are of importance to establish the level of functioning and support needed by the patient, as comorbidity in ASD significantly affects daily activities, decreases the quality of life, and accentuates problems in people with ASD (Fitzpatrick et al., 2016; Maskey et al., 2012).

Hossain et al. (2020) identified in their umbrella review of 14 systematic reviews and 12 meta-analyses, variations in the prevalence of comorbid mental disorders ranging from 54.8% to 94% prevalence for at least one comorbid disorder. They also identified in the literature several comorbid mental disorders among people with ASD such as: anxiety disorders, depressive disorders, bipolar and mood disorders, schizophrenia spectrum and other psychotic disorders, suicidal behavior disorders, sleep disorders, obsessive-compulsive and related disorders, disruptive, impulsive, and conduct disorders, attention-deficit/hyperactivity disorder (ADHD), eating disorders, substance use disorders, etc.

Comorbid mental disorders in ASD thus pose a challenge to already overburdened health services (Murray et al., 2012) and constitute more problems in the daily lives of those with ASD and their families (Maskey et al., 2012). In addition to the high prevalence of comorbid disorders, the variation in the type of co-occurring disorders, ranging from genetic and medical conditions to neurodevelopmental, mood, sleep or psychotic disorders, hinders the screening, diagnosis and treatment of ASD as it introduces unique factors that have to be accounted for differently in every case (Masi et al 2016; Hossain et al., 2020; Maskey et al., 2012).

Treatment

Treatment of ASD is also affected by the heterogeneity of the disorder which makes it essential to adapt interventions to each individual's necessities. Severity of symptoms, age, gender,

developmental status, and comorbid disorders among other factors, determine the treatment to pursue which may be behavioral, psychosocial, educational, pharmacological, or other (Weitlauf et al., 2014; Sharma et al., 2018).

Pharmacological treatments, which are widely used to treat other psychiatric disorders, are not yet widespread in the treatment of ASD due to its heterogeneity and the lack understanding of its underlying mechanisms (Howes et al., 2018; Genovese et al., 2020). Therefore, pharmacological treatment has relied on strategies such as repurposing medical drugs from psychiatric disorders that have common symptoms with ASD (Howes et al., 2018).

The British association of psychopharmacology (BAP) is in its consensus guidelines of 2018 (Howes et al., 2018) cautious in its recommendations on use of pharmacological agents in people with ASD. This applies to pharmacological treatments aiming at core symptoms of ASD as well as comorbid disorders. Limited evidence of efficacy in children and adults and the dangers of potential side effects, push the BAP to recommend caution when prescribing medicaments for people with ASD as well as consideration of behavioral interventions for certain symptoms prior to prescription (Howes et al., 2018).

Behavioral interventions are indeed the most common alternative for individuals with ASD. An important set of behavioral therapies have been based on Applied Behavioral Analysis (ABA) which describes principles and techniques used to assess, treat and prevent challenging behaviors and promote new desired behaviors and skills (Weitlauf et al., 2014). Applied to ASD, it has served to develop several treatment options that can improve core social skills and specific behaviors in individuals with ASD. ABA has especially inspired early intensive behavioral and developmental interventions, which are treatments undertaken by a therapist in a one-on-one situation over many hours a week (Weitlauf et al., 2014; Lord et al., 2018). These sessions aim to teach diverse developmental skills such as language and imitation, or cognitive tasks such as matching or sorting

(Lord et al., 2018). Intensive interventions like these are undertaken early in life and are the most popular form of treatment for behavioral symptoms associated with ASD, although their supposed effectiveness varies in the research (Masi et al., 2016; Weitlauf et al., 2014). They are also expensive and resource-demanding to implement in a good way, making them difficult to access for part of the population (Lord et al., 2018).

Other behavioral interventions available are parent-mediated treatments which coach parents on how to interact with children with ASD. These treatments tend to be non-intrusive for families, lower in cost, and can help give families some feeling of control and thus reduce stress (Weitlauf et al., 2014; Lord et al., 2018). Play/interaction-focused interventions and social skills interventions are other behavioral interventions that aim to improve social interactions and other important abilities through interactions between children and parents or peers (Weitlauf et al., 2014).

Cognitive behavioral therapy (CBT) has also been used in individuals with ASD to treat both core and co-occurring symptoms (Sharma et al., 2018). CBT has long been used to treat mental disorders such as anxiety and depression and it could also be used to treat these and other emotional and behavioral symptoms in people with ASD. Many of CBT's methods and attributes, like its more structured form, can be beneficial to people with ASD, although interventions should accommodate the social, cognitive, and behavioral impairments of these individuals (Spain & Happe, 2019). Spain and Happe (2019) highlight the lack of empirically derived guidelines for the adaptation of CBT to individuals with ASD and urge researchers to further explore this avenue as it might enable a more efficient and structured implementation of CBT.

Goals and objectives of this review

Being conversational agents (CAs) systems designed to be used by people to obtain some type of value, developers and researchers are concerned with the type of user experience CAs provide. This is key to achieving positive results and expanding their use to larger populations (Nielsen,

2012). The symptoms and heterogeneity that are associated with ASD require from the developers greater attention to user experience since users are more varied. The importance that these CAs could have in the lives of people with ASD could be substantial, meaning all aspects of their experience should be accounted for and improved.

The aim of this scoping review is therefore to give an overview of the existing literature on conversational agents for people with ASD, focusing on user's reported experiences using these systems, including topics such as usability, utility, satisfaction, independence, and personalization.

The objective of this review is to grant an overview of the different experiences that people with ASD have when using conversational agents, with the purpose of supporting future development and implementation of these systems.

Methodology

This review followed the methodological guidelines for the conduct of scoping reviews of the Joanna Briggs Institute (JBI; Peters et al., 2020). A group of four other reviewers served as support in the process of outlining this methodology and discussing different aspects of it.

The two main components of this review are the literature search and the data extraction process. The criteria for these will be described next.

Eligibility criteria

The criteria for the eligibility of sources of evidence were based on the aim of granting an overview of the different experiences that people with ASD have when using conversational agents, with the purpose of supporting future development and implementation of these systems.

To be selected for this review, papers are required to include data on user experience as reported by users, researchers or other observers like caregivers. Only CAs designed to be handled by people with ASD will be included, meaning CAs targeting caregivers, therapists or teachers of people with ASD will be excluded. CAs targeting people suffering from other neurodevelopmental disorders, for example ADHD or Childhood-onset fluency disorder, will also be excluded. There are no imposed limits on the age, gender or country of origin of participants, nor the severity or expression of their disorder.

Given the heterogeneity of ASD and the variety of approaches to treatment and training, this review will include CAs that allow written, spoken, and visual interaction with users. Serious games, augmented reality (AR) and virtual reality (VR) implementations of CAs will be excluded, as well as CAs requiring specific hardware other than screens or audio. This is motivated by an interest in CAs with the potential to be widespread, accessible, and affordable. CAs targeting core symptoms as well as comorbid disorders in people with ASD will be included. There are no restrictions on the type of intervention used by the CAs.

Only articles presenting primary research findings published in English after the year 2014 were included. Peer-reviewed articles, books, published doctoral theses, and conference proceedings were included, while systematic reviews, editorial letters, conference reviews and conference abstracts were excluded. Articles without full-texts available to the author were also excluded.

There are no restrictions on the research design and methodology. Papers focusing solely on the development and design of a CA will be excluded unless they systematically test the CA on participants and report on their user experience.

Information sources

To find potentially relevant documents, a search was conducted on seven bibliographic databases between the 21st and 23rd of march of 2023. The selected databases were: Scopus, IEEE, Web of Science, PubMed, Embase, Medline (Ebsco), and Google Scholar. Only the top 100 results from Google Scholar were added since the database retrieves several hundred publications ordered by relevance. This was also in an effort to ensure that no relevant publications were missed. Access to some of the databases and publications was granted due to affiliation to the Norwegian University of Science and Technology (NTNU).

The search strategy was drafted in conjunction with the group of four reviewers. This included discussions regarding databases, limits, eligibility criteria and search terms. MeSH terms were used in Medline (Ebsco). The same search string was used on the other databases, including search terms relating to CAs and autism. The used search string was:

("chatbot" OR "conversational agent*" OR "virtual agent*" OR "chatterbot") AND ("autism" OR "autism spectrum disorder*" OR "autistic")*

Limits and filters in accordance with the previously stated eligibility criteria were added to the searches when possible in order to decrease the number of irrelevant results. Some examples of this are: excluding systematic and scoping reviews and other unwanted types of documents, excluding virtual reality, excluding documents published before 2015, etc.

Selection of sources of evidence

Two reviewers participated in the screening and selection process. The screening and selection of documents was based on the eligibility criteria previously detailed. The study selection process started with a manual screening of titles and abstracts, which was done independently by the two

reviewers. Disagreements were resolved by consensus after discussion. The full texts of the studies selected after the first screening were then reviewed by the two reviewers following the same process.

Data extraction

Thematic analysis was used to extract data from the selected papers (Braun & Clarke, 2006). Data was extracted and presented in the form of themes which represent recurrent topics in the literature that are relevant to user experience. The resources used to guide the creation of themes were the “User Experience Questionnaire” (UEQ; Laugwitz et al., 2008; Schrepp et al., 2017), the “System Usability Scale” (SUS; Brooke, 1995), and “Usability 101: Introduction to usability” (Nielsen, 2012).

Based on these, several themes were established a priori and specifically sought after in the selected papers. These were:

- Satisfaction: relating to joy, comfort, excitement and other hedonic qualities.
- Utility: relating to the system’s ability to lead users to their desired outcomes.
- Usability: relating to how easy the system is to use.
- Independence: relating to independent use of the system or the development of independence as a result of using the system.

It is important to note that these themes are related and affect each other.

Additionally, any new themes encountered during the process of data extraction that had relevance to the topic of user experience, were added. This resulted in the inclusion of “personalization” as a theme. Several other characteristics of the included studies, like information on population and type of publication, were also retrieved as part of the data extraction process for more context.

Results

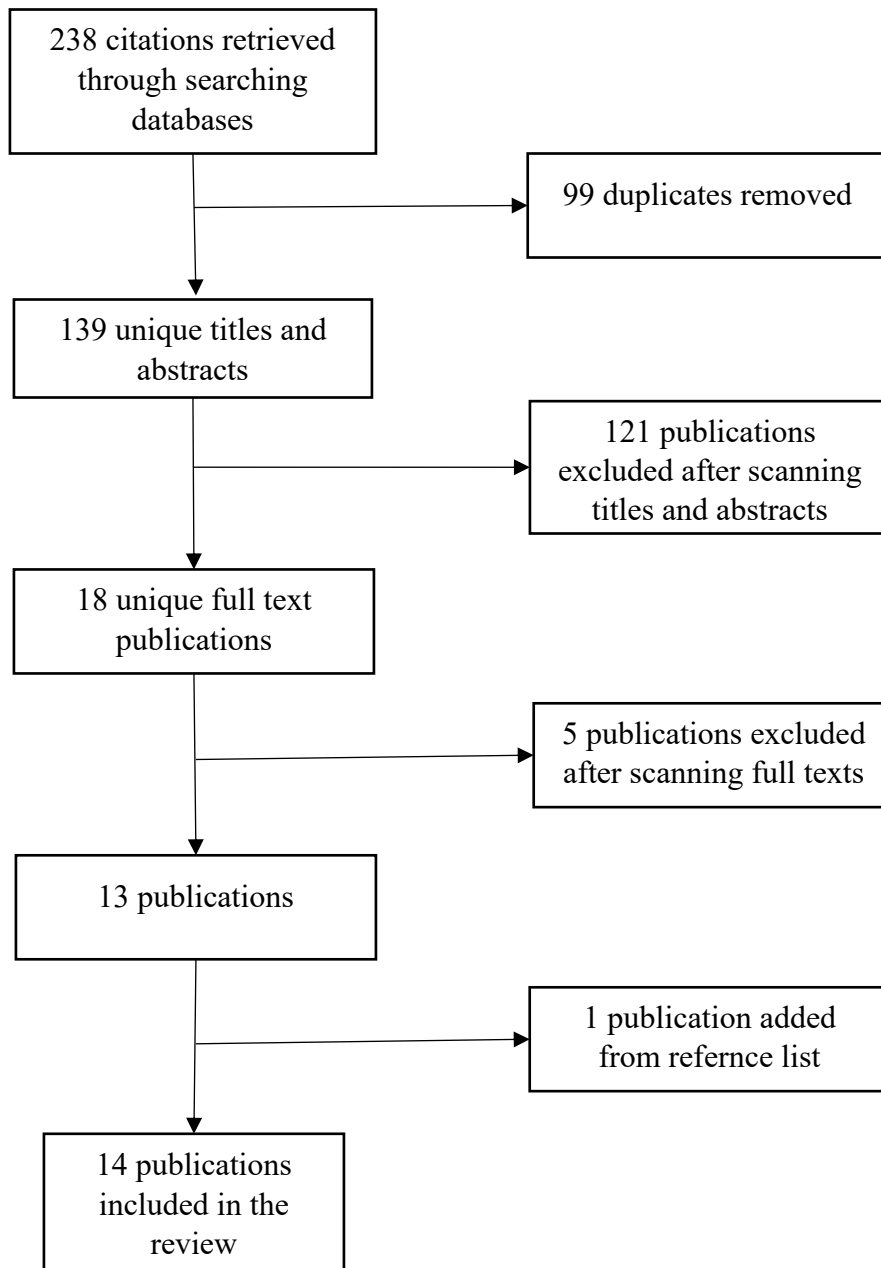
This section will present the results of the literature search and the data extraction described above. The results of the data extraction will be divided into two sections: one containing various characteristics of the documents retrieved and the other containing the themes related to user experience.

Search results

Figure 1 shows a flow chart of the literature search. The search on electronic databases yielded 238 results. Removal of duplicates left 139 unique documents to review. After reviewing titles and abstracts 41 documents were discarded because they were irrelevant to user experience, 34 were not on autism, 29 were the wrong type of document, 16 were on VR, AR, or serious games, 11 were not on CAs and eight did not have available full texts. Of the remaining 18 studies, five were discarded after reviewing the full texts. Bowrin and Iqbal (2020) was discarded because it only presented a protocol, Ghosh and Guha (2021) because they used VR, Hadri and Bouramoul (2023) and Mujeeb et al. (2017) lacked data relevant to the research question, and Hartholt et al. (2019) summarized the contents of a different study. This was a study by Burke et al. (2018) which was inspected and included in the review due to its relevance. The final number of studies included in this scoping review was 14.

Figure 1

Flow Chart of the Literature Search



Characteristics of sources of evidence

Relevant characteristics of the selected publications were retrieved and presented in text and table format.

Table 1 presents various characteristics of the included studies. Notably, social and communication skills was the most targeted issue, being the focus of eight studies (Ali et al., 2020; Burke et al., 2018; Milne, 2018; Milne et al., 2018; Patel et al., 2016; Porayska-Pomsta et al., 2018; Razavi et al., 2016; Tanaka et al., 2017). It was followed by issues in learning (Aljameel et al., 2018; Aljameel et al., 2019), different specific behaviors (Cha et al., 2021; Parvin et al., 2022), non-cooperative tendencies in therapy (Hadri & Bouramoul, 2023), and anxiety and stress (Palma et al., 2023).

Studies presented also differences in their population, with six studies targeting children (Aljameel et al., 2018; Aljameel et al., 2019; Hadri & Bouramoul, 2023; Milne, 2018; Milne et al., 2018; Parvin et al., 2022; Porayska-Pomsta et al., 2018), five targeting adolescents (Ali et al., 2020; Cha et al., 2021; Patel et al., 2016; Razavi et al., 2016; Tanaka et al., 2017), and only two targeting adults (Burke et al., 2018; Palma et al., 2023). Sample sizes go from 3 participants to 35 participants and males are overrepresented compared to females (Table 1). There were also differences in the severity of ASD in participants, with high functioning individuals being the most commonly recruited. These participants present milder symptoms of ASD. All but one study (Aljameel et al., 2019) included participants that were diagnosed with ASD.

Table 1*Characteristics of Sources of Evidence*

Author (year)	Age of participants (years)	Sample size	Gender (male)	Country	Study design based on:	Severity of ASD in participants	Type of publication	Sample type neurotypical (NT) vs ASD	Topic	Control group
Ali et al. (2020)	13-17	9	8	UK	Interview	High functioning	Conference proceeding	ASD	Social communication skills	No
Aljameel et al. (2019)	10-12	24	Unknown	UK	Statistical methods	High functioning	Journal article	NT	Learning	Yes
Aljameel et al. (2018)	10-12	3	0	Saudi Arabia	Questionnaire and interview	High functioning	Journal article	ASD	Learning	No
Burke et al. (2018)	19-31	32	25	USA	Statistical methods	mixed	Journal article	70% ASD	Job interview training	No
Cha et al. (2021)	16-19	8	7	Japan	Interview	All participants were verbal	Journal article	ASD	Daily life activities, emotional regulation, social skills	No
Hadri and Bouramoul (2023)	10-14	35	25	unspecified	Questionnaire	mixed		ASD	Virtual companion for therapy	No
Milne (2018)	6-12	31	Unspecified	Australia	Statistical methods	High functioning	Dr. thesis	ASD	Social tutor, communication/social skills	Yes
Milne et al. (2018)	6-12	32	Unspecified	Australia	Statistical methods	High functioning	Journal article	ASD	Social tutor	Yes
Palma et al. (2023)	20-34	15	14	Unspecified	Interview	Unspecified	Conference proceeding	ASD	Emotional help, anxiety and stress	No
Parvin et al. (2022)	8-11	3	2	Italy	Interview	mixed	Journal article	ASD	Support oral hygiene	No
Patel et al. (2016)	11-18	34	unspecified	USA	Statistical methods	unspecified	Conference proceeding	ASD	Emotional recognition skills	Yes
Porayska-Pomsta et al. (2018)	4-14	15	14	UK	Observation	low functioning	Journal article	ASD	Social communication skills	No
Razavi et al. (2016)	15-17	5	Unspecified	USA	Questionnaire	Unspecified	Conference proceeding	ASD	Social communication skills/conversational skills	No
Tanaka et al. (2017)	ASD: 7-19 NT: 22-26	ASD: 10 NT: 18 Total: 28	ASD: 10 NT: 15	Japan	Statistical methods and observation	High functioning	Journal article	Experimental group: ASD Control group: NT	Social communication skills	Yes

Table 2 presents features of the conversational agents presented in the studies. There are 13 different conversational agents in the selected studies, with seven relying on written communication, three on spoken and visual, two on visual, one on spoken, and one on spoken and multimodal elements like videos, music, radio, alarms light control, etc. Eight CAs focused on training social skills, two aimed to reduce learning difficulties, two focused on specific behaviors, and one aimed to help with anxiety and stress.

Table 2

Features of Conversational Agents

Author (year)	Interaction modality	Virtual character	Targeted symptom	Name of CA
Ali et al. (2020)	Spoken and Visual	Yes, Realistic	Social skills	LISSA
Aljameel et al. (2019)	Written	Yes, Cartoon	Learning difficulties	LANA CITS
Aljameel et al. (20198)	Written	Yes, Cartoon	Learning difficulties	LANA-I
Burke et al. (2018)	Spoken and Visual	Yes Realistic	Social skills	ViTA
Cha et al. (2021)	Spoken, multimedia	No	Emotion regulation issues, social skills, specific behaviors	NUGU CANDLE
Hadri and Bouramoul (2023)	Written	No	Non-cooperative tendencies	Friendly
Milne (2018)	Written	Yes, Cartoon	Social skills	Head X and Thinking Head Whiteboard
Milne et al. (2018)	Written	Yes, Cartoon	Social skills	Head X and Thinking Head Whiteboard

Author (year)	Interaction modality	Virtual character	Targeted symptom	Name of CA
Palma et al. (2023)	Written	No	Anxiety and stress	MindBot
Parvin et al. (2022)	Spoken	No	Routine keeping, defiant behavior	Alexa
Patel et al. (2016)	Visual	Yes, Cartoon	Social skills	MeEmo
Porayska-Pomsta et al. (2018)	Visual	Yes, Cartoon	Social skills, cognitive behavioral skills	ECHOES
Razavi et al. (2016)	Spoken and visual	Yes, Realistic	Social skills	LISSA
Tanaka et al. (2017)	Spoken and visual	Yes, Cartoon	Social skills	No name

Themes

This section presents the themes of satisfaction, utility, usability, independence and personalization as encountered in the literature.

Satisfaction

Satisfaction is an important theme to research as it may directly affect the effectiveness of a conversational agent through different factors. Positive emotions towards the CA might motivate regular and prolonged use of the system, which in turn may lead to better outcomes. Negative emotions may have the opposite effect.

The theme of satisfaction is addressed to different degrees in 11 studies (Ali et al., 2020; Aljameel et al., 2018; Aljameel et al., 2019; Cha et al., 2021; Hadri & Bouramoul, 2023; Milne et al., 2018; Milne, 2018; Palma et al., 2023; Parvin et al., 2022; Porayska-Pomsta et al., 2018; Razavi et al.,

2016), with different aspects of satisfaction being discussed such as comfort, enjoyment, rewards and positive feedback, friendliness, empathy, realism, and frustration.

All of the studies that address user satisfaction report feelings of comfort, enjoyment or entertainment connected to the use of the CA which are then used to explain different positive outcomes like participants' desire to use the CA again. Example engaging fun want use again.

Direct questions and responses about the level of comfort, joy, or entertainment of a user are rare to come across, and these feelings are often inferred from the participants' general positive feedback. Participants in Aljameel et al. (2018) mention for example that they enjoyed using the CA but nothing more is added. The same is true for participants in Cha et al. (2021).

Rewards (Milne, 2018; Milne et al., 2018; Porayska-Pomsta et al., 2018) and positive feedback (Ali et al., 2020; Porayska-Pomsta et al., 2018) are features requested and praised by users as they guide participants and increase their joy and motivation. The perceived friendliness of a CA is another aspect that affects satisfaction (Aljameel et al., 2019; Cha et al., 2021; Milne et al., 2018; Milne, 2018; Palma et al., 2023; Parvin et al., 2022).

Friendliness might be especially important for individuals with ASD as many of the CAs aim to improve social skills and relationships with people, which may be difficult to achieve if the situation feels hostile to the user. Parvin et al. (2022) address how changing the voice of the CA to that of an authority figure, like a dentist, which at the same time is perceived as familiar, can help uphold certain behaviors. Aljameel et al. (2018) examine children's views of CAs as friends and compare them to their views of teachers. They find that some children are more motivated to learn from a friendly CA than a teacher. Participants in Palma et al. (2023) recommend ways to make the CA more friendly. Some of them envision the CA sending them follow up messages the day after

they experienced something stressful, being asked about their hobbies and interests, getting empathetic responses, and communicating with the CA through the message application like they would with a human friend.

Closely related to friendliness is empathy, which is briefly touched on. It is requested by a participant in Palma et al. (2023) and may influence the ability of some individuals with ASD to regulate their emotions. Interestingly, users in Cha et al. (2021) reported that the CA's lack of emotion made it easier for them to express their feelings to it. This felt good and provided them with comfortable practice and more security in themselves.

Human-like features like empathy and friendliness can be connected to the feeling of realism that a CA gives. This is another briefly discussed topic with benefits and disadvantages, as some realistic features are requested more than others. Empathy and friendliness as described earlier are examples of realistic features that are mostly regarded as positive. A Participant in Ali et al. (2020) appreciated that the CA was realistic in its conversations and provided complex and private interactions. Ali et al. (2020) discussed also the pros and cons of realistic virtual characters in CAs compared to cartoon characters.

Some papers also report feelings of frustration associated to challenges in voice-recognition or lack of interesting conversation topics (Cha et al., 2021; Milne et al., 2018). A teenage participant in Ali et al. (2020) for example, reported that using a CA felt childish and that they preferred to talk to adults or peers.

Utility

Utility is a theme addressed in all the selected studies. The utility of a conversational agent is connected to its ability to provide the features and outcomes that the user needs. Users have

reported opinions on existing or potential features such as personalization (addressed as a theme), feedback, adaptation to the user, inclusion of more challenging content, and inclusion of game-like elements which may help users achieve desired outcomes. These are addressed in eight studies (Ali et al., 2020; Cha et al., 2021; Milne, 2018; Milne et al., 2018; Palma et al., 2023; Porayska-Pomsta et al., 2018; Razavi et al., 2016; Tanaka et al., 2017). The outcomes of the interactions with CAs are reported using both quantitative and qualitative methods. Keeping track of effective and ineffective features in a CA and the effect of its use is detrimental to guarantee an adequate user experience.

Feedback on the tasks that users do guides the development of skills and seems therefore to be a highly valued feature (Ali et al., 2020; Milne et al., 2018; Palma et al., 2023; Razavi et al., 2016; Tanaka et al., 2017). Participants in Ali et al. (2020) appreciated having lights in the interface of the CA that told them if what they did was right or wrong but commented that they would like negative feedback to take less space compared to positive.

A CA's ability to adapt to the interests and needs of a user appears also to be beneficial and is praised by users. The ability of the CA in Aljameel et al. (2018) and Aljameel et al. (2019) to adapt to the user's learning style is a celebrated feature, and it reportedly contributes to more effective learning. Adapting conversation topics to users' interests is a positively regarded feature too (Milne, 2018; Cha et al., 2021; Ali et al., 2020). Participants in Cha et al. (2021) for example, expected the CA to provide information and conversations on topics they were interested in and wanted to get better at, and were frustrated whenever this was not the case.

Two studies address directly the difficulty level of the tasks given by the CA (Milne, 2018; Milne et al., 2018). Milne et al. (2018) gathered seemingly contradictory observations and responses from study participants, with some encountering difficulties that affected their scores and others

describing activities as being “just right” or “a little too easy”. This suggests that both things may have been true at various times, or it reflects the heterogeneity of individuals on the autism spectrum, the authors argue.

Some participants in Milne et al. (2018) also suggested including more game-like elements, what is known as gamification, to motivate and engage children more. CAs like those in Patel et al. (2016) and Porayska-Pomsta et al. (2018) include games as part of their interface.

Regarding the effect of the interventions provided by the CAs, this is measured with statistical methods (Milne, 2018; Milne et al., 2018; Patel et al., 2016; Tanaka et al., 2017; Aljameel et al., 2019; Burke et al., 2018), questionnaires (Aljameel et al., 2018; Hadri & Bouramoul, 2023; Razavi et al., 2016), observation of participants (Porayska-Pomsta et al., 2018; Tanaka et al., 2017), or interviews with users, observing caregivers, therapists or teachers (see also Table 1; Parvin et al., 2022; Ali et al., 2020; ; Cha et al., 2021; Palma et al., 2023; Aljameel et al., 2018). Five studies employ both experimental and control groups to research the utility and effect of their CA (Table 1; Aljameel et al., 2019; Milne, 2018; Milne et al., 2018; Patel et al., 2016; Tanaka et al., 2017). The lack of studies using a control group is criticized by Milne et al. (2018).

The generalizability of learned skills to different contexts was an element of the CA related to outcomes and considered in some studies. This is a factor implicit in the goals of every study; Burke et al. 2018 for example, present a CA that aims to prepare people with ASD for real job interviews by providing a safe practice arena. Milne (2018), Milne et al. (2018), Porayska-Pomsta et al. (2018) and Tanaka et al. (2017) comment on it more directly. Porayska-Pomsta et al. (2018) for example, discuss the degree to which skills transfer from their study and CA to the classroom. Teachers participating in this research reported good outcomes and wanted children to continue

using it. Milne et al. (2018) discuss the inclusion of optional homework lessons to encourage users to generalize their knowledge to real-world contexts.

Usability

Usability is connected to whether a CA is used in the intended manner and the degree to which its different features are easy to use. It appears in eight of the selected studies (Ali et al., 2020; Cha et al., 2021; Milne, 2018; Milne et al., 2018; Parvin et al., 2022; Tanaka et al., 2017; Palma et al., 2023; Hadri & Bouramoul, 2023).

Challenges in usability in the included studies are related to challenges in communication and interaction with the conversational agent, and may be connected to spoken, written, or facial recognition features. How the CA is presented to the users may also be a key factor for usability, but this is not explored too much in depth.

Verbal difficulties are not uncommon among people with ASD. Participants in several studies commented on the favorable aspects and difficulties they experienced trying to communicate verbally with the CA (Ali et al., 2020; Cha et al., 2021; Milne, 2018; Parvin et al., 2022). Participants in Milne et al. (2018) and Milne (2018) reported that the CA had a clear and understandable voice and participants in Ali et al. (2020) also reported liking the voice of the CA, although some of them believed there to be room for improvement in terms of responsiveness. Clear voices appear therefore to facilitate usage. Parents of children with more severe ASD, reported in Parvin et al. (2022) challenges when trying to activate the CA using voice commands. Similarly, one participant in Cha et al. (2021) experienced difficulties activating the CA due to his inaccurate pronunciation. However, after much practice, this participant's pronunciation improved, and he managed to activate the CA regularly.

Emotional expression and recognition are other common struggles for people with ASD. Challenges linked to facial recognition are therefore bound to arise. Nevertheless, few of the included articles address this challenge. Ali et al. (2020) showcase both sides of the coin, with some participants reacting favorably to the CA's automatic facial feature detection and reporting it made interaction easier, and others criticizing its lack of precision in recognizing certain facial expressions like smiles. Although not based on direct feedback from users, Tanaka et al. (2017) infer that their CA, featuring a cartoon avatar, was easy to interact with due to the improvements in narrative skills they observed in participants.

With respect to written features, none of the studies presenting CAs with written interaction modalities report specific benefits or problems. However, some participants in Palma et al. (2023) and Hadri and Bouramoul (2023) express their desire to communicate verbally with the CA rather than in writing. This change may make interaction easier for some.

Some authors highlight the importance of good initial instructions to ensure that users do not encounter any problems using the CA. Ali et al. (2020) discuss how an appropriate briefing of users about the CA's purpose might benefit them in their experience, both in teaching them the expected way of using the CA and clarifying the behavioral goals. Cha et al. (2021) consciously take a slightly different approach where they avoid providing users with common and specific behavioral goals, and guide participants more cautiously in order to let them explore freely. These are examples of researchers clarifying for users and providing them instructions, something a caregiver may or may not be able to do. The only explicit mention of an inbuilt tutorial comes from Milne et al. (2018). Here, the authors mention the inclusion of an optional tutorial in addition to explanations for each activity, which the authors believe some of the participants with lower scores may have not found, or the instructions of which may have been insufficient.

Independence

Gaining independence can be an important goal for a lot of people with disabilities or mental health disorders. This includes people with ASD who in many cases, and depending on the severity of the disorder, need support from other people to complete certain activities. It is therefore crucial to assess the degree to which a CA can be used independently by people with ASD, and to ensure that using the CA will later increase their independence from others. These two approaches to independence are found in eight studies (Aljameel et al., 2018; Hadri & Bouramoul, 2023; Milne, 2018; Milne et al., 2018; Burke et al., 2018; Cha et al., 2021; Parvin et al., 2022; Aljameel et al., 2018).

The first of these approaches can be understood through good usability, which is necessary to provide a CA that can be used independently. Features like having spoken CAs with clear and understandable voices and providing users with clear instructions of use, as described in the usability theme above, are examples of this. Additionally, authors in four of the selected studies explicitly connect usability features to independent use of their CA (Aljameel et al., 2018; Hadri & Bouramoul, 2023; Milne, 2018; Milne et al., 2018). Milne et al. (2018) mention that the interface in their CA was designed to be simple and intuitive so that participants could use it without assistance. Aljameel et al. (2018) comment that participants were able to use the CA independently after receiving some instructions and contrast this observation with the children's teachers. Hadri and Bouramoul (2023) give an account of the number of children in their study that managed to interact with the CA independently. Lastly, three caregivers in Milne (2018) appreciated that their children could use the CA on their own.

The other form of independence is connected to helping users attain or improve on skills that will make them independent. This is a goal that is practically implicit in all the included studies. A prime

example of this is Burke et al. (2018), which presents a CA that aims to train adults with ASD in job interviews, supporting them to find a job and become financially independent, among other benefits. In a more explicit manner, Cha et al. (2021) address in their article the CA's ability to enhance self-care skills in the daily context. The conversational agent they present provides support for several everyday activities and shows potential to reduce caregivers' and therapists' involvement in the daily lives of people with ASD, especially for adolescents. Caregivers in Parvin et al. (2022) report that the CA has increased the autonomy of their children to the point where they can brush their teeth on their own at the correct time of the day. Teachers participating in Aljameel and colleagues' study (2018) also believed that using the CA in class might reduce the student's dependence on the teacher.

Personalization

Personalization was added as a theme after finalizing the process of data extraction due to its prominence and its potential to affect the satisfaction, utility, usability and independence capabilities of a CA. The ability to personalize different elements within a conversational agent, such as conversation topics, goals, and audiovisual features, gives users the possibility to create CAs specifically tailored to their needs, situation, and abilities. This is important for people with ASD due to the number of individual differences that exist. This theme appears in 6 studies (Ali et al., 2020; Cha et al., 2021; Parvin et al., 2022; Palma et al., 2023; Milne, 2018; Milne et al., 2018)

Participants in several studies felt that the CAs lacked variation in the topics it was able to discuss. This is the case for participants in Ali et al. (2020), Cha et al (2021), Parvin et al. (2022), and Palma et al. (2023). Some participants in Palma et al (2023) mentioned they would like to include their hobbies and interests in the CA so that it could ask them about these interests. Similarly, participants in Ali et al. (2020) believe that controlling the CA's topics of conversation would keep them

engaged longer and help them practice. Parents of children in Parvin et al. (2022) commented that being able to personalize the CA's output considering individual needs, expectations, and different profiles of autism is an important feature of a CA. Comparably, participants in Cha et al. (2021) expressed their desire to more accurately influence how they reach their different behavioral goals. This may be achieved by selecting the type of information that the CA provides, the type of conversations they want to engage in, and various other functions like music and changing lights. Personalization of visual features of the CA is also addressed in some studies. Participants in Milne (2018) requested more personalization of visual aspects like reward-stickers and a way to customize the virtual character in the CA, or the possibility to choose between different characters. One caregiver in Milne et al. (2018) also suggested making visual rewards like stickers customizable to motivate children. Burke et al. (2018) include in their CA six different virtual characters to pick between, with varying genders, ages, behavioral dispositions, and ethnicities to provide more training variations for job interviews. Palma et al. (2023) give users the possibility to change theme colors and font size.

Regarding audio features, parents in Parvin et al. (2022) appreciate that they can adapt the voice of the conversational agent to the situation or mood of their children, being able to choose a more authoritative voice when deemed necessary. Milne (2018) discusses incorporating customization options for speech speed that may help to improve voice related difficulties. Ali et al. (2020) discuss the same issue, as some participants expressed wanting the CA to respond faster. Giving the possibility to change speech settings may be helpful to users with different characteristics, they argue.

Lastly, an interesting feature related to personalization and data protection was made in Palma et al. (2023). The CA they present gives users the possibility to remove and save parts of their chat

history, which gives users more control over their sensitive data. One participant valued highly that they could save specific messages they wanted to remember and eliminate the rest.

Discussion

Summary of evidence

This scoping review aimed to provide an overview of the experiences that people diagnosed with ASD have when using conversational agents. 14 studies from online bibliographical databases were selected after a systematic literature search and selection process. This resulted 13 different CAs that aimed to help people with ASD improve their social communication skills, learning capabilities, and solve problems related to various behaviors or disorders. These CAs relied on spoken, visual, or written communication, with some additionally taking advantage of videos, music, or game elements among others (Table 2).

Studies included mostly participants diagnosed with ASD with different degrees of severity, where high functioning individuals were the most likely to come across in the literature. Sample sizes varied substantially with the smallest studies recruiting 3 participants and the largest recruiting up to 35 participants. Children and adolescents were the most targeted group, with little focus given to adults. The number of male participants in the selected studies clearly outnumbered that of females (Table 1).

The four themes established a priori: satisfaction, utility, usability, and independence, were all covered in the literature in addition to the added theme of personalization, though to different degrees. The theme of utility was the most prevalent, being included in all the selected studies. It was addressed in the form of feedback on various features of CAs such as ability to adapt to the user, provide feedback, provide challenging enough content, and inclusion of game-like elements.

The utility of the CAs was additionally analyzed using various research methods to determine the outcomes and effect of the interaction with the CA. Different variations of statistical methods were the most popular, being present in six studies, followed by interviews, questionnaires, and observation of participants (see Table 1). It was also noted that five of the selected studies included a control and experimental group (Table 1). The generalizability of learned skills was also a topic present in the literature.

Following utility, was the satisfaction theme which appears in 11 studies. This theme appears in the form of discussions and feedback on comfort, enjoyment, rewards and positive feedback, friendliness, empathy, realism and frustration.

Next was usability, which was addressed in eight of the studies. The challenges in communication and interaction with the conversational agent were the focus of the studies in terms of usability. This included challenges relating to spoken, visual and written communication, which relate for example to aspects of ASD like verbal difficulties and emotional expression and recognition challenges. The importance of providing good instructions is also mentioned in the literature as a factor to increase usability.

The topic of independence was addressed in eight studies as a function of two slightly different yet connected understandings of the concept. Some studies presented independence as a function of usability, meaning how easy it is for participants with ASD to use the CA independently. An example of this is Milne and colleagues' (2018) assertion that the interface of their CA was designed to be simple so that users can operate it without assistance. In other studies, independence was discussed more as the degree of freedom the CA gives people with ASD from others. An example were the adolescents in Cha et al. (2021) who gained independence from their parents by leaning on the CA to uphold certain daily activities.

The last of the topics presented was personalization. This theme was addressed in 6 studies where researchers and participants discussed customization of conversation topics, goals, and audiovisual features within the CA. The topic of data protection was also briefly mentioned in connection with personalization and the ability of users to edit their chat history (Palma et al., 2023).

Synthesis of results

These five themes interact and affect each other in various ways. Analyzing them separately does therefore give an incomplete understanding of user experience. For example, feedback from CAs is a topic that can be analyzed from different perspectives. It can be evaluated as a tool for emotional regulation in the form of rewards and to keep users engaged for longer, as guidelines for the correct use of a CA, or as a direct measure of the results obtained by the user in the form of a score. All of these are dimensions of feedback that should be understood together if one is to provide good feedback.

This is done to some degree in the literature, especially by connecting different aspects of user experience to outcomes and utility. For example, CAs with intuitive interfaces lead to more effective practice and better social skills (Milne et al., 2018). Future research on user experience in CAs for people with ASD might benefit from understanding the interactions between all the dimensions of user experience and how they affect each other. The effect of an intuitive interface on a user's enjoyment of a CA might give a deeper understanding of why it can lead to more effective practice and better social skills.

In this review, independence was highlighted as a relevant dimension of user experience that people with ASD could benefit from based on the characteristics of this disorder. It was argued in the results section that this idea is implied in many of the selected studies, but not explicitly addressed.

An example of this is Burke et al. (2018) who present a CA that aims to help people with ASD find a job, an activity that increases independence from others, although this is not explicitly addressed in the study. Intentionally addressing independence and actively comparing it to other dimensions of user experience such as usability or satisfaction, could lead to a better understanding of how independence is achieved by using a CA. The development of independence through CAs is something that needs to be addressed more thoroughly considering multiple other dimensions of user experience.

Another theme that should be understood in comparison to many more dimensions of user experience is personalization. Personalization was added as a theme due to its potential to affect other facets of the user experience. In addition, the heterogeneous nature of the disorder makes personalization a useful feature to include in order to reach a bigger population.

It is challenging to develop a CA that caters to the specific needs of every individual with ASD, but personalization has the potential to be an important feature of CAs. Being able to customize a CA with knowledge on the user's interests and hobbies for example, can lead to an increase in comfort and enjoyment of the interaction, which in turn can lead to more engagement, repeated and prolonged use of the CA, and better outcomes, as suggested by the literature (Ali et al., 2020; Cha et al., 2021; Parvin et al., 2022; Palma et al., 2023). This thought can be applied to personalization of many features of a CA so it is the job of researchers to determine which features should be customizable for users and which ones should not. An analysis of the interactions between personalization and other dimensions of user experience could make this possible.

Something to be wary of is that too many personalization choices could again damage usability by making the CA overly complicated, unintuitive, and confusing. Developing CAs with the ability to “automatically” adapt to the users' needs might be an alternative. An example of this are the CAs

in Aljameel et al. (2018) and Aljameel et al. (2019) which manage to adapt to the learning style of users by having them first fill in a questionnaire. Results in these two studies suggest that this adaptation is beneficial for the user at multiple levels and results in better outcomes.

An additional aspect that should be commented on concerns the populations studied in the literature, as there seems to be a slight preference for participants with milder symptoms of ASD, i.e., high functioning. More variation in population would yield more representative results on user experience. There seems also to be a preference for children. Although treating ASD early is essential for the good development of children with this disorder, adults might also benefit from the possibility to use CAs as support.

In conclusion, to develop desired dimensions of user experience in a CA, like independence or personalization, one should consider the interactions these have with other dimensions. This happens to a limited extent in the included studies, so it would be beneficial to take a more holistic approach to user experience in future research, comparing and assessing multiple dimensions in relation to each other.

Limitations

This scoping review was an individual project. Support from other reviewers was granted in the process of drafting a search strategy. A second reviewer helped in the selection of sources of evidence, although the review would have benefited from including a third or fourth reviewer in this process.

The process of data extraction, however, was only carried out by one reviewer due to time constraints. The review would have gained in reliability and validity if more reviewers had participated in this process. The risk of overlooking relevant information from the sources of

evidence is high, and future research of the same nature should include more active authors. This would also allow for a more comprehensive search strategy and possibly the inclusion of more bibliographical databases and sources of evidence.

The search strategy did not include forward and backward reference list checking, which may have increased the number of sources of evidence used. This review did also not consider grey literature, which might have contributed something since the field of research at hand is relatively new.

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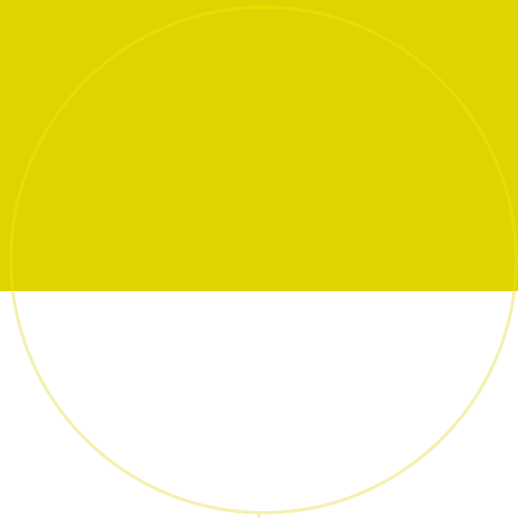
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