Adjusting Conversational User Interfaces to fit Communication Needs of People with Dementia

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Abstract
The decline in cognition of people with dementia can result in difficulties in various aspects of communication, such as articulation, comprehension, pragmatics, and memory. These challenges can cause miscommunication when people with dementia interact with Conversational User Interfaces (CUIs). This paper outlines specific communication challenges of people with various forms of dementia and proposes ways that CUIs can address them.

Author Keywords
Conversational User Interfaces; Dementia; Communication; Symptoms

CCS Concepts
•Human-centered computing → Accessibility;

Introduction
Dementia refers to a cluster of cognition symptoms that affect memory, thinking, language, motor abilities, and social abilities. Dementia is most commonly caused by a variety of progressive neurodegenerative diseases, including Alzheimer's Disease (AD), Frontotemporal Dementia (FTD), Vascular Dementia (VD), Lewy Body Dementia (LBD), Parkinson's Disease Dementia (PDD), each of which has distinct characteristics. Dementia is a progressive disease strongly related to age that severely impairs a

person's quality of life, particularly in the later stages of the disease.

With the number of people with dementia expected to rise and no cure yet available [28], there is a growing demand for innovative technologies to support their daily challenges and enhance their quality of life [4]. Conversational User Interfaces (CUIs) are one such category of technology that deploy natural language to interact with their users. They can be voice-based (e.g., Google Assistant, Apple's Siri, and Amazon's Alexa) or text-based (e.g., ChatGPT), and are currently used for a variety of purposes for people with dementia, including task guidance [10], and diet advice [16], as well as assisting with early dementia detection [1]. However, dementia can cause damage to parts of the brain that control language [36], and effective communication is a significant daily challenge for people with dementia [18, 23, 21, 35]. Because language is the primary mode for controlling and receiving information from CUIs, interacting with such systems can be difficult for people with dementia. As a result, this study investigates how CUIs can address the communication challenges of people with dementia. This information can help current CUIs align with the needs and abilities of people with dementia and future CUIs designed as a communication aid to help overcome some of the communication challenges that people with dementia may face.

Three factors influence the onset and progression of language problems in people with dementia: the person's personality (e.g., prior intelligence and education levels), the dementia type and stage, and how the person manages the language problems [36, 15, 19]. Therefore, the success of incorporating CUIs into the daily lives of people with dementia is dependent on the system's ability to adapt to their individual changing needs and capabilities [29]. The communication difficulties associated with five common types of dementia are depicted in Table 1. We consider three variants of FTD because their communication challenges differ significantly: frontal or behavioural variant (fvFTD), temporal, aphasic variant Semantic Dementia (SD), and progressive non fluent aphasia (PNFA) [8]. Boschi et al. [7] divided communication challenges into four linguistic levels: phonetic-phonological (sound), lexico-semantic (words), morpho-syntactic (grammar), and discourse-pragmatic (adaptation to context) [7]. The different types of dementia influence these levels in different ways. However, keep in mind that research has primarily focused on Alzheimer's Disease, as it is the most prominent, which may have resulted in under-reported symptoms of other types of dementia.

Phonetics - phonological

Dementia can impact speech articulation, with *apraxia of speech* impairing speech movement programming in AD and PNFA[11, 37, 8]. While *dysarthria* impairs speech execution in VD [31], PDD [22], and LBD [2]. These speech impairments can lead to non-articulated speech, impaired prosody of speech, reduced verbal fluency, and slow or soft speech [23]. Moreover, people with the PNFA may experience *phonemic paraphasia*, which involves replacing a word with another of similar sound ("head" instead of "bed," or "efelant" for "elephant) [37, 8]. CUIs should be capable of handling unclear pronunciation [5] and provide flexibility of input methods (text and audio) in case articulation worsens over time [24]. CUIs should not assume that a pause in the speaker's speech means that no response will be given and also be capable of saving the state of the conversation and returning to it later if necessary [24]. Additionally, holding a smartphone microphone close to the user may reduce ambient noise and improve speech recognition [5].

Hearing loss is common among older adults [17] and can

Table 1: Communication Challenges Common in Five types of Dementia

		Alzheimer's Disease (AD)	fronto variant FTD (fvFTD)	Semantic Dementia (SD)	Progressive NonFluent Aphasia (PNFA)	Vascular Dementia (VD)	Lewy Body Dementia (LBD)	Parkinson's Disease Dementia (PDD)
Phonetics - phonological (speech sounds)	Apraxia of speech	X			X			
	Dysarthria					X	X	X
	Pure word deafness	X						
	Phonemic paraphasias				X			
Lexico - semantic (words)	Logopenia	X			X		X	
	Anomia	X		X	X			
	Semantic paraphasias			X				
	Logorrhoe	X		X				
Morpho - syntactic (grammar)	Agrammatism				X		X	X
Discourse - pragmatics (meaning in context of discourse)	Discourse organisation	X	X	X	X			
	Apathy		X					
	Mutism		X					
	Palilalia	X						X
	Echolalia	X						X
	Inappropriate langage	X	X					
	Social behavour change		X	X				
	Socioemotional agnosia			X				
	Orofacial apraxia	X						X
	Impaired repetition							
	Amnesia (Episodic memory)	X		X				
	Time shifting	X						
	Hallucinations						X	
	Phonagnosia			X				
	Prosopagnosia			X				

impact their ability to interpret sounds. In AD, *pure word deafness* can impair spoken language comprehension, but not reading, writing, or speaking [6]. CUIs can provide flexibility to users with text and audio options[24], particularly in noisy environments or when the user is not wearing a hearing aid. The CUI should produce a clear sound with personalised volume, confirm whether the user has heard the information, and repeat it if necessary [33, 30].

Lexico - semantic

AD, SD, and PNFA often cause *anomia*, the inability to name images, objects, or concepts [34, 23, 37, 8]. In PNFA, anomia is more significant for verbs than for nouns [8]. In addition, people with AD, PNFA, and DLB may experience *logopenia*, a difficulty with word-finding [32, 37, 34, 13, 23]. This results in the use of fewer and less diverse words, an increase in semantically empty words (e.g., "thing," "stuff"), and more incomplete sentence fragments [15, 22]. In SD, individuals often exhibit *semantic paraphasia*, which involves replacing a word with another of similar meaning ("son" instead of "daughter" or "orange" instead of "apple") [37, 8]. Later stages of AD can result in the loss of languages later learned in life [3], and communication may become less complex, less efficient, and shorter [13]. People with SD and AD may show signs of *logorrhoe* where they use grammatically correct language but without any substance or meaning [37, 15, 34]. To compensate, CUIs should understand the context of the user's speech and learn the user's language to understand the speaker's vague expressions [5]. The system should also recognise different languages and accents [5] if users return to their native language. Additionally, CUIs could capture non-verbal communication through video, include non-verbal touch selection inputs, or allow the user to capture and reuse small segments of speech to aid those with word-finding problems [30]. When speech has become completely incomprehensible, the system should at least be equipped to recognise the user's emotional state through their voice or facial expression [5] and provide appropriate emotional support.

Morpho-syntactic

Dementia can hinder grammatical abilities. *Agrammatism* means there is a presence of grammatical errors in speech, such as a lack or incorrect use of articles ("cow jumped over moon"), prepositions ("dog walk bridge"), or verbs ("cat eated mouse"), and is common in LBD, PDD, and PNFA [37, 2, 8]. This can also lead to comprehension difficulties [2, 39], particularly with complex sentences [23]. People with AD may moreover struggle with nonliteral and abstract comments and miss the point with jokes or sarcastic remarks [13]. CUIs should be able to comprehend inconsistent grammar and use short, unambiguous sentences with reduced syntactic complexity and slower speech rate [33, 30]. Additionally, the system could check for user understanding at strategic intervals [33, 30] and use more direct language for those struggling with jokes or sarcastic remarks.

Discourse - pragmatics

Dementia can impair communication skills, including the ability to adjust communication to context and conversation partner [14]. In particular, AD and all three variants of FTD (fvFTD, SD, and PNFA) can cause difficulties with *discourse organisation*, such as maintaining topics, introducing new topics, managing speech turns, and providing feedback [32]. People with dementia may also exhibit pathological talking disorders, such as repeating oneself (*palilalia*) in AD and PDD [12, 15] or using loud or *inappropriate language* (like swearing or sexual terms) in AD and fvFTD [22, 15, 8]. *Echolalia*, meaningless use of repetition of others, is also seen in AD, PDD, and fvFTD [12, 37, 38], although in fvFTD

it can also be meaningful [26]. People with fvFTD and SD may display *changes in social behaviour* [19, 8], including impaired greeting, attention, and engagement [32]. Moreover, people with fvFTD can show apathy, and mutism [8] with a reduced desire to socialise. Therefore, CUIs should not assume typical conversation behavior with people with dementia and allow for interruptions and repetitions. Systems must allow the conversation to be initiated without verbal greeting, and gaze detection may be used instead [25]. CUIs can also play a more active role in the conversation by introducing new topics and asking questions to maintain engagement.

Dementia can also impair the expression and recognition of non-verbal cues. PDD can cause *orofacial apraxia*; facial and bodily freezing that hinders facial mimicry and posture in non-verbal communication [27]. SD can cause *socioemotional agnosia* that diminishes the capacity to perceive others' emotions [9, 20] and thus recognising non-verbal communication. Consequently, CUIs should recognise emotions through multiple cues (e.g., voice) for those with limited facial expressivity. Moreover, when expressing emotions to those with trouble recognising emotions, the CUIs should not rely on subtle facial expressions or tone of voice but directly state the emotion in words.

People with AD and SD may experience *amnesia*, which impairs their ability to recall past and new information [3, 37]. AD mainly affects episodic memory of recent events, resulting in a repetition of topics, comments, and questions and forgetting what they say mid-sentence (aposiopesis) [3, 13, 15]. In SD, it seems to preserve recent memory and instead impair autobiographical memory [8], with older memories being impaired. Therefore, a CUI should avoid relying on learned phrases or passwords to control the system and could give extra prompts on calendar events and to-do notes to ensure they are not forgotten. The system must be aware of the user's history to aid with autobiographical memory and answer users' questions about their past.

Lastly, dementia can affect time and person recognition. AD can lead to *time-shifting*, causing confusion between the past and present [3]. Meanwhile, LBD can cause auditory and visual *hallucinations* [20], while SD can impair recognition of voices (*phonagnosia*) [20] or faces (*prosopagnosia*) [6, 8]. Thus, CUIs need to introduce themselves in every interaction. Systems must also be aware that the user may shift in time and not try to correct them if it happens to not unnecessarily upset them. Instead, the system should know subtle ways to remind the user of the present or be able to go along with the user in their experience of time.

Conclusion

The communication challenges faced by people with dementia are unique and vary over time and across different forms of dementia. Thus CUIs must be able to adjust to each individual's needs. Failing to address these challenges adequately could result in miscommunication and distress. Once CUIs are designed to be well adapted to the communication challenges of people with dementia, future developments may include CUIs that help trigger, assist, or augment rewarding conversations in relation to people with dementia and their social circles.

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