Using Embodied Conversational Agents to Combat Loneliness in Older Adults: A Scoping Review

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Abstract

Background. Loneliness has a high prevalence among older people, and with an increasingly aging population, combatting elderly loneliness becomes an important health care issue. In response to this and given the rapid developments of new technologies and its use in psychological interventions, research started to investigate the potential of using Embodied Conversational Agents (ECA) to combat feelings of loneliness.

Objective. This scoping review aims to map what is known about ECAs used to reduce loneliness in older adults, focusing on the ECAs' main design features, effectiveness, factors influencing older adult's intention to use ECAs, and the types of attitudes older adults have towards ECAs.

Method. The scoping review was conducted according to the PRISMA-ScR guidelines. A literature search was performed in PsycINFO, PubMed, and Scopus with a combination of search terms related to loneliness, older adults, and ECAs. The quality of the included articles was assessed based on the framework proposed by Ter Stal (2021).

Results. A final set of 5 articles were included in the review. Except one, all studies included less than 50 participants and thus, received the lowest quality label. Three studies reported that either loneliness decreased, or social support increased after participants used the ECA. Several design features were identified which were in line with prior research. Solely one study statistically investigated use-related outcomes which did not show to predict ECA use. Older adults' attitudes towards ECAs mainly concerned perceived strengths and weaknesses. Overall, more positive than negative aspects were reported, with strengths mainly addressing the offered companionship by the ECA, and as weaknesses primarily mentioning the restricted options of communication between user and ECA.

Conclusion. ECAs can be effective in reducing loneliness in older adults but further research is needed as results on their effectiveness are divergent. Based on the insights on design features, ECA's abilities to have natural and unrestricted conversations show to be important for the elderly users. Therefore, the communication modalities need to be especially considered when designing ECAs to reduce loneliness. Research on use-related outcomes for ECAs in that context is scarce and needs further investigation.

Keywords: Embodied conversational agent, eHealth, loneliness, older adults, health care, review

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Introduction

The number of elderly people in the world's population is growing. According to the World Health Organization (2021), the number of people aged 60 years and older will increase from 1 billion to 2.1 billion between 2020 and 2050. The proportion of people aged 80 years and over is expected to rise to the threefold, reaching 426 million by 2050. Loneliness is known to have a high prevalence among the elderly individuals (Chawla et al., 2021; Elias, 2018; Surkalim et al., 2022) as well as detrimental consequences on their physical and psychological health (Crewdson, 2016; Groarke et al., 2020; Theeke, 2009). Consequently, this trend towards an ageing population makes combating loneliness an increasingly important health care issue. In response to this rising problem and given the rapid advancement of new technologies and its use in psychological interventions, researchers have begun to explore the possibilities of using technology to counteract loneliness (Baker et al., 2018; Chen & Schulz, 2016). To contribute to this important and current topic, this review aims to gain further insights into the potential of technology as a solution to the growing problem of elderly loneliness.

Loneliness among Older Adults

Loneliness is a distressing emotion that arises from a disparity between perceived and desired social relationships (Palgi et al., 2020) and has been revealed as a common phenomenon among older adults (Chawla et al., 2021; Elias, 2018; Surkalim et al., 2022). In a systematic review and meta-analysis about loneliness prevalence across 29 high income countries, Chawla et al. (2021) showed that one in four older adults aged over 60 years feels lonely. Whether a person feels lonely does not depend exclusively on their factual state of being alone or the quantity of their social interactions. It is rather about a person's subjective perception of feeling connected (Luchetti, 2020). A person who perceives to have a good social network and a sufficient social support from their environment, tends to feel more socially isolated may imply the opposite and a person will rather feel lonely (Petersen et al., 2016; Satici, Uysal, & Deniz, 2016; Schnittger et al., 2012).

Loneliness in older age is often a consequence of decreasing personal resources. Many older individuals experience a decline in their social network and must cope with the bereavement of their partners. In addition, physical mobility usually decreases with age and the resulting restricted participation in (social) activities can lead to feelings of social isolation (Garattini, Wherton & Prendergast, 2012). Since the start of the COVID-19 pandemic (World

Health Organization, 2020), governmental measures, such as curfews and quarantines, have added to the reduction of social interactions, thereby amplifying older adults' risk to social isolation and feelings of loneliness (Groarke et al., 2020). Although elderly individuals living alone may be expected to be particularly at risk for feeling lonely, elderly people residing in long-term health care institutions do not show to be less affected by loneliness. Based on their systematic review, Gardiner et al. (2020) suggest that 61% of older adults living in residential and nursing care homes show moderate feelings of loneliness and 35% display severe loneliness, which might be due to the lack of personnel in health care facilities as it creates difficulties for caregivers to respond adequately to the residents' social needs (Slettebø, 2008). Overall, it is not only the high prevalence of lonely older people that is alarming, but also the health effects that loneliness has on the individual.

Effects of Loneliness on Older Adults' Health

Loneliness can be a major threat to individuals' physical and psychological well-being (Theeke, 2009). Loneliness in older adults is associated with several negative effects on their physical health, including a lowered function of the immune system and higher levels of inflammation (Crewdson, 2016), as well as a range of cardiovascular effects, such as hypertension, heart attacks, and stroke. All these symptoms increase the risk for an earlier death (Ong, Uchino, & Wethington, 2016). In addition, there is an association between loneliness and a decline in all motor areas and overall mobility. The results of a study by Buchman et al. (2010) showed that when comparing individuals with divergent baseline loneliness scores, a "person with a 1-point higher loneliness score would exhibit a 40% more rapid annual rate of motor decline" (Buchman et al., 2010, p. 6), even when controlling for covariates, such as depressive symptoms. In turn, decreased mobility leads to greater dependency, which might result in being surrounded by a greater number of individuals offering support, but also in feeling more socially isolated and lonely since participating in (social) activities becomes difficult without this needed support (Crewdson, 2016). Moreover, loneliness in the elderly population has been associated with impaired cognitive performance and the development of dementia, making the need for admissions to care homes more likely (Crewdson, 2016; Ong, Uchino, & Wethington, 2016). With regard to their psychological well-being, lonely older adults show a heightened risk for depression and anxiety (Ong, Uchino, & Wethington, 2016), and pre-existing mental health problems may be exacerbated (Groarke et al., 2020). Sleeping problems and insomnia, which are common phenomena related to elderly loneliness, can greatly impact a person's wellbeing, and worsen existing psychological as well as physical problems (Ong, Uchino, & Wethington, 2016). Moreover, the deterioration of a lonely person's health is also facilitated by behavioural changes, as loneliness in older individuals is associated with increased alcohol consumption, decreased food intake, and lowered physical activity (Crewdson, 2016). Generally, the above mentioned psychological, physical, and behavioural effects are not only each related to loneliness, but these symptoms are also interrelated and may reinforce each other, for example in the case of the association between depression, alcohol consumption, and declined cognition, or between declined motor abilities, physical activity, and cardiovascular diseases (Crewdson, 2016).

To conclude, all these accompanying symptoms of loneliness pose a significant health risk to a growing part of the population, may further enhance feelings of loneliness, thereby creating a vicious cycle between loneliness and the symptoms discussed, and may lead to a higher demand for health care among lonely older adults (Gerst-Emerson & Jayawardhana, 2015). To address these issues, researchers began to look for ways to combat loneliness in the older population.

Use of Technology to combat Loneliness

With the development of novel technologies and its promising use in psychological interventions, researchers have begun to investigate effective ways to implement loneliness interventions using information and communication technologies (ICT) (Baker et al., 2018; Chen & Schulz, 2016; Siegel & Dorner, 2017). ICTs bring benefits in combatting social isolation and loneliness by overcoming critical barriers to social interaction. They offer the possibility to communicate independently of time and place, for instance, through videocall or chat (Chen & Schulz, 2016), which is particularly beneficial for older people who have limited mobility or live in a nursing care home away from their social environment of friends and family. Also, social contact can be maintained despite COVID-19 related social distancing measures. However, while facilitating communication can increase interaction between older adults and their social contacts, many people generally miss a sufficient social network in older age due to, for example, bereavement of their partners, friends, or family members (Garattini, Wherton & Prendergast, 2012). In this case, ICTs such as artificial agents may also serve as a substitute for human social interaction or as an additional companion. Artificial agents which offer this companionship are also often referred to as companion agents and may not only be helpful when a person does not have adequate relationships (Wister, Fyffe, & O'Dea, 2021), but also if sufficient social interaction between caregivers and elderly people cannot be ensured (Slettebø, 2008). This potential of using companion agents in health care, especially, to address loneliness, induced researchers to start to develop different types of agents and investigate their effectiveness on lonely individuals.

Embodied Conversational Agents as Companion

Embodied Conversational Agents (ECA) are, besides social robots, a common companion agent used in health care. ECAs can be defined as "computer-based dialogue systems that have virtual embodiments, typically presented on a computer screen" (Loveys et al., 2022, para. 1.1). The dialogue systems of ECAs are usually driven by an automated computer but can also be controlled by a human who interacts with the user through the ECA's avatar (Chi et al., 2017). Similar to social robots, ECAs can be used to offer companionship and emotional support by showing affection and interacting with the user (Loveys et al., 2022). Both agents typically show animal or human features to mimic a pet or friend and interact with the user to the extent allowed by the system used (Demiris et al., 2016). The application of ECAs in health care interventions offers multiple benefits as they are relatively inexpensive compared to robots, adaptable to the different needs of users, portable, as well as continuously available to provide their service whenever it is needed (Loveys et al., 2020).

The number of studies on the effectiveness of ECAs on older adults' loneliness are – especially compared to studies on social robots – rather limited and show divergent results (Gasteiger et al., 2021). A study by Sidner et al. (2018) found rather contradictory results since several participants reported in the interviews that the ECA offered them companionship and social support during the 30-day intervention, but there was no significant decrease in loneliness when using quantitative measures (Sidner et al., 2018). However, other studies on the use of ECAs to counteract loneliness reported a significant decrease in older people's loneliness who used an ECA (e.g., Bott et al., 2019; Ring et al., 2015). Further studies also showed that participants stated during interviews and in diary entries that the companion agent provided them with companionship (Chi et al., 2017; Vardoulakis et al., 2012) or social support, acted as a friend, or that they felt less lonely using it (Ring et al., 2015). Thus overall, the use of ECAs to counteract elderly loneliness holds promise. Continuous usage of the ECA, however, is an important factor for the effectiveness of such interventions. If this is not the case, the intended effects of the ECA cannot be produced in the long term (Cole-Lewis, Ezeanochie, & Turgiss,

2019; Provoost et al., 2017). Therefore, important factors will be discussed in the following to be considered when developing an ECA.

Design of Embodied Conversational Agents

Previously, researchers investigated relevant design features providing a base on which ECAs can be designed and evaluated. Ruttkay, Dormann, and Noot (2004) developed a taxonomy which outlines several design aspects of ECAs. They differentiated between different parameters, such as embodiment and mental capacities. An ECA's mental capacities are, for example, its personality, social role, ability of user modeling, or its capability of showing emotional states. The embodiment includes the look, i.e., the static visual appearance of the ECA, and its communication modalities, such as body gestures and facial expressions, or verbal and textual output (Leonhardt, 2012; Ruttkay, Dormann, & Noot, 2004). Straßmann and Krämer (2017) further specified differences in the appearance and established the following categories defining the agent's embodiment: (1) Species, differentiating between zoomorphic (animal) or anthropomorphic (human) agents but also mystical creatures, robots, and objects; (2) Realism, including stylization, resolution, and detailedness; (3) 2D vs. 3D; and (4) Feature specification which can include the agent's socio-demographic characteristics, such as gender and ethnicity, and its styling related to clothing, hair, and make up.

Previous research showed that such design features can influence how the ECA is perceived by the user. In a systematic review, Loveys et al. (2020) explored the impact of design features on the relationship quality with, and social perceptions and behaviour towards ECAs. Generally, it was found that an embodied agent elicited more rapport in the user than voice-only agents (Loveys et al., 2020). Also, verbal combined with non-verbal cues seemed beneficial for the user's relationship quality with the ECA (Loveys et al., 2020). These include, for example, social dialogue, communication on a meta-relational level, empathic expressions, and immediacy behaviour, such as head nods, eye gaze, and hand gestures. Especially eye gaze, which was mainly directed to the user, improved rapport, increased self-disclosure intimacy, and was perceived as more trustworthy. An ECA that generally showed emotions – whether positive or negative – showed to increase users' felt intimacy with the ECA. Also, empathic language and facial expressions had a positive effect on building trust, and feelings of rapport, but also on ratings of enjoyment, intention to use the ECA, and its perceived usefulness (Loveys et al., 2020).

As these features show to have an influence on the user's relationship with the ECA, they are important to consider when developing an ECA intended to act as a companion to combat loneliness. However, for older adults to build a relationship with the agent, they must first be willing to engage with it.

Older Adults' Attitudes towards Embodied Conversational Agents

The attitude of the user towards the technology plays a decisive role in whether it will be used and is therefore successful in terms of its goal. Consequently, for an ECA to be effective in reducing elderly loneliness, older adults must have a positive attitude towards it to be motivated to continuously use the ECA. In a qualitative study, Tsiourti et al. (2014) investigated the attitudes and expectations of older adults towards ECAs used as virtual assistive companions to complement human caregiving. They found that after being introduced to the concept of the virtual assistive companion, the older individuals accepted the ECA in their daily life during the period of the study and showed a positive attitude towards further using the ECA in the future (Tsiourti et al., 2014). According to Vromann, Arthanat, and Lysack (2015), negative attitudes towards technologies, such as ECAs, can arise from anxiety, fear, and a lack of interest or motivation to adopt it. Additionally, older adults often underestimate their abilities to use technology. After they successfully used it, however, such concerns were reduced and attitudes showed to be more positive (Vromann, Arthanat, & Lysack, 2015). Thus, additional factors that positively influence older adults' intention to engage with an ECA can lead to more confidence and a subsequent more positive attitude towards it.

Older Adult's Intention to use Embodied Conversational Agents

A well-known model explaining a person's intention to use a technology is the Unified Theory of Acceptance and Use of Technology (UTAUT) as it combines eight influential models about acceptance (Nordhoff et al., 2020). According to the UTAUT, if one wants to predict whether a person will actually use a technology, such as ECAs, four factors need to be considered. The extent to which (1) the technology is perceived to be useful by the individual, i.e., performance expectancy; (2) the technology is thought to be easy to use, i.e., effort expectancy; and (3) the technology is acknowledged in the person's social network, i.e., social influence. These three factors predict a user's behavioural intention to use the technology. Further, this behavioural intention, as well as (4) the degree to which individuals perceive themselves to have the resources to use the technology, i.e., facilitating conditions, then influence actual use. It is thought that further moderating influences are gender, age, experience, and voluntariness (Venkatesh et al., 2003).

To successfully implement an ECA to decrease loneliness in older adults, the UTAUT can be useful for identifying which of these relevant factors are not sufficiently met in order to target these aspects and finally, ensure that older individuals will use the ECA.

Objective of this Scoping Review

As discussed in the previous paragraphs, knowledge about the design principles and factors influencing older adults' use of ECAs is important for the development and implementation of such technologies to ultimately ensure its effectiveness in reducing elderly loneliness. Therefore, the purpose of this scoping review is to map what is known about ECAs that are aimed at diminishing loneliness in older adults, and to identify potential knowledge gaps that should be addressed in further research. Therefore, the following research questions will be answered in this review:

- 1. What main design features of ECAs intended to diminish loneliness in older adults can be identified?
- 2. What is known about the effectiveness of ECAs to reduce loneliness in older adults?
- 3. What is known about factors influencing older adults' intention to use an ECA intended to combat loneliness?
- 4. What types of attitudes do older adults have towards using ECAs intended to reduce loneliness?

Method

The present scoping review was conducted according to the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines (Tricco et al., 2018).

Search Strategy

The bibliographic databases through which relevant literature was obtained, were chosen based on their systematic search qualities (Gusenbauer & Haddaway, 2019) and the scope of literature they provide. The following three electronic databases were selected: PsycINFO because of its extensive bibliography across the behavioural and social sciences,

PubMed as it provides a wide range of biomedical and health literature, and Scopus which is a comprehensive database covering social sciences, science, technology, and medicine.

The literature search was conducted in April and May 2022. To scan the mentioned electronic databases and identify relevant literature, the following search terms were used:

(lonel* OR companion* OR isolated OR isolation OR "social isolation" OR "social support" OR "social network*" OR "social participation" OR "social connect*") AND

("older adult*" OR "older people" OR elder* OR senior* OR geriatric OR aged) AND

("animated character*" OR "interface character*" OR "artificial agent*" OR "artificial intelligence assistant*" OR "assistant chat program*" OR "assistive social agent*" OR "social agent*" OR "chatbot program*" OR "communicative agent*" OR "companion agent" OR "companion assistant*" OR "conversational agent*" OR "conversational agent*" OR "conversational agent*" OR "digital assistant*" OR "embodied agent*" OR "interactive agent*" OR "interface agent*" OR "embodied conversational agent*" OR "embodied conversational interface agent*" OR "embodied conversational agent*" OR "pedagogical agent*" OR "persuasive ECA" OR "relational agent*" OR "relational assistant*" OR "software agent*" OR "virtual agent*" OR "virtual counselor*" OR "virtual counselor*" OR "virtual health counselor*" OR "virtual health counselor*" OR "virtual health coach" OR "virtual health coach" OR "virtual health agent*" OR "virtual therapist*" OR "virtual web assistant*")

For databases that offered the following search options, the listed serach terms were searched in the article title, abstract and keywords. For the database PubMed, there was the option to search in the title and abstract. Since ECAs are a relatively novel technology, the literature search was not limited in terms of a study's publication year.

Selection of Studies

The following four inclusion criteria were formulated to assess the literature's quality and eligibility with respect to the purpose of the present review. First, solely original studies of scientific origin were included. Second, participants of the selected studies had to be at least 60 years old to be classified as elderly people, as defined by Selwyn et al. (2003), and thus, to belong to the relevant population for the present scoping review. Third, the discussed intervention had to include the use of ECAs. Last, the use of the ECA had to focus on the overall outcome of decreasing loneliness in order to provide suitable information to answer the research questions. Therefore, the study had to include an outcome measure which assessed loneliness, or a construct related to loneliness. These included perceived social isolation, social support, and social connectedness (Petersen et al., 2016; Satici, Uysal, & Deniz, 2016; Schnittger et al., 2012). Additionally, search criteria were determined to ensure the feasibility of the scoping review. These included that the selected studies had to be published in English and the full-text had to be available.

The following steps were taken for the process of the study selection. At first, relevant titles were identified by searching the mentioned electronic databases using the determined search terms. In the second step, duplicates were removed by using EndNote X9. After screening the remaining titles, the abstracts were reviewed. After that, the full-text articles were read and examined for their relevance. Articles which did not meet the search or inclusion criteria, were excluded in the selection process. Finally, the backward snowball method was used to screen the references of the included articles applying the same strategy as used for the database screening.

Data Extraction

After the study selection, the final included articles were successively read, and the following data was extracted and collected in an Excel file. First, the article information, including name of author(s), year, and location of publication. Second, information about the study, i.e., the study objective, its design, and the setting and duration of the intervention. Also, population characteristics, thus, number of participants, participants' demographics as well as number of dropouts and reasons for withdrawal were collected. Regarding the sample sizes and participants' age, the grand means and standard deviations were calculated using Excel. Further, data that provided information to answer the research questions were extracted. These included (1) descriptions given on the design features of the ECA, categorised into features related to the ECA's appearance (i.e., species, socio-demographics, realism, and dimension) and related to the interaction with the ECA (i.e., type of output, content of output, facial and body expression) (Ruttkay Dormann, & Noot, 2004; Straßmann & Krämer, 2017; Ter Stal, 2021); (2) relevant information on the ECA's components targeting loneliness to have an outline on how the intervention intends to reduce loneliness, (3) outcome measures and results on loneliness, social support, and social connectedness; (4) any outcomes found by the study related to factors influencing older adults' intention to use ECAs; and (5) reported qualitative data of the participants on their attitudes towards using the ECAs. If articles included more than one study, information were only reported for those that met the inclusion criteria and were therefore, relevant for the scope of this review.

Quality Assessment

To evaluate the quality of the included studies, the labels proposed in the dissertation by Ter Stal (2021) were used. These labels were based on the renewed framework for the evaluation of telemedicine by Jansen-Kosterink, Vollenbroek-Hutten and Hermens (2016). This framework differentiates between four evaluation stages: (1) Technical efficacy, which focuses on the technology's feasibility and usability; (2) Specific system objectives, focusing on gaining a first impression of the working mechanisms and potential given value for clinical practice; (3) System analysis, assessing the technology's effectiveness and adoption by the end-user as it will be implemented in clinical practice; and (4) External validity, which elaborates on the third stage's evaluation by addressing the involvement of all relevant stakeholders to ensure continued implementation of the technology. Additionally, Ter Stal (2021) divided the first evaluation stage into two different study quality labels based on the number of participants taking part in the study. Consequently, the quality labels were assigned as follows:

Label 1: Low	Stage 1 (technical efficacy) and less than 50 participants
Label 2: Fair	Stage 1 (technical efficacy) and more than 50 participants
Label 3: Moderate	Stage 2 (specific system objectives)
Label 4: Good	Stage 3 (system analysis)
Label 5: Excellent	Stage 4 (external validity)

Results

Study Selection

The initial search in the electronic databases resulted in 218 records. These records included 206 articles and 12 proceedings. The proceedings comprised 374 additional articles. Thus, a total number of 580 articles were included in the screening process. After removing duplicates, and screening and assessing for eligibility based on the aforementioned inclusion and search criteria, four studies were identified to be included in the review. Through backward snowballing for the four identified studies, 157 additional records were generated. After the

removal of duplicates, the screening process, and assessment of eligibility, one additional study was identified, resulting in a final set of five articles included in the review. Figure 1 illustrates the steps in the study selection process, the number of articles excluded in each step, as well as the reasons for their exclusion.

Quality of the Included Studies

Based on the proposed quality assessment by Ter Stal (2021), four of the fives studies were given the lowest quality label as they included less than 50 participants after excluding dropouts (Demiris et al., 2016; Bickmore et al., 2005; Brandenburgh et al., 2014; Kramer et al., 2022). The study by Bott et al. (2019) included more than 50 participants that completed the study and the ECA was previously pilot tested with older adults for its feasibility and usability. Also, the study focused on the ECA's potential value for clinical practice, its effectiveness, and adoption by the end-user, i.e., by hospitalized older adults. Therefore, the study by Bott et al. (2019) received the label 4, indicating a good quality. The requirements of the last stage were not met as the study did not focus on all stakeholders that would be relevant for a continuous implementation of the ECA.

Figure 1

PRISMA Flow Diagram of Study Selection



Note. The reasons for exclusion of articles are given based on inclusion and search criteria. C1 = Criterion 1: not an original study; C2 = Criterion 2: participant's age < 60 years; C3 = Criterion 3: no ECA included in intervention; C4 = Criterion 4: no outcome measure related to loneliness; C5 = Criterion 5: limited or no access to full-text of article.

Characteristics of Included Studies

The five included studies were published between the years 2005 and 2022. Three of the five studies were conducted in the United States (Bickmore et al., 2005; Bott et al., 2019; Demiris et al., 2016), and the remaining two studies were conducted in The Netherlands (Brandenburgh et al., 2014; Kramer et al., 2022). A description of each study's objective is presented in Table 1. All five studies used either a pre-post-test design or a randomized controlled trial (RCT) design. Except for one study (Bott et al., 2019), whose intervention was delivered in a community hospital, all other studies' interventions took place in participants' homes (Bickmore et al., 2005; Brandenburgh et al., 2014; Demiris et al., 2016; Kramer et al., 2022). The shortest intervention lasted approximately 4 days (Bott et al., 2019), while the longest intervention took 3 months (Demiris et al., 2016). Table 1 provides a detailed overview of the studies' characteristics and interventions' characteristics.

Table 1

Authors, Year	Location of	Study objective	Study design	Intervention	Intervention
	publication			setting	duration
Demiris et al., 2016	USA	Feasibility assessment of a digital	Pretest-posttest design	Participants'	3 months
		companion system for older adults	without control group	homes	
		with MCI			
Bickmore et al., 2005	USA	Discussing the design of a	Two-armed RCT	Participants'	2 months
		relational agent and evaluating the		homes	
		acceptance and efficacy of a			

Overview and Characteristics of Included Studies

		relational exercise advisor agent			
		for older adults			
Bott et al., 2019	USA	Effectiveness assessment of a	Pretest-posttest design	Urban community	For the duration
		relational ECA for hospitalized	with control group	hospital	of participant's
		older adults on loneliness,			hospital stay
		depressions, delirium, and falls			(average of 4
					days)
Brandenburgh et al.,	The	Feasibility assessment of an	Pretest-posttest design	Participants'	6 weeks
2014	Netherlands	ambient system including a virtual	(without control group)	homes	
		coach, on older adults' physical			
		and social activity			
Kramer et al., 2022	The	Effectiveness assessment of older	Two-armed RCT	Participants'	8 weeks
	Netherlands	adults' ECA use on dietary		home	
		behaviour and loneliness; Testing			
		of pathways to effects;			
		Assessment of factors influencing			
		ECA use			

Note. MCI = mild cognitive impairment; RCT = randomized controlled trial.

Characteristics of Participants

The sample sizes of the included studies ranged from 7 to 95 (M = 31.8, SD = 36.7) participants after subtracting dropouts. Except from the sample in Brandenburgh et al.'s (2014) study, participants were predominantly female. Among all included studies that provided the participants' age range, the youngest participant was 63 years (Bickmore et al., 2005) and the oldest was 89 years (Demiris et al., 2016). The grand mean of participants' age was 75 years (M = 75.4, SD = 2.4), excluding the study by Brandenburgh et al. (2014) as they only provided the participants' age range. In the study of Demiris et al. (2016), the focus was specifically on older adults with mild cognitive impairments and in the study by Bott et al. (2019) on hospitalized older adults (see Table 1). Table 2 provides a more detailed overview of the studies' sample sizes, participants' gender, age, and cultural background, as well as number of and reasons for dropouts.

Table 2

Participant Characteristics

Sample size	Age range (<i>M</i>) in	Cultural background	Number of	Reasons for dropouts
(% females)	years		dropouts	
10 (100%)	68-89	Caucasian (90%),	2	1. difficulty due to advanced cognitive
	(M = 78.3)	Native American (10%)		impairment; 2. problems with new Wi-
				Fi and missing interpersonal connection
				to digital companion
	Sample size (% females) 10 (100%)	Sample size Age range (M) in (% females) years 10 (100%) 68-89 (M = 78.3)	Sample sizeAge range (M) inCultural background(% females)years10 (100%)68-89Caucasian (90%), $(M = 78.3)$ Native American (10%)	Sample sizeAge range (M) inCultural backgroundNumber of $(\% \text{ females})$ yearsdropouts $10 (100\%)$ 68-89Caucasian (90%),2 $(M = 78.3)$ Native American (10%)

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Bickmore et al.,	21 (86%)	63-85	INT: Caucasian (10%),	4	Health problems with themselves or
2005	INT: 10	(M = 74.0)	African American (90%)	INT: 2	family members
	(100%)	INT: <i>M</i> = 73.8	CON: Caucasian (27%),	CON: 2	
	CON: 11	CON: <i>M</i> = 74.2	African American (64%),		
	(63%)		Other (9%)		
Bott et al., 2019	95 (55%)	n.r. (<i>M</i> = 76.5)	INT: Caucasian (24%),	No dropout	n.a.
	INT: 41 (68%)	INT: <i>M</i> = 76.8	African American (54%),		
	CON: 54	CON: <i>M</i> = 76.2	Asian/Pacific Islander		
	(44%)		(12%), Hispanic (7%),		
			Other (2%)		
			CON: Caucasian (26%),		
			African American (41%),		
			Asian/Pacific Islander		
			(22%), Hispanic (9%),		
			Other (2%)		
Brandenburgh et al., 2014	7 (43%)	64-77 (n.r.)	n.r.	No dropout ^a	n.a.

51 (n.r.); After	After dropout:	n.r.	19	PACO service (intervention) was not
dropout: 32	65-85			used for 14 successive days by
(56%)	(M = 73.0)			participant
INT: n.r.	INT: n.r.			
CON: n.r.	CON: n.r.			
	51 (n.r.); After dropout: 32 (56%) INT: n.r. CON: n.r.	51 (n.r.); After After dropout: dropout: 32 65-85 (56%) (M = 73.0) INT: n.r. INT: n.r. CON: n.r. CON: n.r.	51 (n.r.); After After dropout: n.r. dropout: 32 $65-85$ (56%) ($M = 73.0$) INT: n.r. CON: n.r.	51 (n.r.); After After dropout: n.r. 19 dropout: 32 65-85 (M = 73.0) INT: n.r. INT: n.r. INT: n.r. CON: n.r. CON: n.r. CON: n.r.

Note. INT = Intervention group; CON = Control group; n.r. = Data not reported; n.a. = Data not applicable.

^a Two participants have stopped using the system during the last 8 and 11 days but were not counted as dropouts.

Design Features of ECAs

All studies provided some level of information on the design characteristics of the ECAs used in the studies. These characteristics were categorised into the following design features shown in Table 3, namely, appearance of the ECA, including species of the avatar, socio-demographic features, realism, and dimension (2D/3D), and interaction which entails the type (text- or speech- based) of interaction possible for user and ECA, the content of the output generated by the ECA, and facial as well as body expressions.

In two of the five studies, the ECA's avatar was depicted as an animal (Bott et al., 2019; Demiris et al., 2016). Both studies used the same dog avatar, but only Bott et al. (2019) reported that the users could decide whether they wanted the avatar to look like a cat or a dog. In the remaining studies, the users were shown a human avatar, either female (Bickmore et al., 2005) or male (Brandenburgh et al., 2014). Only one intervention included two avatars, one female and one male (Kramer et al., 2022). The human avatars could be identified as adults or older adults and as Caucasian (Kramer et al., 2022) or racially ambiguous (Bickmore et al., 2005). Additionally, all human avatars were specific roles assigned, as coach (Brandenburgh et al., 2014), exercise advisor (Bickmore et al., 2005), cook, or peer (Kramer et al., 2022). They were all in colour, either shown in 3D (Bickmore et al., 2005; Demiris et al., 2016) or 2D (Kramer et al., 2022), and besides one (Kramer et al., 2022), all avatars were animated. Except for one study (Brandenburgh et al., 2014), all provided a picture of the ECA that was used in the respective intervention. These are depicted in Figure 2.

Figure 2

ECA Avatars of Included Studies



Note. The avatars used in the study by Bott et al. (2019) and Demiris et al. (2016) (left), Bickmore et al. (2005) (middle), and Kramer et al. (2022) (right).

Two of the ECAs were able to interact with the older adults through speech (Bott et al., 2019; Demiris et al., 2016), with one also providing subtitles (Bott et al., 2019). The remaining ECAs (Bickmore et al., 2015; Kramer et al., 2022) gave textual output. The scope of possible content varied widely. In the studies by Demiris et al. (2016) and Bott et al. (2019), the ECAs were able to provide the largest variety in conversational responses since the conversations with the older people were monitored by trained staff or health advocates who provided individualized and compassionate answers. Other avatars were also able to have social and empathic conversations, as well as meta-relational conversations without being generated live by an individual (Bickmore et al., 2015). The remaining ECAs gave more intervention-related information, which is further outlined in Table 3 and Table 4 (Brandenburgh et al., 2014; Kramer et al., 2022). Four studies also gave information on the ECAs' capability to show facial and bodily expressions (Bickmore et al., 2005; Bott et al., 2019; Brandenburgh et al., 2014; Demiris et al., 2016) which are described in more detail in Table 3. For an overview of the design features of each study's ECA, see Table 3.

ECA Components Aimed at Decreasing Loneliness

The five included ECAs took one of two roles in order to decrease loneliness in the older adults – the role of the companion to build a relationship with or of the facilitator giving advice on how to build relationships with others (see Table 4). The ECAs that acted as a companion, aimed at decreasing loneliness by providing companionship and building a relationship with the user. This was mainly aimed to achieve by the ECA having conversations and interacting with the older adults in a sociable and compassionate way (Bickmore et al., 2005; Bott et al., 2019; Demiris et al., 2016). Bickmore et al.'s (2005) ECA was specifically programmed to mimic natural relationship-building by gradually increasing relational behaviour, such as humour, self-disclosure, and empathy, and engaging in increasingly personal conversations. The ECAs used by Brandenburgh et al. (2014) and Kramer et al. (2022) also interacted with the older adults but mainly acted as facilitators for building new relationships with other individuals in order to ultimately decrease feelings of loneliness. The ECAs provided friendship lessons (Kramer et al., 2022) or modules (Brandenburgh et al., 2014) which gave advice and prompted the users to make new friends by engaging in social activities or provided opportunities for the user to connect with other people, for instance through skype and chat functions. A more detailed overview of the lessons' and modules' content is given in Table 4.

Effectiveness of ECAs on Decreasing Loneliness

Overall, the included studies reported mixed results regarding the ECAs' effects on older adult's feelings of loneliness and perceived social support. The studies by Bickmore et al. (2005) and Kramer et al. (2022) did not find a significant decrease in loneliness over the time the ECAs were used. Also, regarding the chat option to connect with other users – which was part of the ECA application studied by Kramer et al. (2022) – the number of messages correlated with loneliness but did not predict it.

In contrast, Demiris et al. (2016) discovered that after using the digital companion, the participants indicated an increase in the social support score, with the largest positive change in the subscale assessing positive social interaction. Also, Bott et al. (2019) reported a significant decrease in older adults' loneliness. Brandenburgh et al. (2014) found a significant decrease of loneliness in three out of seven participants. Additionally, it was stated that "there has been a decrease in the overall loneliness score among six participants" (Brandenburgh et al., 2014, p. 496). Since no further statistics were provided, it is thought that for three participants – out of the six – the decrease in the loneliness score was significant and for the remaining three non-significant. The seventh participant, however, reported to have perceived almost no change. Table 4 provides an overview of each studies' outcome measures and findings with the corresponding statistics.

Table 3

Design Features of ECAs

Study	Appearance of avatar				Interaction			
	Species of avatar	Socio- demo- graphic features	Realism	2D / 3D	Type of output (text/speech)	Content of Output	Facial expressions	Bodily expressions
Demiris et al., 2016	Animal (dog)	n.a.	Animated, coloured, cartoon style	3D	User: voice Agent: voice & expressions Interaction through voice	small talk and any topic of concern of the user (responses by trained stuff)	"e	xpressions"
Bickmore et al., 2005	Human	Female; exercise advisor; racially ambiguous appearance	Animated, coloured, cartoon style	2D	Interaction through text or multiple- choice options	Social dialogue, empathy exchanges, meta relational communication	Non-verbal i	mmediacy behaviour

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Bott et al., 2019	Animal (dog or cat)	n.a.	Animated, coloured, cartoon style	3D	Interaction through voice (with captions above avatar's head on screen)	Sociable, compassionate, and conversational responses by health advocate; programmed protocols asking for comfort, need of bathroom use, seeking assistance by calling nurse station every 2 days	Facial expression, emotions (e.g., tears)	bodily reactions to touch & petting, showing heart symbols, sleeping & snoring
Brandenburgh et al., 2014	Human	Male; coach	Animated, coloured	3D	Interaction through voice	Provision of and prompts to complete friendship lessons and feedback on physical activity level (compliments or motivation)	basic expressions (e.g., smiling and winking)	Bodily expressions (e.g., giving a thumb up)
Kramer et al., 2022	2 Human avatars	1 male (cook), 1 female	not animated,	2D	Interaction through text	Nutritional and social advice		n.r.

(peer);	coloured,
Caucasian;	cartoon
middle	style
aged/ older	
age	

Note. n.a. = Data not applicable; n.r. = Data not reported.

Table 4

ECA's Effectiveness and Components Targeting Loneliness

Study	ECA components targeting loneliness	Role of ECA	Outcome measure	Results
Demiris et al.,	Relationship-building: Interaction with	Companion	Social support:	Average increase of 1.36 in the
2016	user (small talk and any topic of user's		19-item MOS Social	social support score (compared
	concern); Provision of media, e.g.,		Support Survey including	to baseline), with the largest
	pictures ^a (see Figure 2)		four subscales, each being	positive change (+6.25) in the
			scored 0-100	subscale assessing positive
				social interaction
Bickmore et	Relationship-building: Conversations on	Companion	Loneliness:	No significant decrease in
al., 2005	casual topics (e.g., about television and		20-item Revised UCLA	loneliness over the time the ECA
	user's neighbourhood); Conversations		Loneliness Scale	was used (paired $t(9) = .50$, $p =$
	become gradually more personal/social			.63)
	by increasing relational behaviour ^b to			
	mimic natural relationship-building			

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Bott et al.,	Relationship-building: Conversational,	Companion	Loneliness:	Significant decrease in
2019	social, and compassionate interaction		3-item UCLA Loneliness	loneliness ($p = .01$) compared
	talking about diverse topics (e.g., user's		Scale Short Form	with control group
	family, interests, and news); Provision of			
	different media, e.g., showing pictures,			
	playing music, or audio (meditation/			
	relaxation tracks)			
Brandenburgh	ECA presents 8 friendship lessons	Facilitator to	Loneliness	Except for one perceiving almost
Drandenburgh	ECA presents o mendship lessons		Lonenness.	Except for one perceiving annost
et al., 2014	aiming to encourage user to form new	build	6-item De Jong Gierveld	no change, six participants
	relationships by giving them exercises	relationships	Loneliness Scale	showed a decline in the overall
	(e.g., going for a walk with another			loneliness score. Three of them
	person); Daily provision of prompts to			"had a significant decrease in the
	complete a lesson and exercise;			final loneliness score"
	additional functions offered by ECA,			(Brandenburgh et al., 2014, p.
	e.g., keeping a contact list, skyping with			496)
	social contacts, calendar to schedule			
	appointments with social contacts			

Kramer et al.,	ECA ^c provides 3 modules targeting	Facilitator to	Loneliness:	Overall, the use of the ECA did
2022	loneliness:	build	6-item De Jong Gierveld	not diminish loneliness ($\chi^{2}_{2} =$
	(1) "Goals": User selects from a given	relationships	Loneliness Scale	.02, $p = .99$). Regarding the chat
	list of social goals and the ECA provides			option to connect with other
	an explanation of the goal and tips			users, the number of messages
	(2) "Stories": User can listen to other			correlated with loneliness ($r =$
	older adults' stories about their physical/			.72, $p = .03$), but did not predict
	virtual social activities to learn from			it ($F_{4,8} = 1.32$, $p = .40$, $R^2 = .14$).
	each other and feel connected; ECA			
	provides further information on the			
	activity			
	(3) "Chat": Interaction between users via			
	chat; Inclusion of ECA asking questions			

Note. UCLA = University of California Los Angeles.

^a Family caregivers can be involved to send pictures to the device of the ECA. ^b Relational behaviour includes social dialogue, meta-relational communication, humour, self-disclosure, empathy, and user modelling to adapt conversational topics to user. ^c The three modules targeting loneliness are provided by the female ECA (peer).

Factors Influencing Intention to Use ECA

Few studies provided information on factors that influence older adults' intention to use ECAs. Kramer et al. (2022) were the only exception who statistically investigated potential use-related factors. Significant correlations were found between the aesthetics of the ECA and usability (r = .44, p = .01) and between enjoyment and perceived usefulness (r = .48, p = .005). Enjoyment (r = .38, p = .03) and perceived usefulness (r = .39, p = .03) also correlated with actual use (in minutes) of the ECA, but they did not show to fully predict ECA use ($F_{2,29} = 1.98$, p = .16, $R^2 = .12$).

Two additional studies (Bickmore et al., 2005; Demiris et al., 2016) assessed some variables which can be linked to the intention to use ECAs based on the UTAUT. They did not, however, assess whether these variables indeed correlated with or predicted use. Concerning perceived ease of use, participants in the study by Demiris et al (2016) indicated their comfort using technology on a 5-point Likert scale (ranging from very comfortable to very uncomfortable) before the start of the intervention. They found that 70% of the participants indicated to be somewhat comfortable to use technology. After the intervention and using the ECA, several participants reported during the interviews that they experienced problems or limitations in the communication with the ECA. Additionally, one participant withdrew from the study because she had problems getting the device to work successfully. These issues might have negatively influenced participants' perception of the ECA's usefulness and ease of use. Bickmore et al. (2005) also assessed the older adults' perceived usability of the implemented ECA and found that all participants perceived the system easy to use with no significant difficulties.

Attitudes towards using ECAs – Perceived Strengths and Weaknesses

Overall, more positive than negative attitudes about the use of ECAs were reported during the interviews. All interviews were conducted after the interventions. Thus, the attitudes towards the respective ECA are based on the previous interaction with it and mainly describe strengths and weaknesses that were perceived while using it.

The strengths reported by the older adults were mainly related to the fact that the ECA could serve as a companion for them (Bickmore et al., 2005; Demiris et al., 2016). For example, participants using the animal avatar mentioned that they liked that the ECA enables them to have a substitute for a pet as they are not able to care for a real animal (Demiris et al., 2016). They also mentioned positively that the ECA enables them to always have a friend available to

talk to, especially when they feel lonely (Bickmore et al., 2005; Demiris et al., 2016). Several older adults liked the social interaction and communication with the ECA and that they perceived the ECA to be sensitive, empathic, and caring towards them (Bickmore et al., 2005; Brandenburgh et al., 2014; Demiris et al., 2016).

Although the ECAs were generally perceived as actual companions that showed human qualities, some perceived weaknesses concerning the missing touch; Especially older adults using the animal avatar missed to touch and pet the dog like a real animal (Demiris et al., 2016). A frequently mentioned weakness, however, related to the restricted possibilities of communicating with the ECAs since their repetitive and limited vocabulary as well as the multiple-choice and text-based interaction restricted natural conversation (Bickmore et al., 2005; Demiris et al., 2016). In the study by Kramer et al. (2022), a few participants also reported a negative attitude towards using the ECA as they perceived them to be too childish and unreal.

Discussion

This scoping review aimed to investigate and map what is known about ECAs used to diminish loneliness in older adults. For this purpose, the current state of the implemented design principles, as well as of the ECAs' intervention components and effectiveness in reducing loneliness was identified. Also, older adults' attitudes towards ECAs and further factors influencing older adults' intentions to use them were explored. Thereby, valuable information for the successful implementation of ECAs to combat elderly loneliness or possible knowledge gaps could be detected.

Principal Findings

In the following, the main findings of the present scoping review and the corresponding recommendations for future research are discussed.

Design and Effectiveness of ECAs

Overall, a rather small number of five articles were identified to be included in this scoping review. Considering that the publication year was not restricted in the literature search, not much research seems to be available on ECAs that are used to diminish older adults' feelings of loneliness. After examining the ECA's intervention components combating loneliness, it can be concluded that the ECAs are not only used as companions to substitute for missing companionship but also as a tool to facilitate connecting and building relationships with others

in the older peoples' lives. Several design features for ECAs that were identified and categorised by previous research (Ruttkay Dormann, & Noot, 2004; Straßmann & Krämer, 2017; Ter Stal, 2021), were also found for the ECAs of the included articles. Comparing the design features of the ECAs that mainly act as companion compared to as facilitator, it can be noted that the companion ECAs show more varied output for a sociable and empathic interaction with the user, such as the ability to have small talks or more complex conversations and showing a range of emotional expressions as well as relational behaviour, such as empathy or meta-relational communication. Regarding the avatars' appearance, the ECAs were either presented as an animal (dog) or human, but otherwise not very similar in appearance.

Considering the perceived strengths and weaknesses of the ECAs reported by the target group, characteristics regarding the ECA's looks were not addressed by the participants, except that both species, human and dog, were appreciated as digital substitute for a friend or pet. In contrast, design features that had an impact on the interaction between the ECA and user, seemed to be more crucial for the older individuals. Strengths that prevailed were related to the ECAs' abilities to offer social interaction and communication, and show human-like emotional states or interpersonal skills, such as empathic reactions. Similarly, stated weaknesses identified by the target group were related to the lack of appropriate and natural communication. These findings are also in line with the findings by Lovey et al. (2020), showing that especially verbal and non-verbal communication, such as empathic expressions, social dialogue, emotions, or immediacy behaviour, showed to positively influence the quality of the relationship between user and ECA.

In terms of the ECAs' effectiveness to reduce loneliness, the included studies showed contrasting results. Three studies, however, proved to be successful and participants reported lower feelings of loneliness or increased perceived social support post-intervention. These findings suggest that interventions using ECAs can be effective in decreasing older people's loneliness. Comparing the ECAs that succeeded in diminishing loneliness with those that did not, neither the difference in intervention components nor in design features provide a clear explanation for the mixed results. Generally, both types of ECAs – companions as well as facilitators – showed success in some studies and ineffectiveness in others in combating loneliness. One explanation for the divergent results of the companion ECAs may be the extent they can provide unrestricted and natural conversations. As outlined above, a lack of these abilities was perceived as weakness by the older individuals. In line with that, the ECA whose conversational output is based on a programmed system and consequently more restricted in

providing natural conversations showed no success in alleviating feelings of loneliness. In contrast, the two companion ECAs whose communication modalities were real-time controlled by humans and therefore provided more complex output showed to be successful. Therefore, the restricted communication might have hindered the appropriate building of a relationship with the ECA and thus, hindered the alleviation of feelings of loneliness (Lovey et al., 2020).

Overall, it can be concluded that ECAs can be effective in combating elderly loneliness, but further studies are recommended to investigate ECA's potential in that context as results still showed to be mixed. Moreover, only one study (Kramer et al., 2022) investigated the effect of specific parts of the ECA application on loneliness. Future research would benefit from also examining the effects of different components of the ECA intervention on feelings of loneliness, as this can provide a clearer picture of the elements that are helpful to achieve the intended goal and therefore, should be included in the development of future ECAs. Based on the findings on ECA's design and older adults' perceived strengths of ECAs communication abilities, special attention should be paid to the design of the ECA's communication modalities and capacities during the design process. One issue that could arise, is the trade-off between communication modalities that are real-time controlled by humans and those that are based on a programmed system. It is not surprising that human-driven ECAs have a wider range of communication possibilities, as the person involved can respond individually to the user, is cable to talk about any topic, and can show a wide range of emotions and interpersonal skills. However, such human involvement also restrains the given advantages of technologies, including unrestricted availability all day and night, not consuming further human resources, and being relatively cheap (Loveys et al., 2020).

Actual Use of ECAs

Although the importance of factors influencing the behavioural intention and actual use of technology is stressed by several models, such as the UTAUT (Venkatesh et al., 2003), only one of the included studies explored use-related outcomes (Kramer et al., 2022). However, previous research has shown that especially for elderly individuals it is necessary to investigate factors that predict the use of technology, since applications for this target group are often rejected because of factors specific for these individuals, such as a lack of adaptability to changes in the person's health (Heerink et al., 2010). The Almere model is a theoretical extension of the UTAUT and was particularly developed to examine older adults' acceptance of assistive social agents to predict use (Heerink et al., 2010). The Almere model does not only

target the group of older individuals, but also specifically includes two aspects of acceptance: (1) Functional acceptance, i.e., acceptance of the social agent regarding ease of use and usefulness, as known from existing models, and (2) social acceptance, i.e., acceptance of the social agent as a potential conversational partner with whom one could build a relationship. The latter aspect is not included in traditional models such as the UTAUT, but crucial in the context of studying social agents which are intended to socially interact and build a relationship with the user. This area of social acceptance includes for example the social presence of the agent, the agent's sociability perceived by the user, and perceived adaptivity to changes in the user's condition, for example regarding cognitive or physical health (Heerink et al., 2010). For ECAs that are intended to provide social interaction and companionship to reduce loneliness, not only functional but especially social acceptance is important. Thus, to ensure elderly people's acceptance and actual use of these ECAs, future research is recommended to take these specific use-related factors into account when designing and studying ECAs in this context.

Limitations of the Scoping Review

This review has three main limitations. First, the articles included in the review were of low quality, overall. Based on the framework by Ter Stal (2021), the quality label 1 were given to four of the five included studies. However, the process of assessing and labelling the studies' quality had its difficulties. In this review, the stages and associated quality labels were treated to be successive. This means that a higher label can only be achieved if the requirements of the previous stages are also met. Following this approach, four of the studies' quality were classified as low because the sample size was below 50 participants. As a sample size of 50 subjects is generally considered to be needed to obtain valid results (Moineddin, Matheson, & Glazier, 2007), the stated results on the ECA's effectiveness and use-related outcomes need to be interpreted with caution.

Further, whether the study by Bott et al. (2019) was correctly assigned with the quality label 4, indicating a good quality, remains questionable. The study included more than 50 participants and fulfilled the requirements of the first three stages by Jansen-Kosterink, Vollenbroek-Hutten and Hermens (2016). The first stage, which focused on the feasibility and usability of the technology, was considered to be fulfilled as a feasibility study had previously been carried out with the ECA used. This feasibility study, however, included less than 50 participants. As sufficient information was missing to accurately replicate Ter Stal's (2021) approach, it remains questionable whether the small sample size of the prior feasibility study

would have prevented the following study by Bott et al. (2019) to achieve a higher label than the lowest one. Also, the information given by Jansen-Kosterink, Vollenbroek-Hutten and Hermens (2016) and by ter Stal (2019) on the renewed framework for the evaluation of telemedicine are somewhat contradicting. While Jansen-Kosterink, Vollenbroek-Hutten and Hermens (2016) stated that case studies and small samples (<50 participants) can be used for stage 1 and stage 2, ter Stal seems to advice a sample size of at least 50 subjects for every stage.

The second limitation of this scoping review concerns the inclusion criterion for participants' age. What age range is considered to define older adults varies across studies and among researchers (Selwyn et al., 2003; Theeke, 2009). This scoping review focused on older adults since these individuals are especially vulnerable to feelings of loneliness (Chawla et al., 2021; Elias, 2018; Surkalim et al., 2022). However, talking about loneliness, the age itself is not the defining factor which increases loneliness. It is rather the changes in the living conditions, such as retirement or admission to nursing homes, a declining health, and changes in the social environment, for example, bereavements, that leads to a decline in social contacts, increased social isolation and loneliness in older adults (Garattini, Wherton & Prendergast, 2012; Gardiner et al., 2020). Thus, individuals aged under 60 years who are in early retirement or living in nursing homes due to cognitive or physical health problems, may therefore also be at risk of loneliness and fit in the target group addressed in this review. Therefore, taking these factors into account when defining the inclusion criteria could be helpful to target the right group when assessing interventions that are intended to combat loneliness.

The last limitation is about the inclusion criterion stating that the included studies need to include an outcome measure assessing loneliness or a related construct. This inclusion criterion was initially chosen to ensure that the examined ECAs were developed with the intention to reduce loneliness in older adults. However, by making these outcome measures a prerequisite, studies which investigated for example design features of ECAs that are intended to reduce loneliness, but which were not empirically tested on their effectiveness to diminish loneliness, were excluded. By applying this inclusion criterion solely for the research question on ECA's effectiveness, more studies could have been identified in the selection process to be included to answer the remining research questions.

Conclusion

This scoping review provided insights into available ECAs used to decrease loneliness in older adults. Therefore, the effectiveness and design features, as well as older adults' attitudes towards ECAs and factors influencing their intention to use them were explored. With mostly positive experiences by the users, and three out of five ECAs being effective in terms of their goal to decrease loneliness, outcomes seem promising but further research, especially on factors predicting older people's use of the ECAs, is needed.

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