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Intelligent assistive technology devices for persons with dementia: A scoping review

by

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The author declares that he/she has observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for Researchers and the Policy Guidelines for responsible research.

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ABSTRACT

Background: Assistive devices with context-aware computing and artificial intelligence (AI) capabilities can be applied for cognitive and communicative impairments experienced by persons with dementia (PwD). Such intelligent assistive technology devices (IATDs) may assist in reducing the activity limitations and participation restrictions of PwD. Research regarding IATDs and augmentative and alternative communication (AAC) devices for PwD is rarely transferred to commercial and clinical use.

Aim: To provide an overview of current literature regarding characteristics of IATDs cognitive and communicative impairments of PwD as well as the areas of impairment addressed by the IATDS; to summarise the reported benefits and limitations of the IATDs and to identify trends and gaps in the research.

Method: A multi-faceted systematic search strategy involving three electronic database platforms, two electronic databases and three electronic journals yielded records of the past decade. Predefined criteria were applied for inclusion and data extraction. Data were thematically analysed and synthesised.

Main Contribution: This review demonstrates that the majority of research involving IATDs in the past decade has focused on cognitive impairments of PwD and have not yet evolved past the conceptual or prototype stages. A summary of commercially available IATDs for PwD is provided at the end of this review.

Conclusion: Research established that IATDs for PwD primarily focus on social robots, especially PARO, addressing cognitive impairments of attention and affect, as well as social-pragmatic communicative impairments. The majority of IATDs are operated by the PwD themselves, and aim to support interpersonal interactions and relationships by enabling and empowering PwD. Few IATDs addressed the linguistic impairments experienced by PwD. Future research should collaborate between computer engineering and health practitioners to address the identified gaps to contribute to evidence-based decision-making for PwD.

Keywords: assistive devices, cognition, communication, dementia, intelligent technology

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AAC	Augmentative and alternative communication
AD	Alzheimer's disease
ADL	Activity of daily living
AI	Artificial intelligence
APA[1]	American Psychiatric Association
APA[2]	American Psychological Association
AR	Augmented reality
AT	Assistive technology
CSV	Comma-separated values
DSM–5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
EADL	Enhanced activity of daily living
GMS	Global mobile communication system
GPS	Global positioning system
HCI	Human-computer interaction
HIV	Human immunodeficiency virus
IADL	Instrumental activity of daily living
IATD	Intelligent assistive technology device
ICF	International Classification of Functioning, Disability and Health
ICT	Information and communication technologies
IRA	Interrater agreement
MCI	Mild cognitive impairment
NCD	Neurocognitive disorder
NLG	Natural language generation
NLP	Natural language processing
PEO	Population, Exposure and Outcome
PRISMA-ScS	Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for Scoping Reviews
PROSPERO	International Prospective Register of Ongoing Systematic Reviews
PwD	Persons with dementia
QoL	Quality of life
RIS	Research information systems
RSS	Really simple syndication
TBI	Traumatic brain injury
UP	University of Pretoria

1. PROBLEM STATEMENT AND LITERATURE REVIEW

1.1 Dementia

Dementia is a clinical syndrome and a major neurocognitive disorder (NCD) that typically affects older people, but is distinct from cognitive decline associated with increased age (American Psychiatric Association [APA[1]], 2013; Prince et al., 2013; Salmon & Bondi, 2009). The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM–5), classifies dementia as a significant acquired cognitive decline in any one or more of the domains of complex attention, executive function, language, learning and memory, perceptual-motor or social cognition. Diagnostic criteria include a decline in any one or more of these six cognitive domains, resulting in an interference with independence and activities of daily living (ADLs) (APA[1], 2013).

Types of dementia that have a primary insidious onset and gradual progression of impairment of cognitive function include dementia due to Alzheimer's disease (AD), frontotemporal dementia and dementia with Lewy bodies (APA[1], 2013). AD is the most frequently occurring type of dementia. Secondary dementia due to causative aetiologies includes vascular dementia, substance/medication-induced dementia as well as dementia due to traumatic brain injury (TBI), human immunodeficiency virus (HIV), Prion disease, Parkinson's disease, Huntington's disease or other medical conditions (APA[1], 2013). Dementia types secondary to health conditions might differ from primary dementia types when considering the disease's treatability, progression and course. For the purpose of this review, the effects and possible support of neurodegenerative dementia (i.e. dementia due to AD, frontotemporal lobar degeneration and Lewy body dementia) are of interest (APA[1], 2013).

Persons with dementia (PwD) often experience memory problems. The types of memory impairment experienced differ, depending on the underlying condition, extent and site of the brain lesions (Van der Roest, Wenborn, Pastink, Dröes, & Orrell, 2017). Prospective memory impairments have significant influences on independent living as it involves remembering tasks without prompts. Retrospective memory impairments affect the recognition or recall of previously acquired information (Van der Roest et al., 2017).

Other neuropsychological symptoms of dementia include deficits of executive functions, which are the higher-order cognitive processes responsible for planning, concept formation, problem-solving and the simultaneous manipulation of information (Salmon & Bondi, 2009). Attention deficits affect tasks that entail the disengagement and shift of attention, as well as the management of attentional resources. Visuospatial and visuoperceptual deficits often occur with AD, although less noticeably in the early stages of AD (Salmon & Bondi, 2009). A large portion of PwD also have mental state symptoms, influencing affect, agitation and psychotic needs such as co-morbid depressive and anxiety symptoms (Meaney, Croke, & Kirby, 2005). The behavioural changes due to cognitive and neuropsychological symptoms contribute to caregiver burden, create a need for institutionalised care and impact on various life areas in PwD (Azermai, 2015).

The International Classification of Functioning, Disability and Health (ICF) model (World Health Organization, 2001) views nine different domains of activity limitations and participation restrictions. These are the result of physiological, psychological body functions and anatomical structures interacting with environmental and personal factors. For example, neurological impairments associated with dementia influence the PwD's capabilities to manage activities and decisions of daily life, maintain appropriate attitude by regulating emotional reactions and perform perceptive movements. This in turn leads to limitations in activities and restrictions in participation (Fried-Oken, Mooney, & Peters, 2015; Scherer et al., 2012). There are nine domains of activity limitations and participation restrictions. These are: (1) learning and applying knowledge, (2) general tasks and demands, (3) communication, (4) mobility, (5) self-care, (6) domestic life, (7) interpersonal interactions and relationships, (8) major life areas, and (9) community, social and civic life (Scherer et al., 2012). PwD are expected to experience activity limitations and participation restrictions and possibly require assistance in all of the above mentioned domains, except in domain (8), major life areas (Scherer et al., 2012).

Caring for PwD increases societal and financial/economic costs due to increases in diseases and healthcare costs and shortages of caregivers (Rashidi & Mihailidis, 2013), which emphasises the importance of timely diagnosis (Hung et al., 2019). Therefore, interventions can then be planned to guide PwD and their families to prepare for the progression of cognitive decline (Koumakis, Chatzaki, Kazantzaki, Maniadi, & Tsiknakis, 2019).

1.2 Assistive Devices for Persons with Dementia

While pharmacological interventions may assist in delaying the progression of dementia symptoms, they are not only costly but also limited to the biological dimensions of dementia (Klimova, Valis, & Kuca, 2018). Aligned to the ICF, functional, holistic goals that facilitate participation and independence of persons with dementia in various life domains can be addressed with non-pharmacological interventions such as assistive technologies (Livingston et al., 2017). Assistive technology (AT) is defined as commercially acquired equipment or product systems that could be customised or modified to be applied toward improving or maintaining the functional capabilities of persons with disabilities (Van Niekerk, Dada, Tönsing, & Boshoff, 2018).

AT devices range from simple, low-technology devices such as calendar clocks to sophisticated, high-technology devices such as automatic lighting or social robots (Kenigsberg et al., 2019). In their review of information and communication technologies (ICT), Martínez-Alcalá, Pliego-Pastrana, Rosales-Lagarde, Lopez-Noguerola, and Molina-Trinidad (2016) also recognised the range of low-level technology, telecare and smart home technology as tools for PwD accessible in the public market.

The main goal of AT for PwD is to enable them to maximise their mental and physical functions in order to continue leading independent and purposeful lives and to continue participating in social networks (Mokhtari et al., 2012). This is achieved by assisting with the following three areas of functional impairments experienced by PwD. The first area is health and well-being, such as reducing the risks of falls and disorientation and supporting medication regimes and reminiscence activities. The second area of functional impairment is safety and independence, such as preventing accidents and getting lost outside the home. The third area pertains to enabling and empowering, such as supporting ADLs, increasing choices and opportunities, assisting with communication and social networks (Kenigsberg et al., 2019).

The integration of technology into care for PwD is a significant opportunity as it can prospectively reshape dementia care (Hung et al., 2019). In this regard, innovations in the technological field can promote independent living, safety and autonomy of PwD. It can also reduce psychological and behavioural symptoms of PwD (Klimova et al., 2018) and increase the quality of life (QoL) experienced by PwD and the family members acting as their informal caregivers (Ienca et al., 2017; Topo, 2009).

Trends in assistive devices have moved toward context-aware computing and the use of artificial intelligence (AI). Systems that are context-aware can sense information about a person and remember the information with the purpose of reducing effort and computer-user communication (Mihailidis & Fernie, 2002). Furthermore, technologies that amplify or augment human abilities have proliferated as service robots and home automation equipment with AI have become commonplace in users' lives (McMurray et al., 2017). Sennott, Akagi, Lee, and Rhodes (2019) defined AI as a machine's capability to mimic human intelligence with the goal to develop machines that are able to use human intelligence characteristics. These traits include emotion, creativity, language, self-awareness, learning, logic, planning and reasoning to solve problems and to adapt to changing environments. AI, a relatively new field in science and engineering, brought about intelligent assistive technology devices (IATDs). IATDs have the ability to support or increase human abilities or activities while sensing and responding to the user's needs and adapting to the changing environment (McMurray et al., 2017; Russel & Norvig, 2014). IATDs employ algorithms for mobile and ambient activity recognition, context modelling, anomaly detection, location and identity distinguishing, and automatic planning and scheduling (Rashidi & Mihailidis, 2013).

Recent technologies with intelligent or context-aware capabilities have developed a variety of IATDs. These include mobile and wearable sensors, assistive robotics and smart homes (Koumakis et al., 2019; Rashidi & Mihailidis, 2013). Firstly, mobile and wearable sensors involve various instruments such as global positioning systems (GPS), proximity sensors, gyroscopes and accelerometers, which are integrated into most smart phones to detect user mobility and activity. Other examples of wearable sensors include patches, small portable or body-worn devices, as well as smart garments. These monitor health signals such as blood pressure, blood glucose and cardiac activity (Rashidi & Mihailidis, 2013). Data from these mobile devices are communicated to the internet or other network access points, or could be connected to a web interface to provide communication options between the user and caregivers (Rashidi & Mihailidis, 2013).

Secondly, assistive robots aim to aid with physical limitations in daily activities. Rashidi and Mihailidis (2013) specified three types of assistive robots that perform the following functions. (1) They provide assistance with ADLs, for instance bathing, grooming, dressing and feeding. (2) They help with instrumental activities of daily living (IADLs), such as medication management, meal preparation, housekeeping, laundry, shopping and telephone use. (3) Also, they support enhanced activities of daily living (EADLs), such as social communication, hobbies and new learning.

Thirdly, regular homes are augmented with various sensors and actuators (devices activated by commands from control mechanisms to control features such as lights, locks or windows) to create smart homes (Rossi et al., 2014). Sensor data are analysed to provide context-rich information. In turn, the information is utilised by a smart home to provide automation and increased comfort and to assess cognitive and physical health of its residents (Rashidi & Mihailidis, 2013). A synopsis of research by Ienca et al. (2017) indicated that distributed systems such as smart home systems dominated the largest portion of indexed technologies for PwD, followed by assistive robots and mobility aids (Liddle, 2017).

Furthermore, researchers have inspected augmented reality (AR) applications for people with cognitive impairments. AR superimposes information through digital screens onto what is seen in the real environment in real time. In this way, customised directions, cues and supplemental information are provided to the PwD (Zanwar, Heyn, McGrew, & Raji, 2018).

Technologies for dementia care can have various users. In a review of AT products for PwD in the United Kingdom, Gibson et al. (2014) found three themes of AT products in terms of their users. Firstly, AT devices could be used independently by the PwD, such as products that assist in everyday activities (e.g. medication dispensers), raising alerts (e.g. reminder alarms) or providing prompts (e.g. signage or memory aids). Secondly, AT devices can be used collaboratively between PwD and other persons, such as reminiscence aids or puzzle games that support, encourage or enable communication. Lastly, AT devices can be used without the PwD’s cooperation, such as products to monitor the PwD’s activities, movement and safety, or to send emergency alerts (Gibson et al., 2014; Topo, 2009).

Applying IATDs for dementia include various benefits. Firstly, the burden on public finances is decreased through delaying institutional care. Also, the psychological burden on formal and informal caregivers is also decreased, counteracting the progressive scarcity of caregivers. The quality of care as well as the QoL of PwD is improved by empowering them (Ienca et al., 2017). Other valuable gains as discussed by Das, Cook, Krishnan, and Schmitter-Edgecombe (2016) are the improved activity initiation and completion assisted by automated prompts, and extended independent living without the safety of PwD being compromised.

1.3 Current Research

IATDs for PwD have sparked interest noted in recent reviews. Summaries of some leading reviews follow next.

A review by Bharucha et al. (2009) examined ATs with direct implications on the functional impairments of PwD. The reviewed studies mainly examined environmental sensors and advanced integrated sensor systems. Other types of IATDs identified by Bharucha et al. (2009) were cognitive aids (mainly memory aids), physiological sensors, wearable radiofrequency transmitters and proactive activity toolkits. Bharucha et al. (2009) recommended critical evaluation of the performance characteristics and utility of commercial products brought about by the proliferation of research in the years following the review.

Ienca et al. (2017) reviewed studies from January 2000 to April 2016 to categorise characteristics of IATDs for PwD according to the technology types, application, impaired function assisted, user-centred design, primary target-user population and evidence of clinical validation. The most common applications of IATDs were for ADL completion and safety monitoring of PwD. The majority of IATDs assisted general-purpose functions. The second most common function assisted with was the cognitive dimension, which included memory, communication, orientation, reasoning and decision-making, in this order (Ienca et al., 2017). Trends toward the development of smart homes and environments, and commercial availability of social robots were identified. The reviewers recommended that IATDs for emotional support of PwD be explored.

Klimova, Maresova, and Kuca (2016) examined ATs applied to the language disorders of PwD and concluded that ATs, specifically augmentative and alternative communication (AAC) technologies, can significantly improve and substitute the spoken and written communication of PwD. However, these ATs were not limited to IATDs. May, Dada, and

Murray (2019) specifically reviewed current AAC interventions for PwD and found the focus of non-electronic aids for memory and communication impairments to be on persons with AD. Similarly, a systematic mapping study indicated that academic research on software-based assistive devices focused on providing assistance to socialisation, leisure and cognitive difficulties (Asghar, Cang, & Yu, 2016). However, the study highlighted that commercially available software-based assistive devices for health and activity monitoring and cognitive difficulties receive more attention (Asghar et al., 2016).

Corresponding with the above, Maresova et al. (2018) also conducted a review on ATs for PwD and found that wearable physiological monitors that track the vital health signs of PwD were the most preferred function of smart homes for persons with AD. Maresova et al. (2018) recommended that professionals in health and social care be made aware of the potential of such ATs for PwD.

Recently, the application of IATDs expanded to communication and socio-contextual use (McMurray et al., 2017). Bemelmans, Gelderblom, Jonker, and De Witte (2012) reviewed studies on socially assistive robotic systems used for care of elderly persons, of which many were PwD. They reported positive socio-psychological and physiological outcomes.

The most recent available review focused on integrated care models for PwD and explored types of AT for PwD, of which most were identified as home-setting ATs and assistive robotics (Koumakis et al., 2019). However, the review by Koumakis et al. (2019) did not identify the parameters of the IATDs that are explored in this review.

1.4 Communication and Communication Devices for PwD

Communication is an especially important ICF domain of the activities and participation of the PwD. Communication involves receiving and producing messages, continuing conversations and applying communication techniques and devices by using signs, symbols and language (Hopper, 2007; World Health Organization, 2001).

The cognitive or neuropsychological symptoms of dementia also have a detrimental effect on the communication abilities of PwD. Extralinguistic deficits such as inattention to tasks, difficulty remembering target words or being distracted by related responses occur when communicating (Kempler & Goral, 2008). Additionally, semantic or conceptual memory impairments affect word meaning and message content (Kempler & Goral, 2008). General communication impairments associated with dementia may include receptive language impairments such as listening comprehension and reading difficulties, as well as expressive language impairments such as verbal expression and writing difficulties (Banovic, Junuzovic-Zunic, & Sinanovic, 2018). Pragmatic impairments are observed when the rules that govern language use in conversation and communicating in social situations are affected; these are observed less frequently in PwD (Banovic et al., 2018; Swan et al., 2018).

Arnott and Alm (2016) also emphasised that PwD experience the deterioration of the ability to communicate as an especially challenging aspect. For instance, the communication of persons with AD is characterised by impaired sociolinguistic abilities. Initially, persons with mild AD still have speech with intact phonological, morphological and syntactical structure. However, lexical-semantic language difficulties such as word finding and naming difficulties, as well as empty speech, become prominent due to affected semantic memory. Persons with moderate to severe AD experience a rapid decrease of verbal fluency and breakdown of comprehension. Thus, AD affects flowing communication, repetition, the understanding of words and sentences, as well as the ability to read and write (Klimova, Maresova, Valis, Hort, & Kuca, 2015). Sociolinguistic difficulties such as poor turn-taking, topic maintenance and inappropriate repetition negatively affect social situations (Klimova et al., 2015). This highlights that the development of interventions such as assistive devices to support communication and conserve relationships between PwD and caregivers is a growing priority in social and healthcare sectors (Arnott & Alm, 2016).

Communication has a significant influence on the other seven domains of the ICF activities and participation (Byrne & Orange, 2009). Learning and applying knowledge, general tasks and demands, self-care, domestic life, interpersonal interactions and relationships, major life areas, and community, social and civic life are the domains affected by the PwD's ability to communicate. The domain of mobility is not affected by communication (Byrne & Orange, 2009).

When considering the communication activity and participation limitations for PwD, impaired communication might lead to certain difficulties. Examples of these difficulties include understanding directions for the use of medication, reading recipes or newspapers, completing any tasks or everyday activities that require the ability to use language for reading, writing, speaking or understanding others. Other difficulties include initiation, maintaining and terminating conversations with other people in addition to the activity limitations and participation restrictions discussed previously (Badarunisa, Sebastian, Rangasayee, & Kala, 2015). The capability approach places emphasis on the possible freedom that technological development and ATs can provide for PwD. By reflecting on activity and participation limitations by using the capability approach (Le Galès & Bungener, 2019), technology can be seen as an enabler that promotes the participation in life activities and capabilities of the PwD (Kenigsberg et al., 2019).

In addition to the ICF model (World Health Organization, 2001), the National Joint Committee for the Communication Needs of Persons with Severe Disabilities (1992) posed a Communication Bill of Rights. This bill states that all persons with disabilities have the basic right to influence the conditions of their lives through communication. This includes persons with severe speech and language impairments due to neurodegenerative diseases such as dementia (National Joint Committee for the Communication Needs of Persons With Severe Disabilities, 1992).

To address this basic human right, the scientific field of AAC endeavours to involve the three components of evidence-based practice as well as development of computer-based technologies to improve QoL through effective communication (Hill, 2006; Schlosser & Sigafoos, 2009). The three components of evidence-based practice include current research evidence, clinical expertise and stakeholder perspectives. AAC technologies are ATs that compensate for communication losses associated with acquired neurological conditions such as dementia (Beukelman, Fager, Ball, & Dietz, 2007). AAC interventions for PwD compensate for, maintain or enhance memory, communication functions, participation and QoL for PwD. This is done by capitalising on remaining cognitive and communicative skills of PwD, such as visual processing and reading skills, by reducing cognitive demands on especially memory, and taking advantage of environmental cues to elicit recall skills (Beukelman et al., 2007; Lanzi, Burshnic, & Bourgeois, 2017). AAC devices for PwD similarly range from low technology such as communication books or printed reminders to high technology such as computerised memory aids (Beukelman et al., 2007).

AAC technologies are also evolving. From the development of AI, a field named natural language processing (NLP) emerged (Russel & Norvig, 2014). NLP examines the automatic analysis, generation or translation of human language in spoken or written form (Langer & Hickey, 1999). By applying statistical language models trained on natural language observations to the acquired input and by using machine learning techniques, the intelligent device can predict and complete words based on patterns observed (Higginbotham, Lesher, Moulton, & Roark, 2012). AAC and NLP are closely linked when considering the influx of high-technology assistive devices or AAC aids (Langer & Hickey, 1999).

NLP techniques have had a positive effect on AAC technology development in the past decade (Mooney, Bedrick, Noethe, Spaulding, & Fried-Oken, 2018a). Applications of NLP in AAC include the processing and generation of outputs by optimising topic identification, word prediction, speech recognition algorithms, and the processing of the context of language use (Elsahar, Hu, Bouazza-Marouf, Kerr, & Mansor, 2019; Trnka, Yarrington, McCoy, & Pennington, 2006). This technology is well suited for AAC devices for PwD. Word sets are automatically built over time and are able to provide content to the user's vocabulary without family or other professionals having to pre-store vocabulary on the device (Mooney et al., 2018a). This provides an AAC user with the opportunity to continue being active and independent participants in their own communication interactions and social networks (Mooney et al., 2018a). Another AI capability that can be used with NLP is natural language generation (NLG) for an increased pace of utterances and social interaction, as well as pre-stored phrases or messages (Dempster, Alm, & Reiter, 2010). Additionally, a global system for mobile communication (GMS) module of an assistive device can send and receive data messages via available mobile networks. It serves as an automated communication function to automatically provide feedback or request help for a person with severe communication difficulties in unfamiliar or emergency situations (Atayero, Ozara, Popoola, & Matthews, 2016). The ultimate goal of AAC devices and systems with AI capabilities may provide enhanced methods to persons with complex communication needs to solve the challenges of participation when their communication needs are hampered by their speech or language abilities (Sennott et al., 2019).

Although current trends of AAC interventions for PwD still involve non-electronic aids, a shift to the incorporation of NLP in AAC devices is seen (May et al., 2019). To take further advantage of devices augmenting communication and memory, PwD are being included in contributing to the development of conversational topics on non-electronic devices to reflect personal agency as advised by the person-centred care approach. However, the evidence in this regard is still emerging (May et al., 2019).

Despite the numerous advantages that IATDs offer PwD to enable their participation and independence in daily activities, there are potential limitations that must be considered. For instance, the ease of access, programming, maintenance, affordability and portability are potential IATD features that may influence usage by PwD (Elsahar et al., 2019).

1.5 Problem Statement

Based on the review of literature, it is evident that considerable effort has focused on development of technological applications for assessment and diagnosis of dementia (Koumakis et al., 2019). However, there appears to be a distinct disparity in how IATDs can be applied by, with or to persons diagnosed with dementia in the home setting (Koumakis et al., 2019). Furthermore, although sophisticated IATDs for cognition and communication (e.g. memory glasses as a prospective memory aid) increase the performance and functioning of PwD in multiple ADLs, there is a lack of evidence on its effectiveness (Klimova et al., 2016).

Moreover, the adoption rate is lower than expected. This is due to inadequate information transfer and dissemination between technology development and medical implementation, lack of clinical validation of IATDs and because clinicians are unaware of new IATDs and the applicability in dementia care (Ienca et al., 2017). Although previous reviews such as the review by Bharucha et al. (2009) encompassed many technologies, only a few IATDs have been investigated with PwD (Gagnon-Roy et al., 2017).

Therefore, the purpose of this review is to provide a recent, comprehensive synthesis of evidence (including studies published up to 2020) about IATDs that have been used by PwD or their caregivers. This review includes information relating to: (1) cognitive and communicative areas assisted, (2) the user operational skills required, (3) benefits, limitations, commercial availability of these IATDs, and (4) identified trends in the development of IATDs for PwD.

2. METHODOLOGY

2.1 Research Aims

2.1.1 Main aim

The main aim of this scoping review is to synthesise the current research evidence of available IATDs applied for the impaired cognitive and communicative functions of PwD, and to identify trends and gaps in the evidence.

2.1.2 Sub-aims

The sub-aims of the study attempt to:

1. Identify research designs of research regarding IATDs for PwD;
2. Identify the types of dementia of the populations exposed to IATDs;
3. Describe the types of IATDs that are used by PwD or their caregivers to assist with impaired cognitive and communicative functions;
4. Identify the primary operators of the IATD in relation to the care of PwD;
5. Determine the skills required by the primary operators to use the IATD;
6. Identify the areas of cognitive and communicative impairment of PwD with which the IATD aids;
7. Identify the availability for purchase of the IATD to the public for the care of PwD;
8. Describe the reported benefits and limitations of the IATD in relation to the care of PwD;
9. Describe the reported recommendations made by the authors in relation to IATDs for PwD;
10. Describe the reported gaps in development and research regarding IATDs for PwD; and
11. Identify trends in current research regarding IATDs for PwD.

2.2 Research Design and Phases

A scoping review is recommended for complex areas that have not yet been reviewed comprehensively, such as the relatively new field of intelligent assistive devices. A scoping study will be able to map the key concepts, main sources and types of evidence available in an area of research (Arksey & O’Malley, 2005). An analytical reinterpretation of the literature can also be performed (Levac, Colquhoun, & O'Brien, 2010). Two reasons to undertake a scoping study would be to summarise and disseminate research findings in terms of IATDs for PwD, and to identify research gaps in the existing literature to guide further research (Arksey & O'Malley, 2005). The methodological framework for a scoping study developed by Arksey and O'Malley (2005) prescribes the following steps. (1) Identify a research question, (2) identify relevant records, (3) record selection, (4) chart the data, (5) collate, summarise and report the results, and (6) optional consultation.

No formal quality assessment of the records selected for inclusion in a scoping review is necessary (Grant & Booth, 2009). Synthesis of data typically takes a tabular form with narrative commentary (Grant & Booth, 2009). Qualitative data analysis was applied through the process of inductive analysis, where specific data were synthesised into general categories and patterns to yield meaning from the data (McMillan & Schumacher, 2014).

The PRISMA-ScS (Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for Scoping Reviews) checklist (Tricco et al., 2018) was followed to increase methodological transparency. The checklist involves title, method, results and discussion elements.

2.3 Ethical Considerations

Firstly, ethical approval was granted by the Research Ethics Committee of the University of Pretoria (UP), Faculty of Humanities (Appendix A).

A researcher has an ethical responsibility of protecting the rights and welfare of the participants in a study (McMillan & Schumacher, 2014). However, since scoping studies only review and summarise literature to disseminate findings and do not involve human participants, no informed consent was necessary. There is no harm or risk to the participants (Arksey & O'Malley, 2005). The original records are expected to have upheld participant privacy and anonymity (McMillan & Schumacher, 2014).

Furthermore, accurate scholarly and scientific knowledge and the protection of intellectual property rights are upheld by accurate referencing techniques (American Psychological Association [APA[2]], 2017). UP's plagiarism policy was also upheld (UP, 2010). To avoid the duplication of a study, it was intended to register this scoping review on PROSPERO (International Prospective Register of Ongoing Systematic Reviews) (University of York, n.d.). However, PROSPERO did not accept scoping studies at the time. Please see Appendix B.

2.4 Protocol

A research protocol was developed before the systematic searches were performed to direct essential procedures of the review. According to Schlosser, Wendt, and Sigafoos (2007), the presence of a protocol increases replicability and transparency of the review process and decreases the probability of selection bias when performing the review. Various persons, including information specialists from three UP Library departments, were consulted. They were from the Speech-Language Pathology and Audiology, Electrical, Electronic and Computer Engineering, and Medical (Centre for Stomatological Studies) departments. Consultations with an expert, Associate Professor Pammi Raghavendra from the College of Nursing and Health Sciences, Flinders University (personal communication, September 27, 2019), also provided valuable information that guided the searches.

2.5 Pilot Search

Pilot searches tested technical adequacy, feasibility of the search terms and applicability of the inclusion and exclusion criteria, and determined whether any changes to the protocol were required (Brereton, Kitchenham, Budgen, Turner, & Khalil, 2007). The procedures of the pilot searches are summarised in Table 1.

Section 2: Methodology

Table 1

Pilot Study Aims, Materials, Procedures, Results and Recommendations

Aim	Materials	Procedures	Results	Recommendations
To determine whether the search terms were effective.	Electronic platforms and databases	Search terms for population, exposure and outcome facets were explored separately and in combination.	Search terms for outcome facet increased number of results yielded significantly.	Search terms for outcome facet removed from search strategy. Records to be screened for outcome facet in title, abstract and full-text levels.
To simplify search terms from all relevant search terms and subject headings.	Electronic platforms and databases	Search terms were explored separately and in combination through process of elimination.	Search terms that yielded manageable number of results selected.	Specific search terms for population combined with exposure decided on. See Table 2.
To investigate yields from various electronic platforms and databases suggested by UP information specialists from Speech-Language Pathology and Audiology, Electrical, Electronic and Computer Engineering and Medical (Centre for Stomatological Studies) departments to determine which to use in systematic search.	Electronic platforms and databases investigated: Academic Search Complete, ACM Digital Library, Cochrane Library, The Cumulative Index to Nursing and Allied Health Literature, EBSCOhost, Education Resources Information Center, EI Engineering Village, Family & Society Studies Worldwide, Health Source – Nursing Edition, IEEE Xplore Digital Library, Inspec, Linguistics & Language Behaviour	Platforms and databases were explored separately and yields investigated.	Some yielded irrelevant records from other areas of research, or yielded too few or too many records. Some yielded acceptable numbers of appropriate records.	Electronic platforms and databases to use for this review identified and combinations selected: Scopus, EBSCOhost (including databases Academic Search Complete, The Cumulative Index to Nursing and Allied Health Literature [CINAHL], E-Journals, Education Resources Information Center [ERIC], Family & Society Studies Worldwide, Health Source: Nursing/Academic Edition, MEDLINE,

	Abstracts, McGraw-Hill's Access Engineering, McGraw-Hill's Access Science, Medline, ProQuest Computer Science Collection, ProQuest Dissertations & Thesis Global, PsychInfo, Science Direct, Scopus.			PsycARTICLES, and PsycINFO), ProQuest (including databases Humanities Index, ProQuest Dissertations & Theses Global, Science Database, Advanced Technologies & Aerospace Collection, ERIC, Linguistics and Language Behavior Abstracts [LLBA], Linguistics Database and Social Science Database), IEEE Xplore DL database, ACM Digital Library database
To investigate yields from various electronic journals available from the UP Library.	Electronic journals investigated: Aging and Disease, Alzheimer's Care Quarterly, Alzheimer's and Dementia: The Journal of the Alzheimer's Association, Assistive Technology, Augmentative and Alternative Communication, Current Alzheimer Research, Dementia and Neurocognitive Disorders, Journal of Robotics, Journal of Robotics, Networking and Artificial Life.	Electronic journals were explored separately and yields investigated	Some yielded too few or irrelevant records.	Electronic journals selected for this review: Alzheimer's and Dementia: The Journal of the Alzheimer's Association, Assistive Technology, Journal of Automation, and Augmentative and Alternative Communication

2.6 Search Strategy

Arksey and O'Malley (2005) recommended a breadth of coverage in a scoping study by maintaining a wide approach. Further decisions about search parameters on extensive bibliographic references should be made only once the general scope and volume of the field have been acquired (Arksey & O'Malley, 2005). Table 2 reports the search terms applied to searches in all the below-mentioned sources.

Table 2

Search Terms as Boolean Phrases

Facet	Search terms as Boolean phrases
Population	"dementia" OR "Alzheimer*" OR "cog* degenerat*" OR "progress* cog* decline" OR "neurocog* dis*"
Exposure	"assist* tech*" OR "assist* dev*" OR "assist* app*" OR "artific* intelligen*" OR "heurist*" OR "robot*" OR "natural language process*" OR "NLP" OR "info* communicat*" OR "cog* tech*" OR "augment*" OR "augment* communicat*" OR "augmentative and alternative communication" OR "AAC" OR "neuro* rehab*" OR "rehab* engin*" OR "communicat* aid" OR "assis* engin*"

Data were compiled from a multi-faceted search strategy to avoid a biased yield (Schlosser, Wendt, Angermeier, & Shetty, 2005). A combination of search methods was utilised. Firstly, electronic database platform searches included: Scopus platform, EBSCOhost platform (including databases Academic Search Complete, The Cumulative Index to Nursing and Allied Health Literature [CINAHL], E-Journals, Education Resources Information Center [ERIC], Family & Society Studies Worldwide, Health Source: Nursing/Academic Edition, MEDLINE, PsycARTICLES, and PsycINFO), ProQuest platform (including databases Humanities Index, ProQuest Dissertations & Theses Global, Science Database, Advanced Technologies & Aerospace Collection, ERIC, Linguistics and Language Behavior Abstracts [LLBA], Linguistics Database and Social Science Database). The search strategies and resulting yields of the relevant electronic database platforms can be found in Appendix C.

Secondly, electronic database searches included IEEE Xplore DL database and ACM Digital Library database. Appendix C also includes the search strategies and resulting yields of the electronic databases based on the search terms and publication requirements, namely published in English in the period 2010–2020. To ensure that any articles added to the platforms or databases after the systematic search date are also sourced, the RSS (Really Simple Syndication) feeds of the searches were applied. This feature allowed updates concerning the search yields from the library databases. Where RSS feeds were not possible, searches were repeated, and duplicates were removed to identify new additions. Appendix C also reports the additional records identified by RSS feeds and second yields with duplicates removed.

Thirdly, hand searches of electronic journals identified through literature readings for the period of 2010–2020 were also included in the systematic search, namely *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *Assistive Technology*, and *Augmentative and Alternative Communication*. Appendix C also reports the yields of the electronic journals.

2.7 Inclusion and Exclusion Criteria

To collate a set of records that will provide accurate answers to the research question, a set of inclusion and exclusion criteria was based on the framework recommended for qualitative research reviews, namely *Population*, *Exposure* and *Outcome* (PEO) (Butler, Hall, & Copnell, 2016). By applying the inclusion and exclusion criteria, irrelevant records were excluded, and only primary research on PwD who were exposed to IATDs and which reported cognitive and communicative outcomes of the PwD was included. Table 3 describes the eligibility criteria for inclusion and exclusion as used by the reviewers.

Table 3

Eligibility Criteria for Inclusion

Criterion	**Inclusion**	**Exclusion**	**Rationale**
POPULATION (age)	Adults (18 years +)	Children and young adults below 18 years.	To limit the topic to adult PwD.
POPULATION (diagnosis)	Persons with degenerative mild to severe primary dementia, with insidious onset, as well as gradual progression of impairment affecting one or more cognitive domains, (APA[1], 2013) including dementia due to Alzheimer's disease, frontotemporal dementia (e.g. primary progressive aphasia), dementia with Lewy bodies.	Adults with dementia that is non-degenerative, does not have an insidious onset, or purely secondary dementia (e.g. vascular dementia, TBI, substance or medication-induced dementia, dementia due to: HIV infection, Prion disease, Parkinson's disease, Huntington's disease, or another medical condition), unspecified dementia (APA[1], 2013), psychiatric disorders (e.g. delirium), dementia with any co-morbidities, or any other diagnosis according to the DSM-5, such as Mild Cognitive Impairment (MCI) (APA[1], 2013).	To limit the topic to adult PwD (APA[1], 2013).
EXPOSURE/IATD interventions	ATs with AI for cognitive and communicative impairments, thus IATDs that respond to the user's needs and adapts to changing environments (McMurray et al., 2017)	Non-intelligent AT devices, IATDs for other areas of impairment (e.g. physical, ADLs), AI devices with the aim to identify, diagnose or classify dementia.	To focus the review on IATDs that assist with the defining areas of impairment of dementia (APA[1], 2013) and exclude technologies used for neuroimaging or diagnosis of neurological disorders.
OUTCOME	Results related to performance of any of the cognitive domains that	Outcomes related to physical assistance (e.g. motor control,	To focus the review on IATDs that assist with the defining areas of

Criterion	Inclusion	Exclusion	Rationale
	experience decline due to dementia: Complex attention, executive function, learning and memory, language, perceptual-motor, or social cognition (APA[1], 2013). Other outcomes related to cognitive faculties such as memory, communication, orientation, reasoning and decision-making (Ienca et al., 2017), and social and emotional faculties (Ienca et al., 2017)	mobility) (Ienca et al., 2017), or outcomes related to the functionality of the IATD.	impairment of dementia (APA[1], 2013)
DESIGN	Quantitative experimental, quantitative non-experimental, qualitative, mixed method design (McMillan & Schumacher, 2014)	Analytical designs (systematic reviews, scoping reviews, literature reviews).	A wide approach is employed to generate a breadth of coverage (Arksey & O'Malley, 2005).
RECORD TYPE	Primary/original research published as peer-reviewed journal articles, unpublished dissertations and theses, conference proceedings, conference abstracts available through the UP Library and databases.	Expert opinions, meta-analyses, systematic reviews, scoping reviews, books. Research sources not available through the UP Library and databases.	To construct an objective and comprehensive scope of primary studies.
TIME AND LANGUAGE	Published in English, publication dated 2010–2020.	Publications not available in English or published before 2010.	Reviewers' language preference and to ensure inclusion of recent literature and unpublished studies.

2.8 Selection of Records

The systematic search yielded a total of 9377 records, which were imported to Covidence systematic review software (Veritas Health Innovation, n.d.) in a research information systems (RIS) format. The software removed 3,523 duplicate records and progressed 5,854 records to title and screening level.

Two reviewers independently performed a screening protocol for each record by reading the title and abstract. Each reviewed the total number of records. Covidence software (Veritas Health Innovation, n.d.) enabled the reviewers to apply the inclusion and exclusion criteria to each record, and cast a “yes/include”, “maybe” or “no/exclude” vote. At this level, 5,295 records were deemed irrelevant for the review. Frequently occurring reasons for exclusion were as follows.

1. Population criteria: Non-human subjects were used for neurophysiological research, or human participants with a diagnosis other than dementia were used for assistive device research, for instance persons with mild cognitive impairment (MCI). MCI is a separate diagnosis for elderly persons with cognitive impairment that is not sufficiently severe to qualify as a dementia diagnosis, as daily functioning is commonly preserved (Petersen et al., 2001), and therefore excluded from population criteria.
2. Exposure criteria: Devices for neurophysiological or neuroimaging research, or IATDs utilised for the prevention, early identification, diagnosis, classification or cognitive training of PwD.
3. Outcome criteria: IATDs applied to PwD for outcomes not involving cognitive or communicative abilities, but rather to assess accuracy or technical efficacy of the devices.
4. Other criteria: Records were not the required source type (e.g. reviews, magazine articles), not in English, or published before 2010.

To conduct the screening conservatively, any records with disagreements between the reviewers were progressed to full-text screening. Thus, 559 records were progressed to full-text screening level. At this level, the software offered “include” or “exclude” vote options, as well as a reason why a record was excluded. The majority of records were excluded based on the following reasons. The IATD was still only in theoretical or conceptual phase (*n* = 125); the IATD was designed for PwD but experimentally applied to other participants such as researchers, students, healthy elderly persons or persons with MCI (*n* = 79); IATDs for PwD were investigated, but no participants were exposed to the IATD (*n* = 11). Many records (*n* = 34) that were excluded concerned IATDs that were digital, pre-programmed or operated remotely by teleoperation, but did not have intelligent, adaptable and context-aware functionality. A large number of records (*n* = 61) were also excluded because they were not available to the reviewers through the UP online library. Figure 1 visualises the PRISMA selection process.

Any disagreements in votes or reasons were labelled by the software as “conflicts”. Disagreements on reasons for exclusion were consolidated to provide a clearer view of the current state of research available. Disagreements about inclusion or exclusion of records were resolved by comparing rationales and establishing a consensus. Interrater agreement was calculated as a percentage of total vote agreements per record. All the included records were deemed appropriate for inclusion by the reviewers; this compiled the set of eligible original research records.

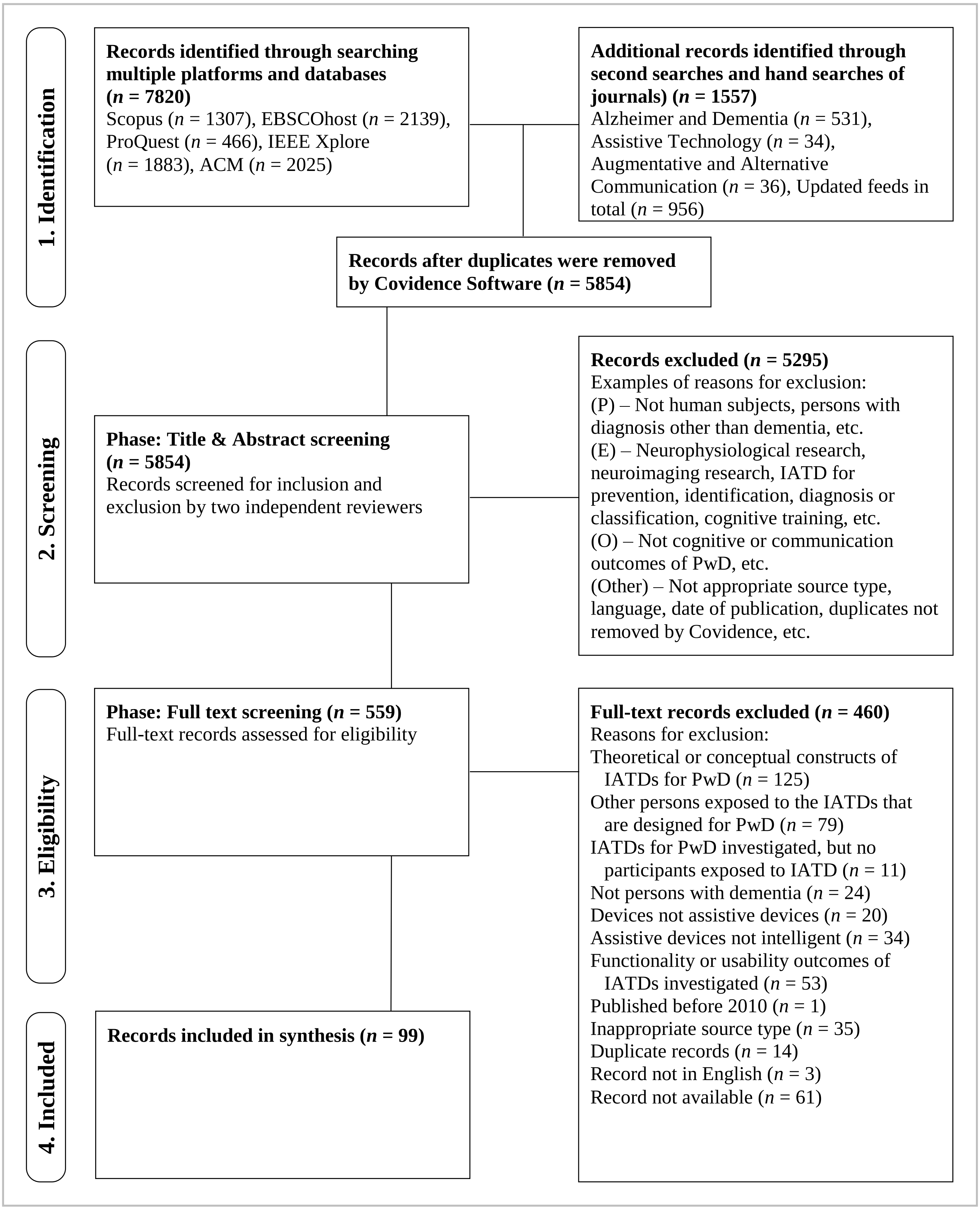


Figure 1. PRISMA flow diagram of selection process.

2.9 Materials and Equipment

The required equipment included a personal computer and internet access. Furthermore, access to the UP library database and Covidence systematic review software (Veritas Health Innovation, n.d.) was required. PROSPERO (International Prospective Register of Ongoing Systematic Reviews) database registration was considered as it decreases the likelihood of duplicate reviews. However, scoping reviews are not accepted for registration by PROSPERO (see Appendix B). Materials that were utilised include the predefined inclusion and exclusion criteria (Table 3) and the data extraction table and code book (Appendix D and Appendix E).

2.10 Data Extraction

2.10.1 Data collection

From the Covidence systematic review software, the eligible records were exported to Microsoft Excel as CSV (comma-separated values) format, from where the charting of records occurred. A code book, developed by the reviewers, accompanied the Microsoft Excel document to ensure clarity of concept definitions. One reviewer extracted the required data relating to the specific sub-aims from 100% of the records. An independent person scrutinised the extracted data from 40% of the records to ensure accuracy of the data. Appendix D provides the data extraction table and Appendix E is the accompanying code book.

2.10.2 Data analysis

Data extraction occurred by the categorisation and verbatim transcription of parameters (as outlined in Appendix D) from the included records. Transcribed data were sorted and charted according to key issues and themes based on the specific research sub-aims (Arksey & O'Malley, 2005). Categories and themes were then synthesised and interpreted.

A common analytical framework was applied to primary research records to collect standard information from each study (Arksey & O'Malley, 2005). The narrative style of the descriptive-analytical method of an evolving framework for qualitative themes is useful in scoping records (Colquhoun et al., 2014). The data were collated in a data charting form in

Microsoft Excel. Appendix F encompasses identifying information of all the eligible records used for data extraction. The complete body of data is available upon request.

2.10.3 Reliability

To address reliability and account for bias that might occur with a single rater or reviewer, two independent reviewers (the student researcher and the main supervisor) assessed the search results for eligibility for inclusion and evaluated data from the included records for categorical analysis at title, abstract and full-text level. Due to the variability among human raters, disagreements at title and abstract screening level, where the raters might have provided differing votes between “yes”, “maybe” and “no”, were advanced to full-text screening level to address the disagreements conservatively.

The percentage of agreement between raters, namely interrater agreement (IRA), was measured at full-text screening level (McHugh, 2012). The percentage of agreement between raters was calculated by dividing the number of votes agreed on (either “include” or “exclude” voted by both reviewers) by the total number of references to be voted on. Disagreements between raters were discussed until agreement to either include or exclude the references had been reached. The calculation of IRA was as follows:

$$IRA = \frac{(total\ records\ total\ at\ full\ text\ screening\ level - number\ of\ conflicts)}{total\ records\ at\ full\ text\ screening\ level} \times 100$$

$$IRA = \frac{(559 - 8)}{559} \times 100$$

$$IRA = 98{,}6\ \%$$

A strategy to enhance reliability of data extraction is verification by independent member checking (McMillan & Schumacher, 2014). A speech-language therapist with a Master’s degree in AAC scrutinised the data extracted from 40% of the records, as deemed appropriate for interobserver or interrater agreement data in AAC (Schlosser, 2003). The above also contributed to internal validity of the review by minimising subjective bias, as personal opinions and beliefs could not influence the outcomes. The level of evidence and validity of a review is also regarded higher than individual studies (Schlosser & Raghavendra, 2009) and the prescribed PRISMA-ScS items of reporting are followed for transparent reporting (Tricco et al., 2018).

3. Results and Discussion

After the screening process had been completed, the eligible records for data extraction (*n* = 99) remained. The aim of the review is to provide an overview of current available evidence of the IATDs (*n* = 105) in the records that address the cognitive and communicative capabilities of PwD. First of all, the types of record are discussed, followed by the population featured in the records. The results of the types of IATDs, as well as the primary operators and required skills to operate the IATDs, are explored. Next, the impaired abilities assisted by the IATDs and the subsequent outcomes are considered. Lastly, the benefits, limitations, recommendations and gaps in research as reported by the authors of the records are discussed.

3.1 Results of Records

As per sub-aim (1), in exploring the types of records, 47 (47.5%) were identified as journal articles and 51 (51.5%) as conference proceedings and a single record (*n* = 1, 1.0%) as a doctoral thesis. This distribution indicates that research involving IATDs for PwD occurs in the fields of medical or caregiving intervention as well as engineering. It also shows the value of combining the fields to yield a wide range of information. This review also aimed to identify the research design of the research regarding IATD for PwD. The majority of the research had a quantitative design: 66 (66.7%) had an experimental design and 7 (7.1%) a non-experimental design. Qualitative designs encompassed more (*n* = 20, 20.2%) and mixed method designs some (*n* = 6, 6.1%) of the records (McMillan & Schumacher, 2014).

3.2 Results of Population

To address sub-aim (2), the results indicated that 25% of the records involved participants with a mix of types of dementia diagnoses. Of this group of records, 23% also involved indistinct groups of participants with dementia as per the inclusion criteria, combined with participants with no cognitive impairment, with MCI or with types of dementia that do not fit the inclusion criteria. The majority of records (73%) did not specify with which type of dementia the involved participants had been diagnosed.

Furthermore, only 46% of the records reported on the severity of dementia of the involved PwD. Less than half of the records (*n* = 41, 41.4%) indicated whether the PwD specifically had mild, moderate or severe stage dementia. Persons with mild dementia were investigated more than those with moderate and severe stage dementia. Wider ranges of stages, such as mild to moderate or moderate to severe stage dementia, were reported by some (*n* = 29, 29.3%) of the records (Figure 2). Considering the large number of records originating from engineering and technology databases, one can assume that the type of dementia diagnosis and the stage of dementia that the PwD is diagnosed with are not important factors to investigate in these fields, as more than half of the records (*n* = 52, 52.5%) did not report on the severity.

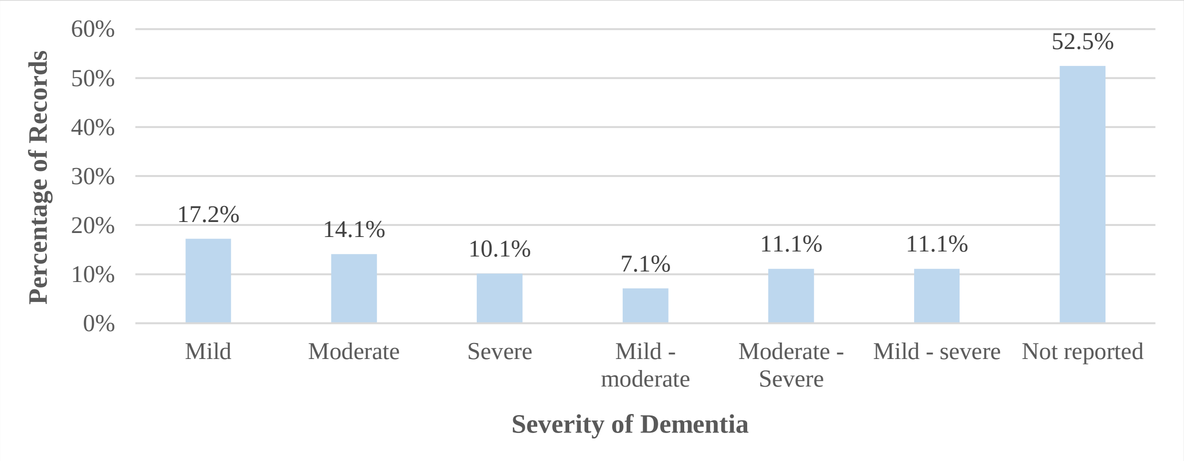


Figure 2. Severity of dementia as reported by the records.

3.3 Types, Operators of and Skills Required for the Use of IATDs

In sub-aims (3), (4) and (5), this review aimed to identify the types of IATDs, primary operators of the IATD, and the skills required to operate the IATDs in relation to the care of the PwD. These results can be found in Table 4. Various types of IATDs featured in the included records. More than half of the IATDs (*n* = 63, 60.0%) were social robots. The remainder of the IATDs were comprised of mobile devices and wearable sensors, smart homes, AR and other IATDS. The vast majority of IATDs were primarily operated by PwD (*n* = 94, 89.5%) and required operational competence (*n* = 103, 98.1%). More detailed results and examples are discussed in Table 4 and the following paragraphs.

Table 4

Types, Users and Skills Required for IATDs

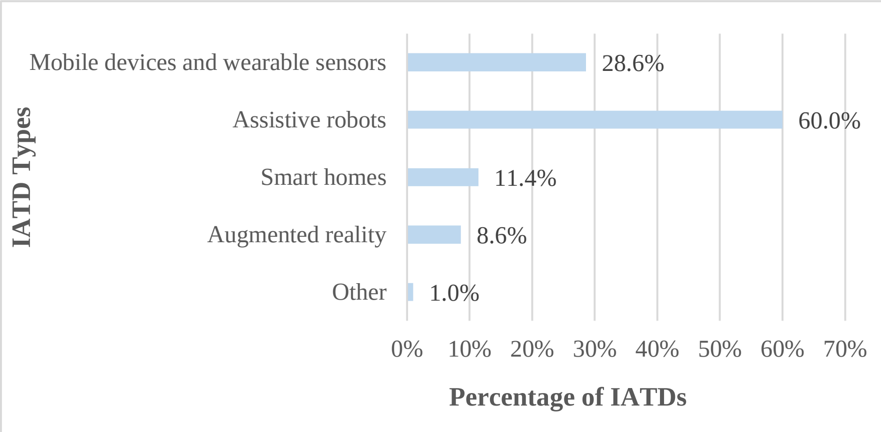
<table>
<tr><th>Figure</th><th>Result</th></tr>
<tr><td>


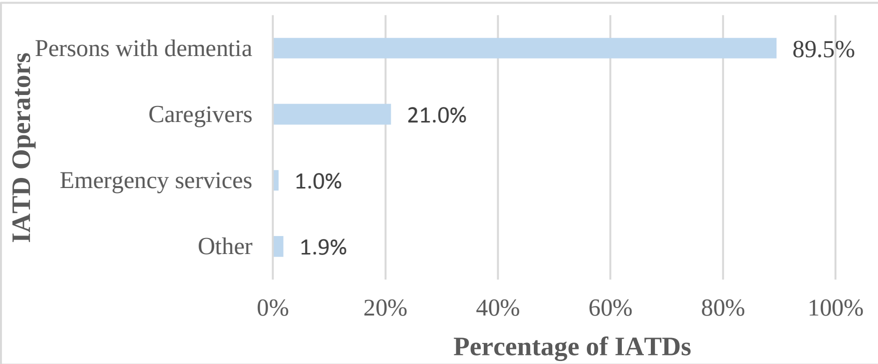
Figure 3. Types of IATDs.
</td><td>According to the results, the majority of IATDs investigated are classified as assistive robots (n = 63, 60.0%), followed by mobile devices and wearable sensors (n = 30, 28.6%), smart homes (n = 12, 11.4%), and AR (n = 9, 8.6%). Other uncategorised types of IATDs comprised the least devices (n = 1, 1.0%). Figure 3 demonstrates the distribution of types of IATDs featured in this review.</td></tr>
<tr><td>


Figure 4. Primary operators of the IATDs.
</td><td>The records reviewed involved IATDs that were mainly used by the PwD (n = 94, 89.5%). Examples of these include social robots, augmented interactions, memory applications and reminiscence devices. Fewer devices, such as physiological monitors and location trackers, were developed to be used primarily by caregivers (n = 22, 21.0%). Single records reported on IATDs that were used by emergency services (n = 1, 1.0%) or clinicians and healthcare workers (n = 2, 1.9%)</td></tr>
</table>

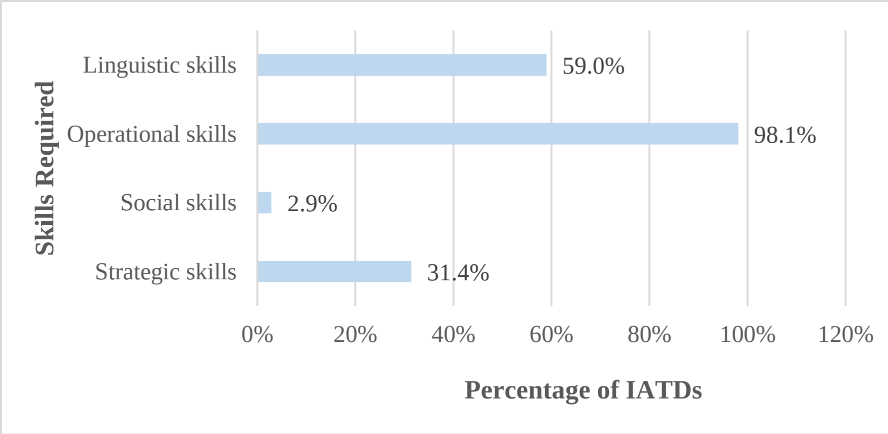
<table>
<tr><th>Figure</th><th>Result</th></tr>
<tr><td></td><td>via automated messages or by accessing a database to plan medical intervention. Figure 4 displays these numbers.</td></tr>
<tr><td>


Figure 5. Skills required by the operator of the IATDs.
</td><td>In terms of operational competence of the primary operator of the IATD, the majority of IATDs require operational skills (*n* = 103, 98.1%) from the users. Linguistic skills are also required by many IATDs (*n* = 62, 59.0%). Fewer devices require strategic (*n* = 33, 31.4%) and social skills (*n* = 3, 2.9%). Figure 5 visualises the results.</td></tr>
</table>

To explore the results of IATDs for PwD further (Figure 3 in Table 4), assistive robots addressing cognitive and communicative impairments frequently take the form of social or companion robots. The results indicate that almost half (*n* = 29, 46.0%) of the research involving social robots mainly focused on PARO the baby seal pup robot. This pet-like robot has been applied to address communication, empathy and emotional stability in PwD. It is able to nod, blink and produce sounds in reaction to the PwD's voice or touch (Koh & Kang, 2018). It is therefore fitting to use for addressing emotional and communication difficulties experienced by PwD. The remaining social robots (*n* = 34, 54.0%) are comprised of 12 other companion robots without speech functions (i.e. Guide, Pepper, Pleo, Bonoid) and 11 conversational robots with speech functions (i.e. Ryan, MARIO, Eva, NAO, Ludwig).

Mobile devices and other wearable sensors (*n* = 30, 28.6%) in this review can be classified under the following functions. Environmental monitoring devices and sensors (*n* = 9, 30.0%) have the functionality to monitor movement of the PwD or other persons in the immediate environment. Information from these devices and sensors can inform caregivers of situations, for instance where the PwD is walking around during the night or spending an unusually long time in the bathroom, indicating possible fall incidents of PwD. Physiological monitoring devices and sensors (*n* = 15, 50%) can inform caregivers of a PwD's health status concerning blood glucose levels, heart rate and hydration. This may assist caregivers in determining the health status of PwD who cannot communicate how they are feeling. Three (10%) of the wearable devices were specifically used for agitation detection to improve caregivers' ability to address the PwD's mood, such as the Detection of Agitation and Aggression (DAAD) system that collects patient information to identify agitation events (Khan et al., 2019).

Additionally, nine (30%) of the mobile devices functioned as memory applications and reminder systems as PwD struggle with impaired memory. Only one mobile device (3%) also assisted with reminiscence, which has been proven to be an effective psychosocial intervention to improve PwD's psychological states (Alarcão, 2017). PwD also struggle with wayfinding and often get lost. A portion of mobile devices and sensors assist PwD with navigation (*n* = 2, 6.7%) and caregivers with location tracking and wandering detection (*n* = 5, 16.7%). These devices have proved to increase the autonomy and safety of PwD and also relieve caregiver burden (Landau & Werner, 2012). Examples of such IATDs were examined by Thorpe, Forchhammer, and Maier (2019) as well as Wessel et al. (2019). A single mobile device (*n* = 1, 3.3%), namely the CoChat (Mooney, Bedrick, Noethe, Spaulding, & Fried-Oken, 2018b), provided language compensation. Another mobile device (*n* = 1, 3.3%), Ticket to Talk, provided conversation, prompting topics for young people and PwD (Welsh et al., 2018).

Smart homes comprised some (*n* = 12, 11.4%) of the IATDs for PwD, as in Figure 3. This term refers to houses with automated control over any electrical house components. In the context of care for PwD, a smart home can assist the resident with independent living for a longer period of time. Furthermore, smart homes can reduce the workload of the caregiver and ease the emotional burden on the family of the PwD, as well as enable communication between the resident and medical professionals, produce reports and allow direct monitoring (Bouchard, Bouchard, & Bouzouane, 2012). The NOCTURNAL system is an example of an interactive smart home system that identifies night-time waking events and provides music and lighting guidance for safety purposes (Martin et al., 2013).

Augmented and virtual reality technology refers to the enhancement or superimposition of computer-simulated elements or environments to the physical environment of the user (D'Cunha et al., 2019). These interactive components rely on computer-based decision-making and learning to adapt the virtual elements to the physical environment. In the context of PwD as users of this technology, it has been utilised for the provision of mental stimulation, reminiscence and positive leisure activities to increase QoL, social interactions and psychological well-being (D'Cunha et al., 2019). Eight of the records examined augmented or virtual reality in this review, utilised actions such as arm movements, walking or feeding animals to achieve the interactional and emotional outcomes described in the literature (Feng et al., 2019, Feng et al., 2018; Ludden, Van Rompay, Niedderer, & Tournier, 2019). The development of this technology is still advancing and has many interesting potential applications to the care of PwD. The small portion (*n* = 9, 8.6%) of IATDs employing this technology can be due to the technology still being in its infancy (D'Cunha et al., 2019). The one other uncategorised device is an adaptable music player for leisure.

To assist with communication impairments experienced by PwD, some IATDs have the functionality to send automated messages to emergency services or caregivers on behalf of the PwD. These are mostly for safety and emergency purposes (Alam, Samin, & Samin, 2018). Few (*n* = 7, 6.7%) of the IATDs in question have this function, although more (*n* = 33, 31.4%) of the IATDs assisted with expressive language in other ways, indicating the need of addressing expressive language difficulties.

Figure 4 in Table 4 also contains the results as related to sub-aim (3) of primary operators of the IATDs. Examples of IATDs that had multiple users include home monitoring systems, AR systems and a conversational prompting system (Welsh et al., 2018).

To be able to use these IATDs, the operators require certain skills. Light and McNaughton (2014) provide descriptions for the four types of competence required to operate assistive devices, namely linguistic, operational, social and strategic competence. As can be seen in Figure 5, a large portion of IATDs (*n* = 62, 59.0%) required a level of linguistic competence as knowledge, understanding and judgement of the language code is required to operate the devices. Some examples of IATDs in this review that required linguistic competence from the PwD include memory applications and reminder systems (Tokunaga et al., 2016), ADL guidance (Abdollahi, Mollahosseini, Lane, & Mahoor, 2017), and conversational social robots (Rudzicz, Raimondo, & Pou-Prom, 2017). The more complex IATDs require caregivers to understand user instructions, messages and results of, for instance, physiological monitors (Bankole et al., 2011) and to upload information (Bormans, Roe, & De Wachter, 2016).

Almost all (*n* = 103, 98.1%) of the IATDs reviewed required operational skills to be utilised. Companion social robots such as PARO react to touch or hand strokes (Bemelmans, Gelderblom, Jonker, & De Witte, 2015); guidance devices react to body movements (Kashimoto, Firouzian, Asghar, Yamamoto, & Pulli, 2016). Most of the other devices require the PwD or the caregiver to physically make selections or navigate the system (Tokunaga et al., 2016).

However, the low number of IATDs (*n* = 3, 2.9%) that require social competence skills can be explained by the small portion of devices that employ conversational interactions. Companion social robots react to repeated words and do not necessarily require pragmatic or discourse skills. The other devices that aim to improve health and safety aspects of the PwD, such as physiological monitors, ADL guidance and navigation devices, require input and provide output. However, they do not call for pragmatic or discourse skills, a variety of communicative functions or socio-relational skills to build relationships.

The number of IATDs (*n* = 33, 31.4%) that require strategic competence is higher than those requiring social skills. These coping strategies to bypass limitations would primarily be required from the caregiver when complications such as connectivity failures or errors occur with the devices. These skills would probably not be expected from a person with more advanced dementia when their IATDs malfunction or encounter problems.

3.4 Impaired Abilities of Dementia with which IATDs Assist

The results, related to sub-aim (6) (Figure 6), indicate that IATDs have been developed to predominantly assist cognitive domains of impairment. These domains are complex attention (*n* = 76, 72.4%) and emotion or affect (*n* = 77, 73.3%), such as the RAMCIP robotic assistance device that provides support for activities and recognising emotions (Antona et al., 2019). Fewer IATDs examined assisted with executive function (*n* = 37, 35.2%), learning and memory (*n* = 20, 19.0%) and perceptual-motor difficulties (*n* = 11, 10.5%).

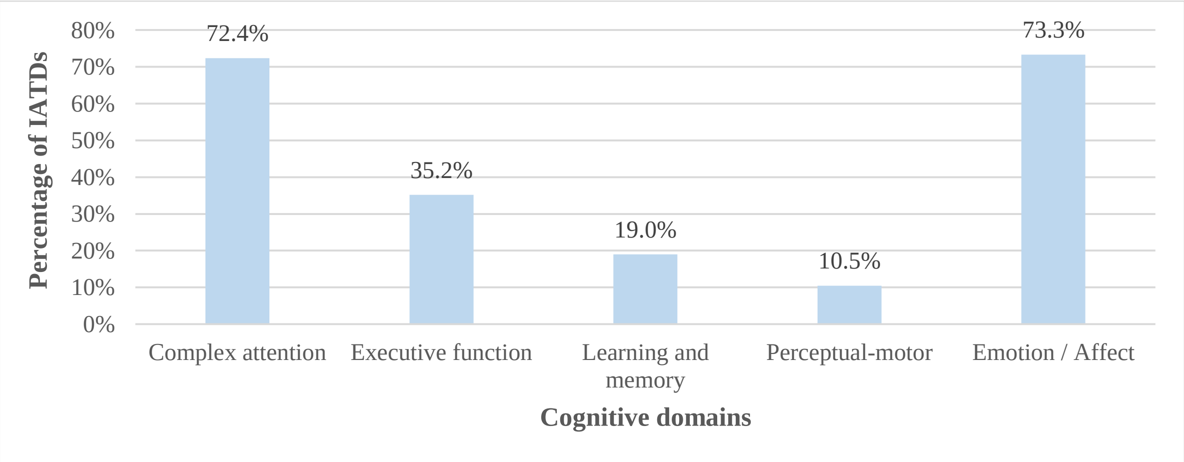


Figure 6. Cognitive domains of impairment assisted by IATDs.

IATDs that assist with communication difficulties were mentioned less than those that assist with cognitive difficulties due to dementia. Figure 7 illustrates the number of IATDs (*n* = 22, 21.0%) that assist with receptive language difficulties. More IATDs (*n* = 33, 31.4%) assist with expressive language difficulties. These language difficulties are mostly addressed by conversational social robots, such as Ryan Companionbot, which can interpret and react to the utterances and facial expressions of PwD (Abdollahi et al., 2017). The majority of the IATDs (*n* = 72, 68.6%) provided social-pragmatic skill assistance via companion social robots such as Pleo, CuDDler and PARO that prompt and reinforce turn-taking and eye contact (Hendrix, Feng, Van Otterdijk, & Barakova, 2019; Moyle et al., 2017, 2015). The distribution of communicative symptoms assisted with is visualised in Figure 7.

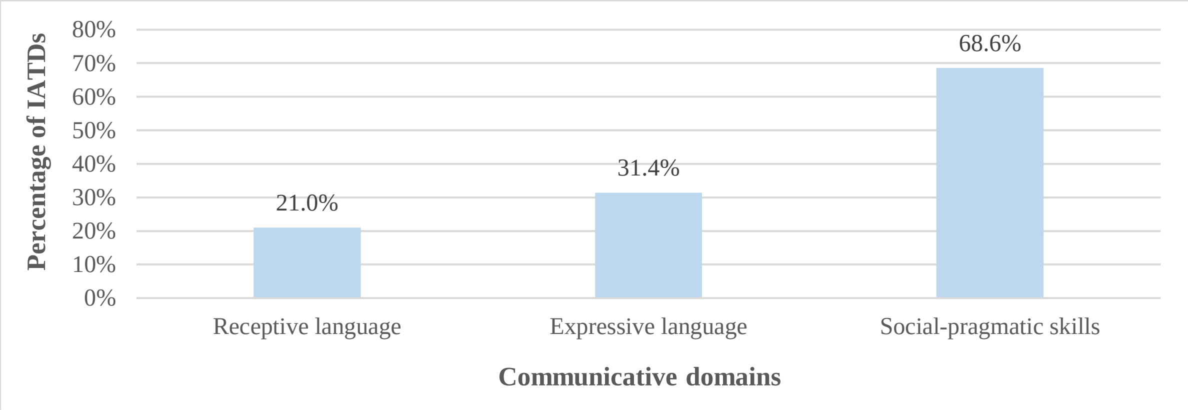


Figure 7. Communicative symptoms of dementia with which IATDs assist.

The ICF core set provides the expected areas of participation and activity in which PwD might face limitations (Scherer et al., 2012). All but one area (8 – Major life areas) are included in the core set of limitations typically experienced by PwD. This review investigated which areas of participation and activity were assisted by IATDs and the results corresponded with the core set, as no IATDs assisted in major life areas, as predicted by the ICF core set. Figure 8 summarises the areas addressed by the reviewed records. According to the results, some (n = 11, 10.5%) of the IATDs addressed the impairments of the first area of participation and activity, namely learning and applying knowledge. Examples such as focusing attention and solving problems were identified in the records. Less than half (n = 43, 41.0%) of the IATDs addressed the second area, namely general tasks and demands such as executing daily routines and multiple tasks.

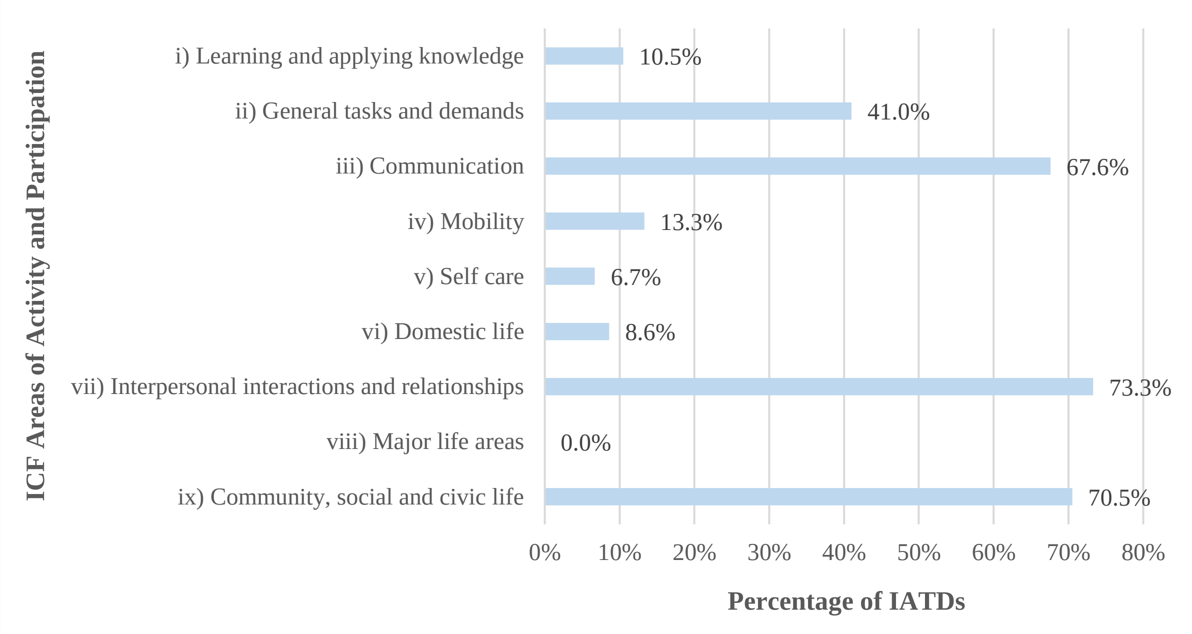


Figure 8. ICF participation and activity areas with which IATDs assist.

The third area, communication, also received more attention (*n* = 71, 67.6%) in research, according to the results of this review. A possible reason for this high percentage is that this area includes all forms of communication, such as receiving and producing verbal, nonverbal and written messages. The high number of examined social or companion robots might also explain this. In contrast to communication, the fourth, fifth and sixth areas did not receive as much attention in research according to the reviewed records. Physical impairment is not a characteristic symptom of dementia, and therefore the fourth area, mobility, was not addressed often (*n* = 14, 13.3%). Activities such as walking and moving to different locations were addressed by navigational and location tracking devices that assisted in the memory and orientation aspects of these activities. The fifth area, self-care, includes activities such as washing, grooming, eating and drinking. Only 6 (6.7%) IATDs addressed this area in the form of reminders or motivation to complete these activities. The sixth area involves activities of domestic life, such as food preparation and household tasks. Some (*n* = 9, 8.6%) IATDs addressed domestic life activities by providing guidance through social robots or smart home devices.

In correlation with the high percentage of the third area (communication), the seventh area (interpersonal interactions and relationships) also received a high percentage (*n* = 77, 73.3%) of attention from the research reviewed. Activities such as basic interpersonal interactions and participation in informal social relationships were addressed by various social and companion robots. The communication, conversation and interaction prompting devices (such as Ticket to Talk application and cARE system) were also aimed at promoting family and social relationships through communication (Welsh et al., 2018; Wolf, Besserer, Sejunaite, Riepe, & Rukzio, 2018).

The eighth area of activity and participation involves major life areas (i.e. education, employment and economic self-sufficiency). This area is not included in the ICF core set of limitations in activities and participation (Scherer et al., 2012). As expected, none of the records reviewed addressed this area, as this does not seem to be applicable to PwD due to their typically advanced age and the severity of dementia.

The ninth and final area of activity and participation involves community, social and civic life. Activities of community life, recreation and leisure are addressed by more than half (*n* = 74, 70.5%) of the records reviewed. In correlation with the high percentages of communication and interpersonal interactions and relationships, this high number might be due to the many social robots used to occupy leisure time with the PwD to address cognitive and communicative outcomes.

In addition to the ICF core set of impairments, Kenigsberg et al. (2019) classified assistive devices into three categories according to their assistance with functional impairments. These categories are: enabling and empowering; health and well-being; and safety and independence. Figure 9 demonstrates which functions provided by IATDs received the most attention in the reviewed articles. Enabling and empowering includes efforts such as supporting what the PwD can do for themselves to support ADLs, increase social connection and inclusion, support cognitive abilities such as memory, decision-making and reasoning, and enhance personal connections via digital and social media. It seems that the majority of IATDs (*n* = 86, 81.9%) aim to fulfil these functions.

Some IATDs (*n* = 35, 33.3%) address health and well-being functions, such as physiological and environmental monitors, reminder systems for medication and devices for improved affective states. Safety and independence received the least reports (*n* = 13, 12.4%), as can be seen in Figure 9. These IATDs aimed to detect wandering, location and falls. Therefore, the assumption can be made that research about PwD from the past decade has formed a trend that focused on IATDs that aim to improve QoL, due to the absence of a cure or successful treatment of dementia. Research efforts have rather investigated ways to enhance the PwD's autonomy and to compensate for the impairments experienced (Kenigsberg et al., 2019).

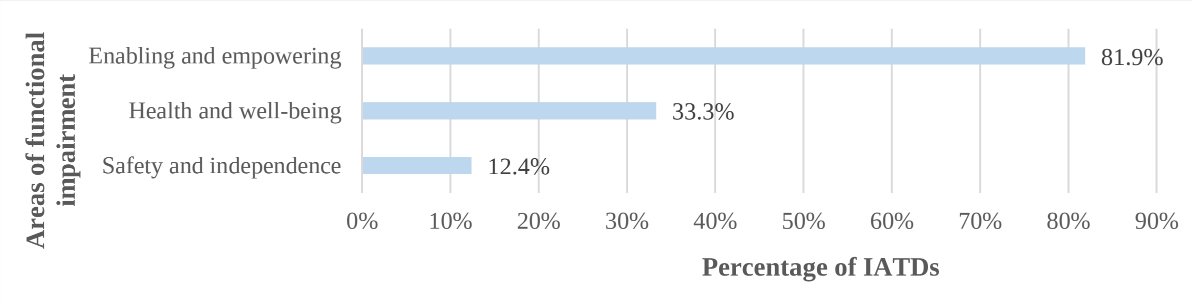


Figure 9. Areas of functional impairment with which IATDs assist.

3.5 Outcomes of IATDs for PwD

With further review of the included records, it is clear that the vast majority of authors reported positive outcomes from their research on IATDs (*n* = 92, 92.9%). The overall conclusion can be made that IATDs have positive outcomes on the cognitive and communicative impairments experienced by PwD. This speaks positively to the possibilities of using IATDs in dementia care in clinical use.

However, some authors also reported negative outcomes of their research (*n* = 14, 14.1%). From these, some mixed outcomes were reported. These included positive outcomes in terms of agitation, attention and comfort for the PwD with PARO but no positive impact on sleep patterns, or PARO causing nightmares after intervention sessions (Demange et al., 2018; Moyle et al., 2018). Some records also reported inconclusive outcomes in relation to some aims (*n* = 6, 6.1%) and some records did not report outcomes (*n* = 2, 2.0%). The results of the outcomes as reported by the authors can be found in Figure 10.

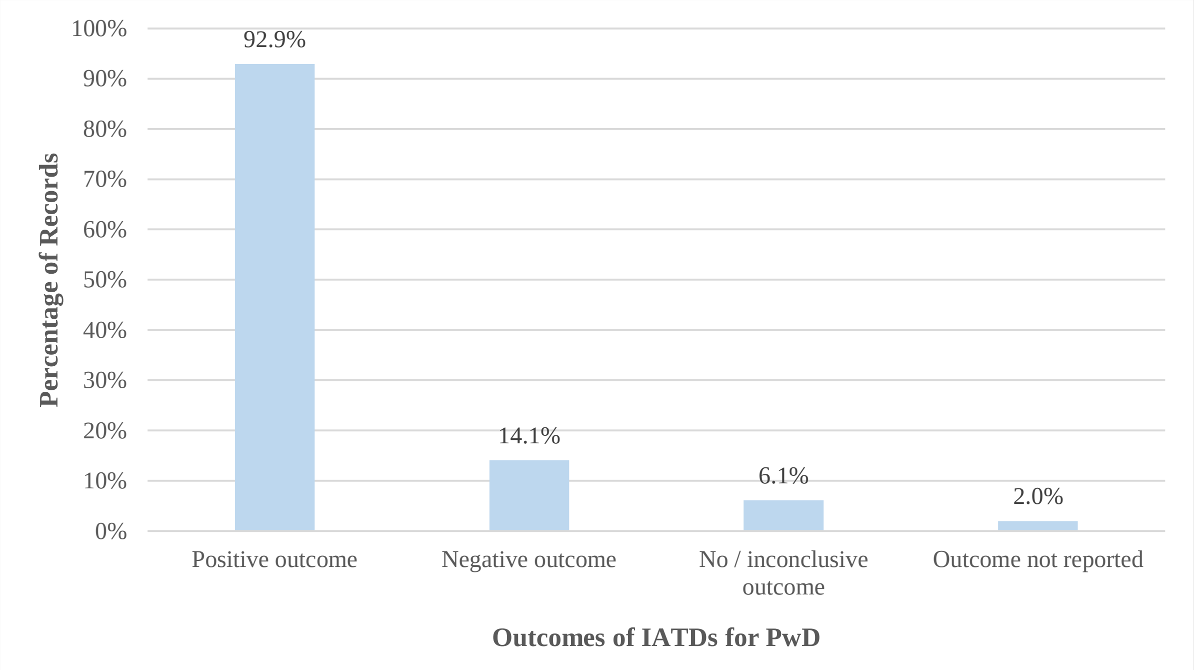


Figure 10. Outcomes of research regarding IATDs for PwD.

3.6 Availability for Purchase

This review further aimed to identify the availability for purchase of the IATDs to the public for the care of PwD in sub-aim (6). Figure 12 shows the percentages of availability according to the records reviewed.

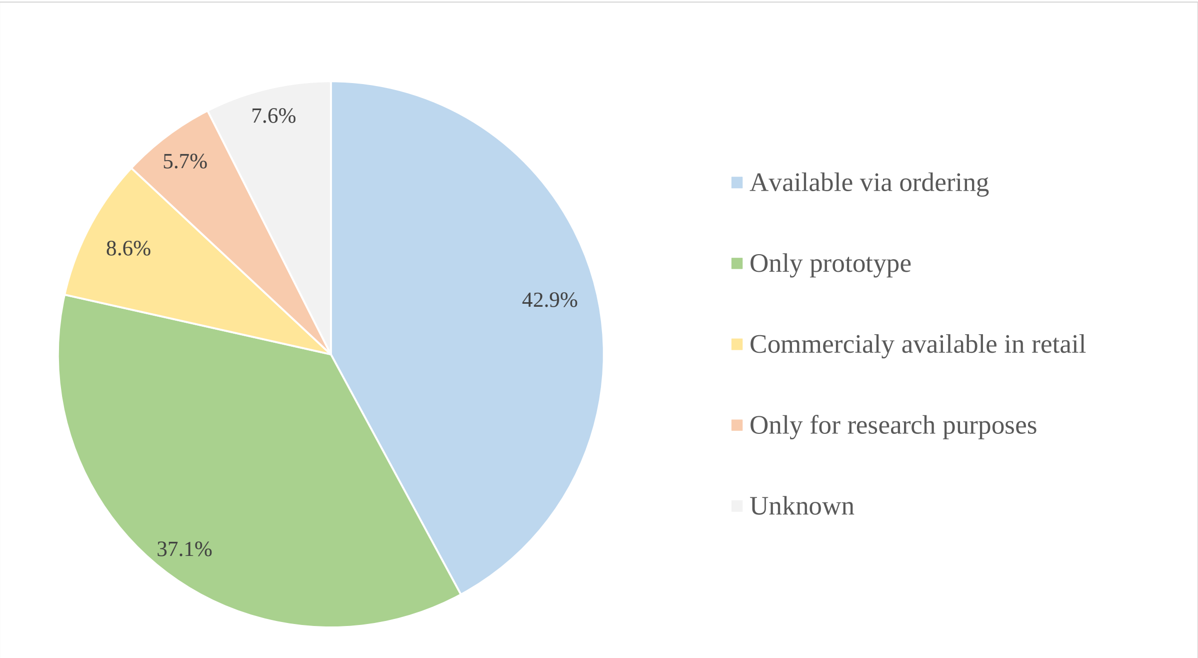


Figure 11. Availability for purchase of IATDs to the public.

The results indicate that a large portion of the IATDs (*n* = 39, 37.1%) took the form of prototypes that were still under development and not yet commercially available. Prototyping is necessary for researchers to develop, refine and assess human-computer interaction (HCI) concepts and systems (Odom et al., 2016). Although prototyping is a positive outcome of an expanding HCI research field, prototypes are only references or placeholders of future systems, services or products that are not yet available outside of the involved research settings (Odom et al., 2016).

The majority of the IATDs (*n* = 45, 42.9%) are available to the public through online ordering, as seen in Figure 11. These completed products can be attained via the respective manufacturers' websites. Many social robots were available for online ordering. The results, however, provide a skewed view of the availability of IATDs for PwD or their caregivers. The research field is dominated by research concerning PARO, the robotic seal pup. When the availability results of PARO (*n* = 29) are separated from the rest, significantly fewer records reported IATDs other than PARO (*n* = 16) are available through online ordering. Figure 12 visualises this disparity when extracted from Figure 11.

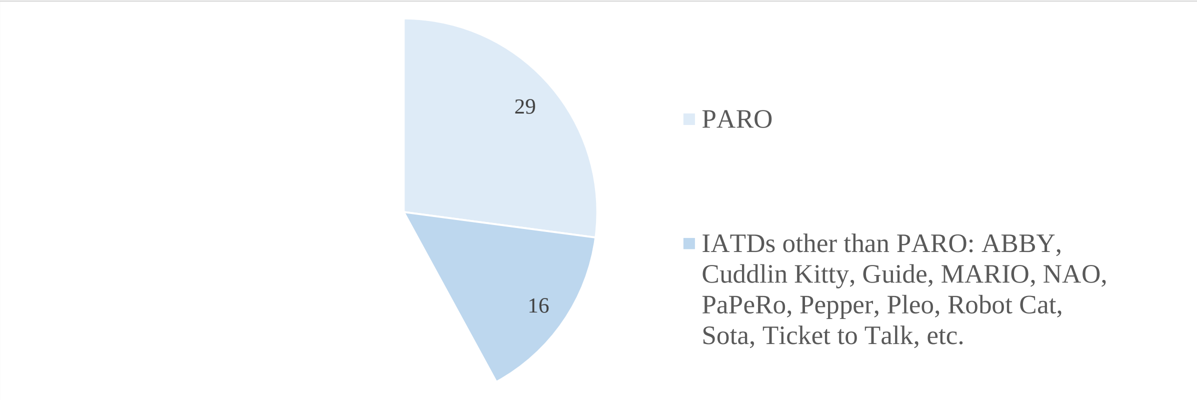


Figure 12. Availability for online ordering (*n* = 45) of IATDs to the public.

Furthermore, a total of 9 (8.6%) of the IATDs are commercially available in retail. However, the research involving these IATDs often combined various off-the-shelf devices or used specific software to achieve IATDs for PwD. The devices rarely functioned as IATDs in isolation. The remaining portion of IATDs examined in the collection of records were reported as only for research purposes (*n* = 6, 5.7%). Finally, the availability of some (*n* = 8, 7.6%) of the IATDs are unknown.

3.7 Qualitative Results as Reported by Authors

The last portion of this review aimed to qualitatively summarise the benefits, limitations, recommendations and gaps in the development of the IATDs and research concerning the IATDs as reported by the authors. This was in line with sub-aims (8), (9) and (10). The authors mainly identified the outcomes of their research as benefits and strengths of the IATDs. From the total number of records (*N* = 99), some (*n* = 38, 38.4%) concluded strengths of the IATDs as bringing improvements in affect of the PwD. Slightly fewer records concluded improved interaction (*n* = 31, 313%), and few improved communicative (*n* = 19, 19.2%) and cognitive functions (*n* = 18, 18.2%) such as autonomy as benefits of the IATDs. Some records (*n* = 12, 12.1%) indicated improved caregiving or decreased caregiver burden as benefits of the IATDs. Other records (*n* = 11, 11.1%) mentioned that the IATDs have the potential to be utilised clinically in care homes for PwD as a benefit. Single to few researchers concluded distinct benefits of the IATDs as being individualised for the PwD (*n* = 5, 5.1%). Some records reported the IATD as being affordable (*n* = 3, 30.0%), accurate (*n* = 1, 1.0%), multimodal (*n* = 1, 1.0%) or available at no cost as an open source application (*n* = 1, 1.0%). Single records reported features as benefits of the IATDs, namely having a touch screen (*n* = 1, 1.0%), having good text-to-speech functionality (*n* = 1, 1.0%) or having a remote control (*n* = 1, 1.0%).

When exploring the limitations of the IATDs, many authors (*n* = 57, 57.6%) did not include limitations of the IATDs in their conclusions. A wide variety of limitations were mentioned in the conclusions of the rest of the records. IATD hardware limitations reported included examples such as physical look and design (*n* = 7, 7.1%), physical size and weight (*n* = 3, 3.0%), technical failures (*n* = 5, 5.1%), internet connection requirement (*n* = 1, 1.0%), incompatibility with other devices (*n* = 1, 1.0%), other equipment (speakers) requirements (*n* = 1, 1.0%), connection difficulties when outdoors (*n* = 1, 1.0%), environment poses obstacles (*n* = 1, 1.0%), sound (*n* = 1, 1.0%) and material limitations (*n* = 1, 1.0%).

Software limitations included devices having limited functions (*n* = 4, 4.0%), algorithm performance issues (*n* = 2, 2.0%), immature development (*n* = 2, 2.0%), devices not being able to make inference (*n* = 1, 1.0%) or confirm data (*n* = 1, 1.0%), poor accuracy (*n* = 2, 2.0%) and poor reliability (*n* = 1, 1.0%). When considering that devices were required to communicate with or receive verbal messages from PwD, few records (*n* = 2, 2.0%) reported limitations of the speech generation technology and some (*n* = 6, 6.1%) limitations of the speech processing technology of the IATDs.

Practical limitations concerning the implementation of the IATDs as reported by the authors involved increased workload for caregivers (*n* = 5, 5.1%) in terms of effort, time, hygiene, storage and charging batteries. Other limitations in terms of consequences of IATDs mentioned were negative outcomes (*n* = 1, 1.0%), poor generalisation (*n* = 1, 1.0%), poor acceptance of the IATD (*n* = 1, 1.0%), poor comprehension of operating instructions (*n* = 3, 3.0%), fatigue of the PwD after using the IATD (*n* = 1, 1.0%) and negative reactions such as sadness and frustration (*n* = 2, 2.0%).

Other noteworthy limitations as reported by the authors include the high costs of the IATDs and their maintenance (*n* = 5, 5.1%), as well as ethical concerns such as the collection and sharing of information of the PwD and indistinct boundaries caused by IATDs between reality and AR (*n* = 5, 5.1%).

This review also aimed to describe the reported recommendations made by the authors in relation to IATDs for PwD. The authors of the eligible records made recommendations in the areas of development, research and implementation. Most of the records (*n* = 53, 53.5%) concluded with recommendations about further research that should be performed. Topics that were addressed in the recommendations include researching the effects, benefits and effectiveness of IATDs with PwD of diverse backgrounds in larger groups and for longer timeframes. It was also suggested to look into the QoL of PwD and user group patterns with the IATDs. Testing after fine tuning, and investigating verification, validity and cost-effectiveness of the IATDs were also mentioned.

The authors also concluded some records (*n* = 32, 32.3%) with recommendations for further development of the IATDs. Recommendations for physical changes included size, weight, robustness, visual display and updated parts. Added features such as emergency buttons, increased autonomy, improved facial recognition, emotional display, extralinguistic interaction and personalisation were mentioned. Improved algorithm functionalities such as flexible behaviour, context recognition, adjustment, planning and timeous feedback were also recommended. In terms of design, it was recommended that IATDs should be designed with the end-users, namely PwD, in mind as well as the environment it has to function in, and that improvements should be based on user evaluation feedback.

Lastly, some (*n* = 3, 3.0%) authors recommended workshops, cooperation and knowledge sharing between academia and the AT industry. Few (*n* = 2, 2.0%) records recommended that the IATDs in question would be clinically useful tools and that IATD architecture should be integrated in group homes for PwD.

Only some (*n* = 4, 4.0%) of the records explicitly discussed gaps in their conclusions of investigating IATDs for PwD. The limited availability of data concerning synthesised or generated speech by ATs was identified as a gap, as well as research about the development and use of social robots. One record implied that literature evidence on the effects of PARO is scarce, although this review found many records on PARO and its effects on PwD. Furthermore, this record reports that the goals and rationales behind the procedure of exposing PwD to PARO are lacking. Overall, HCI and the user experience of such innovative technologies still lack evidence, especially in the field of AT for PwD. Hopefully, this review contributes to an overall view of IATDs for PwD and eliminating gaps in the field.

3.8 Discussion

This review aimed to synthesise current research evidence of available IATDs applied to the impaired cognitive and communicative functions of PwD, and to identify trends and gaps in the evidence. To address sub-aim (11), the first trend was identified by the high number of records that were excluded at full-text level. The trend revealed that the field of IATDs for PwD is heavily dominated by research that has not evaluated the devices developed for PwD with PwD. Furthermore, the research has not assessed the cognitive and communicative outcomes of PwD following implementation of an IATD. This indicates a need to include PwD as research participants of IATDs studies and to involve PwD in assessing the social validity of the cognitive and communicative outcomes of these interventions, as aligned with evidence-based practice (Schlosser & Raghavendra, 2003). It should also be mentioned that the type of dementia diagnosis and severity of impairment of the PwD is often not specified in the research records. A reason for this could be that computer science and engineering fields do not deem it as important as health and non-pharmacological intervention fields that address cognitive and behavioural difficulties, such as activity and communication impairments (Livingston et al., 2017).

This correlates with recommendations of authors that suggested that research should aim to examine IATD interaction of different user groups to determine patterns of outcomes in relation to severity of impairment (Hebesberger, Dondrup, Gisinger, & Hanheide, 2017; Heerink et al., 2013).

The records eligible for inclusion demonstrated that a large proportion of evidence in the field is concerned with social robots for PwD, and that PARO is especially popular with researchers, which also forms a definite trend. Due to the high number of records examining social robots, the symptoms of attention, affect and social-pragmatic skills are especially highlighted, as participation in interactions and social activities such as leisure feature frequently. The positive outcomes of physiological and environmental monitoring also feature, although not as much as the outcomes of social robots. The review also shows how little attention is given to research pure intelligent communication devices for PwD, even though communication difficulties form a substantial part of the symptoms experienced by PwD.

Another aspect this review aimed to report on is the availability of IATDs for PwD or their caregivers. It seems that IATDs are not easily accessible to the public, as many are only prototypes under research, and those available for ordering are very costly. Although authors reported many limitations of IATDs due to the early phase of development, this field seems to be filled with potential for future IATDs for PwD.

4. Critical Evaluation, Implications and Conclusions

4.1 Critical Evaluation of the Study

The strengths of this review lie in the broad scope of sources used to collect eligible records. Electronic platforms, databases and journals from computer engineering as well as medical research fields were included. Different types of sources, namely journal articles, conference proceedings and dissertations and theses were incorporated, although only one thesis passed the inclusion criteria.

The aim of this review was to investigate the scope of IATDs for PwD broadly. This review did not critically evaluate the quality of research findings of the eligible records, as this is not a function of a scoping review. This may, however, implicate that records of lesser quality are viewed equally to records of high quality.

Furthermore, this review regarded IATDs as ATs with intelligent, adaptive functionalities. The aim was not to provide a scientific definition of what intelligent technology, or AI, is or the technicalities of how these new developments are applied to ATs for PwD.

Limitations of this review include the possibility of reviewer bias, although reviewers were blinded to each other's inclusion or exclusion votes. Unfortunately, not all records yielded by the systematic searches could be accessed to be evaluated for inclusion in the review, and linguistic bias occurred with the exclusion of records that were not published in English.

4.2 Clinical Implications

Involving PwD in decision-making regarding advance care planning, as well as considering the PwD's aspirations, values and beliefs to support their expression of agency is valuable (Boyle, 2014). Therefore, this scoping review can inform PwD about the current developments of IATDs that might assist with the cognitive and communicative difficulties they experience. Furthermore, translating research evidence into practice requires dissemination of information, policy considerations and workforce training (Gitlin, Marx, Stanley, & Hodgson, 2015). The outcomes of this scoping review can thus inform clinicians or caregivers of PwD exploring IATD procurement, and might be used in policy or training development. Information about the IATDs mentioned in this review available for purchase or ordering is made available in Appendix G to assist informed decision-making.

4.3 Recommendations for Further Studies

It is highly recommended that future research regarding cognitive and communicative IATDs, or AAC devices, for PwD places focus on developing technology where PwD are involved as collaborators. Future research should also include participants with dementia who are physically exposed to the IATDs, and the subsequent cognitive and communicative outcomes should be evaluated to contribute to evidence-based decision-making and practice (Schlosser & Raghavendra, 2009). Populations should be specified in terms of dementia diagnosis and severity to identify outcome patterns.

Research concerning social robots other than PARO, other types of IATDs and IATDs with other functions, especially communication, will also benefit the field of communication intervention for PwD greatly. Evidence-based decision-making regarding AAC technology will further benefit from research investigating NLP and its applications for different areas of communicative impairment.

Lastly, collaboration between computer engineering and health practitioners is recommended. The collated evidence for clinical application and advancement from prototypical stages to commercial availability will be beneficial.

4.4 Conclusion

PwD experience various impairments, especially those affecting cognitive and communicative faculties. Technological advances such as adaptable, context-aware and artificially intelligent computing has opened many possibilities for non-pharmacological treatment of the impairments experienced by PwD. However, numerous research efforts concerning this topic have not yet investigated the effects of the technology when used by PwD. This scoping review aimed to synthesise research evidence about this matter from the last decade. Trends identified include the bulk of research focusing on social robots to address interaction, leisure and social-pragmatic communication skills of the PwD, especially featuring the PARO seal pup robot. The majority of the IATDs were designed to be operated by the PwD themselves to enable and empower them. Furthermore, research results prove overwhelmingly positive outcomes, especially in the areas of complex attention, affect and social interaction.

Current gaps in the research, as reported by the included records of this review, involve unspecified population groups, making patterning of outcomes attributable to exposure to the IATDs difficult. Furthermore, prototypes featuring in the research have not yet progressed to commercially available products, limiting the potential for clinical use. IATDs for AAC purposes and outcomes also require further development and research, as communication difficulties are prevalent in PwD.

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Section 5: References

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Appendix A

Appendix A

Letter of Ethical Approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Humanities 100.
1919 - 2019
Research Ethics Committee

4 October 2019

Dear Miss C Hyman

Project Title:	Intelligent assistive technology devices for persons with dementia: A scoping review
Researcher:	Miss C Hyman
Supervisor:	Prof S Dada
Department:	CAAC
Reference number:	26131481 (HUM026/0919)
Degree:	Masters

Thank you for the application that was submitted for ethical consideration.

The Research Ethics Committee notes that this is a literature-based study and no human subjects are involved.
The application has been **approved** on 3 October 2019 with the assumption that the document(s) are in the public domain. Data collection may therefore commence, along these guidelines.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. However, should the actual research depart significantly from the proposed research, a new research proposal and application for ethical clearance will have to be submitted for approval.

We wish you success with the project.

Sincerely

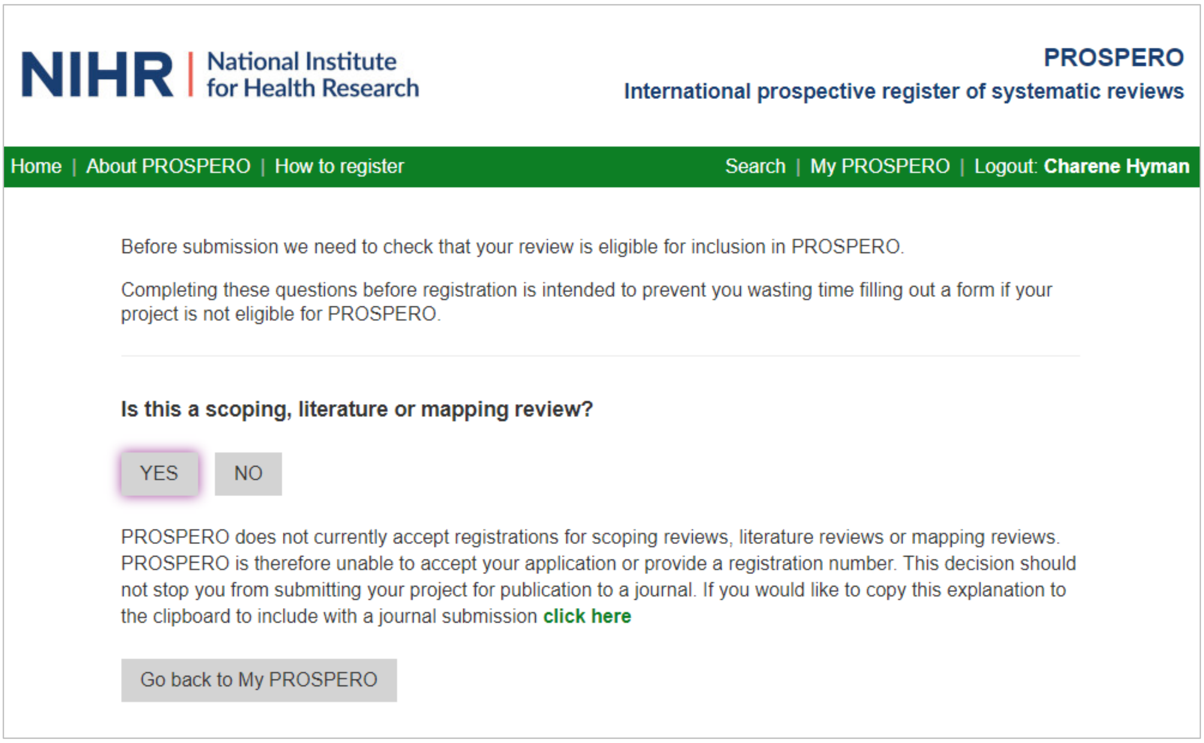
Prof Maxi Schoeman
Deputy Dean: Postgraduate Studies and Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail:PGHumanities@up.ac.za

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Appendix B

Appendix B

Prospero Registration Page



Screenshot from http://crd.york.ac.uk/prospero/#registernew on November 18, 2019 at 19:33

Appendix C

Appendix C

Appendix Search strategies and yields

Electronic platform, database, or journal	Search strategy	Initial yield	Second yields *(Total)
Scopus	(ABS ("dementia" OR "Alzheimer*" OR "cog* degenerat*" OR "progress* cog* decline" OR "neurocog* dis*") AND ABS ("assist* tech*" OR "assist* dev*" OR "assist* app*" OR "artific* intelligen*" OR "heurist*" OR "robot*" OR "natural language process*" OR "NLP" OR "info* communicat*" OR "cog* tech*")) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))	630	*21
	(ABS ("dementia" OR "Alzheimer*" OR "cog* degenerat*" OR "progress* cog* decline" OR "neurocog* dis*") AND ABS ("augment*" OR "augment* communicat*" OR "augmentative and alternative communication" OR "AAC" OR "neuro* rehab*" OR "rehab* engin*" OR "communicat* aid" OR "assis* engin*")) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))	677	
EBSCOhost (Academic Search Complete, CINAHL, E-Journals, ERIC, Family & Society Studies Worldwide, Health Source: Nursing/Academic Edition, MEDLINE, PsycARTICLES, PsycINFO)	AB (“dementia” OR “Alzheimer*” OR “cog* degenerat*” OR “progress* cog* decline” OR “neurocog* dis*”) AND AB (“dementia” OR “Alzheimer*” OR “cog* degenerat*” OR “progress* cog* decline” OR “neurocog* dis*”) Limiters: Published Date: 20100101-20201231 Source Types: Academic Journals, Dissertations	2,139	*350

Appendix C

Electronic platform, database, or journal	Search strategy	Initial yield	Second yields *(Total)
ProQuest (Humanities Index, ProQuest Dissertations & Theses Global information, Science Database, Advanced Technologies & Aerospace Collection, ERIC, Linguistics and Language Behavior Abstracts [LLBA], Linguistics Database, Social Science Database)	ab(“dementia” OR “Alzheimer*” OR “cog* degenerat*” OR “progress* cog* decline” OR “neurocog* dis*”) AND ab(“assist* tech*” OR “assist* dev*” OR “assist* app*” OR “artific* intelligen*” OR “heurist*” OR “robot*” OR “natural language process*” OR “NLP” OR “info* communicat*” OR “cog* tech*” OR “augment*” OR “augment* communicat*” OR “augmentative and alternative communication” OR “AAC” OR “neuro* rehab*” OR “rehab* engin*” OR “communicat* aid” OR “assis* engin*”) Scholarly Journals OR Dissertations & Theses OR Conference Papers & Proceedings 2010 - 2019	466	*506
IEEE Xplore DL	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results: "Abstract":“assist* tech*” OR “assist* dev*” In results: Journals, Conferences, 2010-2019	221	*48
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“assist* app*” OR “artific* intelligen*” In results: Journals, Conferences, 2010-2019	484	
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“heurist*” OR “robot*” In results: Journals, Conferences, 2010-2019	132	
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“natural language process*” OR “NLP” OR “info* communicat*” OR “cog* tech*” In results: Journals, Conferences, 2010-2019	653	
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“augment*” OR “augment* communicat*” OR “augmentative and alternative communication” OR “AAC” In results: Journals, Conferences, 2010-2019	25	
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“neuro* rehab*” OR “rehab* engin*” In results: Journals, Conferences, 2010-2019	49	

Appendix C

Electronic platform, database, or journal	Search strategy	Initial yield	Second yields *(Total)
	"Abstract":“dementia” OR “Alzheimer*” OR “cog* degenerat*” In results:"Abstract":“communicat* aid” OR “assis* engin*” In results: Journals, Conferences, 2010-2019	228	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” "Abstract":“assist* tech*” OR “assist* dev*” In results: Journals, Conferences, 2010-2019	7	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“assist* app*” OR “artific* intelligen*” In results: Journals, Conferences, 2010-2019	15	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“heurist*” OR “robot*” In results: Journals, Conferences, 2010-2019	7	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“natural language process*” OR “NLP” OR “info* communicat*” OR “cog* tech*” In results: Journals, Conferences, 2010-2019	44	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“augment*” OR “augment* communicat*” OR “augmentative and alternative communication” OR “AAC” In results: Journals, Conferences, 2010-2019	1	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“neuro* rehab*” OR “rehab* engin*” In results: Journals, Conferences, 2010-2019	10	
	"Abstract":“progress* cog* decline” OR “neurocog* dis*” In results:"Abstract":“communicat* aid” OR “assis* engin*” In results: Journals, Conferences, 2010-2019	7	

Appendix C

Electronic platform, database, or journal	Search strategy	Initial yield	Second yields *(Total)
ACM Digital Library	Searched for keywords.author.keyword:(“dementia” OR “Alzheimer*” OR “cog* degenerat*” OR “progress* cog* decline” OR “neurocog* dis*”;) AND recordAbstract:(“assist* tech*” OR “assist* dev*” OR “assist* app*” OR “artific* intelligen*” OR “heurist*” OR “robot*” OR “natural language process*” OR “NLP” OR “info* communicat*” OR “cog* tech*” OR “augment*” OR “augment* communicat*” OR “augmentative and alternative communication” OR “AAC” OR “neuro* rehab*” OR “rehab* engin*” OR “communicat* aid” OR “assis* engin*”;)	2,025	*44
Alzheimer's & Dementia: The Journal of the Alzheimer's Association	"assistive technology" OR "AT" OR "assistive device" OR "assistive application" Limiters: Article type: Research articles, Conference abstracts Year: 2010-2020	40	NA
	"artificial" OR "intelligent" OR "heuristic" OR "natural language processing" OR "NLP" OR "information communication" Limiters: Article type: Research articles, Conference abstracts Year: 2010-2020	236	
	"augment" OR "augmentative communication" OR "augmentative and alternative communication" OR "AAC" OR "communication aid" Limiters: Article type: Research articles, Conference abstracts Year: 2010-2020	220	
	"robot" OR "neurological rehabilitation" OR "rehabilitation engineering" OR "cognitive technology" OR "assistive engineering" Limiters: Article type: Research articles, Conference abstracts Year: 2010-2020	35	
Assistive Technology	"dementia" OR "Alzheimer's disease" OR "Alzheimer's disorder" OR "cognitive degeneration" OR "progressive cognitive decline" OR "neurocognitive disorder" [All: "dementia"] OR [All: "alzheimer's disease"] OR [All: "alzheimer's disorder"] OR [All: "cognitive degeneration"] OR [All: "progressive cognitive decline"] OR [All: "neurocognitive disorder"] AND [in Journal: Assistive Technology] AND [Publication Date: (01/01/2010 TO 12/31/2019)]	34	NA

Appendix C

Electronic platform, database, or journal	Search strategy	Initial yield	Second yields *(Total)
Augmentative and Alternative Communication	Keywords: (“dementia” OR “Alzheimer’s disease” OR “Alzheimer’s disorder” OR “cognitive degeneration” OR “progressive cognitive decline” OR “neurocognitive disorder”) AND (“assistive technology” OR “assistive device” OR “assistive application” OR “artificial” OR “intelligent” OR “heuristic” OR “natural language processing” OR “NLP” OR “information communication” OR “augment” OR “augmentative communication” OR “augmentative and alternative communication” OR “AAC” OR “communication aid” OR “robot” OR “neurological rehabilitation” OR “rehabilitation engineering” OR “cognitive technology” OR “assistive engineering”) Limiters: 2010-2020	36	NA

Appendix D

Appendix D

Data Extraction Table

1. Number
2. Identifying information of record:
   - 2.1. Title
   - 2.2. Author(s)
   - 2.3. Year
   - 2.4. Source
   - 2.5. Source type (journal article, dissertation/thesis, conference proceeding)
3. Research design (quantitative: experimental, quantitative: non-experimental, qualitative, mixed method, analytical)
4. Reference
5. Participants:
   - 5.1. Age (range, average)
   - 5.2. Sex (male, female)
   - 5.3. Severity (mild, moderate, severity)
   - 5.4. Diagnosis
   - 5.5. Number
6. Information re. IATD:
   - 6.1. Name
   - 6.2. Type (mobile devices and wearable sensors, assistive robots, smart homes, augmented reality, other)
   - 6.3. Main functionality of IATD
   - 6.4. Symptoms of dementia IATD assists
     - 6.4.1. Cognitive symptoms: executive function, learning and memory, perceptual-motor, emotion
     - 6.4.2. Communication symptoms: receptive language, expressive language, social-pragmatic skills
   - 6.5. Automated communication
   - 6.6. Areas of ICF Participation & Activity assisted with (learning and applying knowledge, general tasks and demands, communication, mobility, self-care, domestic life, interpersonal interactions and relationships, major life areas, community, social, and civic life)
   - 6.7. Areas of functional impairment assisted (enabling and empowering, health and well-being, safety and independence)
   - 6.8. Primary operator(s) of the IATDs (PwD, caregiver of PwD, emergency services, other)

6.9. Skills required for the IATD (linguistic competence, operational competence, social competence, strategic competence)

7. Outcomes of IATDs (positive outcome, negative outcome, no outcome / inconclusive, not reported)

8. Availability for purchase (commercially available in retail, available for online ordering, only prototype, only for research purposes, not available for purchase, unknown)

9. Benefits of IATDs as reported

10. Limitations of IATDs as reported

11. Recommendations for development as reported

12. Gaps in development and research as reported

Appendix E

Appendix E

Data Extraction Code Book

Item No.	Data to extract	Instruction for extracting data and applying code
1	Number	Assigned by researcher
2	Title	Copy from article
3	Author(s)	Copy from article
4	Year	Copy from article
5	Journal/Publication	Copy from article
6	Source type	(Select single option)
	Journal article	Indicate [1] if applicable
	Dissertation/Thesis	Indicate [1] if applicable
	Conference proceeding	Indicate [1] if applicable
7	Research design	(Select single option)
	Quantitative: Experimental (True experimental, Quasi-experimental, single-subject)	Indicate [1] if applicable
	Quantitative: Non-experimental (Descriptive, Comparative, Correlational, Survey, Ex post facto, Secondary data analysis)	Indicate [1] if applicable
	Qualitative (Ethnographic, Phenomenological, Case study, Grounded theory, Critical studies)	Indicate [1] if applicable
	Mixed Method (Explanatory, Exploratory, Triangulation)	Indicate [1] if applicable
	Analytical (Policy analysis, Concept analysis, Historical analysis)	Indicate [1] if applicable
8	Reference	Insert reference with referencing software
9	Participants	
	i. Age	
	Range	Describe from article
	Average	Describe from article
	Not reported	Indicate [1] if applicable
	ii. Sex	
	Male	Indicate [1] if applicable
	Male: number	Describe from article
	Female	Indicate [1] if applicable
	Female: number	Describe from article
	Not reported	Indicate [1] if applicable
	Not reported: number	Describe from article
	iii. Severity	
	Mild	Indicate [1] if applicable
	Mild: number	Describe from article
	Moderate	Indicate [1] if applicable

Appendix E

Item No.		Data to extract	Instruction for extracting data and applying code
		Moderate: number	Describe from article
		Severe	Indicate [1] if applicable
		Severe: number	Describe from article
		Mild – moderate	Indicate [1] if applicable
		Mild – moderate: number	Describe from article
		Moderate – severe	Indicate [1] if applicable
		Moderate – severe: number	Describe from article
		Mild – severe	Indicate [1] if applicable
		Mild – severe: number	Describe from article
		Not reported	Indicate [1] if applicable
		Not reported - number	Describe from article
	iv.	Diagnosis	
		Normal/no cognitive impairment	Indicate [1] if applicable
		Normal/no cognitive impairment: number	Describe from article
		Mild Cognitive Impairment (MCI)	Indicate [1] if applicable
		Mild Cognitive Impairment (MCI) : number	Describe from article
		Dementia - not specified	Indicate [1] if applicable
		Dementia - not specified: number	Describe from article
		Alzheimer’s disease	Indicate [1] if applicable
		Alzheimer’s disease: number	Describe from article
		Mixed dementia	Indicate [1] if applicable
		Mixed dementia: number	Describe from article
		Vascular dementia	Indicate [1] if applicable
		Vascular dementia: number	Describe from article
		Cardiovascular accident (CVA)	Indicate [1] if applicable
		Cardiovascular accident (CVA): number	Describe from article
		Dementia with Lewy Bodies	Indicate [1] if applicable
		Dementia with Lewy Bodies: number	Describe from article
		Frontotemporal degeneration	Indicate [1] if applicable
		Frontotemporal degeneration: number	Describe from article
		Alcohol-related dementia	Indicate [1] if applicable
		Alcohol-related dementia: number	Describe from article
		Dementia – type unknown	Indicate [1] if applicable
		Dementia – type unknown: number	Describe from article
		Dementia – due to multiple aetiologies	Indicate [1] if applicable
		Dementia – due to multiple aetiologies: number	Describe from article
		Dementia – unspecified type	Indicate [1] if applicable
		Dementia – unspecified type: number	Describe from article

Appendix E

Item No.	Data to extract	Instruction for extracting data and applying code
	Dementia – due to other general medical reasons	Indicate [1] if applicable
	Dementia – due to other general medical reasons: number	Describe from article
	Primary progressive aphasia (PPA)	Indicate [1] if applicable
	Primary progressive aphasia (PPA) : number	Describe from article
	Parkinson's disease dementia	Indicate [1] if applicable
	Parkinson's disease dementia: number	Describe from article
	Not reported	Indicate [1] if applicable
	Not reported: number	Describe from article
	v. Number	
	Total number of participants	Describe from article
	Not reported	Indicate [1] if applicable
10	Name	
	Name of IATD	Describe from article
	Off-the-shelf elements of IATD	Describe from article
11	Type of IATD	(Select multiple options if applicable)
	Mobile devices and wearable sensors	Indicate [1] if applicable
	Assistive robotics	Indicate [1] if applicable
	Smart homes	Indicate [1] if applicable
	Augmented reality	Indicate [1] if applicable
	Other / not specified	Indicate [1] if applicable
12	Main functionality of IATD	Copy from article - thematic analysis to follow post-collection
	Theme identified: Environmental monitor	Indicate [1] if applicable
	Theme identified: Physiological monitor	Indicate [1] if applicable
	Theme identified: Physiological monitor – agitation detection	Indicate [1] if applicable
	Theme identified: Memory and reminiscence	Indicate [1] if applicable
	Theme identified: navigation	Indicate [1] if applicable
	Theme identified: Location tracker / wandering detection	Indicate [1] if applicable
	Theme identified: Language compensation	Indicate [1] if applicable
	Theme identified: Conversation prompter	Indicate [1] if applicable
	Theme identified: Conversational agent	Indicate [1] if applicable
	Theme identified: Social robot	Indicate [1] if applicable
	Theme identified: Augmented/virtual reality	Indicate [1] if applicable
	Theme identified: Entertainment robot	Indicate [1] if applicable
	Theme identified: Music player	Indicate [1] if applicable
13	Areas of impairment IATD assists	(Select multiple options if applicable)

Appendix E

Item No.	Data to extract	Instruction for extracting data and applying code
	Cognition	
	i. Complex attention: Description: "When attention deficits do occur, they are usually evident on dual-processing tasks, tasks that require the disengagement and shifting of attention, and working memory tasks that are dependent upon the control of attentional resources." Examples: "Prominent selective and divided attention deficits", "pervasive impairment", "severely affected attention, fluctuating alertness" (Mahendra, Hickey, & Bourgeouis, 2018).	Indicate [1] if applicable
	ii. Executive function: Description: "… higher-order cognitive processes involved in planning, concept formation, problem-solving, cue-directed behavior, and the concurrent manipulation and retention of information" (Salmon & Bondi, 2009). Examples: "Pervasive difficulty completing IADLs", "difficulty planning, switching response sets, and inhibiting inappropriate responses" (Mahendra, Hickey, & Bourgeouis, 2018).	Indicate [1] if applicable
	iii. Learning and memory: Description: "Episodic memory: memory for autobiographical events and episodes that depend upon temporal and/or spatial contextual cues for their retrieval", "Semantic memory: general fund of knowledge that consists of overlearned facts and concepts that are not dependent upon contextual cues for retrieval (e.g., meanings of words and well-known geographical, historical, and arithmetical facts)". Examples: "Deficits in episodic and working memory", "profound deficits in episodic and working memory", "severely affected including recognition of familiar persons" (Mahendra, Hickey, & Bourgeouis, 2018).	Indicate [1] if applicable
	iv. Perceptual-motor: Examples: "Mild to severe deficits on more complex tasks" (Mahendra, Hickey, & Bourgeouis, 2018).	Indicate [1] if applicable
	v. Emotion / Affect: Description: Mood disorders are frequent in dementia and often precede cognitive dysfunction. ... Apathy (50-80%), verbal aggressivity, agitation (40-60%), emotional lability or abrupt changes in mood, irritability and violence are commonly associated with mood disorders in Alzheimer's disease.	Indicate [1] if applicable
	Communication	
	i. Receptive language: Examples: "Impaired ability to comprehend abstract language and complex conversation", "difficulty comprehending multi-step-commands; impaired reading comprehension", "severely limited spoken and written language comprehension" (Mahendra, Hickey, & Bourgeouis, 2018) Word finding/naming difficulties, subtle conversational skill difficulties, descriptive ability difficulties, comprehension difficulties, reading difficulties, following conversation difficulties (Woodward, 2013).	Indicate [1] if applicable
	ii. Expressive language: Examples: "Difficulty with word retrieval", "Increasing difficulty with empty speech, anomia, and discourse breakdowns", "inability to express needs and wants; repetitive, disruptive vocalizations; near-mutism in end stage" (Mahendra, Hickey, & Bourgeouis, 2018) Difficulties with functional language use,	Indicate [1] if applicable

Item No.		Data to extract	Instruction for extracting data and applying code
		concept formation difficulties, writing difficulties, syntactic ability difficulties, sensible verbal output difficulties, they may be silent, exhibit speech patterns such as echolalia, or utter words/phrases without meaning (Woodward, 2013).	
	iii.	Social-pragmatic abilities: Description: Pragmatics is the system that combines the above language components in functional and socially appropriate communication (ASHA, 1993). Examples: Difficulties maintaining conversation topics, repeating questions, difficulties maintaining close relationships, difficulties with social and personal interactions (Woodward, 2013).	Indicate [1] if applicable
14		Presence of automated communication as a function of the IATD	Indicate [1] if applicable
15		ICF core set for dementia: Activities and Participation domains the IATD assists	(Select multiple options if applicable)
	i.	Learning and applying knowledge: Includes: copying, rehearsing, focusing attention, thinking, reading, writing, calculating, solving problems, making decisions	Indicate [1] if applicable
	ii.	General tasks and demands: Includes: undertaking a single task, undertaking multiple tasks, carrying out a daily routine	Indicate [1] if applicable
	iii.	Communication: Includes: communicating with - receiving - spoken messages, communicating with - receiving - nonverbal messages, communicating with - receiving - written messages, speaking, producing nonverbal messages, writing message, conversation, using communication devices and techniques	Indicate [1] if applicable
	iv.	Mobility: Includes: changing basic body position, maintaining a body position, fine hand use (picking up, grasping), walking, moving around in different locations, driving	Indicate [1] if applicable
	v.	Self-care: Includes: washing oneself, caring for body parts (e.g. brushing teeth, grooming), toileting, dressing, eating, drinking, (looking after one's health)	Indicate [1] if applicable
	vi.	Domestic life Includes: acquisition of goods and services (shopping, etc.), preparation of food, housekeeping, household tasks, assisting others	Indicate [1] if applicable
	vii.	Interpersonal Interactions and Relationships: Includes: basic interpersonal interactions, complex interpersonal interactions, informal social relationships, family relationships, intimate relationships	Indicate [1] if applicable
	viii.	(Major life areas): (Includes: education, employment, basic economic transactions, economic self-sufficiency)	Indicate [1] if applicable
	ix.	Community, social and civic life: Includes: community life, recreation and leisure, (religion and spirituality)	Indicate [1] if applicable
16		Area of functional impairment assisted with (Kenisberg et al., 2019)	(Select multiple options if applicable)

Appendix E

Item No.	Data to extract	Instruction for extracting data and applying code
	i. Enabling and empowering: Description: "To support what people can, and want to do for themselves. To increase choice and opportunity. To support what is important to the person with dementia and their families and carers. To support the ordinary everyday activities of daily life. To reduce isolation and disconnection from personal and social communities. To maximize existing skills and abilities and support the development of new skills. To assist with communication and reduce the impact of sensory loss. To support memory, reasoning, judgment, and decision-making. To maintain social networks and enhance personal connection through social and digital media." (Kenisberg et al., 2019)	Indicate [1] if applicable
	ii. Health and well-being Description: "To maximize confidence, capacity, and capability of the individual to self-manage their dementia and any other health conditions they may have. To support physical and mental health and well-being through the use of technology enabled care. To help create or maintain routine. To support the search for information, advice, support, and help. To reduce the risks associated with falls and disorientation. To support reminiscence and life story work. To support medication regimes." (Kenisberg et al., 2019)	Indicate [1] if applicable
	iii. Safety and independence: Description: "To provide individualized solutions to concerns about safety, security, and independence. To reduce risk of fire and prevent accidents. To support people with dementia to walk freely and safely both indoors and outdoors. To encourage going out and about and reduce the risk of being lost or the risks associated with being lost. To facilitate the person with dementia to communicate with a remote partner in care should clarity or reassurance be required. To automatically alert a remote partner in care to the real-time occurrence of a risk to the person or property." (Kenisberg et al., 2019)	Indicate [1] if applicable
17	Primary operator if the IATD (or multiple)	(Select multiple options if applicable)
	PwD	Indicate [1] if applicable
	Caregiver of the PwD	Indicate [1] if applicable
	Emergency services	Indicate [1] if applicable
	Other - Specify	Indicate [1] if applicable
18	Skills required for the IATD (Light & McNaughton, 2014)	(Select multiple options if applicable)
	i. Linguistic competence: Description: "Sufficient knowledge, judgement, and skills in the linguistic code of the languages spoken and written in the individual's family and broader social community, including receptive skills and as many expressive skills in these languages as possible." (Light & McNaughton, 2014).	Indicate [1] if applicable
	ii. Operational competence: Description: "Skills in the technical operation of AAC strategies and techniques, including (a) skills to produce the hand or body positions…; (b) skills to utilize selection techniques…; and, (c)	Indicate [1] if applicable

Item No.		Data to extract	Instruction for extracting data and applying code
		skills to navigate and operate aided AAC systems accurately and efficiently..." (Light & McNaughton, 2014).	
	iii.	Social competence: Description: "Sociolinguistic skills refer to the pragmatic aspects of communication, in other words, discourse skills (e.g., taking turns, initiating and terminating interactions, maintaining and developing topics) and skills to express a wide range of communicative functions (e.g., requesting attention, requesting information, providing information, confirming). Socio-relational skills refer to the interpersonal aspects of communication that form the foundation for developing effective relationships." (Light & McNaughton, 2014).	Indicate [1] if applicable
	iv.	Strategic competence: Description: "Develop coping strategies that allow them to bypass limitations. These compensatory strategies may be temporary, used for a time while the individual recovers or learns new linguistic, operational, and/or social skills; or the compensatory strategies may be required long term in situations where limitations in the linguistic, operational, and/or social domain cannot be remediated." (Light & McNaughton, 2014).	Indicate [1] if applicable
19	Outcome of the IATD as reported by author(s)		* Select multiple options if applicable
	Positive outcome		Indicate [1] if applicable
	Negative outcome		Indicate [1] if applicable
	No outcome / inconclusive		Indicate [1] if applicable
	No outcome reported		Indicate [1] if applicable
20	Availability for purchase of the IATD to the public		Copy from article
	Commercially available in retail (in combination / with modifications)		Indicate [1] if applicable
	Available via ordering (online/mail/delivery)		Indicate [1] if applicable
	Not available for purchase		Indicate [1] if applicable
	Only prototype		Indicate [1] if applicable
	Only for research purposes		Indicate [1] if applicable
	Not reported		Indicate [1] if applicable
21	Benefits of the IATD as reported by author(s)		Copy from article
	Not reported		Indicate [1] if applicable
	Theme identified: Caregiving implications		Indicate [1] if applicable
	Theme identified: Positive outcomes		Indicate [1] if applicable
	Theme identified: Outcomes re. interaction		Indicate [1] if applicable
	Theme identified: Outcomes re. affect		Indicate [1] if applicable
	Theme identified: Outcomes re. cognition		Indicate [1] if applicable
	Theme identified: Outcomes re. communication		Indicate [1] if applicable
	Theme identified: User friendly		Indicate [1] if applicable
	Theme identified: User experience		Indicate [1] if applicable
	Theme identified: User expectations		Indicate [1] if applicable

Appendix E

Item No.	Data to extract	Instruction for extracting data and applying code
	Theme identified: Assists memory	Indicate [1] if applicable
	Theme identified: Assists ADLs	Indicate [1] if applicable
	Theme identified: Assists safety	Indicate [1] if applicable
	Theme identified: Assists pain	Indicate [1] if applicable
	Theme identified: Collaboration of professionals	Indicate [1] if applicable
	Theme identified: Integrated system	Indicate [1] if applicable
	Theme identified: Clinical potential	Indicate [1] if applicable
	Theme identified: Accurate	Indicate [1] if applicable
	Theme identified: Individualised	Indicate [1] if applicable
	Theme identified: Open source available	Indicate [1] if applicable
	Theme identified: Affordable / low cost	Indicate [1] if applicable
	Theme identified: Multimodal	Indicate [1] if applicable
	Theme identified: Feature: touch screen	Indicate [1] if applicable
	Theme identified: Feature: text-to-speech tech	Indicate [1] if applicable
	Theme identified: Feature: remote control	Indicate [1] if applicable
22	Limitations of the IATD as reported by author(s)	Copy from article
	Not reported	Indicate [1] if applicable
	Theme identified: Limited functions/topics addressed	Indicate [1] if applicable
	Theme identified: Reliability	Indicate [1] if applicable
	Theme identified: Immature development	Indicate [1] if applicable
	Theme identified: Algorithm performance	Indicate [1] if applicable
	Theme identified: Lacks inferencing	Indicate [1] if applicable
	Theme identified: Lacks confirmation	Indicate [1] if applicable
	Theme identified: Poor accuracy	Indicate [1] if applicable
	Theme identified: Speech processing tech	Indicate [1] if applicable
	Theme identified: Speech generation tech	Indicate [1] if applicable
	Theme identified: Physical look / design	Indicate [1] if applicable
	Theme identified: Technical failures	Indicate [1] if applicable
	Theme identified: Sound	Indicate [1] if applicable
	Theme identified: Material	Indicate [1] if applicable
	Theme identified: Physical size / weight	Indicate [1] if applicable
	Theme identified: Requires internet	Indicate [1] if applicable
	Theme identified: Limited physical distance	Indicate [1] if applicable
	Theme identified: Incompatible with other devices	Indicate [1] if applicable
	Theme identified: Other equipment required	Indicate [1] if applicable
	Theme identified: Poor connection	Indicate [1] if applicable
	Theme identified: Environmental obstacles	Indicate [1] if applicable
	Theme identified: Caregiver administration	Indicate [1] if applicable

Appendix E

Item No.	Data to extract	Instruction for extracting data and applying code
	Theme identified: Caregiver workload / time	Indicate [1] if applicable
	Theme identified: Poor generalisation	Indicate [1] if applicable
	Theme identified: Poor outcomes	Indicate [1] if applicable
	Theme identified: Negative reactions of PwD	Indicate [1] if applicable
	Theme identified: Fatiguing	Indicate [1] if applicable
	Theme identified: Poor acceptance from PwD	Indicate [1] if applicable
	Theme identified: Use difficulties for PwD	Indicate [1] if applicable
	Theme identified: Confusion / poor comprehension for PwD	Indicate [1] if applicable
	Theme identified: High cost / expensive	Indicate [1] if applicable
	Theme identified: Ethical considerations	Indicate [1] if applicable
23	Recommendations for development as reported by author(s)	Copy from article
	Not reported	Indicate [1] if applicable
	Theme identified: Further development	Indicate [1] if applicable
	Theme identified: Further research	Indicate [1] if applicable
	Theme identified: Cooperation / collaboration	Indicate [1] if applicable
	Theme identified: Clinical use	Indicate [1] if applicable
24	Gaps in development/research as reported by author(s)	Copy from article
	Not reported	Indicate [1] if applicable

Appendix F

Appendix F

Eligible Records for Data Extraction

No.	Title	Author(s)	Year	Source	Reference:
1	A pilot study on using an intelligent life-like robot as a companion for elderly individuals with dementia and depression	Abdollahi, Ali Mollahosseini, A., Lane, J. T., & Mahoor, M. H.	2017	IEEE-RAS 17th International Conference on Humanoid Robotics (Humanoids)	Abdollahi, H., Mollahosseini, A., Lane, J. T., & Mahoor, M. H. (2017). A pilot study on using an intelligent life-like robot as a companion for elderly individuals with dementia and depression. In *IEEE-RAS 17th International Conference on Humanoid Robotics (Humanoids)* (pp. 541-546). IEEE. doi:10.1109/HUMANOIDS.2017.8246925
2	Motion biomarkers for early detection of dementia-related agitation	Alam, R., Gong, J., Hanson, M., Bankole, A, Anderson, M., Smith-Jackson, T., & Lach, J.	2017	DigitalBiomarkers'17: Proceedings of the 1st Workshop on Digital Biomarkers	Alam, R., Gong, J., Hanson, M., Bankole, A., Anderson, M., Smith-Jackson, T., & Lach, J. (2017). Motion biomarkers for early detection of dementia-related agitation. In *DigitalBiomarkers '17: Proceedings of the 1st Workshop on Digital Biomarkers* (pp. 15–20). ACM. doi:10.1145/3089341.3089344
3	My robot is happy today: How older people with mild cognitive impairments understand assistive robots' affective output	Antona, M., Ioannidi, D., Foukarakis, M., Gerłowska, J., Rejdak, K., Abdelnour, C., Hernández, J., Tantinya, N., & Roberto, N.	2019	PETRA '19: Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments	Antona, M., Ioannidi, D., Foukarakis, M., Gerlowska, J., Rejdak, K., Abdelnour, C., … Roberto, N. (2019). My robot is happy today: How older people with mild cognitive impairments understand assistive robots' affective output. In *PETRA '19: Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments* (pp. 416-424). ACM. doi:10.1145/3316782.3322777
4	Impact of assistive technologies in supporting people with dementia	Asghar, I.	2018	A thesis submitted in partial fulfilment of the requirements of Bournemouth University for the degree of Doctor of Philosophy, Department of Computing and	Asghar, I. (2018). Impact of assistive technologies in supporting people with dementia (Doctoral thesis, Bournemouth University, UK). Retrieved from http://eprints.bournemouth.ac.uk/30860/

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
				Informatics, Faculty of Science and Technology, Bournemouth University	
5	Continuous, non-invasive assessment of agitation in dementia using inertial body sensors	Bankole, A., Anderson, M., Knight, A., Oh, K., Smith-Jackson, T., Hanson, M.A., Barth, A.T., & Lach, J.	2011	WH'11: Proceedings of the 2nd Conference on Wireless Health	Bankole, A., Anderson, M., Knight, A., Oh, K., Smith-Jackson, T., Hanson, M. A., … Lach, J. (2011). Continuous, non-invasive assessment of agitation in dementia using inertial body sensors. In *WH '11: Proceedings of the 2nd Conference on Wireless Health* (pp. 1-9). ACM. doi:10.1145/2077546.2077548
6	Environment-aware system for alzheimer's patients	Barreto, A., Oliveira, R., Sousa, F., Cardosoy, A., & Duarte, C.	2014	4th International Conference on Wireless Mobile Communication and Healthcare - Transforming Healthcare Through Innovations in Mobile and Wireless Technologies (MOBIHEALTH) 2014	Barreto, A., Oliveira, R., Sousa, F., Cardoso, A., & Duarte, C. (2014). Environment-aware system for Alzheimer's patients. In *4th International Conference on Wireless Mobile Communication and Healthcare - Transforming Healthcare Through Innovations in Mobile and Wireless Technologies (MOBIHEALTH*, (pp 8–11). IEEE. doi:10.1109/MOBIHEALTH.2014.7015970
7	A virtual environment gesture interaction system for people with dementia	Bejan, A., Wieland, M., Murko, P., & Kunze, C.	2018	DIS'18 Companion: Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems	Bejan, A., Wieland, M., Murko, P., & Kunze, C. (2018). A virtual environment gesture interaction system for people with dementia. In *DIS '18 Companion: Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems (pp* 225–230). ACM. doi:10.1145/3197391.3205440
8	How to use robot interventions in intramural psychogeriatric care; A feasibility study	Bemelmans, R., Gelderblom, G. J., Jonker, P., & deWitte, L.	2016	Applied Nursing Research	Bemelmans, R., Gelderblom, G. J., Jonker, P., & de Witte, L. (2016). How to use robot interventions in intramural psychogeriatric care; A feasibility study. *Applied Nursing Research, 30*, 154–157. doi:10.1016/j.apnr.2015.07.003

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
9	Effectiveness of robot PARO in intramural psychogeriatric care: a multicenter quasi-experimental study	Bemelmans, R., Gelderblom, G. J., Jonker, P., & deWitte, L.	2015	Journal of the American Medical Directors Association	Bemelmans, R., Gelderblom, G. J., Jonker, P., & de Witte, L. (2015). Effectiveness of robot Paro in intramural psychogeriatric care: A multicenter quasi-experimental study. *Journal of the American Medical Directors Association*, 1–5. doi:10.1016/j.jamda.2015.05.007
10	Rekindling imagination in dementia care with the resonant interface rocking chair	Bennett, P., Hinder, H. & Cater, K.	2016	Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems	Bennett, P., Hinder, H., & Cater, K. (2016). Rekindling Imagination in Dementia Care with the Resonant Interface Rocking Chair. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp 2020–2026).ACM. doi:10.1145/2851581.2892505
11	The use of smartwatches for health monitoring in home-based dementia care	Boletsis, C., McCallum, S., & Landmark, B.F.	2015	Human Aspects of IT for the Aged Population. Design for Everyday Life - Lecture Notes in Computer Science	Boletsis, C., McCallum, S., & Landmark, B. F. (2015). The use of smartwatches for health monitoring in home-based dementia care. *Human Aspects of IT for the Aged Population. Design for Everyday Life - Lecture Notes in Computer Science*, 15–26. doi: 10.1007/978-3-319-20913-5
12	Virtual memory palaces to improve quality of life in Alzheimer's disease	Bormans, K., Roe, K., & De Wachter, D.	2016	Annual Review of Cybertherapy and Telemedicine	Bormans, K., Roe, K., & De Wachter, D. (2016). Virtual memory palaces to improve quality of life in Alzheimer' s disease. *Annual Review of CyberTherapy and Telemedicine, 14*, 227 232. Retrieved from https://lirias.kuleuven.be/457858?limo=0
13	Employing companion robots to enhance social engagement for people with dementia	Casey, D., Murphy, K., Burke, M., Santorelli, A., Barrett, E., Whelan, S., Kovacic, T., & Cortis, K.	2018	Alzheimer's & Dementia: Technology and Dementia Preconference	Casey, D., Murphy, K., Burke, M., Santorelli, A., Barrett, E., Whelan, S., … Cortis, K. (2018). Employing companion robots to enhance social engagement for people with dementia. In *Alzheimer's & Dementia: Technology and Dementia Preconference, 14* (pp. 186–187). Elsevier. doi:10.1016/j.jalz.2018.06.2019
14	Use of seal-like robot PARO in sensory group therapy for older adults with dementia	Chang, W.L., Šabanović, S., & Huber, L.	2013	8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)	Chang, W.L., Šabanović, S., & Huber, L. (2013). Use of seal-like robot PARO in sensory group therapy for older adults with dementia. In *8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 101–102). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2447556.2447587
15	Service innovation through social robot engagement	Chu, M.T., Khosla, R., Khaksar,	2017	Assistive Technology	Chu, M. T., Khosla, R., Khaksar, S. M., & Nguyen, K. (2017). Service innovation through social robot engagement to improve

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
	to improve dementia care quality	SMS., & Nguyen, K.			dementia care quality. *Assistive Technology*, *29*(1), 8–10. doi:10.1080/10400435.2016.1171807
16	A conversational robot to conduct therapeutic interventions for dementia	Cruz-Sandoval, D. & Favela, J.	2019	IEEE Pervasive Computing	Cruz-Sandoval, D., & Favela, J. (2019). A conversational robot to conduct therapeutic interventions for dementia. *IEEE Pervasive Computing*, 10–19. doi:10.1109/MPRV.2019.2907020
17	Co-designing ambient-assisted interventions using digital interlocutors for people with dementia	Cruz-Sandoval, D. & Favela, J.	2017	UbiComp '17: Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers	Cruz-Sandoval, D., & Favela, J. (2017). Co-designing ambient-assisted interventions using digital interlocutors for people with dementia. In *UbiComp '17: Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers* (pp. 813–821). ACM. doi:10.1145/3123024.3125615
18	Strategies to facilitate the acceptance of a social robot by people with dementia	Cruz-Sandoval, D., Favela, J., & Sandoval, E.B.	2018	HRI '18: Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction	Cruz-Sandoval, D., Favela, J., & Sandoval, E. B. (2018). Strategies to facilitate the acceptance of a social robot by people with dementia. In *HRI '18: Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction* (pp 95–96). ACM. doi:10.1145/3173386.3177081
19	Combining social robotics and music as a non-medical treatment for people with dementia	de Kok, R., Rothweiler, J., Scholten, L., van Zoest, M., Boumans, R., & Neerincx, M.	2018	27th IEEE International Symposium on Robot and Human Interactive Communication	De Kok, R., Rothweiler, J., Scholten, L., van Zoest, M., Boumans, R., & Neerincx, M. (2018). Combining social robotics and music as a non-medical treatment for people with dementia. In *27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN*) (pp.465–467). IEEE. doi:10.1109/ROMAN.2018.8525813
20	Sharing and collaborating with the end-users around the robot extention paradigm. Using robots and computers by older people with dementia	Delacroix, D., Gaboriau, R., Sakka, S., Billonnet, L., & Couégnas, N.	2018	International Conference on e-Health	Delacroix, D., Gaboriau, R., Sakka, S., Billonnet, L., & Couégnas, N. (2018). Sharing and collaborating with the end-users around the robot extention paradigm. Using robots and computers by older people with dementia. In *International Conference on eHealth* (pp. 196–200). HAL. Retrieved from https://hal.univ-rennes2.fr/LS2N/hal-02481691v1

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
21	Improving well-being in patients with major neurodegenerative disorders: Differential efficacy of brief social robot-based intervention for 3 neuropsychiatric profiles	Demange, M., Lenoir, H., Pino, M., Cantegreil-Kallen, I., Rigaud, A.S., & Cristancho-Lacroix, V.	2018	Clinical Interventions in Aging	Demange, M., Lenoir, H., Pino, M., Cantegreil-Kallen, I., Rigaud, A. S., & Cristancho-Lacroix, V. (2018). Improving well-being in patients with major neurodegenerative disorders: Differential efficacy of brief social robot-based intervention for 3 neuropsychiatric profiles. *Clinical Interventions in Aging, 13,* 1303–1311. doi:/10.2147/CIA.S152561
22	The effectiveness of a non-pharmacological interactive intervention, using the NAO robot, for dementia-related apathy	Demange, M., Benveniste, S., Neau, M., Michel-Pellegrino, V., Engasser, O., Chabanel, B., Rigaud A.S., & Pino, M.	2019	Alzheimer's & Dementia (Supplement) Alzheimer's Association International Conference	Demange, M., Benveniste, S., Neau, M., Michel-Pellegrino, V., Engasser, O., Chabanel, B., … Pino, M. (2019). The effectiveness of a non-pharmacological interactive intervention, using the NAO robot, for dementia-related apathy. In *Alzheimer's Association International Conference* (pp. 6–7). Elsevier. doi:10.1016/j.jalz.2019.06.4067
23	Effects of a distraction method using a social robot on pain and anxiety management in major neurocognitive disorders	Demange, M., Pino, M., Charlieux, B., Kerhervé, H., Rigaud, A.S., & Cantegreil-Kallen, I.	2019	Alzheimer's and Dementia (Supplement) Alzheimer's Association International Conference	Demange, M., Pino, M., Charlieux, B., Kerhervé, H., Rigaud, A.-S., & Cantegreil-Kallen, I. (2019). Effects of a distraction method using a social robot on pain and anxiety management in major neurocognitive disorders. In *Alzheimer's Association International Conference* (pp. 226–227). Elsievier. doi:10.1016/j.jalz.2019.06.4581
24	LiveNature: Ambient display and social robot-facilitated multi-sensory engagement for people with dementia	Feng, Y., Yu, S., van de Mortel, D., Barakova, E., Hu, J., & Rauterberg, M.	2019	DIS '19: Proceedings of the 2019 on Designing Interactive Systems Conference	Feng, Y., Yu, S., van de Mortel, D., Barakova, E., Hu, J., & Rauterberg, M. (2019). LiveNature: Ambient display and social robot-facilitated multi-sensory engagement for people with dementia. In *DIS '19: Proceedings of the 2019 on Designing Interactive Systems Conference* (pp. 1321-1333). ACM. doi:10.1145/3322276.3322331
25	Closer to Nature: Multi-sensory engagement in interactive nature experience for seniors with dementia	Feng, Y., Yu, S., van de Mortel, D., Barakova, E., Rauterberg, M., & Hu, J.	2018	ChineseCHI '18: Proceedings of the Sixth International Symposium of Chinese CHI	Feng, Y., Yu, S., van de Mortel, D., Barakova, E., Rauterberg, M., & Hu, J. (2018). Closer to nature: Multi-sensory engagement in interactive nature experience for seniors with dementia. In *ChineseCHI '18: Proceedings of the Sixth International Symposium of Chinese CHI* (pp. 49-56). ACM. doi:10.1145/3202667.3202674

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
26	Shall I compare thee…to a robot? An exploratory pilot study using participatory arts and social robotics to improve psychological well-being in later life	Fields, N., Xu, L., Greer, J., & Murphy, E.	2019	Aging & Mental Health	Fields, N., Xu, L., Greer, J., & Murphy, E. (2019). Shall I compare thee … to a robot? An exploratory pilot study using participatory arts and social robotics to improve psychological well-being in later life. *Aging & Mental Health*, 1–10. doi:10.1080/13607863.2019.1699016
27	Activating people with dementia using natural user interface interaction on a surface computer	Gündogdu, R., Bejan, A., Kunze, C., & Wölfel, M.	2017	PervasiveHealth '17: Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare	Gündogdu, R., Bejan, A., Kunze, C., & Wölfel, M. (2017). Activating people with dementia using natural user interface interaction on a surface computer. In *PervasiveHealth '17: Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare* (pp.386–394). ACM. doi:10.1145/3154862.3154929
28	A smartphone application to evaluate technology adoption and usage in persons with dementia	Hartin, P.J., Nugent , C.D., McClean, S.I., Cleland, I., Norton, M.C., Sanders, C., & Tschanz, J.T.	2014	36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society	Hartin, P. J., Nugent, C. D., McClean, S. I., Cleland, I., Norton, M. C., Sanders, C., & Tschanz, J. T. (2014). A smartphone application to evaluate technology adoption and usage in persons with dementia. In *36th Annual International Conference of the IEEE Engineering in Medicine and Biology Societ*, (pp.5389–5392). IEEE. doi:10.1109/EMBC.2014.6944844
29	Lessons learned from the deployment of a long-term autonomous robot as companion in physical therapy for older adults with dementia. A mixed methods study	Hebesberger, D., Koertner, T., Gisinger, C., Pripfl, J., & Dondrup, C.	2016	11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)	Hebesberger, D., Dondrup, C., Koertner, T., Gisinger, C., & Pripfl, J. (2016). Lessons learned from the deployment of a long-term autonomous robot as companion in physical therapy for older adults with dementia: A mixed methods study. In *11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp.27–34). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2906831.2906838
30	Patterns of use: How older adults with progressed dementia interact with a robot	Hebesberger, D., Dondrup, C., Gisinger, C., & Hanheide, M.	2017	HRI '17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction	Hebesberger, D., Dondrup, C., Gisinger, C., & Hanheide, M. (2017). Patterns of use: How older adults with progressed dementia interact with a robot. In *HRI '17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 131-132). ACM. doi:10.1145/3029798.3038388

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
31	Exploring requirements and alternative pet robots for robot-assisted therapy with older adults with dementia	Heerink, M., Albo-Canals, J., Valenti-Soler, M., Martinez-Martin, P., Zondag, J., Smits, C., & Anisuzzaman, S.	2013	Social Robotics, ICSR 2013, Lecture Notes in Computer Science	Heerink, M., Albo-Canals, J., Valenti-Soler, M., Martinez-Martin, P., Zondag, J., Smits, C., & Anisuzzaman, S. (2013). Exploring requirements and alternative pet robots for robot assisted therapy with older adults with dementia. In *International Conference on Social Robotics. ICSR 2013. Social Robotics* pp. 104-115. Springer. doi:10.1007/978-3-319-02675-6_11
32	Adding a context: Will it influence human-robot interaction of people living with dementia?	Hendrix, J., Feng, Y., van Otterdijk, M., & Barakova, E.	2019	International Conference on Social Robotics: Lecture Notes in Computer Science	Hendrix, J., Feng, Y., van Otterdijk, M., & Barakova, E. (2019). Adding a context: Will it influence human-robot interaction of people living with dementia? In *International Conference on Social Robotics. ICSR 2019. Social Robotics* (pp. 494-504). Springer. doi:10.1007/978-3-030-35888-4
33	Aging in place: A multi-sensor system for home-based enablement of people with dementia	Hopper, L., Joyce, R., Newman, E., Smeaton, A.F., & Irving, K.	2015	Alzheimer's & Dementia	Hopper, L., Joyce, R., Newman, E., Smeaton, A. F., & Irving, K. (2015). Aging in place: A multi-sensor system for home-based enablement of people with dementia. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *11*, 164. doi:10.1016/j.jalz.2015.07.109
34	Development of health care system based on wearable devices	Huang, P.C., Lin, C.C., Wang, Y.H., & Hsieh, H.J.	2019	Prognostics and System Health Management Conference	Huang, P. C., Lin, C. C., Wang, Y. H., & Hsieh, H. J. (2019). Development of health care system based on wearable devices. In *Prognostics and System Health Management Conference (PHM-Paris)*, (pp.249–252). IEEE. doi:10.1109/PHM-Paris.2019.00049
35	Exploring the perceptions of people with dementia about the social robot PARO in a hospital setting	Hung, L., Gregorio, M., Mann, J., Wallsworth, C., Horne, N., Berndt, A., Liu, C., Woldum, E., Au-Yeung, A., & Chaudhurry, H.	2019	Dementia	Hung, L., Gregorio, M., Mann, J., Wallsworth, C., Horne, N., Berndt, A., … Chaudhurry, H. (2019). Exploring the perceptions of people with dementia about the social robot PARO in a hospital setting. *Dementia*, 1–20. doi:10.1177/1471301219894141
36	Exploring the perception of patients with dementia	Hung, L., Gregorio, M., Mann, J.,	2019	Innovation in Aging	Hung, L., Gregorio, M., Mann, J., Horne, N., Wallsworth, C., Berndt, A., & Chaudhury, H. (2019). Exploring the perception of

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Appendix F

No.	Title	Author(s)	Year	Source	Reference:
	about a social robot PARO in a hospital setting	Horne, N., Wallsworth, C., Berndt, A., & Chaudhury, H.			patients with dementia about a social robot PARO in a hospital setting. *Innovation in Aging, 3,* 195. doi:10.1093/geroni/igz038.701
37	Narratives and emotions in seniors affected by dementia: a comparative study using a robot and a toy	Iacono, I. & Marti, P.	2016	25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)	Iacono, I., & Marti, P. (2016). Narratives and emotions in seniors affected by dementia: A comparative study using a robot and a toy. In *25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp.318–323). IEEE. doi:10.1109/ROMAN.2016.7745149
38	Field-based development of an information support robot for persons with dementia	Inouea, T., Niheib, M., Naritab, T., Onodab, M., Ishiwataa, R., Mamiyaa, I., Shinob, M., Kojimac, H., Ohnakad, S., Fujitad, Y., & Kamatab, M.	2012	Technology and Disability	Inoue, T., Nihei, M., Narita, T., Onoda, M., Ishiwata, R., Mamiya, I., … Kamata, M. (2012). Field-based development of an information support robot for persons with dementia. *Technology & Disability, 24,* 263–271. doi:10.3233/TAD-120357
39	The communication supporting robot based on “humanitude” concept for dementia patients	Iwabuchi, Y., Sato, I., Fujino, Y., & Yagi, N.	2019	IEEE 1st Global Conference on Life Sciences and Technologies (LifeTech)	Iwabuchi, Y., Sato, I., Fujino, Y., & Yagi, N. (2019). The communication supporting robot based on “Humanitude” concept for dementia patients. In *IEEE 1st Global Conference on Life Sciences and Technologies (LifeTech)* (pp.219–223). IEEE. doi:10.1109/LifeTech.2019.8884049
40	Does cognitive impairment and agitation in dementia influence intervention effectiveness? Findings from a cluster-RCT with the therapeutic robot, PARO	Jones, C., Moyle, W., Murfield, J., Draper, B., Shum, D., Beattief, E., & Thalib, L.	2018	Journal of the American Medical Directors Association	Jones, C., Moyle, W., Murfield, J., Draper, B., Shum, D., Beattie, E., & Thalib, L. (2018). Does cognitive impairment and agitation in dementia influence intervention effectiveness? Findings from a cluster-RCT with the therapeutic robot, PARO. *Journal of the American Medical Directors Association, 19*(7), 623–626. doi:10.1016/j.jamda.2018.02.014
41	Effects on symptoms of agitation and depression in persons with dementia	Jøranson, N., Pedersen, I.,	2015	Journal of the American Medical Directors Association	Jøranson, N., Pedersen, I., Marie, A., Rokstad, M., & Ihlebæk, C. (2015). Effects on symptoms of agitation and depression in persons with dementia participating in robot-assisted activity: A

No.	Title	Author(s)	Year	Source	Reference:
	participating in robot-assisted activity: A cluster-randomized controlled trial	Rokstad, A.M.M., & Ihlebæk, C.			cluster-randomized controlled trial. *Journal of the American Medical Directors Association*, *16*(10), 867–873. doi:10.1016/j.jamda.2015.05.002
42	Change in quality of life in older people with dementia participating in Paro-activity: A cluster-randomized controlled trial	Jøranson, N., Pedersen, I., Rokstad, A.M.M., & Ihlebæk, C.	2016	Journal of Advanced Nursing	Jøranson, N., Pedersen, I., Rokstad, A. M. M., & Ihlebæk, C. (2016). Change in quality of life in older people with dementia participating in Paro-activity: A cluster-randomized controlled trial. *Journal of Advanced Nursing*, *72*(12), 3020–3033. doi:10.1111/jan.13076
43	Assisting individuals with Alzheimer's disease using mobile augmented reality with voice interaction: an acceptance experiment with individuals in the early stages	Kanno, K.M. Lamounier, E.A., Cardoso, A., Lopes, E.J., & Filho, S.A.F.	2019	Research on Biomedical Engineering	Kanno, K. M., Lamounier, E. A. J., Cardoso, A., Lopes, E. J., & Fakhouri Filho, S. A. (2019). Assisting individuals with Alzheimer's disease using mobile augmented reality with voice interaction: An acceptance experimet with individuals in the early stages. *Research on Biomedical Engineering*, *35*, 223–234. doi:10.1007/s42600-019-00025-y
44	Twinkle Megane: Near-eye LED indicators on glasses in tele-guidance for elderly	Kashimoto, Y., Firouzian, A., Asghar, Z., Yamamoto, G., & Pulli, P.	2016	IEEE International Conference on Pervasive Computing and Communication Workshops (PerCom Workshops)	Kashimoto, Y., Firouzian, A., Asghar, Z., Yamamoto, G., & Pulli, P. (2016). Twinkle megane: Near-eye LED indicators on glasses in tele-guidance for elderly. In *IEEE International Conference on Pervasive Computing and Communication Workshops (PerCom Workshops)* (pp. 1-6). IEEE doi:10.1109/PERCOMW.2016.7457134
45	The effects of robot therapy in the elderly facilities	Kawaguchi, Y., Shibata, T., & Wada, K.	2010	Alzheimer's Association International Conference on Alzheimer's Disease	Kawaguchi, Y., Shibata, T., & Wada, K. (2010). The effects of robot therapy in the elderly facilities. In *Alzheimer's Association International Conference on Alzheimer's Disease* (pp.133–133). Elsevier. doi.:10.1016/j.jalz.2010.05.416
46	Agitation detection in people living with dementia using multimodal sensors	Khan, S.S., Spasojevic, S., Nogas, J., Ye, B., Mihailidis, A., Iaboni, A., Wang, A., Schindel	2019	41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)	Khan, S. S., Spasojevic, S., Nogas, J., Ye, B., Mihailidis, A., Iaboni, A., … Newman, K. (2019). Agitation detection in people living with dementia using multimodal sensors. In *41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 3588-3591). IEEE. doi:10.1109/EMBC.2019.8857781

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
		Martin, L., & Newman, K.			
47	Engagement and experience of older people with socially assistive robots in home care	Khosla, R., Chu, M.T., Khaksar, S.M.S., Nguyen, K., & Nishida, T.	2019	Assistive Technology	Khosla, R., Chu, M.-T., Khaksar, S. M. S., Nguyen, K., & Nishida, T. (2019). Engagement and experience of older people with socially assistive robots in home care. *Assistive Technology,* 1–15. doi:10.1080/10400435.2019.1588805
48	Human-robot engagement and acceptability in residential aged care	Khosla, R., Nguyen, K., & Chu, M.T.	2017	International Journal of Human-Computer Interaction	Khosla, R., Nguyen, K., & Chu, M.-T. (2017). Human Robot Engagement and Acceptability in Residential Aged Care. *International Journal of Human-Computer Interaction, 33*(6), 510–522. Retrieved from http://10.0.4.56/10447318.2016.1275435
49	Assistive robot enabled service architecture to support home-based dementia care	Khosla, R., Nguyen, K., & Chu, M.T.	2014	IEEE 7th International Conference on Service-Oriented Computing and Applications	Khosla, R., Nguyen, K., & Chu, M.-T. (2014). Assistive robot enabled service architecture to support home-based dementia care. In *IEEE 7th International Conference on Service-Oriented Computing and Applications* (pp.73–80). IEEE. doi: 10.1109/SOCA.2014.53
50	Effects of intervention using PARO on the cognition, emotion, problem behavior, and social interaction of elderly people with dementia	Koh, I.S. & Kang, H.S.	2018	Journal of Korean Academy of Community Health Nursing	Koh, I. S., & Kang, H. S. (2018). Effects of intervention using PARO on the cognition, emotion, problem behavior, and social interaction of elderly people with dementia. *Journal of Korean Academy of Community Health Nursing, 29*(3), 300–309. doi:10.12799/jkachn.2018.29.3.300
51	Supporting situation awareness of dementia patients in outdoor environments	Koldrack, P., Henkel, R., Krüger, F., Teipel, S., & and Kirste, T.	2015	9th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth)	Koldrack, P., Henkel, R., Krüger, F., Teipel, S., & Kirste, T. (2015). Supporting situation awareness of dementia patients in outdoor environments. In *9th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth)* (pp.245–248). IEEE. doi:10.4108/icst.pervasivehealth.2015.259288
52	Interacting with dementia: The MARIO approach	Kouroupetroglou, C., Casey, D., Raciti, M., Barrett, E., D'Onofrio, G., Ricciardi, F.,	2017	Studies in Health Technology and Informatics	Kouroupetroglou, C., Casey, D., Raciti, M., Barrett, E., D'Onofrio, G., Ricciardi, F., … Santorelli, A. (2017). Interacting with dementia: The MARIO approach. *Studies in Health Technology and Informatics, 242(Harnessing the Power of Technology to Improve Lives),* 38–47. doi:10.3233/978-1-61499-798-6-38

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		Giuliani, F., Greco, A., Sancarlo, D., Mannion, A., Whelan, S., Pegman, G., Koumpis, A., Reforgiato Recupero, D., Kouroupetroglou, A., & Santorelli, A.			
53	Wearable technology for detecting significant moments in individuals with dementia	Lai Kwan, C., Mahdid, Y., Motta Ochoa, R., Lee, K., Park, M., & Blain-Moraes, S.	2019	BioMed Research International	Lai Kwan, C., Mahdid, Y., Motta Ochoa, R., Lee, K., Park, M., & Blain-Moraes, S. (2019). Wearable Technology for Detecting Significant Moments in Individuals with Dementia. *BioMed Research International*, *2019*(1). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eoah&AN=51044040&site=ehost-live&scope=site
54	Effects of assistive home technology on quality of life and falls of people with dementia and job satisfaction of caregivers; results from a pilot randomized controlled trial	Lauriks, S., Meiland, F.J.M., Osté, J.P., Hertogh, C.M.P.M., & Dröes, R.M.	2018	Assistive Technology	Lauriks, S., Meiland, F. J. M., Osté, J. P., Hertogh, C. M. P. M., & Droës, R.-M. (2018). Effects of assistive home technology on quality of life and falls of people with dementia and job satisfaction of caregivers; Results from a pilot randomized controlled trial. *Assistive Technology*, 1–8. doi:10.1080/10400435.2018.1531952
55	A novel and intelligent home monitoring system for care support of elders with cognitive impairment	Lazarou, I., Karakostas, A., Stavropoulos, T.G., Tsompanidis, T., Meditskos, G., Kompatsiaris, I., & Tsolaki, M.	2016	Journal of Alzheimer's Disease	Lazarou, I., Karakostas, A., Stavropoulos, T. G., Tsompanidis, T., Meditskos, G., Kompatsiaris, I., & Tsolaki, M. (2016). A novel and intelligent home monitoring system for care support of elders with cognitive impairment. *Journal of Alzheimer's Disease, 54,* 1561–1591. doi:10.3233/JAD-160348

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
56	A pilot randomized trial of a companion robot for people with dementia living in the community	Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U.M., Skoluda, N., & Broadbent, E.	2017	Journal of the American Medical Directors Association	Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U. M., … Broadbent, E. (2017). A pilot randomized trial of a companion robot for people with dementia living in the community. *Journal of the American Medical Directors Association*, 1–8. doi:10.1016/j.jamda.2017.05.019
57	Environmental design for dementia care towards more meaningful experiences through design	Ludden, G.D.S., van Rompay, T.J.L., Niedderer, K., & Tournier, I.	2019	Maturitas	Ludden, G. D. S., van Rompay, T. J. L., Niedderer, K., & Tournier, I. (2019). Environmental design for dementia care: Towards more meaningful experiences through design. *Maturitas*, *128*, 10–16. doi:10.1016/j.maturitas.2019.06.011
58	Cloud-based smart dog music therapy and pneumonia detection system for reducing the difficulty of caring for patients with dementia	Lyu, M.J. & Yuan, S.M.	2020	IEEE Access	Lyu, M.-J., & Yuan, S.-M. (2020). Cloud-based smart dog music therapy and pneumonia detection system for reducing the difficulty of caring for patients with dementia. *IEEE Access*, *8*, 20977–20990. doi:10.1109/ACCESS.2020.2969482
59	Autonomous robotic dialogue system with reinforcement learning for elderlies with dementia	Magyar, J., Kobayashi, M., Nishio, S., Sinčák, P., & Ishiguro, H.	2019	IEEE International Conference on Systems, Man and Cybernetics (SMC)	Magyar, J., Kobayashi, M., Nishio, S., Sinčák, P., & Ishiguro, H. (2019). Autonomous robotic dialogue system with reinforcement learning for elderlies with dementia. In *IEEE International Conference on Systems, Man and Cybernetics (SMC)* (pp. 3416–3421). IEEE. doi:10.1109/SMC.2019.8914248
60	Participatory research to design a novel telehealth system to support the night-time needs of people with dementia: NOCTURNAL	Martin, S., Augusto, J.C., McCullagh, P., Carswell, W., Zheng, H., Wang, H., Wallace, J., & Mulvenna, M.	2013	International Journal of Environmental Research and Public Health	Martin, S., Augusto, J. C., McCullagh, P., Carswell, W., Zheng, H., Wang, H., … Mulvenna, M. (2013). Participatory research to design a novel telehealth system to support the night-time needs of people with dementia: NOCTURNAL. *International Journal of Environmental Research and Public Health*, *10*, 6764–6782. doi:10.3390/ijerph10126764
61	A web-based mobile app with a smartwatch to support social engagement in persons with memory	McCarron, H.R., Zmora, R., & Gaugler, J.E.	2019	JMIR Aging	McCarron, H. R., Zmora, R., & Gaugler, J. E. (2019). A web-based mobile app with a smartwatch to support social engagement in persons with memory loss: Pilot randomized controlled trial. *JMIR Aging*, *2*(1). doi:10.2196/13378

No.	Title	Author(s)	Year	Source	Reference:
	loss: Pilot randomized controlled trial				
62	Mobile technology to support lexical retrieval during activity retell in primary progressive aphasia	Mooney, A., Bedrick, S., Noethe, G., Spaulding, S., & Fried-Oken, M.	2018	Aphasiology	Mooney, A., Bedrick, S., Noethe, G., Spaulding, S., & Fried-Oken, M. (2018). Mobile technology to support lexical retrieval during activity retell in primary progressive aphasia. *Aphasiology, 32*(6), 666–692. doi:10.1080/02687038.2018.1447640
63	Memory palaces to improve quality of life in dementia	Morel, A., Bormans, K., & Rombouts, K.	2015	Conference on Raising Awareness for the Societal and Environmental Role of Engineering and (Re)Training Engineers for Participatory Design (Engineering4Society)	Morel, A., Bormans, K., & Rombouts, K. (2015). Memory palaces to improve quality of life in dementia. *Conference on Raising Awareness for the Societal and Environmental Role of Engineering and (Re)Training Engineers for Participatory Design (Engineering4Society)* (pp. 80–84). IEEE. doi:10.1109/Engineering4Society.2015.7177904
64	"She had a smile on her face as wide as the great Australian bite": A qualitative examination of family perceptions of a therapeutic robot and a plush toy	Moyle, W., Bramble, M., Jones, C.J., & Murfield, J.E.	2019	Gerontologist	Moyle, W., Bramble, M., Jones, C. J., & Murfield, J. E. (2019). "She had a smile on her face as wide as the great Australian bite": A qualitative examination of family perceptions of a therapeutic robot and a plush toy. *Gerontologist, 59*(1), 177–185. doi:10.1093/geront/gnx180
65	Care staff perceptions of a social robot called Paro and a look-alike plush toy: A descriptive qualitative approach	Moyle, W., Bramble, M., Jones, C.J., & Murfield, J.E.	2018	Aging & Mental Health	Moyle, W., Bramble, M., Jones, C., & Murfield, J. (2018). Care staff perceptions of a social robot called Paro and a look-alike plush toy: A descriptive qualitative approach a descriptive qualitative approach. *Aging & Mental Health, 22*(3), 330–335. doi:10.1080/13607863.2016.1262820
66	Exploring the effect of companion robots on emotional expression in older adults with dementia: A pilot randomized controlled trial	Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., & Gray, C.	2013	Journal of Gerontological Nursing	Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., & Gray, C. (2013). Exploring the effect of companion robots on emotional expression in older adults with dementia: A pilot randomized controlled trial. *Journal of Gerontological Nursing, 39*(5), 46–53. doi:10.3928/00989134-20130313-03

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
67	Social robots helping people with dementia: assessing efficacy of social robots in the nursing home environment	Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S.	2013	6th International Conference on Human System Interactions (HSI)	Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S. (2013). Social robots helping people with dementia: Assessing efficacy of social robots in the nursing home environment. In *6th International Conference on Human System Interactions (HSI)* (pp. 608–613). IEEE. doi:10.1109/HSI.2013.6577887
68	Use of a robotic seal as a therapeutic tool to improve dementia symptoms: A cluster-randomized controlled trial	Moyle, W., Jones, C.J., Murfield, J.E., Thalib, L., Beattie, E.R.A., Shum, D.K.H., O'Dwyer, S.T., Mervin, M.C., & Draper, B.M.	2017	Journal of the American Medical Directors Association	Moyle, W., Jones, C. J., Murfield, J. E., Thalib, L., Beattie, E. R. A., Shum, D. K. H., … Draper, B. M. (2017). Use of a robotic seal as a therapeutic tool to improve dementia symptoms: A cluster-randomized controlled trial. *Journal of the American Medical Directors Association*, *18*, 766–773. doi:10.1016/j.jamda.2017.03.018
69	Using a therapeutic companion robot for dementia symptoms in long-term care: reflections from a cluster-RCT	Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., & Draper, B.	2019	Aging & Mental Health	Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., & Draper, B. (2019). Using a therapeutic companion robot for dementia symptoms in long-term care: Reflections from a cluster-RCT. *Aging & Mental Health*, *23*(3), 329–336. doi:10.1080/13607863.2017.1421617
70	Effect of a robotic seal on the motor activity and sleep patterns of older people with dementia, as measured by wearable technology: A cluster-randomised controlled trial	Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., O'Dwyer, S., Mervina, M.C., & Draper, B.	2018	Maturitas	Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., … Draper, B. (2018). Effect of a robotic seal on the motor activity and sleep patterns of older people with dementia, as measured by wearable technology: A cluster-randomised controlled trial. *Maturitas*, *110*, 10–17. doi:10.1016/j.maturitas.2018.01.007
71	What effect does an animal robot called CuDDler have on the engagement and emotional response of older people with dementia? A pilot feasibility study	Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V.	2015	International Journal of Social Robotics	Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V. (2015). What effect does an animal robot called CuDDler have on the engagement and emotional response of older people with dementia? A pilot feasibility study. *International Journal of Social Robotics*, *8*, 145–156. doi:10.1007/s12369-015-0326-7

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
72	Intervention tailoring in augmented cognition systems for elders with dementia	Navarro, R.F., Rodríguez, M.D., & Favela, J.	2014	IEEE Journal of Biomedical and Health Informatics	Navarro, R. F., Rodríquez, M. D., & Favela, J. (2014). Intervention tailoring in augmented cognition systems for elders with dementia. *IEEE Journal of Biomedical and Health Informatics, 18*(1), 361–367. doi:10.1109/JBHI.2013.2267542
73	Social HRI for people with dementia: One size fits all?	Perugia, G., Díaz Boladeras, M., Barakova, E., Català Mallofré, A., & Rauterberg, M.	2017	HRI '17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction	Perugia, G., Díaz Boladeras, M., Barakova, E., Català Mallofré, A., & Rauterberg, M. (2017). Social HRI for people with dementia: One size fits all? In *HRI '17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 257–258). ACM. doi:10.1145/3029798.3038353
74	The utilization of robotic pets in dementia care	Petersen, S., Houston, S., Qin, H., Tague, C., & Studley, J.	2017	Journal of Alzheimer's Disease	Petersen, S., Houston, S., Qin, H., Tague, C., & Studley, J. (2017). The utilization of robotic pets in dementia care. *Journal of Alzheimer's Disease, 55,* 569–574. doi:10.3233/JAD-160703
75	Exploring the effects of interaction with a robot cat for dementia sufferers and their carers	Picking, R. & Pike, J.	2017	Internet Technologies and Applications (ITA)	Picking, R., & Pike, J. (2017). Exploring the effects of interaction with a robot cat for dementia sufferers and their carers. In *Internet Technologies and Applications (ITA)* (pp.209–210). IEEE. doi:10.1109/ITECHA.2017.8101940
76	How people with dementia perceive a therapeutic robot called PARO in relation to their pain and mood: A qualitative study	Pu, L., Moyle, W., & Jones, C.	2020	Journal of Clinical Nursing	Pu, L., Moyle, W., & Jones, C. (2020). How people with dementia perceive a therapeutic robot called PARO in relation to their pain and mood: A qualitative study. *Journal Of Clinical Nursing, 29*, 437–446. doi:10.1111/jocn.15104
77	Suitability of healthcare robots for a dementia unit and suggested improvements	Robinson, H., MacDonald, B.A., Kerse, N., & Broadbent, E.	2013	Journal of the American Medical Directors Association	Robinson, H., MacDonald, B. A., Kerse, N., & Broadbent, E. (2013). Suitability of healthcare robots for a dementia unit and suggested improvements. *Journal of the American Medical Directors Association, 14*(1), 34–40. doi:10.1016/j.jamda.2012.09.006
78	Technology integrated health management for dementia	Rostill, H., Nilforooshan, R., Morgan, A., Barnaghi, P.,	2018	British Journal of Community Nursing	Rostill, H., Nilforooshan, R., Morgan, A., Barnaghi, P., Ream, E., & Chrysanthaki, T. (2018). Technology integrated health management for dementia. *British Journal of Community Nursing, 23*(10). doi:10.12968/bjcn.2018.23.10.502

Appendix F

No.	Title	Author(s)	Year	Source	Reference:
		Ream, E., & Chrysanthaki, T.			
79	Ludwig: A conversational robot for people with Alzheimer’s	Rudzicz, F., Raimondo, S., & Pou-Prom, C.	2017	Alzheimer's & Dementia - Technology and Dementia	Rudzicz, F., Raimondo, S., & Pou-Prom, C. (2017). Ludwig: A conversational robot for people with Alzheimer’s. In *Alzheimer’s & Dementia, 13* (pp. 164). Elsevier. doi:10.1016/j.jalz.2017.06.2611
80	Help me! MyDem application for early stage dementia patients	Savita, K.S., Abidin, A.I.Z., Marrima, J.J.D.A., Taib, S.M., & Muniandy, M.	2018	IEEE Conference on e-Learning, e-Management and e-Services (IC3e)	Savita, K. S., Marrima, J. J. D. A., Muniandy, M., Abidin, A. I. Z., & Taib, S. M. (2018). Help me! MyDem application for early stage dementia patients. In *IEEE Conference on e-Learning, e-Management and e-Services (IC3e)* (pp.173–178). IEEE. doi:10.1109/IC3e.2018.8632632
81	AMI: An Adaptable Music Interface to support the varying needs of people with dementia	Seymour, P.F., Matejka, J., Foulds, G., Petelycky, I., & Anderson, F.	2017	ASSETS '17: Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility	Seymour, P. F., Matejka, J., Foulds, G., Petelycky, I., & Anderson, F. (2017). AMI: An adaptable music interface to support the varying needs of people with dementia. In *ASSETS ’17: Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility* (pp.150–154). ACM. doi:10.1145/3132525.3132557
82	Recreating living experiences from past memories through virtual worlds for people with dementia	Siriaraya, P. & Ang, C.S.	2014	CHI '14: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems	Siriaraya, P., & Ang, C. S. (2014). Recreating living experiences from past memories through virtual worlds for people with dementia. In *CHI ’14: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp.3977–3986). ACM. doi:10.1145/2556288.2557035
83	Multimodal sensing and intelligent fusion for remote dementia care and support	Stavropoulos, T.G., Meditskos, G., Briassouli, A., & Kompatsiaris, I.	2016	MMHealth '16: Proceedings of the 2016 ACM Workshop on Multimedia for Personal Health and Health Care	Stavropoulos, T. G., Meditskos, G., Briassouli, A., & Kompatsiaris, I. (2016). Multimodal sensing and intelligent fusion for remote dementia care and support. In *MMHealth ’16: Proceedings of the 2016 ACM Workshop on Multimedia for Personal Health and Health Care* (pp. 35–39). ACM. doi:10.1145/2985766.2985776
84	Comparison of verbal and emotional responses of elderly people with mild/moderate dementia and those with severe	Takayanagi, K., Kirita, T., & Shibata, T.	2014	Frontiers in Aging Neuroscience	Takayanagi, K., Kirita, T., & Shibata, T. (2014). Comparison of verbal and emotional responses of elderly people with mild/moderate dementia and those with severe dementia in responses to seal robot, PARO. *Frontiers in Aging Neuroscience, 6*, 1–5. doi:10.3389/fnagi.2014.00257

No.	Title	Author(s)	Year	Source	Reference:
	dementia in responses to seal robot, PARO				
85	Behavioral responses of nursing home residents to visits from a person with a dog, a robot seal or a toy cat	Thodberg, K., Sørensen, L.U., Videbech, P.B., Poulsen, P.H., Houbak, B., Damgaard, V., Keseler, I., Edwards, D., & Christensen, J.W.	2016	Anthrozoös	Thodberg, K., Sørensen, L. U., Videbech, P. B., Poulsen, P. H., Houbak, B., Damgaard, V., … Christensen, J. W. (2016). Behavioral responses of nursing home residents to visits from a person with a dog, a robot seal or a toy cat. *Anthrozoös*, *29*(1), 107–121. doi:10.1080/08927936.2015.1089011
86	Adapting mobile and wearable technology to provide support and monitoring in rehabilitation for dementia: Feasibility case series	Thorpe, J., Forchhammer, B.H., & Maier, A.M.	2019	JMIR Formative Research	Thorpe, J., Forchhammer, B. H., & Maier, A. M. (2019). Adapting mobile and wearable technology to provide support and monitoring in rehabilitation for dementia: Feasibility case series. *JMIR Formative Research, 3,* 1–18. doi:10.2196/12346
87	Towards personalized and context-aware reminder service for people with dementia	Tokunaga, S., Horiuchi, H., Takatsuka, H., Saiki, S., Matsumoto, S., Nakamura, M., & Yasuda, K.	2016	International Joint Conference on Neural Networks (IJCNN)	Tokunaga, S., Horiuchi, H., Takatsuka, H., Saiki, S., Matsumoto, S., Nakamura, M., & Yasuda, K. (2016). Towards personalized and context-aware reminder service for people with dementia. In *International Joint Conference on Neural Networks (IJCNN)* (pp. 2946–2953). IEEE. doi:10.1109/IJCNN.2016.7727572
88	Social robots in advanced dementia	Valentí-Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., Osa-Ruiz , E., Barrios Sánchez,	2015	Frontiers in Aging Neuroscience	Valentí Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., … Martínez Martín, P. (2015). Social robots in advanced dementia. *Frontiers in Aging Neuroscience, 7*(133), 1-12 doi:10.3389/fnagi.2015.00133

No.	Title	Author(s)	Year	Source	Reference:
		A., Herrero Cano, V., Carrasco Chillón, L., Felipe Ruiz, S., López Alvarez, J., León - Salas, B., Cañas Plaza, J.M., Martín Rico, F., Abella Dago, G., & Martínez Martín, P.			
89	Preliminary results for measurement and classification of overnight wandering by dementia patient using multi-sensors	Wallace, B., Harake, T.N.E., Goubran, R., & Valech, N.	2018	IEEE International Instrumentation and Measurement Technology Conference (I2MTC)	Wallace, B. (2018). Preliminary results for measurement and classification of overnight wandering by dementia patient using multi-sensors. In *IEEE International Instrumentation and Measurement Technology Conference (I2MTC)* (pp. 1–6). IEEE. doi:10.1109/I2MTC.2018.8409727
90	Location-aware fall detection system for dementia care on nursing service in Evergreen Inn of Jianan Hospital	Wang, P., Chen, C.S., & Chuan, C.C.	2016	IEEE 16th International Conference on Bioinformatics and Bioengineering	Wang, P., Chen, C.-S., & Chuan, C.-C. (2016). Location-aware fall detection system for dementia care on nursing service in Evergreen Inn of Jianan Hospital. In *IEEE 16th International Conference on Bioinformatics and Bioengineering (BIBE)* (pp. 309–315). IEEE. doi:10.1109/BIBE.2016.70
91	Monitoring and analysis of sleep pattern for people with early dementia	Wang, H., Zheng, H., Augusto, J.C., Martin, S., Mulvenna, M., Carswell, W., Wallace, J., Jeffers, P., Taylor, B., & McSorley, K.	2010	IEEE International Conference on Bioinformatics and Biomedicine Workshops	Wang, H., Zheng, H., Augusto, J. C., Martin, S., Mulvenna, M., Carswell, W., … McSorley, K. (2010). Monitoring and analysis of sleep pattern for people with early dementia. In *IEEE International Conference on Bioinformatics and Biomedicine Workshops (BIBMW)* (pp. 405–410). IEEE. doi:10.1109/BIBMW.2010.5703836
92	Usability assessment of interaction management support in LOUISE, an ECA-based user interface	Wargnier, P., Benveniste, S.,	2018	Technology and Disability	Wargnier, P., Benveniste, S., Jouvelot, P., & Rigaud, A. (2018). Usability assessment of interaction management support in LOUISE, an ECA-based user interface for elders with cognitive

No.	Title	Author(s)	Year	Source	Reference:
	for elders with cognitive impairment	Jouvelot, P., & Rigaud, A.S.			impairment. *Technology and Disability*, *30*(3), 105–126. doi:10.3233/TAD-180189
93	Ticket to Talk: Supporting conversation between young people and people with dementia through digital media	Welsh, D., Morrissey, K., Foley, S., McNaney, R., Salis, C., McCarthy, J., & Vines, J.	2018	CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems	Welsh, D., Morrissey, K., Foley, S., McNaney, R., Salis, C., McCarthy, J., & Vines, J. (2018). Ticket to Talk: Supporting conversation between young people and people with dementia through digital media. In *CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp.1–14). ACM. doi:10.1145/3173574.3173949
94	Configuration in smart service systems: A practice-based inquiry	Wessel, L., Davidson, E., Barquet, A.P., Rothe, H., Peters, O., & Megges, H.	2019	Information Systems Journal	Wessel, L., Davidson, E., Barquet, A. P., Rothe, H., Peters, O., & Megges, H. (2019). Configuration in smart service systems: A practice-based inquiry. *Information Systems Journal*, *29*, 1256–1292. doi:10.1111/isj.12268
95	Designing for dementia: The impact of interactive ambient technology on well-being in long-term care homes	Wilkinson, A., Chignell, M., Kanik, M., & O'Neill, J.	2018	Alzheimer's & Dementia (Supplement)	Wilkinson, A., Chignell, M., Kanik, M., & O'Neill, J. (2018). Designing for dementia: The impact of interactive ambient technology on well-being in long-term care homes. In *Alzheimer's & Dementia, 14* (pp. 636). Elsievier. doi:10.1016/j.jalz.2018.06.2678
96	cARe: An augmented reality support system for dementia patients	Wolf, D., Besserer, D., Sejunaite, K., Riepe, M., & Rukzio, E.	2018	UIST '18 Adjunct: The 31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings	Wolf, D., Besserer, D., Sejunaite, K., Riepe, M., & Rukzio, E. (2018). cARe: An augmented reality support system for dementia patients. In *UIST '18 Adjunct: The 31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings (pp.* 42–44). ACM. doi:10.1145/3266037.3266095
97	Feasibility and effect of a therapeutic robot PARO on moods and social interaction in older adults with declining cognitive function	Yu, R., Woo, J., Hui, E., Lee, J., Poon, D., Ip, K., & Yeung, F.	2014	Gerontechnology	Yu, R, Woo, J., Hui, E., Lee, J., Poon, D., Ip, K., & Yeung, F. (2014). Feasibility and effect of a therapeutic robot PARO on moods and social interaction in older adults with declining cognitive function. *Gerontechnology*, *13*, 317. doi:10.4017/gt.2014.13.02.149.00
98	Use of a therapeutic, socially assistive pet robot	Yu, R., Hui, E., Lee, J., Poon, D., Ng,	2015	JMIR Research Protocols	Yu, R., Hui, E., Lee, J., Poon, D., Ng, A., Sit, K., … Woo, J. (2015). Use of a therapeutic, socially assistive pet robot (PARO)

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Appendix F

No.	Title	Author(s)	Year	Source	Reference:
	(PARO) in improving mood and stimulating social interaction and communication for people with dementia: study protocol for a randomized controlled trial	A., Sit, K., Ip, K., Yeung, F., Wong, M., Shibata, T., & Woo, J.			in improving mood and stimulating social interaction and communication for people with dementia: Study protocol for a randomized controlled trial. *JMIR Research Protocols, 4*(2), 1–12. doi:10.2196/resprot.4189
99	Alzheimer's disease rehabilitation using smartphones to improve patients' quality of life	Zmily, A. & and Abu-Saymeh, D.	2013	7th International Conference on Pervasive Computing Technologies for Healthcare and Workshops	Zmily, A., & Abu-Saymeh, D. (2013). Alzheimer's disease rehabilitation using smartphones to improve patients' quality of life. In *7th International Conference on Pervasive Computing Technologies for Healthcare and Workshops* (pp. 393–396). ACM. doi:10.4108/icst.pervasivehealth.2013.252248

Appendix G

Appendix G

Summary of Availability of IATDs

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
activity monitor/ location tracker	smartphone (Nexus 5 running Android OS v6.0.1.), smartwatch (Sony SmartWatch 3 running Android Wear)	Retail	Thorpe, J., Forchhammer, B. H., & Maier, A. M. (2019). Adapting mobile and wearable technology to provide support and monitoring in rehabilitation for dementia: Feasibility case series. *JMIR Formative Research, 3,* 1–18. doi:10.2196/12346
location tracker	-	Retail	Wessel, L., Davidson, E., Barquet, A. P., Rothe, H., Peters, O., & Megges, H. (2019). Configuration in smart service systems: A practice-based inquiry. *Information Systems Journal, 29,* 1256–1292. doi:10.1111/isj.12268
wandering detection	Infrared motion sensors (Samsung SmartThings Motion Sensor), bed sensor (Ecolink DWZWAVE2-ECO with Ideal Security SK630 Pressure Mat), magnetic latch sensors	Retail	Wallace, B. (2018). Preliminary results for measurement and classification of overnight wandering by dementia patient using multi-sensors. In *IEEE International Instrumentation and Measurement Technology Conference (I2MTC)* (pp. 1–6). IEEE. doi:10.1109/I2MTC.2018.8409727
physiological monitoring	Basis B1 smartwatch	Retail	Boletsis, C., McCallum, S., & Landmark, B. F. (2015). The use of smartwatches for health monitoring in home-based dementia care. *Human Aspects of IT for the Aged Population. Design for Everyday Life - Lecture Notes in Computer Science*, 15–26. doi: 10.1007/978-3-319-20913-5
physiological monitoring	Triple Point Sensor (TPS) (Thought Technology Ltd. ©) with Events Finder custom software, (a freely available MATLAB toolbox, https://github.com/BIAPT/Events-Finder)	Retail	Lai Kwan, C., Mahdid, Y., Motta Ochoa, R., Lee, K., Park, M., & Blain-Moraes, S. (2019). Wearable Technology for Detecting Significant Moments in Individuals with Dementia. *BioMed Research International, 2019*(1). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eoah&AN=51044040&site=ehost-live&scope=site
agitation detection	TEMPO 3	Retail	Bankole, A., Anderson, M., Knight, A., Oh, K., Smith-Jackson, T., Hanson, M. A., … Lach, J. (2011). Continuous, non-invasive assessment of agitation in dementia using inertial body sensors. In *WH '11: Proceedings of the 2nd Conference on Wireless Health* (pp. 1-9). ACM. doi:10.1145/2077546.2077548

Appendix G

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
conversational prompt	Ticket to Talk application	Order	Welsh, D., Morrissey, K., Foley, S., McNaney, R., Salis, C., McCarthy, J., & Vines, J. (2018). Ticket to Talk: Supporting conversation between young people and people with dementia through digital media. In *CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp.1–14). ACM. doi:10.1145/3173574.3173949
ambient interaction	ABBY (Ambient Activity Technologies)	Order	Wilkinson, A., Chignell, M., Kanik, M., & O'Neill, J. (2018). Designing for dementia: The impact of interactive ambient technology on well-being in long-term care homes. In *Alzheimer's & Dementia, 14* (pp. 636). Elsievier. doi:10.1016/j.jalz.2018.06.2678
Social robot	FurReal Friends Lulu Cuddlin Kitty	Retail	Heerink, M., Albo-Canals, J., Valenti-Soler, M., Martinez-Martin, P., Zondag, J., Smits, C., & Anisuzzaman, S. (2013). Exploring requirements and alternative pet robots for robot assisted therapy with older adults with dementia. In *International Conference on Social Robotics. ICSR 2013. Social Robotics* pp. 104-115. Springer. doi:10.1007/978-3-319-02675-6_11
Social robot	Guide Robot (ED Robotics Company)	Order	Robinson, H., MacDonald, B. A., Kerse, N., & Broadbent, E. (2013). Suitability of healthcare robots for a dementia unit and suggested improvements. *Journal of the American Medical Directors Association, 14*(1), 34–40. doi:10.1016/j.jamda.2012.09.006
Social robot	MARIO	Order	Kouroupetroglou, C., Casey, D., Raciti, M., Barrett, E., D'Onofrio, G., Ricciardi, F., … Santorelli, A. (2017). Interacting with dementia: The MARIO approach. *Studies in Health Technology and Informatics, 242(Harnessing the Power of Technology to Improve Lives),* 38–47. doi:10.3233/978-1-61499-798-6-38
Social robot	NAO (SoftBank Robotics	Order	Delacroix, D., Gaboriau, R., Sakka, S., Billonnet, L., & Couégnas, N. (2018). Sharing and collaborating with the end-users around the robot extention paradigm. Using robots and computers by older people with dementia. In *International Conference on eHealth* (pp. 196–200). HAL. Retrieved from https://hal.univ-rennes2.fr/LS2N/hal-02481691v1
			Demange, M., Benveniste, S., Neau, M., Michel-Pellegrino, V., Engasser, O., Chabanel, B., … Pino, M. (2019). The effectiveness of a non-pharmacological interactive intervention, using the NAO robot, for dementia-related apathy. In *Alzheimer's Association International Conference* (pp. 6–7). Elsevier. doi:10.1016/j.jalz.2019.06.4067
			Fields, N., Xu, L., Greer, J., & Murphy, E. (2019). Shall I compare thee … to a robot? An exploratory pilot study using participatory arts and social robotics to improve psychological well-being in later life. *Aging & Mental Health*, 1–10. doi:10.1080/13607863.2019.1699016

Appendix G

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
			Valentí Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., … Martínez Martín, P. (2015). Social robots in advanced dementia. *Frontiers in Aging Neuroscience*, *7*(133), 1-12 doi:10.3389/fnagi.2015.00133
Social robot	PaPeRo (Partner Personal Robot) (NEC Corporation)	Order	Inoue, T., Nihei, M., Narita, T., Onoda, M., Ishiwata, R., Mamiya, I., … Kamata, M. (2012). Field-based development of an information support robot for persons with dementia. *Technology & Disability*, *24*, 263–271. doi:10.3233/TAD-120357
Social robot	Pepper (Softbanks Robotics Pepper Robot)	Order	De Kok, R., Rothweiler, J., Scholten, L., van Zoest, M., Boumans, R., & Neerincx, M. (2018). Combining social robotics and music as a non-medical treatment for people with dementia. In *27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN*) (pp.465–467). IEEE. doi:10.1109/ROMAN.2018.8525813
Social robot	PLEO Robot - Camarasaurus (Innvo Labs)	Order	Heerink, M., Albo-Canals, J., Valenti-Soler, M., Martinez-Martin, P., Zondag, J., Smits, C., & Anisuzzaman, S. (2013). Exploring requirements and alternative pet robots for robot assisted therapy with older adults with dementia. In *International Conference on Social Robotics. ICSR 2013. Social Robotics* pp. 104-115. Springer. doi:10.1007/978-3-319-02675-6_11
			Hendrix, J., Feng, Y., van Otterdijk, M., & Barakova, E. (2019). Adding a context: Will it influence human-robot interaction of people living with dementia? In *International Conference on Social Robotics. ICSR 2019. Social Robotics* (pp. 494-504). Springer. doi:10.1007/978-3-030-35888-4
			Perugia, G., Díaz Boladeras, M., Barakova, E., Català Mallofré, A., & Rauterberg, M. (2017). Social HRI for people with dementia: One size fits all? In *HRI '17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 257–258). ACM. doi:10.1145/3029798.3038353
Social robot	"Sota" communication robot; Intel RealSense Depth Camera D415	Order, Retail	Iwabuchi, Y., Sato, I., Fujino, Y., & Yagi, N. (2019). The communication supporting robot based on "Humanitude" concept for dementia patients. In *IEEE 1st Global Conference on Life Sciences and Technologies (LifeTech)* (pp.219–223). IEEE. doi:10.1109/LifeTech.2019.8884049
Social robot	Sugar	Retail	Iacono, I., & Marti, P. (2016). Narratives and emotions in seniors affected by dementia: A comparative study using a robot and a toy. In *25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp.318–323). IEEE. doi:10.1109/ROMAN.2016.7745149

Appendix G

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
Social robot	(unnamed robot cat)	Order	Picking, R., & Pike, J. (2017). Exploring the effects of interaction with a robot cat for dementia sufferers and their carers. In *Internet Technologies and Applications (ITA)* (pp.209–210). IEEE. doi:10.1109/ITECHA.2017.8101940
Social robot	PARO (the Intelligent Systems Research Institute (ISRI));	Order	Bemelmans, R., Gelderblom, G. J., Jonker, P., & de Witte, L. (2016). How to use robot interventions in intramural psychogeriatric care; A feasibility study. *Applied Nursing Research*, *30*, 154–157. doi:10.1016/j.apnr.2015.07.003
			Bemelmans, R., Gelderblom, G. J., Jonker, P., & de Witte, L. (2015). Effectiveness of robot Paro in intramural psychogeriatric care: A multicenter quasi-experimental study. *Journal of the American Medical Directors Association*, 1–5. doi:10.1016/j.jamda.2015.05.007
			Chang, W.L., Šabanović, S., & Huber, L. (2013). Use of seal-like robot PARO in sensory group therapy for older adults with dementia. In *8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 101–102). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2447556.2447587
			Demange, M., Lenoir, H., Pino, M., Cantegreil-Kallen, I., Rigaud, A. S., & Cristancho-Lacroix, V. (2018). Improving well-being in patients with major neurodegenerative disorders: Differential efficacy of brief social robot-based intervention for 3 neuropsychiatric profiles. *Clinical Interventions in Aging*, *13*, 1303–1311. doi:/10.2147/CIA.S152561
			Demange, M., Pino, M., Charlieux, B., Kerhervé, H., Rigaud, A.-S., & Cantegreil-Kallen, I. (2019). Effects of a distraction method using a social robot on pain and anxiety management in major neurocognitive disorders. In *Alzheimer's Association International Conference* (pp. 226–227). Elsievier. doi:10.1016/j.jalz.2019.06.4581
			Hung, L., Gregorio, M., Mann, J., Wallsworth, C., Horne, N., Berndt, A., … Chaudhurry, H. (2019). Exploring the perceptions of people with dementia about the social robot PARO in a hospital setting. *Dementia*, 1–20. doi:10.1177/1471301219894141
			Hung, L., Gregorio, M., Mann, J., Horne, N., Wallsworth, C., Berndt, A., & Chaudhury, H. (2019). Exploring the perception of patients with dementia about a social robot PARO in a hospital setting. *Innovation in Aging*, *3*, 195. doi:10.1093/geroni/igz038.701
			Iacono, I., & Marti, P. (2016). Narratives and emotions in seniors affected by dementia: A comparative study using a robot and a toy. In *25th IEEE International Symposium on Robot and*

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
			Human Interactive Communication (RO-MAN) (pp.318–323). IEEE. doi:10.1109/ROMAN.2016.7745149
			Jones, C., Moyle, W., Murfield, J., Draper, B., Shum, D., Beattie, E., & Thalib, L. (2018). Does cognitive impairment and agitation in dementia influence intervention effectiveness? Findings from a cluster-RCT with the therapeutic robot, PARO. *Journal of the American Medical Directors Association*, *19*(7), 623–626. doi:10.1016/j.jamda.2018.02.014
			Jøranson, N., Pedersen, I., Marie, A., Rokstad, M., & Ihlebæk, C. (2015). Effects on symptoms of agitation and depression in persons with dementia participating in robot-assisted activity: A cluster-randomized controlled trial. *Journal of the American Medical Directors Association*, *16*(10), 867–873. doi:10.1016/j.jamda.2015.05.002
			Jøranson, N., Pedersen, I., Rokstad, A. M. M., & Ihlebæk, C. (2016). Change in quality of life in older people with dementia participating in Paro-activity: A cluster-randomized controlled trial. *Journal of Advanced Nursing*, *72*(12), 3020–3033. doi:10.1111/jan.13076
			Kawaguchi, Y., Shibata, T., & Wada, K. (2010). The effects of robot therapy in the elderly facilities. In *Alzheimer's Association International Conference on Alzheimer's Disease* (pp.133–133). Elsevier. doi.:10.1016/j.jalz.2010.05.416
			Koh, I. S., & Kang, H. S. (2018). Effects of intervention using PARO on the cognition, emotion, problem behavior, and social interaction of elderly people with dementia. *Journal of Korean Academy of Community Health Nursing*, *29*(3), 300–309. doi:10.12799/jkachn.2018.29.3.300
			Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U. M., … Broadbent, E. (2017). A pilot randomized trial of a companion robot for people with dementia living in the community. *Journal of the American Medical Directors Association*, 1–8. doi:10.1016/j.jamda.2017.05.019
			Moyle, W., Bramble, M., Jones, C. J., & Murfield, J. E. (2019). "She had a smile on her face as wide as the great Australian bite": A qualitative examination of family perceptions of a therapeutic robot and a plush toy. *Gerontologist*, *59*(1), 177–185. doi:10.1093/geront/gnx180
			Moyle, W., Bramble, M., Jones, C., & Murfield, J. (2018). Care staff perceptions of a social robot called Paro and a look-alike plush toy: A descriptive qualitative approach a descriptive qualitative approach. *Aging & Mental Health*, *22*(3), 330–335. doi:10.1080/13607863.2016.1262820

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
			Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., & Gray, C. (2013). Exploring the effect of companion robots on emotional expression in older adults with dementia: A pilot randomized controlled trial. *Journal of Gerontological Nursing, 39*(5), 46–53. doi:10.3928/00989134-20130313-03 Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S. (2013). Social robots helping people with dementia: Assessing efficacy of social robots in the nursing home environment. In *6th International Conference on Human System Interactions (HSI)* (pp. 608–613). IEEE. doi:10.1109/HSI.2013.6577887 Moyle, W., Jones, C. J., Murfield, J. E., Thalib, L., Beattie, E. R. A., Shum, D. K. H., … Draper, B. M. (2017). Use of a robotic seal as a therapeutic tool to improve dementia symptoms: A cluster-randomized controlled trial. *Journal of the American Medical Directors Association*, *18*, 766–773. doi:10.1016/j.jamda.2017.03.018 Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., & Draper, B. (2019). Using a therapeutic companion robot for dementia symptoms in long-term care: Reflections from a cluster-RCT. *Aging & Mental Health, 23*(3), 329–336. doi:10.1080/13607863.2017.1421617 Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., … Draper, B. (2018). Effect of a robotic seal on the motor activity and sleep patterns of older people with dementia, as measured by wearable technology: A cluster-randomised controlled trial. *Maturitas, 110,* 10–17. doi:10.1016/j.maturitas.2018.01.007 Petersen, S., Houston, S., Qin, H., Tague, C., & Studley, J. (2017). The utilization of robotic pets in dementia care. *Journal of Alzheimer's Disease, 55,* 569–574. doi:10.3233/JAD-160703 Pu, L., Moyle, W., & Jones, C. (2020). How people with dementia perceive a therapeutic robot called PARO in relation to their pain and mood: A qualitative study. *Journal Of Clinical Nursing, 29*, 437–446. doi:10.1111/jocn.15104 Robinson, H., MacDonald, B. A., Kerse, N., & Broadbent, E. (2013). Suitability of healthcare robots for a dementia unit and suggested improvements. *Journal of the American Medical Directors Association, 14*(1), 34–40. doi:10.1016/j.jamda.2012.09.006 Takayanagi, K., Kirita, T., & Shibata, T. (2014). Comparison of verbal and emotional responses of elderly people with mild/moderate dementia and those with severe dementia in responses to seal robot, PARO. *Frontiers in Aging Neuroscience, 6,* 1–5. doi:10.3389/fnagi.2014.00257

Function of IATD	Name of IATD or off-the-shelf devices	Availability (retail or online order)	References to consult
			Thodberg, K., Sørensen, L. U., Videbech, P. B., Poulsen, P. H., Houbak, B., Damgaard, V., … Christensen, J. W. (2016). Behavioral responses of nursing home residents to visits from a person with a dog, a robot seal or a toy cat. *Anthrozoös, 29*(1), 107–121. doi:10.1080/08927936.2015.1089011 Valentí Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., … Martínez Martín, P. (2015). Social robots in advanced dementia. *Frontiers in Aging Neuroscience, 7*(133), 1-12 doi:10.3389/fnagi.2015.00133 Yu, R, Woo, J., Hui, E., Lee, J., Poon, D., Ip, K., & Yeung, F. (2014). Feasibility and effect of a therapeutic robot PARO on moods and social interaction in older adults with declining cognitive function. *Gerontechnology, 13,* 317. doi:10.4017/gt.2014.13.02.149.00 Yu, R., Hui, E., Lee, J., Poon, D., Ng, A., Sit, K., … Woo, J. (2015). Use of a therapeutic, socially assistive pet robot (PARO) in improving mood and stimulating social interaction and communication for people with dementia: Study protocol for a randomized controlled trial. *JMIR Research Protocols, 4*(2), 1–12. doi:10.2196/resprot.4189

Appendix H

Appendix H

Declaration by Language Editor

Letter KRAFT
LANGUAGE SERVICES
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Editing Declaration

Lené Kraft
Postal Address: PO Box 2313 Lichtenburg 2740
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To whom it may concern

13 June 2020

I hereby declare that I am a professional editor and have edited and proofread the following dissertation:

Intelligent assistive technology devices for persons with dementia: A scoping review
(Chapters 1 to 5)

by

Charene Hyman
Student no: 26131481

As a professional editor with an English major obtained from the University of Pretoria in 2003, I am also a Full Member of the Professional Editors' Guild and a member of SATI (membership number 1002503).

Yours sincerely

Mrs Lené Kraft