

Influences of cognitive impairment and healthy ageing on conversational use of verbs, nouns, and pronouns

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by
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DECLARATION OF ORIGINAL WORK

I hereby declare that this thesis is my own original work. It contains no material written or published by a third party, nor any that has been submitted toward completion of another degree or diploma at any institute of higher learning.

PUBLISHED WORK BY AUTHOR INCORPORATED INTO THE THESIS

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ABSTRACT

Alzheimer's disease (AD) leads to language impairments and higher-level cognitive communication problems. Language impairments experienced by people with AD (pwAD) include lexical-semantic deficits that may result in use of a simplified vocabulary. Reliance on these nonspecific words may contribute to declines in informative content, creating or exacerbating communication problems. Knowledge of this relationship is limited, however, as prior research into language in AD has focused largely on discrete production of words, particularly nouns. This thesis aimed to investigate lexical-semantic changes in discourse by pwAD, with a focus on use of nouns, pronouns, and verbs. The guiding hypothesis was that pwAD would differ from healthy older people in the use of words within and across these parts of speech (POS) in spontaneous speech.

Investigation of this hypothesis began with a systematic review (Chapter 2 of thesis) that aimed to synthesise findings on verb processing and identify directions for future research on the use of verbs and other POS by pwAD. Database searches were conducted in 2018 and updated in 2021, leading to the identification of 57 studies that reported on verb processing at word level, in individual sentences, and in discourse. At word level, pwAD were impaired in comprehending and producing both verbs and nouns compared to controls, with greater impairments for verbs than nouns. Effects of frequency and age of acquisition (AoA) were present for pwAD on word production tasks, suggesting that learning history may factor into language changes in AD. On tasks assessing comprehension of individual sentences, pwAD had difficulty with sentences that included multiple verbs or verbs with reversible thematic roles. Few studies were identified that reported on sentence production or discourse comprehension. Discourse production by pwAD was marked by the use of similar or higher numbers of verbs than controls, along with fewer nouns and more pronouns. pwAD relied on simplified language, including high-frequency words such as light verbs (e.g., *be*), and were found to use a narrower range of words than controls. Holistically, the discourse produced by pwAD was marked by declines in total

output and propositional content. It was also observed that, in some studies, a lack of information on performance by controls limited conclusions that could be drawn on performance by pwAD.

Two subsequent corpus analyses further investigated possibilities that declines in informative content in spontaneous speech by pwAD may relate to changes in word use by POS or to effects of learning history. These studies also considered the need for thorough reporting on language changes in healthy ageing to create a baseline for interpretation of changes in AD. The first of these studies (Chapter 3 of thesis) analysed conversation samples of a standardised length produced by 12 pwAD and 12 cognitively healthy, age-matched controls for the Carolinas Conversations Collection. Measures included noun, pronoun and verb counts and ratios, lexical diversity, copula use, and frequencies and ages of acquisition (AoA) of nouns and verbs produced. pwAD used fewer nouns and a narrower range of words than controls. Findings also suggested use of more pronouns and a narrower range of nouns. Age affected noun frequencies differently within each group. With age, pwAD were found to produce nouns of lower frequencies, possibly relating to the aggressive course of early-onset AD. Meanwhile, healthy controls ranging in age from 71 to 101 produced nouns of higher frequencies with age. pwAD were found to use nouns of higher AoA than controls, possibly due to group differences in noun token counts. Verb use differed little by group.

Together, findings from that study suggested that both healthy ageing and cognitive impairment—declines beyond those seen in healthy ageing—may lead to changes in word use, particularly in the use of nouns. Changes differed by group, with healthily ageing controls using nouns of higher frequencies with age, while pwAD used fewer nouns and more pronouns. However, both types of change might result in the communication of less detail. The second corpus study here (Chapter 4) sought to explore effects of ageing and cognitive ability on word use in a larger group of older participants differentiated not binarily but at a finer level, by global cognitive assessment score. This study analysed quantities of nouns, pronouns, and verbs as well as frequencies and ages of acquisition (AoAs) of nouns and verbs in conversation samples of a standardised length by 241 participants ranging from 64 to 91 years old and from 14 to 30 in Montreal Cognitive Assessment

(MoCA) score. Lower MoCA scores were significantly associated with the use of fewer nouns and more pronouns. MoCA scores did not predict verb quantities or noun or verb frequencies or AoAs. These findings on effects of global cognition were in line with those of the previous study. Age did not predict noun quantities, frequencies, or AoAs. It did not predict verb quantities or frequencies but predicted their AoAs. General trends here indicated use of less sophisticated words with age, thus providing some support for findings on effects of ageing from the previous study.

In summary, this thesis demonstrated that distinguishing between POS in analyses of spontaneous speech is useful in identifying language changes associated with healthy ageing and cognitive impairment. Findings here indicate that declines in information content in the speech of people experiencing cognitive impairment likely relate to changes in the use of words across POS. Use of pronouns rather than nouns provides less detail about people, places, things, or abstract entities. In contrast to nouns, context may facilitate the production of verbs, which interact more with words around them. Alternatively, it is possible that changes comparable to those for nouns occur among verbs, but that these cannot be captured through traditional POS distinctions. Studies of the use of pro-verbs, which act like pronouns but replace verbs, would help to identify these changes. Findings here suggest that healthy ageing may also lead to lexical-semantic changes that affect information content in spontaneous speech. Unlike people experiencing cognitive impairment, these changes may include use of less sophisticated words within POS. Such findings were inconsistent across the two corpus studies reported here. However, general trends toward use of less sophisticated words as age progresses beyond 64 years old suggest a need for further research on language changes in normal age-related cognitive decline. Findings would facilitate distinctions between language changes suggestive of cognitive impairment and those that may be considered a part of healthy ageing.

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CHAPTER 1. THE ROLE OF LANGUAGE IN UNDERSTANDING AND MANAGING ALZHEIMER'S DISEASE

1.1 Dementia, Alzheimer's, and ageing

Fifty-five million people worldwide suffer from a major neurocognitive disorder (NCD), or dementia, a condition characterised by cognitive decline sufficient to interfere with activities of daily living (ADL)—i.e., cognitive impairment (American Psychiatric Association, 2013; WHO, 2021). Early, accurate diagnosis is a principal goal for dementia care (WHO, 2021), as it can facilitate planning by the person with dementia, family members, and healthcare professionals based on the expected clinical course of the disease. Diagnosis of one of the multiple types of NCD is established in part through assessments of the extent to which any of six cognitive domains—learning and memory, language, executive function, complex attention, perceptual-motor, and social cognition—are affected (American Psychiatric Association, 2013).

Alzheimer's disease (AD) is the most common major NCD, accounting for about 70% of diagnoses (Plassman et al., 2007). An earlier diagnostic criterion for AD was memory impairment sufficient to interfere with ADL, with episodic memory considered to be affected first (Ivanoiu et al., 2004; Schott & Petersen, 2015). More recent guidelines no longer specifically include memory impairment as a diagnostic criterion for AD in its earliest stages (Schott & Petersen, 2015). While these guidelines reflect an advancing awareness that AD is a heterogenous entity that may affect cognition differently in different people (Mukherjee et al., 2020), the recognition that early AD can significantly affect cognitive domains other than memory has implications for NCD diagnosis. It is increasingly recognised, for example, that AD can involve a primary language impairment (Mukherjee et al., 2020). Language impairments also feature in multiple variants of frontotemporal dementia (FTD) (Gorno-Tempini et al., 2011). Differential diagnosis of these conditions therefore requires a thorough knowledge of the language impairments relevant to each.

AD diagnosis is further complicated by the fact that age is the strongest risk factor for major NCDs (American Psychiatric Association, 2013). NCDs are not considered a normal part of ageing, given that they affect as little as five percent of people under the age of 80 (Nelson et al., 2011; Plassman et al., 2007). Normal ageing is nonetheless believed to involve more modest effects on cognitive abilities affected in NCDs, including memory (Lighthall et al., 2019), processing speed (Salthouse, 1996), and language (Wright, 2016). However, there is a lack of clarity around normal cognitive declines with age—many of the declines believed to be associated with healthy ageing may instead stem from prodromal effects of various NCDs, including AD (Harrington et al., 2018; Wilson et al., 2010). A perception on the part of caregivers or clinicians that declines are normal and not attributable to disease processes may lead to decreased vigilance in monitoring declines, hindering early diagnosis. Because ADL performance is a key consideration in determining whether declines in ageing amount to impairment, clear understanding of declines in various cognitive domains—including language—and their potential impacts on ADL are necessary in monitoring and diagnosis of preclinical and early AD.

Instrumental ADLs (IADLs), activities that support independent living, begin to be affected in mild AD (Gauthier et al., 1997; Lawton & Brody, 1969). In addition to the role this gives them in diagnosis, monitoring performance of IADLs is important through moderate stages of AD because facilitating independent living for as long as possible is considered a best practice in dementia care (Yates et al., 2019). Communication is fundamental to the completion of IADLs (Wilson et al., 2012). However, Alzheimer's disease (AD) is accompanied by a broad range of communication issues. In mild to moderate stages, these include declines in overall content, exclusion of relevant information, and inclusion of irrelevant information (Croisile et al., 1996). Declines in informative content, which likely relate to heavy reliance on a simplified vocabulary that does not convey sufficient detail, have resulted in characterisations of spoken discourse by people with AD (pwAD) as vague or even meaningless (Appell et al., 1982; Fraser et al., 2016). These communicative declines are detrimental to ADL performance. However, effective communicative interventions can help to optimise joint performance of ADLs by pwAD and their caregivers (Wilson et al., 2012). Studies of language are thus positioned to

provide information relevant to AD diagnosis, monitoring, and intervention through language's role as both an affected cognitive domain and a tool for communication.

1.2 Overview of language declines in Alzheimer's disease

Language problems have been associated with dementia at least since Alzheimer, in the earliest modern descriptions of progressive dementia, emphasised the prominence of aphasic symptoms as an early marker of the disease (Alzheimer, 1977). This observation stimulated further investigation into the use of language symptoms in dementia diagnosis (Critchley, 1964; Stengel, 1943, 1964). Specific focuses of early studies of language in dementia included nominal aphasia (Barker & Lawson, 1968), naming errors (de Ajuriaguerra & Tissot, 1975), and performance on fluency and spontaneous speech tasks (Miller & Hague, 1975). These studies, grounded in budding understandings of neurocognition, failed to distinguish between dementias of different aetiologies. Nevertheless, they provided early direction for advancing research on language impairments in neurodegenerative disorders.

By the mid-to-late 1970s, distinctions were being made between different types of dementia (Katzman, 1976; Katzman & Karasu, 1975; Sherwin & Seltzer, 1977). Accordingly, studies began to focus on language changes in participants with specific dementias, beginning with testing of hypotheses based on findings from earlier, less refined studies. The earliest findings on language specific to pwAD suggested that they all presented with language problems, that these worsened as the disease progressed, and that anomia was prominent among them (Appell et al., 1982; Cummings et al., 1985; Kertesz, 1979). Findings by Emery (1985) suggested pwAD exhibited more severe declines in language areas that were also affected in healthy ageing. Reporting by Appell et al. (1982) that naming was the most impaired of five language functions they assessed, while syntax was relatively preserved, led to early conclusions that semantic impairment was a defining feature of language use by pwAD.

Those early findings continue to influence current research and clinical practice related to AD. Expanding on them, results of subsequent investigations have indicated that both ageing and AD lead

to decreases in the use of nouns and increases in the use of light verbs, which convey little semantic information (Kavé & Dassa, 2018; Kintz & Wright, 2022). These findings reinforce an established awareness that language declines in AD are marked by semantic impairments, with syntactic abilities less affected (Verma & Howard, 2012). This awareness helps guide differentiation of AD from, for example, the non-fluent variant of primary progressive aphasia (PPA), a language disorder associated with FTD and characterised by agrammatism (Gorno-Tempini et al., 2011). Further exploration of semantic impairments is also the focus of research attempting to better distinguish AD from the semantic variant of PPA (Montembeault et al., 2017). AD with early age of onset has been associated with more rapid global decline and with effects on different aspects of language than typical, or late-onset, AD (Lam et al., 2013)—for example, early-onset AD is more likely to involve agrammatism.

While previous language studies have improved understanding of AD, further knowledge of language changes in AD and how they differ from changes seen in healthy ageing would improve diagnosis and monitoring of AD and facilitate effective communicative intervention. Given the prominence of semantic impairments in AD, enhanced understanding of word use in context, including specifically the use of words acting as nouns and verbs, should be a focus of these investigations.

1.3 Part of speech in studies of language in Alzheimer’s disease

Early studies of language in AD focused largely on the production or comprehension of single words, but did not consider the part of speech (POS) of target words. Wilson et al. (1983), for example, found differences in word recognition by pwAD based on frequencies of stimulus words. However, no indication is given as to whether stimuli included both nouns and verbs. If this was the case, the authors neglected to account for POS as a confound arising from the considerable differences between nouns and verbs in word frequency (Mätzig et al., 2009). Other studies distinguished between POS but did not treat it as a variable of interest. Many early studies of language in AD investigated anomia (Ripich, 1994), with a focus on the naming of objects using concrete nouns. These studies rarely limited their conclusions to the naming of objects, however. Kirshner et al. (1984), for example, in a study of

people with dementia presumed to be AD, used findings on object naming to remark on a seemingly global naming disorder. In contrast to prevalent practices, Bowles et al. (1987) had participants name actions rather than objects. This was not done, though, to explore knowledge of verbs or actions in pwAD. Instead, the authors reasoned that using actions might lead to more response attempts. Presumably this was to elicit more data on which to base conclusions about a global naming impairment, as the authors again did not limit their conclusions to action naming.

Two prominent early studies on language in AD did, by contrast, draw meaningful distinctions between nouns and verbs. Their results provided early evidence that separating out POS may help researchers more accurately detail language impairments in pwAD. Martin and Fedio (1983) tested 14 pwAD on four single-word tasks, including an assessment of semantic ability requiring the matching of words to images. This task included nouns, verbs, and modifiers, with nouns used to express both objects and emotions. The pwAD performed significantly less accurately than 11 controls in matching object nouns, verbs, and modifiers to images. Notably, the groups did not differ in matching nouns to emotions. Together with the findings on objects, this suggested that performance could not even be generalised across nouns and so should not be considered to apply across POS. Unlike that study, Nicholas et al. (1985) did not directly compare group performance by POS. However, their findings did reinforce a need to account for potential differences between the POS. These authors correlated discourse measures to performance in naming both actions and objects, finding differences in correlations by naming task for a group of 19 pwAD. Action naming correlated only with mentions of important content elements, while object naming correlated with these and was also negatively correlated with use of highly nonspecific nouns in discourse.

In addition to their findings by POS, these studies are notable in that they reflect the relevance of aphasia research to investigations of language impairments in AD at the time. Nicholas et al. (1985) framed their study as an extension of work being done in aphasiology. They included groups of 16 people with Wernicke's and 8 people with anomic aphasia for comparison against pwAD and noted similarities in language use between pwAD and participants with anomic aphasia. Martin and Fedio

(1983) emphasised aphasia to a lesser extent, but noted similarities between their findings on pwAD and prior findings on people experiencing aphasia in conjunction with focal brain lesions. Such associations between language impairments in AD and aphasia, prevalent through the 1980s (Cummings et al., 1985; Kertesz et al., 1986), appear to have contributed to increasing interest in breakdowns by POS in studies of language in AD. While early aphasia research on verbs had focused on their syntactic properties, the view was expanding in the 1980s to include interest in them as lexical items, and particularly how they compared in this respect to nouns (Druks, 2002). Research had indicated that people with both anomia and Broca's aphasia, characterised by agrammatism, exhibited advantages in producing nouns over verbs (Basso et al., 1990; Williams & Canter, 1987). This provided support for the claim that verbs were more complex than nouns (Gentner, 1981) and contributed to a hypothesis that the word classes were represented separately in the brain, which explained differences in findings by POS (Caramazza & Hillis, 1991; Druks, 2002).

Increased research interest in processing of discrete nouns and verbs in AD in the 1990s drew directly on findings of class-specific deficits in aphasia and sought to examine claims about complexity and lexicon organisation by POS. Robinson et al. (1996) found 20 pwAD impaired in naming both verbs and nouns compared to 18 controls and, within the AD group, more impaired for verbs than nouns. The authors characterised their findings as the first to reveal a relative deficit for naming of verbs compared to nouns in AD. These findings were supported by those of White-Devine et al. (1996), who found 21 pwAD impaired compared to 14 controls for both verbs and nouns in naming and word-picture matching tasks and, within the AD group, less accurate with verbs on both tasks. These authors hypothesized that word class differences may relate to the greater amounts of information associated with verbs, processing of which results in increased cognitive demands. Grossman et al. (1996), looking exclusively at verbs, found 25 pwAD to be impaired versus 16 controls on a semantic judgment task as well as a task requiring judgments of verb coherence in particular syntactic frames. Each of the three studies rejected the hypothesis that lexical-semantic representations in the brain are organized by POS, proposing instead that organization is based on hierarchies of semantic features. Under this theory,

stronger hierarchies among nouns would facilitate their preservation, thus playing a role in the relative deficits for verbs.

An expanded body of evidence, now including imaging studies, continues to contradict the hypothesis that lexical-semantic processing in the brain is organized by POS (Crepaldi et al., 2011; Vigliocco et al., 2011). Despite these findings, single-word studies continue to suggest differences in the processing of nouns and verbs by pwAD (Cotelli et al., 2006; Almor et al., 2009). It is unclear whether these differences result from AD, however, as there is mixed evidence of differences in processing by POS in healthy controls (Cotelli et al., 2006; Hough et al., 2004). Investigations reporting on properties of stimulus words have indicated that word frequency and age of acquisition (AoA) affect retrieval of nouns and verbs by pwAD but not controls (Rodríguez-Ferreiro et al., 2009). Differences in frequencies and AoAs of nouns and verbs are examples of differences between the POS that may contribute to disparities in their processing by pwAD regardless of organizational properties in the brain. These differences in processing by POS may contribute to changes in words relied on, resulting in use of a simplified vocabulary that factors into findings of decreased information content in spoken discourse by pwAD. However, further research is needed on these matters, as language findings are not generalizable across task types (Sabat, 1994; Sajjadi et al., 2012) and breakdowns of words by POS in discourse produced by pwAD have been limited.

1.4 Findings on language in Alzheimer's disease from connected speech

Findings from single-word tasks should not be seen to provide a complete picture of language changes in AD or used to draw conclusions on communication by or with pwAD. Differences in tasks result in changes to language processing demands (Siri et al., 2007). For example, the production of verbs in context incorporates aspects of syntactic processing that are not relevant to their production in isolation, such as considerations of the number (i.e., singular or plural) or semantic content of surrounding nouns (Mätzig et al., 2009). A growing body of evidence suggests that different aspects of language processing are supported by different areas of the brain, so that performance on different

tasks involves different brain areas (Jarret et al., 2022; Matias-Guiu et al., 2022). Given that early AD affects a specific area of the brain—the medial temporal lobe—more so than other areas (De Wit et al., 2021), it is likely that effects of AD on language production also vary by task type. While a great deal of information exists on performance by pwAD on discrete language tasks, less information has been available on their production of connected speech. Knowledge of connected speech production in AD is relevant to diagnosis, monitoring, and intervention, particularly from a patient-centred perspective. A chief concern of patients and family members is function in daily life, including the performance of daily activities. Clinical interest in discrete aspects of language and cognition is seen by patients and family as decontextualised and focused on abilities that do not relate to everyday life (Lindeberg et al., 2021). It is the use of language for communicative purposes that affects the social life and behaviour of pwAD (Sabat, 1994). Analyses of language abilities demonstrated in connected speech can be used to assess and enhance interpersonal communication, including in the performance of ADLs, thus helping to identify and mitigate functional consequences of AD (Sabat, 1994; Wilson et al., 2012).

While early studies of language in AD were primarily interested in performance on single-word tasks, a minority of studies reported on analyses of language produced in connected speech. Their findings provided insight into the lexical-semantic impairments in AD that had been suggested in results of single-word studies. Nicholas et al. (1985), for example, found pwAD to produce less informative content than healthy controls in picture descriptions. pwAD exhibited tendencies to produce empty phrases, pronouns without reference to a specified noun, and words that were semantically related to a target but not accurate. Similarly, in spontaneous speech, Appell et al. (1982) reported decreased information content accompanied by tendencies toward circumlocutions and verbal substitutions. Blanken et al. (1987), seemingly the first study of spontaneous speech by pwAD to exhibit an interest in word use by POS, found decreased use of nouns and increased use of verbs, with a tendency to use the same nouns and verbs repeatedly. These changes were accompanied by information deficits. In contrast to lexical-semantic changes, these early studies reported syntactic production by pwAD to be generally intact.

In recent years, there has been greater interest in connected speech production by pwAD. In addition to an increasing recognition of the limitations of conclusions drawn from the production of isolated words, this likely has to do with a proliferation of computational tools that facilitate more objective, less labour-intensive language analyses. Most studies of connected speech in AD have focused on language production in relatively constrained discourse tasks such as picture descriptions or story narration (Slegers et al., 2018; Boschi et al., 2017). Unsurprisingly, lexical-semantic declines are prominent in performance by pwAD on these tasks. Consensus findings from a recent review by Boschi et al. (2017) indicate that pwAD produce less informative speech than controls, providing less accurate information while committing more semantic errors, experiencing more word-finding difficulties, and using more indefinite terms. Use of less advanced words may contribute to the lack of information content. pwAD use more closed class words than controls, specifically higher ratios of pronouns to nouns. While findings thus far do not indicate that they use words of lower AoA, pwAD appear to use words of higher frequencies, including both verbs and nouns (Slegers et al., 2018; Yeung et al., 2021). The verbs that pwAD use have also been found to be less complex semantically than those used by controls. These consist of higher numbers of light verbs, a set of high-frequency verbs that provide little semantic information, and particularly of forms of *be* (Kintz and Wright, 2022; Kim & Thompson, 2004).

Despite the focus of these studies on connected speech, their results—like those from discrete language tasks—should not necessarily be seen as reflective of performance in everyday communication. Demands of different connected speech tasks affect the language that is produced and thus how findings should be interpreted (Boschi et al., 2017; Sajjadi et al., 2012). Picture descriptions elicit speech that is unnaturally standard in its lexical-semantic content, including a targeted set of nouns (March et al., 2006). Less constrained tasks elicit speech that is more spontaneous and so more closely resembles everyday conversation. Participants may be better able to compensate for anomia on less constrained tasks (Garrard & Forsyth, 2010). These differences by task type suggest that analyses of spontaneous speech may more accurately capture changes in the use of

words of a given POS in communication, including effects of strategies adopted in everyday conversations to make up for issues such as word recall.

However, studies of spontaneous speech by pwAD that include breakdowns of words by POS have been particularly rare. A recent review by Boschi et al. (2017) identified just three such studies—by Jarrold et al. (2014), Bucks et al. (2000), and Guinn and Habash (2012). Findings were mixed. Jarrold et al. (2014) found decreased use of nouns and increased use of pronouns and verbs by pwAD, while Bucks et al. (2000) reported increased use only of verbs and Guinn and Habash (2012) found no changes by word class. None of these studies reported on frequencies or AoA of words used overall or by word class. A more thorough understanding of potential changes, in everyday communication, to reliance on words by POS or the specificity of information these words convey may lead to improved diagnostic and monitoring assessments and aid in the development of interventions to facilitate more effective communication by and with pwAD.

1.5 Aims of the present research

The overall aim of this research was to investigate whether the lexical-semantic changes associated with AD include changes in the use of words across and within POS in spontaneous speech. Knowledge of effects of AD on the production of specific POS may be useful in the design of language assessments that play a role in disease diagnosis and monitoring. This knowledge may also benefit developers of interventions that address communication problems to improve the everyday lives of pwAD and caregivers.

To address the overall aim of this research, a systematic review and two corpus studies were conducted. A first aim of the systematic review, reported in Chapter 2 of this thesis, was to synthesize findings on verb processing by pwAD. This was seen as necessary in accomplishing the overall aim of the thesis because preliminary literature searches had indicated that findings on verbs were less common than findings on nouns and that understandings of verb processing by pwAD were based on performance on a diverse range of tasks. A second aim was to identify directions for future research on

the use of verbs and other POS by pwAD. This would help refine the aims of subsequent studies in the thesis. Findings from the review suggested that pwAD were impaired compared to controls on single-word tasks and were more impaired for verbs than nouns. Word frequency and AoA affected their accuracy with both verbs and nouns on these tasks. In connected speech, pwAD were found to use similar or higher numbers of verbs than controls, along with fewer nouns and more pronouns. They also exhibited a preference for high-frequency words such as generic verbs. The review identified a lack of prior reporting of findings by POS in spontaneous speech production and noted that, in some studies, insufficient descriptions of performance by controls limited potential interpretations of performance by pwAD.

Based on findings of that review, two subsequent corpus studies aimed to investigate changes in the use of words both across and within POS in spontaneous speech by people experiencing cognitive impairments and people ageing healthily. To investigate changes across POS, these studies analysed quantities and ratios of nouns, pronouns, and verbs. To investigate changes within POS, they analysed frequencies and AoAs of nouns and verbs. Because age is the strongest predictor of AD and other major NCDs and is itself believed to involve modest cognitive declines, both studies aimed to distinguish changes accompanying cognitive impairment from changes accompanying healthy ageing. The first corpus analysis, reported in Chapter 3, aimed to identify language changes resulting specifically from the cognitive declines associated with AD by comparing use of nouns, pronouns, and verbs in conversational interviews by pwAD and healthy controls. Findings suggested that both cognitively healthy older people and pwAD exhibited changes in the use of nouns that might lead to decreases in the production of informative content. However, these changes varied by group, with healthy ageing associated with use of nouns of higher frequencies, while AD was associated with use of fewer nouns and more pronouns. To follow up on these findings, the second corpus analysis, reported in Chapter 4, aimed to further explore effects of ageing versus cognitive ability on word production by analysing use of nouns, pronouns, and verbs in a larger group of participants ($n = 241$) across a range of ages and MoCA scores.

CHAPTER 2. LANGUAGE CHANGES IN ALZHEIMER’S DISEASE: A SYSTEMATIC REVIEW OF VERB PROCESSING

Chapter 2 is an adaptation of the publication entitled “Language changes in Alzheimer’s disease: A systematic review of verb processing”, published in 2021 in the journal Brain and Language. Reference information appears below. Text here has been modified in places to ensure consistency with and relevance to the broader thesis.

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Keywords and Abstract

Keywords

Alzheimer’s disease, language, verbs, semantic, comprehension, production, discourse, processing, memory, systematic review

Abstract

Alzheimer’s disease (AD) results in language impairments and higher-level communication problems. Research into the language of people with AD (pwAD) has mainly focused on nouns; however, improved understanding of verb processing by pwAD could improve diagnostic assessments and communicative interventions. This systematic review synthesizes findings of AD’s effects on verbs from single-word, sentence, and discourse tasks. Review of 57 studies revealed that pwAD were less accurate than controls on single-word tasks and less accurate with verbs than nouns on these tasks. They had difficulty comprehending sentences featuring multiple verbs or verbs with reversible thematic roles. Discourse production by pwAD was marked by vagueness, including declines in total output and propositional content and a preference for generic verbs and simple syntax. Few studies examining sentence production or discourse comprehension were found. Future research should address relationships between long-term memory and language preservation as well as verb use in discourse.

2.1 Introduction

Alzheimer's disease (AD) is the most commonly occurring type of dementia (Plassman et al., 2007), and the number of people with AD (pwAD) is expected to triple in the next thirty years alongside rises in global population and life expectancy (WHO, 2017). Early AD affects the medial temporal lobe and is marked by corresponding impairments in declarative memory, also known as explicit memory (De Wit et al., 2021). Both subtypes of declarative memory, episodic and semantic, are affected (Ivanoi et al., 2004). Early diagnosis is a principal goal in dementia care (WHO, 2019), and the ties between semantic memory and language mean language impairments are of interest as an early diagnostic and prognostic indicator of AD as well as a target for intervention (Verma & Howard, 2012).

As outlined in Chapter 1 of this thesis, early studies of language disturbances in AD focused on nouns. This was consistent with a belief that noun processing occurred in the left temporal lobe while verb processing was linked to the left frontal lobe (Cappa & Perani, 2003; Grossman et al., 1996). However, accumulating evidence on the neural correlates of these grammatical classes suggests their processing is not separated in the brain, but processed by a shared network (Crepaldi et al., 2011; Vigliocco et al., 2011). Instead of representing different grammatical classes, brain areas correlate to aspects of language that shape understandings of grammatical class, including semantics, syntax, and morphosyntax (Price, 2012; Vigliocco et al., 2011). These correlates appear to vary depending on the difficulty of processing involved (Price, 2012). Because aspects of language that are harder to learn are also more difficult to process (Vigliocco et al., 2011), learning history likely factors into neural correlates of language processing.

The organizational properties of language processing in the brain highlight the potential contributions of studies of verb processing to understandings of neurological and cognitive changes in AD. Verbs impose greater semantic processing demands than nouns (Mätzig et al., 2009; Vigliocco et al., 2011). This may relate to the close relationship, at word level, between grammatical class and

meaning. Nouns usually refer to objects, while verbs are mainly used to describe actions (Vigliocco et al., 2011). Due to this relationship, verbs and nouns typically draw on different semantic features at word level. For example, semantic features associated with verbs are more frequently related to motion (Auclair-Ouellet et al., 2020). The actions or events that verbs tend to describe also involve participants that must be processed (Vigliocco et al., 2011). In addition to these differences, the greater semantic processing demands for verbs may relate to organizational properties of nouns that likely facilitate storage and retrieval, including clearer, frequently hierarchical relationships and greater overlap in semantic features (Mätzig et al., 2009). Verbs result in greater syntactic processing difficulties through their roles in determining the number, order, and types of arguments around them (Mätzig et al., 2009; Vigliocco et al., 2011). Verbs are also more complex morphosyntactically due to their tendency, across languages, to have a greater number of inflected forms than nouns (Vigliocco et al., 2011). Learning history may factor into greater difficulties processing verbs, since verbs tend to be acquired later in life than nouns (Mätzig et al., 2009).

The possibility that language processing is organized based on language domains and degrees of processing difficulty thus positions verbs to play an important role in both early and improved diagnosis of AD. The increased semantic processing difficulty of verbs over nouns may make them a more sensitive indicator of the early semantic declines experienced by pwAD (Papp et al., 2016). These word classes could also be used in combination to assess semantic processing, given the important semantic interrelationship between verbs and their thematic roles, which are often nouns (Edmonds, 2016; Vigliocco et al., 2011). The possibility that language loss in AD occurs in reverse order of acquisition (Emery, 2000; cf. Lust et al., 2015) suggests verbs could be affected earlier than nouns, reinforcing their potential as an early marker of AD onset and progression.

As touched on in Chapter 1, effects on language vary by dementia type. This means detailed knowledge of changes to verbs in AD could also contribute to differential diagnosis. AD shares many clinical features with primary progressive aphasia (PPA), a “language-based dementia” (Mesulam, 2003; Mesulam et al., 2014). Current knowledge indicates that people with PPA are more likely than

pwAD to exhibit morphosyntactic impairments (Faroqi-Shah et al., 2020). However, a systematic review by Auclair- Ouellet (2015) suggests morphosyntactic impairments in these populations are more nuanced. The review reports, for example, that while participants with the non-fluent variant of PPA did not exhibit systematic impairments in their use of inflectional morphology, pwAD had difficulty inflecting verbs on production tasks. They were able to produce regular past tense verb forms, possibly due to the relative sparing of procedural—or implicit—memory until late in disease progression (Ullman et al., 1997). However, pwAD had difficulties producing irregular forms, possibly relating to the semantic memory impairments that are present in AD. While such impairments are not a diagnostic criterion for non-fluent PPA, they are characteristic of the semantic variant of PPA (Gorno-Tempini et al., 2011). Verbs have been shown to be better preserved than nouns in this PPA variant, with nonverbal processing of actions being an area of relative strength (Auclair-Ouellet et al., 2020). These findings are suggestive of the potential for observations of verb use in context to help inform differential diagnosis of AD and the different variants of PPA.

In summary, knowledge of the processing of verbs by pwAD can improve early and differential diagnosis of AD, leading to improvements in treatment and quality of life. To date, findings on verb processing by pwAD have been reported in studies of comprehension and production of single words, sentences, and discourse. The aim of this systematic review is to provide an overview of existing knowledge of verb comprehension and production by pwAD. This will be accomplished through the reporting of comparisons of performance by pwAD and controls from studies that presented findings on verbs using single-word, sentence, and discourse tasks. The review is guided by the following question: How does mild or moderate Alzheimer’s disease affect comprehension and spoken production of verbs?

2.2 Methods

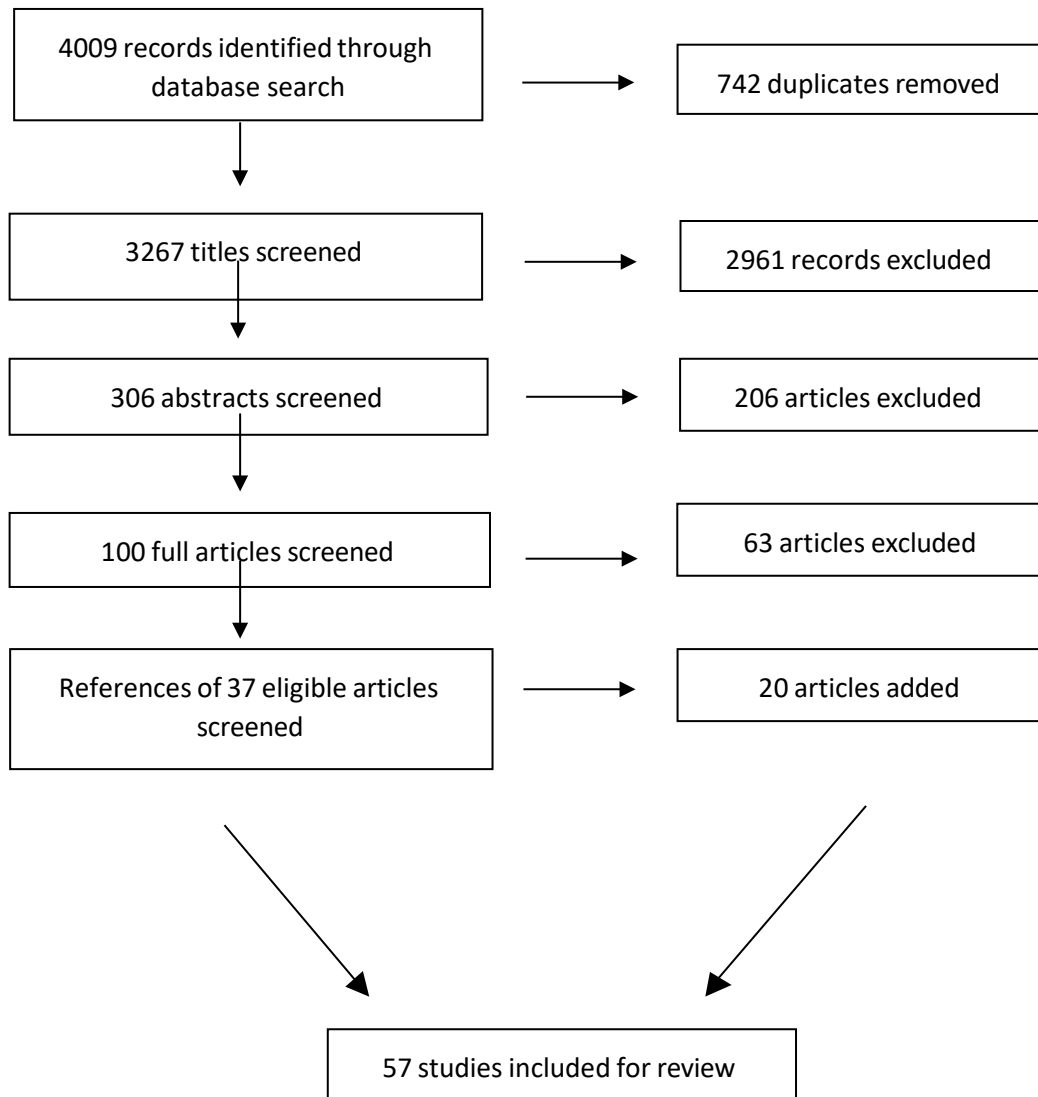
A PICOS framework was developed in collaboration with a subject librarian (Moher et al., 2009). Population included individuals of any age and was limited to those with mild or moderate AD. People with severe AD were excluded as they may be non-communicative (Ripich, 1994). Studies had to compare participants with AD ($n > 1$) to cognitively healthy adults, with reported outcomes on comprehension or spoken production of verbs. Studies were required to be observational, as intervention studies may confound findings on naturally occurring language in AD. Additional criteria for inclusion and exclusion of studies were arrived at after scoping searches but prior to development of the final search strategy. Studies were included only if they were published in English as peer-reviewed journal articles or book chapters and reported primary research utilizing quantitative, qualitative, or mixed-methods analysis. In addition, investigations of inflectional morphology were excluded due to the recency of the Auclair-Ouellet (2015) review. Studies only reporting on responses to commands, studies whose primary focus was the validation of an instrument, and machine learning and brain imaging studies were excluded as these did not provide transparent data on verb use.

Search terms were selected to reflect the broad scope of the review. In scoping searches, the terms *senile dementia* and *presenile dementia* were used in addition to *Alzheimer's disease*. Studies identified using these terms were excluded from review, however, as they did not further specify dealing exclusively with AD. Population-related terms were combined with outcome-related terms to identify studies of verb comprehension and spoken production. In addition to the word *verb*, terms *action fluency*, *action naming*, and *thematic role* were included due to the identification of these in scoping searches as common focuses of investigation of verbs in AD.

The search strategy was entered into databases Medline (Ovid), PsycInfo, and CINAHL on 7 May 2018, identifying a total of 3575 records. The study selection process (Figure 2.1) consisted of de-duplication and title screening, followed by screening of abstracts and full articles by the first author and a qualified speech-language therapist. References of 32 eligible studies were screened through

Figure 2.1

Study Selection Process



an identical process to identify reviewable studies not captured via electronic search. Nineteen were added, for a total of 51 to be reviewed. Search results were updated on 20 May 2021, resulting in the identification of a further 434 records. Results of an identical study selection process led to the addition of six studies, for a total of 57 included for review.

2.2.1 Analysis

Preliminary analysis of articles revealed that tasks used to investigate verb production and comprehension by pwAD tended to focus on single words, short stretches of words (phrases or sentences), or longer stretches (discourse). Studies were grouped according to these focuses and sub-grouped depending on specifics of the task(s) employed. From each study, the following data were extracted, where relevant: (1) comparisons of verb use by pwAD and controls; (2) comparisons of descriptions of actions by pwAD and controls; (3) comparisons of additional relevant measures of language and communication, such as within-group performance with verbs vs. nouns; (4) results of error analyses; and (5) information on properties of stimuli, such as word frequency, and how they affected performance. Reporting is qualitative, using a narrative approach.

2.3 Results

The aim of this systematic review was to synthesize findings on effects of mild or moderate AD on comprehension and spoken production of verbs. Tasks used in the 57 studies reviewed focused on single words, phrases and sentences, or discourse, with three studies (Grossman et al., 1996; Kim & Thompson, 2004; Price & Grossman, 2005) focusing on more than one of these. Word-level studies (n=31) are described first, followed by studies on phrases and sentences (n=16) and, lastly, studies on discourse (n=13).

2.3.1 Verb production and comprehension at word level

Of the 31 word-level studies, 18 examined production only, while nine assessed comprehension only and four covered both. In 23 of these studies, participants were assessed in English. Other languages studied were Italian, Spanish, Brazilian Portuguese, and Chinese. Data regarding comprehension is reviewed first, followed by data on production. Within-group comparisons of performance with verbs and nouns emerged as a common focus of studies. As such, these comparisons are reported but are separated from reporting and discussion of between-group comparisons for verbs where possible.

2.3.1.1 *Verb comprehension at single-word level*

Reporting on comprehension of individual verbs by pwAD (Table 2.1) is divided into sections on matching, association, lexical acquisition, comparisons of verbs to nouns, and relationships in the comprehension of verbs and sentences. pwAD were generally impaired compared to controls in their comprehension of verbs and, where assessed, more impaired for verbs than nouns.

Matching: Four studies compared matching of action verbs to pictures. pwAD consistently performed less accurately than controls (Cotelli et al., 2006; Martin & Fedio, 1983; Masterson et al., 2007; White-Devine et al., 1996). Masterson et al. (2007) also reported longer response times by pwAD. These issues were present regardless of whether verbs were presented auditorily (Cotelli et al., 2006) or in writing (Martin & Fedio, 1983; Masterson et al., 2007; White-Devine et al., 1996) and regardless of whether groups were described as mildly (Cotelli et al., 2006; Martin & Fedio, 1983) or mildly-to-moderately (Masterson et al., 2007; White-Devine et al., 1996) impaired.

Association: Five studies compared associations of verbs to other verbs (e.g., *sneeze* and *sniff*). Three studies (Colombo et al., 2009; Fung et al., 2001; Grossman et al., 1996) found pwAD to exhibit deficits compared to controls in verb associations, while two (Fung et al., 2000; Price & Grossman, 2005) found no significant differences between the groups. All studies included mildly to

Table 2.1

Single Word Comprehension

Task	Study	Number of participants		Mean age		Between groups		Within groups (noun/verb)	
		pwAD	Control	pwAD	Control	Nouns	Verbs	pwAD	Control
Word-picture matching	Martin & Fedio, 1983	14	11	58	62	objects: c > pwAD emotions: ns	c > pwAD	objects, actions > emotions ^a	objects, actions > emotions ^a
Word-picture matching	White-Devine et al., 1996	21	14	72	75	c > pwAD	c > pwAD	n > v (p < .059)	ns ^a
Word-picture matching	Cotelli et al., 2006 (Italian)	10	10	75	63	c > pwAD	c > pwAD	n > v	ns
Word-picture matching	Masterson et al., 2007	23	23	78	78	c > pwAD	c > pwAD	ns	ns
Association	Grossman et al., 1996	25	16	71	68		c > pwAD		
Association	Fung et al., 2000	9	11	83	78	dependent on noun type	ns	dependent on noun type	ns
Association	Fung et al., 2001	18	40			c > pwAD	c > pwAD	dependent on noun type	ns
Association	Price & Grossman, 2005	15	17	76	73		ns		
Association	Colombo et al., 2009 (Italian)	20	10	74	74		c > pwAD ^a		
Lexical acquisition	Grossman et al., 1997	16	10	72	69		c > pwAD ^b		

Lexical acquisition	Grossman et al., 2007	11	17	74	70		c > pwAD ^b
Semantic priming	Bushell & Martin, 1997	16	16	73	74	c > pwAD	c > pwAD
Naming to description	Yi et al., 2007	29	17	73	78		n > v

Notes:

X > Y indicates better performance for X compared to Y

ns = differences were not significant

^a Significance not reported.

^b Controls and pwAD differed on some but not all measures of lexical acquisition (see text).

moderately impaired participants; only Colombo et al. (2009) distinguished between these, reporting no significant differences between mild and moderate AD groups. All studies appear to have used written stimuli. Studies differed in using infinitive, continuous, or mixed forms and in their semantic categorization (e.g., action vs. perception) of verbs; however, none of these variations to stimuli were consistently associated with impairments for pwAD on this task.

Lexical acquisition: Two studies (Grossman et al., 1997; Grossman et al., 2007) compared the natural acquisition of authentic but very rare English verbs. Each found pwAD less capable than controls of acquiring the meaning and argument structure, but not the grammatical form class, of the verbs. The later study concluded that preserved implicit memory in pwAD had facilitated the successful acquisition of word class, while impaired episodic and semantic memory systems had contributed to the failure to acquire meanings and argument structures. These conclusions highlight the role of memory in learning and language processing and the potential confound it represents in studies of these processes.

Verbs vs. nouns: Reporting on nouns and within-group comparisons of performance with verbs and nouns was common in studies of single-word comprehension, being included in studies of word-picture matching, association, priming, and matching words to descriptions. In addition to less accurate performance than controls with verbs, all four word-picture matching studies reported that pwAD were generally less accurate than controls with nouns. Each reported within-group comparisons across word classes¹. Cotelli et al. (2006) found significantly less accurate comprehension of verbs than nouns by pwAD. White-Devine et al. (1996) also found this to be the case at a marginally significant level, while Masterson et al. (2007) found comparable accuracy across word classes but longer response times for verbs. Martin and Fedio (1983), by contrast, reported similar performance by pwAD for actions and objects. No differences were reported by

¹ Yi et al. (2007) also included a task involving matching concrete nouns and motion verbs to videos. Results of this task are not reported here because between-group comparisons are not reported. Of control performance, the authors report only that controls judged videos accurately. pwAD were found to be better at matching nouns than verbs to videos.

word class in control groups, aside from the indication by Martin and Fedio (1983) that controls had more difficulty comprehending nouns of emotion than verbs and other nouns. White-Devine et al. (1996) matched nouns and verbs for frequency and visual complexity, while other studies did not report matching stimuli across word classes. pwAD frequently erred by choosing distractors semantically related to targets, with error types not differing by word class (Masterson et al., 2007; White-Devine et al., 1996).

Two studies (Fung et al., 2001; Fung et al., 2000) compared associations by word class, with both including multiple categories of nouns—biological, abstract, and nonbiological—in addition to verbs. Each found pwAD more accurate with nonbiological nouns and verbs than with biological or abstract nouns, while neither found control performance to differ across categories. pwAD were slower to respond than controls for all categories of words (Fung et al., 2001). Both studies matched stimuli for frequency across categories. Fung et al. (2000) further matched stimuli for length and regularity, while Fung et al. (2001) matched stimuli for controls' accuracy and reaction time, familiarity, and complexity. Given the limited number of studies and the appearance of verbs in the present continuous (i.e., *~ing* forms, which can also be read as nouns) in both studies, further comparisons are necessary to determine whether pwAD have disproportionate difficulty with verbs on association tasks.

Bushell and Martin (1997) assessed semantic priming in pwAD and controls to investigate differences in the semantic representations of verbs and nouns. To minimize attention and retrieval demands, they presented two words consecutively and required the participant to read the first silently and the second aloud as quickly as possible. Reaction time (RT) was seen to indicate the extent to which the first word activated related semantic representations, allowing the participant to pronounce the related target more quickly. Verbs were classified as motion or non-motion and nouns as concrete or abstract. pwAD exhibited priming—faster RTs for related words—for concrete nouns only, while controls demonstrated priming for these and for motion verbs. The

authors suggest that the dissociation in pwAD results from less overlap in semantic networks for verbs, which leaves them more vulnerable to semantic impairment in AD.

Within-group comparisons were also the focus of a verbal matching task in Yi et al. (2007), who found pwAD to be more accurate in selecting nouns than verbs to match descriptions presented both orally and in writing. pwAD were significantly less accurate overall than controls on this task, though the authors did not report the significance of between-group results by word class or within-group results for controls. pwAD were better with concrete than abstract nouns but exhibited no differences between verbs of motion and cognition (e.g., *jump* vs. *think*). Error analyses revealed that of three distractor types for verbs, pwAD most often chose ones that reversed the thematic roles of agent and recipient of the action—e.g., “buy” in place of “sell.” To confirm that performance on this task was not affected by the verbal nature of the descriptions, participants completed the word-image matching task discussed above. Performance across the tasks did not differ significantly, suggesting a word class effect for pwAD regardless of mode of presentation.

Relationships between individual verb and sentence comprehension: Two studies (Grossman et al., 1996; Price & Grossman, 2005) explored relationships between verb meaning and sentence comprehension. Reporting impairments for pwAD both at single-word level and in judging the fit of verbs within given sentence frames, Grossman et al. (1996) suggest a relationship between the impairments. Price and Grossman (2005) found pwAD not to be significantly less accurate than controls on a semantic task, but reported that their performance on the task correlated with sensitivity to thematic role agreement violations. In light of this correlation and of overall findings on verb semantics in AD, the authors hypothesize that as knowledge of verb meaning is lost to pwAD, thematic role knowledge also becomes impaired.

2.3.1.2 *Verb production at single-word level*

Fifteen studies of confrontation naming and nine of fluency were identified (Table 2.2), with two studies (Beber et al., 2015; Lai & Lin, 2013) including both tasks. In general, pwAD exhibited impairments relative to healthy controls in their production of verbs.

Action naming: Fifteen studies compared action naming by pwAD and controls. All between-group comparisons found pwAD impaired compared to healthy speakers in the naming of actions. Thirteen studies also assessed naming of objects, with twelve comparing accuracy across word classes. As with actions, between-group comparisons overwhelmingly found pwAD impaired compared to healthy speakers in naming objects. Nine studies reported greater impairments in naming of verbs than nouns by pwAD, with only one (Williamson et al., 1998) finding the reverse. Comparisons of action to object naming in healthy ageing were less conclusive, with findings mixed. Latency results were remarkably similar across three studies that reported them, with each (Almor et al., 2009; Druks et al., 2006; Masterson et al., 2007) finding pwAD slower as a group overall. However, both groups took longer to name verbs than nouns, and pwAD did not take disproportionately longer to name verbs than controls.

Error patterns were analysed in eleven studies. Classification schemes lacked uniformity, but errors were generally found to differ by group. pwAD committed more errors in naming actions than objects, with patterns often similar across word classes. Errors included use of words semantically related or unrelated to the target, failures to respond, and use of definitions or descriptions in place of the target. Controls' errors were not often compared across word classes and tended to be semantic or visual. Several studies examined the roles of stimulus properties in naming, most prominently word frequency. Findings generally indicated that lower frequency was associated with less accurate naming for pwAD but not controls. Beber et al. (2015) describe a frequency effect in verb naming that seems to become more pronounced as the disease progresses. However, it cannot be said that the effect was specific to verbs, as the study did not include an object naming task. Other studies found effects of frequency across word classes (Rodríguez-Ferreiro et al., 2009) with no disproportionate effect for verbs (Robinson et al., 1996; Williamson et al., 1998). Druks et al. (2006)

reported that higher frequency among action than object stimuli did not lead to an advantage for actions in either pwAD or controls, while imageability predicted action and object naming accuracy in pwAD but not controls. Rodríguez-Ferreiro et al. (2009) found later age of acquisition (AoA) and lower name agreement to factor into less accurate naming by pwAD than controls across word classes. Almor et al. (2009) found controls but not pwAD to exhibit an advantage in naming instrument over manner verbs, concluding that pwAD have a disproportionate impairment for instrument verbs. Fung et al. (2001) compared naming of actions in videos to naming of actions and objects in still pictures; pwAD were significantly better with videos than still pictures. Further study is needed of stimulus characteristics and how they affect task performance both overall and by word class.

Action fluency: Eight studies assessed verb production on category fluency tasks, which test the ability to search for, retrieve, and produce words meeting a specified criterion within a given timeframe. In each study, pwAD produced fewer actions than healthy controls on these tasks. Only two studies reported on qualitative characteristics of verbs produced. While Beber et al. (2015) found no differences across groups in the frequencies of verbs produced, Paek and Murray (2021) found pwAD to produce verbs of higher frequencies, earlier AoAs, and shorter phoneme and syllable lengths than controls. Six of these studies also assessed noun category fluency, each finding pwAD to produce fewer nouns than controls. Only two studies (Davis et al., 2010; Lai & Lin, 2013) explicitly reported within-group comparisons of verb vs. noun production on fluency tasks, with neither reporting significant differences across word classes for pwAD. No studies reported comparisons of qualitative characteristics of verbs vs. nouns produced on fluency tasks.

Letter fluency: Wakefield et al. (2014) employed a letter fluency task, instructing participants to produce words beginning with specific letters of the alphabet; words of any grammatical class were acceptable. They found pwAD to produce significantly fewer words overall than controls, including significantly fewer of both nouns and verbs. On an accompanying noun fluency task, pwAD

Table 2.2

Single Word Production

Study	Number of participants		Mean age		Naming				Fluency			
					Between groups		Within groups (noun/verb)		Between groups		Within groups	
	pwAD	Control	pwAD	Control	Nouns	Verbs	pwAD	Control	Nouns	Verbs	pwAD	Control
Nicholas et al., 1985	19	30	67	63			Word classes correlated to different discourse measures.	Word classes correlated to the same discourse measures.				
Bowles et al., 1987	10	40 ec 39 yc	59	73 ec 34 yc		yc > ec > pwAD						
White-Devine et al., 1996	21	14	72	75	c > pwAD	c > pwAD	n > v	ns ^a				
Robinson et al., 1996	20	18	74	77	c > pwAD	c > pwAD	n > v	a				
Williamson et al., 1998	10	10	74	74	c > pwAD	c > pwAD	v > n	ns ^a				
Cappa et al., 1998 (Italian)	19	15	77	72	c > pwAD ^a	c > pwAD ^a	n > v ^a	a				
Fung et al., 2001	18	40			c > pwAD	c > pwAD	Still pictures: ns	ns ^a				
Hough et al., 2004	15	15	70	69	ns	c > pwAD	n > v	v > n				
Druks et al., 2006	19	19			c > pwAD	c > pwAD	n > v	n > v ^a				

Cotelli et al., 2006 (Italian)	10	10	75	63	c > pwAD	c > pwAD	n > v	ns	
Masterson et al., 2007	23	23	78	78	c > pwAD	c > pwAD	n > v ^a	n > v ^a	
Rodríguez-Ferreiro et al., 2009 (Spanish)	20	20	78	83	c > pwAD ^a	c > pwAD ^a	n > v (ns)	n > v (ns)	
Almor et al., 2009	14	14	83	80	c > pwAD	c > pwAD	n > v ^a	n > v ^a	
Davis et al., 2010	33	20	72	57					c > pwAD c > pwAD ns ns
McDowd et al., 2011	23	30 ec 36 yc	74	72 ec 22 yc					c > pwAD c > pwAD
Lai & Lin, 2013 (Chinese)	20	20 ec 20 yc	78	72 ec 50 yc	yc, ec > pwAD	yc, ec > pwAD	ns	ns	yc, ec > pwAD yc, ec > pwAD ns yc, ec: n > v
Clark et al., 2014	10	25	75	70					c > pwAD c > pwAD
Wakefield et al., 2014	30	30 ec	69	70 ec 19 yc					Category: ec > pwAD Letter: ec > pwAD Letter: ec > pwAD
Beber et al., 2015 (Brazilian Portuguese)	35	35	78	73		c > pwAD			c > pwAD
Kochhann et al., 2018 (Brazilian Portuguese)	21	27	74	68					c > pwAD c > pwAD

Alegret et al., 2018 (Spanish)	367	568	79	63		c > pwAD	c > pwAD
Paek & Murray, 2021	12	12	76	71			c > pwAD

Notes:

yc = younger controls; ec = elderly controls

X > Y indicates better performance for X compared to Y

ns = differences were not significant

[^] Here the authors refer to the language of participants as “Chinese” rather than as Mandarin, Cantonese, etc.

^a Significance not reported.

tended to produce words of an earlier AoA than those produced by controls. As verbs are acquired later in life than nouns, the authors interpreted this combination of findings to evidence an AoA effect on fluency task performance in AD. This is in line with the findings of Paek and Murray (2021) discussed above and demonstrates the additional knowledge that can be gained by breaking down responses on letter fluency tasks by word class. Such analyses have been rare, but ratios by word class are reported in studies of discourse production (see section 3.3.2), and their reporting in fluency tasks would provide insight into relationships in performance across these task types. Letter fluency studies that report information by word class should address how they determine this in cases of potential ambiguity.

Verbs vs. nouns: Results above suggest that pwAD perform less accurately with actions than objects on naming but not fluency tasks. Additionally, Lai and Lin (2013) and Beber et al. (2015) compared the usefulness of naming and fluency tasks in determining severity of dementia. Lai and Lin (2013) found tasks eliciting verbs to more strongly predict degree of dementia than tasks eliciting nouns. Action fluency was a stronger predictor of dementia severity than action naming. Beber et al. (2015) also reported differences according to severity of dementia, as people with mild AD performed better than people with moderate AD when naming actions. However, the two groups performed similarly on the action fluency task. These mixed findings indicate that while verb production tasks are useful in assessing the semantic skills of pwAD, further study is needed on their potential for assessing severity of AD.

2.3.1.3 *Conclusions from single-word studies*

Results of 31 single-word studies suggest that pwAD are commonly impaired in the comprehension and production of single verbs. Consensus findings indicate impaired comprehension and production of both verbs and nouns by pwAD compared to healthy controls. Within groups, pwAD tended to perform less accurately for verbs than nouns, particularly on naming and word-picture matching tasks. Only White-Devine et al. (1996) directly compared the performance of pwAD

on these tasks, finding less accurate performance for verbs than nouns on both tasks and less accurate performance with naming than matching.²

A recurring issue in single-word studies was the failure to account for differences in AD severity in the reporting of results. Though several studies only included participants with mild AD, others reported on single groups described as having “mild-to-moderate” AD. Such broad groupings fail to account for the significant changes that occur as AD progresses and result in findings that provide less detail on language impairments in AD than if these changes were accounted for. Studies that report on such groups would do well, at a minimum, to report relationships between general cognitive measures and performance on experimental tasks (as in, e.g., Grossman et al., 1997). Often, too, studies did not account for or report on stimulus characteristics and how they affected task performance. An example is the prevalent use of static images to assess action naming. pwAD have been found to more accurately name actions portrayed in videos than in static images (Fung et al., 2001). This may relate to the dynamic nature of an action, including the involvement of motion. A second, related example is the potential confounding of a word’s grammatical class and its semantic features, e.g., of verbs vs. words that describe actions, a distinction that frequently went unaddressed in studies here. Similarly, analyses of both correct responses and errors have provided insight into the semantic declines experienced by pwAD. For example, frequency and AoA have been identified as factors in both correct responses and errors committed by pwAD when producing individual verbs. Explorations of characteristics of stimuli and other task demands, correct responses, and errors provide detail on how AD affects language and should be normalized in studies involving single-word tasks.

² While their findings are not discussed in the body of the review because they did not assess controls on these tasks, Kim and Thompson (2004) reported greater difficulty for pwAD in naming verbs than either naming nouns or matching verbs. Significant differences were not found between comprehension of verbs and nouns, nor between comprehension and production of nouns. This relative difficulty with verb retrieval along with impairments in sentence completion and narrative production (see sections 3.2.2 and 3.3.2, respectively) led the authors to hypothesize it is breakdowns in the verb lexicon that impede verb retrieval in pwAD.

2.3.2 Production and comprehension of verbs in phrases and sentences

Sixteen studies assessed the ability of pwAD to comprehend, repeat, or rephrase phrases or sentences. These will primarily be referred to as sentence studies from now on. Thirteen sentence studies covered comprehension only, while two investigated production only and one study covered both. Except for one German study, all participants were assessed in English.

2.3.2.1 *Comprehension of verbs in phrases or sentences*

Fourteen studies of verbs in sentences (Table 2.3) reported on a broad range of aspects of verb and sentence comprehension.

Five studies investigated whether sentence comprehension by pwAD was affected by the number of thematic roles, or arguments, around a verb. More arguments—generally nouns—around a verb mean more information associated with the verb (compare *I cry* vs. *I send her a card*). The number of arguments a verb obligates can thus be viewed as a marker of its complexity. Consensus findings from three studies by the same study group (Rochon et al., 1994; Waters et al., 1995; Waters et al., 1998), reporting on five experiments, indicate similar performance by pwAD and controls in comprehending sentences differing only in the number of thematic roles taken by the sentence's lone verb. Kim and Thompson (2004), too, found pwAD to have little difficulty with argument structure, performing with 94.3% accuracy on a grammaticality judgment task involving ungrammatical additions or deletions of arguments. Grossman et al. (1996) reported that their pwAD were less accurate than controls in judging two-argument frames that are more accepting of motion or cognition verbs, but not a three-argument frame that accepts both verb types. Their participants also exhibited word-level difficulties, suggesting that compromised understanding of the relationship between syntax and semantics and not syntactic considerations alone lead to sentence

Table 2.3

Comprehension of Syntactic Features of Sentences

Comprehension by number of thematic roles								
Study	Number of participants		Mean age		Between groups	Within groups		
	pwAD	Control	pwAD	Control		pwAD	Control	
Rochon et al., 1994	23	23	71	71	2 thematic roles: ns 3 thematic roles: ns	ns		
Waters et al., 1995	14	14	70	70	2 thematic roles: ns 3 thematic roles: ns	ns	ns	
Grossman et al., 1996	25	16	71	68	Judgment of fit of verb into sentence frame: c > pwAD			
Waters et al., 1998 ^b	12 (exp. 1)	12 (exp. 1)	82 (exp. 1)	81 (exp. 1)	(exp. 1) 2 thematic roles: ns 3 thematic roles: ns	(exp. 1) ns	(exp. 1) ns	
	13 (exp. 2)	13 (exp. 2)	69 (exp. 2)	71 (exp. 2)	(exp. 2) 2 thematic roles: ns 3 thematic roles: ns	(exp. 2) ns	(exp. 2) ns	
	14 (exp. 3)	14 (exp. 3)	75 (exp. 3)	75 (exp. 3)	(exp. 3) 2 thematic roles: c > pwAD ^a 3 thematic roles: c > pwAD ^a			
Kim & Thompson, 2004	14	10	77	70	Grammaticality judgment: c > pwAD ^a	Grammaticality: ns		
Comprehension of transitivity								
Study	Number of participants		Mean age		Task type	Between groups (verb type)	Within groups	
	pwAD	Control	pwAD	Control			pwAD	Control

Grossman & White-Devine, 1998	22	17	74	72	Offline	Transitive: c > pwAD Causative: c > pwAD	Transitive: active, passive > periphrastic frame Causative: periphrastic > passive frame	
Kempler et al., 1998	11	9	81	77	Online	Transitive and intransitive: ns		
Bickel et al., 2000 (German)	7 7	7	70	71	Offline	Transitive: ns Intransitive: c > mo	Transitive > intransitive ^a	Intransitive > transitive ^a
Price & Grossman, 2005	15	17	76	73	Online	Transitive and intransitive: ns		

Comprehension of reversible thematic roles

Study	Number of participants		Mean age		Reversible	Between groups		Within groups	
	pwAD	Control	pwAD	Control		Nonreversible	pwAD	Control	
Grober & Bang, 1995	22 (exp. 1)	22 (exp. 1)	83 (exp. 1)	79 (exp. 1)	(exp. 1) c > pwAD	(exp. 1) c > pwAD	(exp. 1) Nonreversible > reversible	(exp. 1) Other sentence types > passive reversible	
	34 (exp. 2)	22 (exp. 1)	82 (exp. 2)				Nonreversible > reversible		
Waters et al., 1998 ^b	12 (exp. 1)	12 (exp. 1)	82 (exp. 1)	81 (exp. 1)	1-verb sentences: ns		1-verb sentences: ns	ns	
	13 (exp. 1)	13 (exp. 1)	69 (exp. 1)	75 (exp. 3)			2-verb sentences: ns		

	13 (exp. 2) 14 (exp. 3)	2) 14 (exp. 3)	2) 75 (exp. 3)		2-verb sentences: c > pwAD			other answer choices > syntactic foils
Grossman & White-Devine, 1998	22	17	74	72	c > pwAD	c > pwAD		Nonreversible > reversible
Manouilidou et al., 2009 ^c	10	11 ec 49 yc	77	84 ec 18-25 yc		ec > pwAD (psych verbs) ec > pwAD (agentive verbs) ^d		Agentive verbs > psych verbs ec: Agentive verbs > psych verbs ^d

Comprehension of sentences in active and passive voices

Study	Number of participants		Mean age		Structure	Between groups Result	Within groups (active/passive)	
	pwAD	Control	pwAD	Control			pwAD	Control
Emery, 1985	20	20 ec 20 yc	80	83 ec 36 yc	Active Passive	yc > ec > pwAD		
Rochon et al., 1994	23	23	71	71	Active Passive	ns ns	ns	
Waters et al., 1995	14	14	70	70	Active Passive	ns ns	ns	ns
Grober & Bang, 1995	22 (exp. 1) 34	22 (exp. 1)	83 (exp. 1) 82 (exp. 2)	79 (exp. 1)	Active Passive	(exp. 1) c > pwAD ^a (exp. 1) c > pwAD ^a	(exp. 1) ns	(exp. 1) Active > passive ^a

Study	(exp. 2)		Mean age		Structure	Between groups	(exp. 2) Active > passive	
	pwAD	Control	pwAD	Control			Result	pwAD
Waters et al., 1998 ^b	12 (exp. 1)	12 (exp. 1)	82 (exp. 1)	81 (exp. 1)	Active	ns		
	13 (exp. 2)	13 (exp. 2)	69 (exp. 2)	71 (exp. 2)	Passive	ns	ns	ns
Kempler et al., 1998	30	23	76	75	Active	c > pwAD	Active > passive	ns
					Passive	c > pwAD		
Grossman and White-Devine, 1998	22	17	74	72	Active	c > pwAD	ns	
					Passive	c > pwAD		
Bickel et al., 2000 (German)	7	7	70	71	Active	c > mo	ns	ns
	7				Passive	c > mo		
Manouilidou et al., 2009 ^c	10	11 ec 49 yc	77	84 ec 18-25 yc	Active	ns	ns	ns
					Passive	ns		

Comprehension of other noncanonical structures

Study	Number of participants		Mean age		Structure	Between groups	Within groups (canonical/noncanonical)	
	pwAD	Control	pwAD	Control			Result	pwAD
Rochon et al., 1994	23	23	71	71	Cleft construction with relative clause	c > pwAD	ns	

					Centre-embedded relative	c > pwAD	Noncanonical > canonical	
					Cleft construction with relative clause	ns	ns	ns
Waters et al., 1995	14	14	70	70	Centre-embedded relative	c > pwAD	ns	ns
	12 (exp. 1)	12 (exp. 1)	82 (exp. 1)	81 (exp. 1)	Cleft construction with relative clause	(exp. 1) c > pwAD ^a (exp. 2) ns (exp. 3) c > pwAD ^a	(exp. 1) ns (exp. 2) ns	(exp. 1) ns (exp. 2) ns
Waters et al., 1998 ^b	13 (exp. 2)	13 (exp. 2)	69 (exp. 2)	71 (exp. 2)	Centre-embedded relative	(exp. 1) c > pwAD ^a (exp. 2) c > pwAD (exp. 3) c > pwAD ^a	(exp. 1) ns (exp. 2)	(exp. 1) ns (exp. 2) ns
	14 (exp. 3)	14 (exp. 3)	75 (exp. 3)	75 (exp. 3)	Centre-embedded relative		Noncanonical > canonical	
Bickel et al., 2000 (German)	7	7	70	71	Centre-embedded relative	c > mi, mo		
	7				OVS word order	SVO: c, mi > mo OVS: c > mo	ns	ns
Manouilidou et al., 2009 ^c	10	11 ec 49 yc	77	84 ec 18-25 yc	Psych verbs	Agentive: ec > pwAD ^d Subject-experiencer: c > pwAD Object-experiencer: c > pwAD	Agentive > Subject-experiencer > Object-experiencer	

Comprehension by number of verbs in sentence

Study	Number of participants		Mean age		Two-verb sentence types	Between groups	Within groups	
	pwAD	Control	pwAD	Control			pwAD	Control

Emery, 1985	20	20 ec 20 yc	80	83 ec 36 yc	Infinitival clause, finite dependent clause	Two verbs: yc, ec > pwAD		
Rochon et al., 1994	23	23	71	71	Conjoined, relative clause	One verb: ns ^e Two verbs: c > pwAD	One verb > two verbs ^e	
Waters et al., 1995	14	14	70	70	Conjoined, relative clause	One verb: ns Two verbs: c > pwAD	One verb > two verbs	ns
Kemper, 1997	20	20 ec 20 yc	69	69 ec 21 yc	Relative clause, finite dependent clause ^f	Two verbs: yc > ec > pwAD		
Waters et al., 1998 ^b	12 (exp. 1)	12 (exp. 1)	82 (exp. 1)	81 (exp. 1) 71 (exp. 2) 75 (exp. 3)	Conjoined, relative clause	(exp. 1) One verb: ns Two verbs: c > pwAD	One verb > two verbs	One verb > two verbs
	13 (exp. 2)	13 (exp. 2)	69 (exp. 2)			(exp. 2) One verb: ns Two verbs: c > pwAD	One verb > two verbs	ns ^e
	14 (exp. 3)	14 (exp. 3)	75 (exp. 3)			(exp. 3) One verb: c > pwAD ^a Two verbs: c > pwAD ^a		
Kempler et al., 1998	30	23	76	75	Relative clause	One verb: c > pwAD Two verbs: c > pwAD	One verb > two verbs ^e	
Grossman & White- Devine, 1998	22	17	74	72	Infinitival clause	One verb: c > pwAD Two verbs: c > pwAD	Transitive: One verb > two verbs Causative: mixed ^g	

Grossman & Rhee, 2001	17	12	71	66	Relative clause	Mixed ^g
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Notes:

yc = younger controls, ec = elderly controls, mi = mild AD, mo = moderate AD

X > Y indicates better performance for X compared to Y

ns = differences were not significant

^a Significance not reported.

^b This study reports the results of 3 experiments. Data used for one task were a subset of data from the Rochon et al. (1994) study. Where results are not reported by experiment, they are true for each experiment that addressed a given measure.

^c Younger controls performed with high accuracy and were not considered in advanced comparisons.

^d Results differed in participant and item analyses.

^e There were exceptions to this overall finding depending on sentence type.

^f Clause types were combined for analysis.

^g Results were mixed depending on properties of sentences.

comprehension difficulties in AD. Overall, these results suggest no noticeable decline for pwAD in comprehending sentences based simply on the number of arguments around a verb.

Four studies considered verb transitivity, whether a verb takes a direct object (e.g., *eat cake*), as a factor in sentence comprehension. These studies used both online and offline tasks—respectively, tasks measuring implicit (e.g., reaction times following grammatical errors on a reading task) or explicit (e.g., asking participants to judge correctness of grammar) judgments of language. Offline tasks may introduce working memory confounds, such as the need to hold a sentence in mind while choosing from multiple pictures (Kempler et al., 1998). Three studies found no significant difficulty for pwAD in comprehending transitive sentences in either online (Kempler et al., 1998; Price & Grossman, 2005) or offline (Bickel et al., 2000) tasks. Indeed, Bickel et al. reported that transitive structures were the easiest for their moderately impaired AD group to comprehend. Grossman and White-Devine (1998), by contrast, found pwAD to have significant difficulty with transitive structures compared to controls in an offline task. Comparing comprehension of transitive versus causative (e.g., *drown*, as in *John drowned the swimmer*) verbs across sentence frames, they also found that within the AD group, performance by verb type was dependent on the sentence frame. Comprehension was better for transitive verbs in active and passive frames but for causative verbs in periphrastic frames that make explicit the thematic roles surrounding a causative verb—e.g., *John made the swimmer drown* rather than *John drowned the swimmer*. These findings are in line with others (Grossman et al., 1996; Kemper, 1997) suggesting impaired sentence comprehension by pwAD involves not syntax alone but also the semantics of the verb, or the syntax-semantics interface.

Three transitivity studies (Bickel et al., 2000; Kempler et al., 1998; Price & Grossman, 2005) assessed comprehension of intransitive structures (e.g., *I ran*). However, only Bickel et al. (2000) reported results in a way allowing for meaningful conclusions to be drawn regarding their comprehension. These authors found that people with moderate but not mild AD had greater difficulty than controls with intransitive structures. In contrast to controls, both groups of pwAD had

more trouble with intransitive than simple transitive structures. This is somewhat surprising, since intransitive structures involve fewer arguments, and lends support to the findings above that number of arguments does not affect comprehension by pwAD.

Four studies assessed comprehension of verbs around which thematic roles could be reversed—e.g., *Jake loves Anna / Anna loves Jake*. Each found pwAD to have difficulty with these as compared both to controls and to nonreversible verbs—e.g., *Jake eats pizza* but not *Pizza eats Jake*. In three studies (Grober & Bang, 1995; Grossman & White-Devine, 1998; Manouilidou et al., 2009), these difficulties were present for one-proposition sentences. Differing explanations were given as to the cause of the impairment. Grossman and White-Devine (1998) argued that pwAD had problems with reversibility due to cognitive and semantic deficits including failure to appreciate selection restrictions, semantic rules as to who can perform an action. The authors viewed similar comprehension of active and passive structures by pwAD (see below) as evidence against syntactic impairment. In contrast, Grober and Bang (1995) theorized that while comprehension of nonreversible structures relies on lexical-semantic knowledge of words and the world, comprehension of reversible structures relies on surface syntactic cues. Because pwAD comprehended nonreversible better than reversible sentences and were aided by elimination of working memory confounds for nonreversible but not reversible sentences, these authors ruled out semantic and working- memory impairments in attributing the reversibility issues to a syntactic deficit. Results of Manouilidou et al. (2009) and Waters et al. (1998) support the latter interpretation that semantic or cognitive deficits do not contribute to impaired comprehension of reversible one-proposition sentences by pwAD. Utilizing psych verbs, which have similar meanings but reverse the order of nouns appearing around them (e.g., *I fear you* vs. *you frighten me*), Manouilidou et al. found evidence that pwAD understood the semantic content of stimulus sentences. Waters et al. reported no impairment for one-proposition sentences on sentence-picture matching tasks. They found comprehension of two-proposition sentences impaired in the presence of syntactic foils, which reverse the thematic roles of nouns in the picture. The authors attribute these findings to the

increased memory demands of holding a two-proposition sentence in mind while analysing pictures (see below for findings on comprehension of two-proposition sentences by pwAD).

Nine studies investigated comprehension of noncanonical structures. The canonicity of thematic roles in a language is essentially their default order in relation to a verb, as seen in the language's most basic clause type. In English, canonical argument realization is seen in the simple transitive sentences discussed above (e.g., *I eat cake*). Thematic roles are noncanonical when they do not appear in this expected order. A common example is the passive voice (e.g., *Cake is eaten by me*). Each of the nine studies assessed comprehension of passive structures, with mixed results as to whether pwAD were impaired compared to controls in their comprehension. Eight studies also assessed comprehension of canonical active structures. In these studies, groups of pwAD were found impaired compared to controls either for both structures or for neither. Bickel et al. (2000), who divided AD groups by severity, reported that a mild group did not differ from controls in comprehending either structure, while a more impaired group was impaired for both. Within-group comparisons generally indicate no effect of voice on sentence comprehension by pwAD or controls. Where an effect was found (Grober & Bang, 1995; Kempler et al., 1998), performance was always significantly better for active than passive sentences. However, overall findings are inconclusive on the benefits of avoiding passive structures when communicating with pwAD.

Five studies assessing comprehension of other noncanonical structures generally support the conclusion that deviations from canonicity do not cause comprehension difficulties for pwAD. Three studies assessing comprehension of cleft constructions with relative clauses (e.g., *It was the dog that the horse passed*) reported mixed results on whether pwAD had trouble compared to controls but consistently found no greater difficulty with these than with canonical sentences. Four studies found comprehension of centre-embedded relative clauses (e.g., *The dog that the pig followed touched the horse*) by pwAD impaired compared to controls. However, this was likely due to the presence of multiple verbs rather than deviation from canonical word order (Rochon et al., 1994; Waters et al., 1995; Waters et al., 1998), particularly given that pwAD were at times found to

comprehend these better than canonical sentences with multiple verbs (Rochon et al., 1994; Waters et al., 1998). A moderately but not a mildly impaired group of pwAD erred more than controls in comprehending grammatical active structures in both canonical subject-verb-object (SVO) and noncanonical OVS orders (Bickel et al., 2000). There were no within-group differences across structures, further implying canonicity is not a main contributor to comprehension difficulty. On a sentence completion task involving the use of canonical agentive—i.e., simple transitive and intransitive—and noncanonical psych verbs, which express similar information but entail reversal of the order of arguments around them (e.g., *fear/frighten*), pwAD had significantly greater difficulty with psych than agentive (i.e., transitive) verbs (Manouilidou et al., 2009). They had greater difficulty with psych verbs deviating from canonical expectations in two ways (object-experiencer verbs) than those doing so in just one (subject-experiencer verbs). Because pwAD erred most often by selecting psych verbs that reversed the thematic roles of target verbs, the authors concluded that pwAD had exhibited retained understanding of semantic content but impaired understanding of thematic role assignment. This argument is in line with findings on comprehension of reversible structures discussed above. Overall, findings on comprehension of noncanonical structures by pwAD suggest that failures to understand these structures are likely attributable to factors other than their syntactic deviations from canonicity.

Eight studies assessed the comprehension of two-verb sentences by pwAD, with seven comparing their performance to that of controls. Five studies compared the comprehension of sentences with two verbs to those with just one. While between-group comparisons for one-verb sentences were mixed, pwAD were always found impaired compared to controls in comprehending two-verb sentences. This included difficulties with each of four sentence types studied—those including relative clauses, other finite clauses, infinitival clauses, or two simple transitive verb phrases associated with the same subject, connected using *and* (e.g., *The elephant followed the lion*

and pulled the dog.). Within groups, pwAD were generally better at comprehending one- than two-verb sentences, though in one study this was found to depend on the branching direction of dependent clauses (Grossman & Rhee, 2001) and in another on combinations of sentence frames and verb types (Grossman & White-Devine, 1998). Overall, studies of two-verb sentence structures indicate that pwAD are impaired in their comprehension of these structures regardless of specifics of the sentence. This is believed to stem from deficits related to aspects of cognition such as memory rather than to syntactic processing deficits (Grossman & Rhee, 2001; Kemper, 1997; Waters et al., 1998).

Overall, this research suggests that AD leads to syntactic, semantic, and cognitive declines that impair processing of verbs and actions, which contributes to difficulties with sentence comprehension. Findings generally indicate that comprehension of sentences by pwAD is not affected by argument structures of verbs. pwAD most often did not differ from controls in comprehending either two- or three-argument sentences and, within groups, did not differ in their comprehension of these sentences. They differed from controls in comprehending transitive structures only when factors related to memory or sentence frames were manipulated. pwAD who had issues comprehending passive structures also had issues with active structures, suggesting that syntactic manipulation of the order of thematic roles does not lead to comprehension issues. However, pwAD were consistently impaired in comprehending sentences whose verbs did not semantically restrict thematic roles of nouns. Grober and Bang (1995) argued that comprehension of reversible sentences is reliant on syntactic analysis, such that failure to comprehend these sentences is indicative of a syntactic deficit. Other researchers appear to agree with this view, as evidenced in their use of reversible sentences to force syntactic analysis on sentence-picture matching tasks (Bickel et al., 2000; Kempler et al., 1998; Rochon et al., 1994; Waters et al., 1995; Waters et al., 1998).

There is evidence here, however, that semantic and cognitive impairments related to verbs also contribute to sentence comprehension issues in AD. pwAD had more difficulty comprehending sentences with two verbs than one, commonly seen to result from memory deficits. pwAD were also found to have trouble comprehending verbs whose semantic properties result in noncanonical argument order (Manouilidou et al., 2009) and verbs with specific semantic properties in specific sentence frames (Grossman et al., 1996; Grossman & White-Devine, 1998). These findings suggest that not all sentence comprehension deficits in AD can be attributed neatly to issues with semantics or syntax. Deficits may instead result from declines in understanding the interrelationship between these language domains or in the cognitive abilities involved in its processing.

2.3.2.2 Production of verbs in phrases or sentences

Three studies compared the production of phrases or sentences by pwAD and healthy controls (Table 2.4). Tasks involved only repetition or paraphrasing, with no generation of complete sentences by pwAD.

Effects of AD on syntactic production were investigated in one sentence repetition study (Small et al., 2000). pwAD were found to repeat sentences less accurately than controls overall. This included less accurate repetition of all sentence types except passives, for which the groups were not significantly different. Findings were mixed on whether pwAD repeated otherwise matched canonical sentences more accurately than noncanonical ones—they repeated passives more accurately than actives, but in sentences with relative clauses, there was an interaction between canonicity and branching direction. The number of verbs in a sentence did not significantly affect repetition. Strong correlations were found between repetition ability and measures of working memory; however, due to sample size, these were not broken down by group.

Table 2.4

Sentence Production

Study	Measure	Number of participants		Mean age		Between groups	Within groups	
		pwAD	Control	pwAD	Control		pwAD	Control
Small et al., 2000	Canonicity in repetition	13	20	72	75	Passive: ns Other: c > pwAD	Passive > active Other: interaction ^b	
	Number of verbs in repetition						ns	
Bayles et al., 1996	Meaningfulness and length in repetition (cross-sectional)	24 mi 33 mo	52	78 mi 80 mo	69	All phrase types: c > mi > mo	mi: short & long, meaningful > long improbable > long meaningless phrases Other > long, meaningless phrases	
	Meaningfulness and length in repetition (longitudinal)	15					mo: short meaningful > other short > other long > long meaningless phrases	
Kim & Thompson, 2004	Sentence rephrasing	14	10	77	70	c > pwAD	Short > other long > long, meaningless phrases Heavy > light (ns) General > specific Simple > complex ^a Heavy > light Specific > general (ns) Complex > simple ^a	

Notes:

mi = mild AD, mo = moderate AD

X > Y indicates better performance for X compared to Y

ns = differences were not significant

^a Significance not reported.

^b This study distinguished between one-verb sentences (active, passive) and two-verb sentences. The latter included relative clauses in two locations. Effects of canonicity in repetition depended on the location of the relative clause.

The role of semantics in phrase and sentence production by pwAD was investigated in two studies, one involving repetition and the other rephrasing. Together, their findings suggest that degradation or loss specifically of the semantic representations of advanced verbs—as opposed to broad semantic decline—may negatively affect sentence production in mild to moderate AD. Bayles et al. (1996) found that controls and people with mild and moderate AD had more difficulty repeating long, meaningless phrases than phrases of other types. This led them to conclude that pwAD appreciated meaning no less than controls. The authors also concluded that AD does not lead to progressive loss of conceptual knowledge, since pwAD were more accurate in repeating meaningful than meaningless stimuli both cross-sectionally and longitudinally. The inconsistency of this finding of preserved semantic knowledge with broader findings of the present review is of particular interest considering a confound present in the study: pwAD were better at repeating all short phrases without verbs than all longer phrases with them, meaning that in addition to length, the presence or absence of a verb may also have affected performance. Kim and Thompson (2004), by contrast, identified semantic issues when assessing people with mild to moderate AD on the ability to rephrase sentences using semantically simpler or more complex verbs. pwAD paraphrased correctly only about half the time, compared to nearly 90% for controls. While controls showed an advantage for use of specific over general verbs and erred most often by substituting complex for simple verbs, pwAD demonstrated an advantage for general verbs and erred most often by substituting simple for complex targets (e.g., *make* in place of *bake*). The authors hypothesized that this was caused by bottom-up degradation or loss of semantic features of verbs—pwAD cannot access a more specific verb and instead a related but less specific one is retrieved. Like findings of effects of frequency and AoA on task performance by pwAD (e.g., Paek & Murray, 2021; Rodríguez-Ferreiro et al., 2009; Wakefield et al., 2014), this supports the hypothesis that semantic decline in pwAD relates to learning history and degree of processing difficulty.

2.3.2.3 Conclusions from studies of phrases and sentences

Results of these studies indicate that pwAD are impaired in their comprehension of sentences. Findings suggest that verbs play a central role in comprehension deficits due to the syntactic, semantic, and cognitive demands they impose. Comprehension studies suggest pwAD have little difficulty with verbs' argument structures, but where these difficulties are present, they arise from syntactic impairments in identifying the roles of nouns around a verb or effects of verb semantics on argument placement. Syntactic and semantic effects may interact, as pwAD demonstrate difficulty comprehending combinations of verbs and sentence frames. pwAD have consistent difficulty comprehending two-verb sentences, likely due to the demands placed on memory.

Little can be reported here on the production of sentences by pwAD. Syntax in sentence production was investigated only in one repetition study, which produced inconclusive findings on syntactic effects. Two studies of semantics in production by people with mild to moderate AD suggest a degradation in representations of advanced or specific verbs. Because these three studies involved repetition or rephrasing, it is important to note that working memory likely played a role in their findings. This review recommends that all future studies of repetition or rephrasing by pwAD account for this possibility. Overall, more evidence is needed before conclusions can be drawn on how verb impairments contribute to sentence production issues in pwAD. Specifically, studies are needed of the spontaneous generation of full sentences by pwAD.

2.3.3 Discourse studies

Thirteen studies identified for review reported on the production of verbs or descriptions of actions in discourse. In eight of these studies, participants were assessed in English. Other languages studied were French, German, Hebrew, and Brazilian Portuguese. A table is not included in this section due to the lack of uniformity in research questions and methods of investigation.

2.3.3.1 Discourse comprehension

No studies of discourse comprehension were identified for review.

2.3.3.2 *Discourse production*

Thirteen studies examined the use of verbs, descriptions of actions, or both in discourse produced on a range of tasks including descriptions of pictures or videos, story retellings, and spontaneously produced monologues or dialogues.

Findings from five studies reporting on descriptions of the Cookie Theft picture generally found that descriptions by pwAD lacked content compared to those of controls. This included the production of fewer information units, words, and syllables (Ahmed et al., 2013; Croisile et al., 1996; Kavé & Dassa, 2018; Zraick et al., 2011). pwAD produced fewer information units and content words even in speech samples that did not differ from those of controls in speech rate or duration and included equal or greater numbers of words (Ahmed et al., 2013; Kavé & Dassa, 2018). pwAD exhibited word-finding issues in two studies (Croisile et al., 1996; Kavé & Dassa, 2018), with Kavé and Dassa (2018) tying this to increased pronoun use, decreased type-token ratio (TTR, a measure of lexical diversity), and greater reliance on high-frequency words. By contrast, Faroqi-Shah et al. (2020) reported no differences between pwAD and controls on measures of word retrieval including lexical diversity. Collectively these studies suggest that the description of actions is not disproportionately impaired in AD. In Ahmed et al. (2013) and Croisile et al. (1996), pwAD produced fewer references to actions, but also to subjects and objects, than controls; Zraick et al. (2011) found no statistically significant differences between the groups for references of any type. By word class, findings of the use of fewer of both nouns and verbs by pwAD than controls (Ahmed et al., 2013; Croisile et al., 1996) appeared to result from decreased overall production, as the groups did not differ in noun-verb ratio or percent of words that were verbs (Croisile et al., 1996; Kavé & Dassa, 2018). Grammatically, while Croisile et al. found pwAD to produce fewer subordinate clauses than controls, the groups generally did not differ in terms of syntactic complexity or numbers of errors committed (Croisile et al., 1996; Faroqi-Shah et al., 2020; Kavé & Dassa, 2018).

Findings on grammar from a tightly controlled discourse situation involving descriptions of actions in videos (Bates et al., 1995) largely supported those from picture descriptions. Here, pwAD were found able to use complex multi-verb sentences but more likely than controls to report the same information using short, simple sentences. A similar phenomenon was noted in older versus younger controls, though pwAD produced a narrower range of syntactic structures than either group. They were able to produce well-formed passives but used them less than controls, doing so more often to describe videos meant to elicit active structures and less often for videos meant to elicit passives. Unlike controls but similarly to children, pwAD here preferred passives with *get* rather than *be*. Despite these group differences, the authors argue that pwAD exhibited retained awareness of the passive structure's pragmatic purpose—topicalization—and effectively used alternative active structures to accomplish this purpose. In terms of content, increased age and AD were found to lead to increasingly vague descriptions that relied heavily on pronouns and, in pwAD, increases in lexical selection errors and the use of *do* to substitute for verbs (e.g., “A hit B, and C did too”). pwAD were also less likely than controls to describe two relevant events when expected to. The authors concluded that language produced by pwAD exhibits lexical and grammatical deficits characterized not by overt errors but by a reliance on high-frequency forms that are sometimes off-target. This conclusion is consistent with findings of effects of word frequency on performance by pwAD in naming tasks (see section 3.1.2) and of reliance on simple, non-specific verbs in sentence production (Kim & Thompson, 2004).

Issues with the lexical forms produced by pwAD were also cited in the reporting of results from a story retelling task and a second video description task. Kim and Thompson (2004) found that pwAD produced fewer verbs than controls in retellings of the Cinderella story, committing more errors with three-argument than one-argument verbs, and that these verbs were not as semantically complex as those produced by controls. This was due primarily to an overreliance on *be*. Age and/or education may have contributed to these findings, as controls were matched to a group of people with aphasia and were significantly younger and more educated than pwAD. The findings led the

authors to hypothesize that verb production deficits in AD stem from bottom-up degradation or loss of semantic features of advanced verbs, leading to the activation of related but less specific ones. Rinaldi et al. (2008) similarly commented that their acceptance of a wide range of descriptions, including ones using generic verbs, along with their use of familiar target actions, may have facilitated success by pwAD in describing actions seen in videos. This study also included a story retelling task, examining relationships between retelling and abilities to describe actions and paraphrase these descriptions. Significant differences were not found between controls and AD groups in describing or paraphrasing. However, pwAD retold stories less accurately than controls, with a moderate group less accurate than a mild. A correlation between action paraphrasing and story retelling led the authors to suggest that story retelling difficulties in pwAD may relate to the working memory demands of retrieving words to formulate an accurate description of a completed action.

Two studies (Blanken et al., 1987; Lyons et al., 1994) analysed spontaneous speech produced by pwAD in semi-structured interviews. As above, each reported intact syntactic abilities in spontaneous production—pwAD maintained the ability to formulate long, complex sentences with multiple verbs. In contrast to controls, though, they tended to spread the same information over multiple simpler sentences, a tendency that Lyons et al. attribute to general cognitive decline. Both studies found that pwAD committed few errors when inflecting verbs or nouns. Findings differed, however, on the quantity of words used by word class. Blanken et al. report that pwAD used fewer nouns but more verbs and adverbs than controls, while Lyons et al. found that people with mild AD used fewer main verbs and people with very mild AD fewer secondary verbs than controls. Across studies, pwAD did not differ significantly from controls in overall (TTR) (Lyons et al., 1994) but did so for TTRs of both nouns and verbs (Blanken et al., 1987). Word retrieval was found neither to be an issue itself (Blanken et al., 1987) nor to be predictive of issues (Lyons et al., 1994) in spontaneous speech by pwAD. Blanken et al. conclude that language disturbances in pwAD exist largely at a higher, pragmatic-conceptual level and affect the content of communications. This latter conclusion

is supported by the Lyons et al. finding of reduced propositional content in utterances by pwAD, which correlated significantly but not strongly with dementia severity.

Relationships between pragmatics and communicative content were further examined in an investigation of speech dysfluencies as indicators of retrieval issues in spontaneous speech (Gayraud et al., 2011). pwAD were found to produce more silent pauses, lengthenings, and hesitations, but not more turn-preserving filled pauses, than controls. Evidence of retrieval issues was also present, including reliance by pwAD on words of higher frequencies after silent pauses. These findings were not broken down by word class. However, pwAD did not pause significantly more than controls before producing verbs, suggesting no differences between the groups in verb retrieval. Instead, pauses increased before the production of adjectives by pwAD and nouns by controls. The authors concluded that decreased total output by pwAD may relate to reduced turn-taking abilities, including the failure to use filled pauses to hold the floor while experiencing retrieval issues.

Decreases in total output and sentence complexity were tied to longitudinal decreases in the use of cohesive devices by pwAD in a study of speech in semi-structured dialogue (Ripich et al., 2000). Cohesive devices include ellipsis, the omission of presupposed information that is unnecessary for understanding an utterance, such as the verb and subject “Do you” in asking “Want some tea?” At baseline, pwAD were found not to differ from controls in omitting verbs to create cohesion. They committed more cohesion errors overall but no more ellipsis errors than controls. However, the use of ellipsis by pwAD declined significantly over 18 months. The authors conclude that these decreases in output, sentence complexity, and cohesion are related and contribute to decreased conversational coherence as AD progresses.

Finally, Sajjadi et al. (2012) analysed discourse produced by pwAD using both picture descriptions and semi-structured interviews. Here, too, syntactic complexity was decreased in the speech of pwAD vs controls. This included the use of fewer arguments per verb. However, again, these reductions were not accompanied by more grammatical errors. Comparing performance

across tasks, pwAD were found to commit more verb agreement errors in picture descriptions than interviews. They also used more closed-class words, or function as opposed to content words, on picture descriptions. Between groups, pwAD committed more semantic errors than controls on picture descriptions but not in interviews. These findings indicate that picture descriptions may not accurately reflect the conversational abilities of pwAD. However, findings on information content generally reflected those discussed above in that pwAD uttered significantly more redundant words and phrases than controls. This would lead to a decrease in informative content by pwAD when using the same number of words as healthy controls.

2.3.3.3 Conclusions from discourse studies

The absence of studies of verb comprehension by pwAD in discourse is noteworthy. While the search strategy used here identified investigations of the comprehension of descriptions of actions, none explicitly considered comprehension of the verbs used in these descriptions. Study of verb comprehension in discourse is needed to determine how the significant impairments exhibited on word and sentence comprehension tasks may manifest in everyday communication.

Studies of the production of discourse by pwAD indicated declines in accuracy, content, and lexical-semantic skills. pwAD were less accurate than controls on these tasks, with memory likely contributing. The content of their discourse was marked by vagueness, including heavy reliance on simple, generic verbs such as *be* and *do* (Bates et al., 1995; Kim & Thompson, 2004), reductions in propositional content and total output, and the omission of relevant information. This included information on actions; however, pwAD were no more likely to omit information on actions than on people or objects. In spontaneous speech, indications that these changes to content may relate to lexical retrieval issues were mixed (Gayraud et al., 2011; Blanken et al., 1987); however, pwAD consistently exhibited retrieval issues in more constrained tasks (Bates et al., 1995; Croisile et al., 1996; Kavé & Dassa, 2018). Considering this alongside findings from section 3.1.2 on production of single words and from Sajjadi et al. (2012) on differences across discourse tasks, it is possible that

pwAD are more likely to exhibit retrieval issues in situations where specific language is being solicited. By grammatical class, pwAD appear not to use proportionally fewer nouns or verbs than controls or to exhibit a selective processing impairment for either word class in discourse production tasks (Blanken et al., 1987; Croisile et al., 1996; Gayraud et al., 2011). Syntactically, pwAD committed more errors in producing verbs with three arguments than those with one (Kim & Thompson, 2004) and used fewer arguments per verb (Sajjadi et al., 2012). Otherwise, they committed few grammatical errors and did not appear to differ from controls in their ability to produce complex grammatical structures, including passives and sentences with multiple clauses. However, pwAD appear to prefer simpler structures. Despite these changes to the content and form of language produced in discourse, pwAD reportedly maintained pragmatic skills associated with effective communication, including appropriate use of topicalization (Bates et al., 1995) and repetition (Blanken et al., 1987) and slower decline in cohesion than semantic skills (Ripich et al., 2000). However, reductions in total output may relate to declining turn-taking ability (Gayraud et al., 2011).

2.4 Discussion

The aim of this systematic review was to synthesize findings on verb comprehension and production in mild to moderate AD. Fifty-seven studies were identified and categorized according to a focus on single words (n=31), phrases and sentences (n=16), or discourse (n=13), with three studies falling into multiple categories. pwAD were less accurate than controls at comprehending and producing individual verbs and nouns. During naming and word-picture matching tasks they exhibited greater impairments for verbs than nouns, and they were more impaired in naming verbs than matching them to pictures (White-Devine et al., 1996). pwAD did not comprehend sentences as well as controls, with findings implicating failures to process verbs or the actions they describe. The comprehension of simple transitive structures by pwAD was largely unimpaired, and their sentence comprehension was unaffected by differences in the number of thematic roles around a verb or syntactic deviations from canonicity. However, pwAD had difficulty comprehending sentences with

two verbs or a single verb whose semantics allowed nouns around it to be transposed. They were also less accurate than controls on production tasks requiring the repetition or rephrasing of phrases and sentences, demonstrating a reliance on semantically simple verbs when rephrasing. Discourse production studies found declines in accuracy and content and, again, increased reliance on simple verbs. Syntactic structures produced by pwAD in discourse tended to be simpler than those of controls despite intact ability to produce complex structures. Overall, these findings reveal an effect of AD on the comprehension and production of verbs that contributes to language and communication deficits.

These findings, along with those of a prior review on inflectional morphology in AD and PPA (Auclair-Ouellet, 2015), highlight the need for studies into effects of neurocognitive disorders on language and communication. Consistent with findings here on sentence comprehension, Auclair-Ouellet reports that factors unrelated to syntax may contribute to findings that seemingly suggest declining syntactic comprehension by pwAD. There, pwAD were impaired more often in offline tasks, those requiring explicit processing, than in online tasks involving implicit processing. This was also seen in studies of sentence comprehension here, specifically of transitivity (see section 3.2.1 and Table 2.3). Studies that included both task types (Grossman & Rhee, 2001; Kempler et al., 1998) found performance across them not to correlate, and a wider body of literature has indicated that offline tasks tend to suggest greater language declines than are found in online tasks (Kempler et al., 1998). This is likely due to task-related resource demands, including demands on working memory (Kempler et al., 1998; Price & Grossman, 2005).

Regarding production, Auclair-Ouellet reports that pwAD had difficulty producing irregular past tense verb forms, particularly infrequent ones, with regular forms spared. Competing psycholinguistic theories have been advanced to explain such findings. One possible dualistic theory sees both procedural (implicit) and declarative (explicit) memory systems to be involved in verb inflection. Knowledge of regular verb forms relies upon procedural, or rule-based, memory, and

knowledge of irregular forms—which are arbitrary and not rule-based—on declarative memory (Ullman et al., 1997). The poor performance by pwAD in inflecting irregular verbs could thus be attributed to impairments in declarative memory, including lexical-semantic skills; the spared knowledge of regular verbs results from intact procedural memory. An alternative single-mechanism theory has it that lexical-semantic skills, and thus declarative memory, are involved in the production of all past tense forms. Here it is not a basis in rules but frequency of inflectional patterns and overlap with present tense forms that is believed to aid in production of regular past tense forms (Joanisse & Seidenberg, 1999). Their basis in rules is only relevant in that rules create the overlap and frequency necessary to facilitate production of these forms. The production of irregular forms, which tend to overlap minimally with present forms and to involve uncommon inflectional patterns, relies less on lexical skills and more on the semantic skills necessary to associate arbitrary form with meaning. The two theories agree in attributing impaired production of irregular past tense forms by pwAD to declarative memory impairments. However, whether preservation of regular forms is attributable to overlap and frequency, and thus also declarative memory, or to a basis in rules and thus procedural memory remains a topic of current debate.

The current review aimed to provide an overview of verb processing by considering both comprehension and production at single word, sentence, and discourse levels. Its findings have further implications for theories on roles of memory in language processing and how they relate to pwAD. In line with the patterns of memory loss characteristic of AD, factors associated with declarative memory featured prominently in findings of semantic declines in people with mild to moderate AD. Word frequency (Beber et al., 2015; Paek & Murray, 2021; Rodríguez-Ferreiro et al., 2009) was found to affect word knowledge, as was AoA (Paek & Murray, 2021; Rodríguez-Ferreiro et al., 2009). Greater overlap among semantic networks for nouns (Bushell & Martin, 1997; Grossman et al., 1996) and differences in age of acquisition of the word classes (Wakefield et al., 2014) have been cited as factors contributing to better performance with nouns than verbs. Semantic declines are also reflected in the choice of verbs used by pwAD in discourse. Kim and Thompson (2004)

report heavy reliance on “light” verbs, a set of simple verbs including *be*, in a story retelling task. They point out that these verbs often serve as core primitives in semantic representations of more complex verbs. This use of simple, generic words likely plays a role in perceptions, and indeed findings, that speech produced by pwAD is vague and uninformative (e.g., Appell et al., 1982; Croisile et al., 1996; Lyons et al., 1994). Together, these findings support a model of semantic growth advanced by Steyvers and Tenenbaum (2005) in which frequency, AoA, and connectedness in the semantic network affect memory for words. This model suggests that the time at which a word enters the semantic network—its age of acquisition—interacts with factors such as frequency to determine the number of connections it will form and thus the likelihood of its retrieval.

In contrast to these semantic declines, findings here indicate relative preservation of grammatical processing in mild to moderate AD. Studies of lexical acquisition demonstrated that pwAD were better able to learn the grammatical than the semantic properties of newly acquired words (Grossman et al., 1997; Grossman et al., 2007). Knowledge of syntax, the rules governing sentence formation, was also mostly intact. pwAD were generally able to comprehend (e.g., Rochon et al., 1994; Waters et al., 1995; Waters et al., 1998) and produce (Bates et al., 1995; Blanken et al., 1987; Lyons et al., 1994) simple and complex structures. While it is possible to explain syntactic and morphosyntactic processing in terms of AoA, frequency, and overlap, the argument has also been advanced that procedural memory governs these processes (Lee & Tomblin, 2015; Dominey, 1997). Thus, intact grammatical processing in mild to moderate AD may relate to the relative sparing of procedural memory in these disease stages.

Where sentence comprehension was compromised, semantic processing of verbs and the arguments they entail likely played a role. The most consistent finding of syntactic impairment in pwAD was in the comprehension of reversible structures. While comprehension of these structures is most often seen to rely on syntactic skills (e.g., Grober & Bang, 1995), it is the semantic features of the words involved that allows for reversal. This impairment can thus be interpreted as a semantic

issue (Grossman & White-Devine, 1998). Other findings of sentence comprehension difficulties can also be attributed directly to semantic properties of verbs (Manouilidou et al., 2009) or to interactions between these properties and syntactic environments (Grossman et al., 1996).

These findings, then, indicate that declines in language processing in AD relate to learning history and its role in declarative memory. However, it remains possible that procedural memory contributes to processing of some aspects of language, either alone or in conjunction with declarative memory. If so, the extent to which a memory system is involved in processing an aspect of language may determine whether or when declines for that aspect of language appear in AD. Relationships between memory and language processing have implications for early diagnosis and interventions to preserve language and communication in people at risk or in the early stages of AD. Research into these relationships would do well to further examine the role of psycholinguistic factors such as AoA and frequency in not only lexical-semantic but also syntactic knowledge, as current understanding of their effects comes primarily from results of word-based tasks. Improved understanding of the role of declarative memory in both semantic and syntactic processing may help contribute to differential diagnosis between AD and PPA, where both memory and language are differentially affected depending on variant. Further work is also needed on the potential role of procedural memory in sentence processing. Related research should clarify potential interactions between structural and semantic aspects of language and the cognitive and neural resources that would be involved in processing language at this syntax-semantics interface. Together, these results would help clarify relationships between language, memory, and AD. Verbs should be a central focus of these investigations, given the multi-faceted processing demands they impose (Vigliocco et al., 2011). Furthermore, because memory and processing abilities decline as AD progresses, studies of memory and language should differentiate and report on AD groups by severity, in addition to providing information on participants' performance on both procedural and declarative memory tasks.

While findings on discrete language and cognitive abilities are valuable, it is the holistic use of language for communicative purposes that affects the social life and behaviour of the pwAD (Sabat, 1994). The behaviours of conversation partners can help minimize communication issues, thereby maintaining relationships and well-being (Kindell et al., 2017). As such, communication skills training for caregivers, including education on the communicative habits and needs of people with dementia, significantly improves quality of life for both parties. Unfortunately, caregivers often receive little training or support in how to communicate with pwAD (Eggenberger et al., 2013; Piersol et al., 2017). This is due in part to a lack of relevant empirical evidence on which to base communication training programs (Eggenberger et al., 2013; Surr et al., 2017). Only thirteen of 57 studies reviewed here presented findings from discourse. Results of this review are in line with those of individual studies (e.g., Palmer et al., 2019) indicating that performance on discrete language tasks is not necessarily indicative of communicative skill. Single-word studies, for example, found pwAD to be more impaired in naming actions or matching verbs to pictures than in naming objects or matching nouns to pictures. However, discourse-level studies suggest that pwAD are no more impaired in describing actions than people or objects in pictures and indicate better preservation of pragmatic than semantic skills. These findings underscore the need for studies of discourse to inform the design of communicative interventions for pwAD. They also necessitate investigation of whether the same participants exhibit intact discourse skills alongside impaired performance on discrete language tasks.

Similarly, it should be noted that discourse studies reviewed here focused predominantly on the generation of monologues, with only four presenting findings from dialogue and none from comprehension. Findings from monologues should not be used to draw conclusions on interpersonal communication. As Sajjadi et al. (2012) suggest, while there may be similarities for some aspects of language, performance across these modalities is not fully generalizable. Further comparison of conversation to monologues would clarify differences in performance by modality and establish aspects of language for which generalization may be justified. However, an increased emphasis on

the study of conversation is the best way to improve understanding of everyday communications involving pwAD. Given the greater processing difficulties associated with verbs than nouns, as well as indications in this review that AD affects the knowledge and use of verbs specifically, future discourse production studies should include analyses of the description of actions and the use of verbs by pwAD. Studies of discourse comprehension by pwAD are also greatly needed. No information was found on this, despite consistent findings of impairments for pwAD in comprehending single words and individual sentences. Results would inform advice given by communication specialists on effective communication with pwAD.

Finally, this review suggests that relatively little is known about how AD affects language in speakers of languages other than English. Only fourteen of the 57 studies involved languages other than English. These dealt with seven languages, primarily European. Limitation of the search to publications in English likely factored into this. However, given that language changes in AD may not be consistent across languages (Bates et al., 2001), further research into effects of AD on speakers of languages other than English is needed. This would broaden knowledge regarding language changes in AD and how AD interacts with properties of language not present in English. Similarly, none of the studies reviewed here reported on people who communicate in multiple languages. Knowledge of the effects of AD in these individuals is increasingly relevant in a world where a high proportion of individuals speak more than one language and in the context of both international mobility and ageing populations. Additional study is needed on the role of multilingualism in the preservation or loss of native language skills in AD. Given the apparent role of learning history in language changes, studies of AD's effects on the preservation or loss of aspects of non-native languages are also of interest.

This review has limitations of which the reader should be aware. Because the intention here was to give a comprehensive overview of verb use across levels of language processing, the review focused on breadth over depth. It did not, however, consider findings on writing by pwAD. The choice to include only findings based on comparisons to healthy controls may have resulted in the exclusion

of informative findings from comparisons to other populations or from exclusively within-group designs. It is again noted that limiting the search to English-language publications has weighted results toward effects of AD on native speakers of English. These findings may apply less consistently to pwAD who are native speakers of other languages or are multilingual. Despite its limitations, this review has highlighted consistencies in findings, directions for future research, and areas of focus for the development of diagnostic assessments as well as evidence-based interventions to benefit pwAD, their caregivers, and specialists working to address the communicative issues they face.

2.5 Conclusion

The aim of this systematic review was to bring together findings on the effects of mild and moderate Alzheimer's disease on comprehension and spoken production of verbs. Research into language impairments in pwAD has mainly focused on nouns, but verbs impose greater semantic processing demands due to both the richness of their meanings and the thematic roles they activate. As such, verbs may be particularly useful in identifying semantic decline, a hallmark of preclinical and early AD. Verbs also require greater syntactic processing demands and are more complex morphologically than nouns. It is therefore likely that any verb-related impairments in pwAD would contribute to communicative breakdowns. Studies reviewed here indicate that AD affects verbs in comprehension and production and at word, sentence, and discourse levels. Impairments for verbs seem to be driven by cognitive and semantic decline, indicating that a focus on verbs in cognitive and semantic assessments could lead to more effective early and differential diagnosis. These findings of verb impairments and their effects on communication can also guide the development of language interventions focused on preserving communicative participation by pwAD. This review's findings motivate the studies reported in Chapters 3 and 4 of this thesis, which examine POS use in spontaneous speech by older participants exhibiting varying levels of global cognitive ability. These participants include but are not limited to pwAD.

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CHAPTER 3. LEXICAL-SEMANTIC PROPERTIES OF VERBS AND NOUNS USED IN CONVERSATION BY PEOPLE WITH ALZHEIMER'S DISEASE

Keywords and Abstract

Keywords

Alzheimer's disease, nouns, verbs, word frequency, age of acquisition

Abstract

Introduction: Alzheimer's disease (AD) is accompanied by language impairments that may play a role in communicative breakdowns. Research into language processing by people with AD (pwAD) has focused largely on the production of nouns in isolation. However, impairments are consistently found in verb production at word and sentence levels, and comparatively little is known about word use by pwAD in conversation.

Methods: This study investigated differences between pwAD and cognitively healthy controls in conversational use of nouns, verbs, and pronouns. Speech samples of 12 pwAD and 12 controls appearing in the Carolinas Conversations Collection were analysed for noun, verb and pronoun counts and ratios, lexical diversity overall and among nouns and verbs, copula use, and frequencies and ages of acquisition (AoA) of nouns and verbs produced.

Results: pwAD used fewer nouns and a narrower range of words than controls, exhibiting increased reliance on pronouns. Age affected noun frequencies differently within each group—pwAD produced nouns of lower frequencies with age, a finding that may be reflective of the aggressive course of early-onset AD, while controls produced nouns of higher frequencies. pwAD were found to use nouns of higher AoA than controls; these results may reflect group differences in noun token counts. Verb use differed little by group.

Conclusions: These findings highlight the need to account for differences between nouns and verbs, including in frequency, AoA, proportion of words spoken, and context-dependent processing demands, when drawing conclusions on language use by pwAD. They also suggest potential for communicative interventions targeting contextual use of both nouns and verbs.

3.1 Introduction

Alzheimer's disease (AD) often results in communicative breakdowns that negatively impact on the person with AD (pwAD), caregivers, and society (El Haj et al., 2016; Reed et al., 2016). These breakdowns appear at least partially attributable to declining amounts of informative content in speech produced by pwAD. Related findings are detailed in Chapter 2 of this thesis, particularly in Section 3.3.2. To summarize, in connected speech, pwAD have been found to produce fewer words than controls, with total output decreasing as the disease progresses (Croisile et al., 1996; Ripich et al., 2000). In the speech they do produce, pwAD describe events less accurately, producing fewer information units than controls and thus omitting relevant information (Ahmed, Haigh, et al., 2013; Rinaldi et al., 2008; Bates et al., 1995). These declines in informative content have resulted in characterizations of spoken discourse by pwAD as vague or empty (Ahmed, Haigh, et al., 2013; Appell et al., 1982; Nicholas et al., 1985).

Knowledge of how specific lexical-semantic changes affect the informative content of speech produced by pwAD may help improve diagnosis and monitoring of the disease (Ahmed, Haigh, et al., 2013; Fraser et al., 2016). An improved understanding of the nature of communicative breakdowns can also facilitate interventions that improve communication between pwAD and their caregivers (Kindell et al., 2017; Ripich et al., 1999). Consensus findings from studies of single-word tasks reviewed in Chapter 2 suggest impaired production of both verbs and nouns by pwAD compared to controls. Those findings also suggest that within groups, pwAD tend to be less accurate with verbs than nouns. Impairments in discrete word production reflect effects of connectedness in the semantic network and contributing psycholinguistic properties (see Chapter 2 or Williams et al., 2021, as well as Steyvers & Tenenbaum, 2005). Word frequency and age of acquisition (AoA) are believed to influence semantic network development, and pwAD perform less accurately on naming tasks requiring retrieval of words that are less frequent or are acquired later in life (Rodríguez-Ferreiro et al., 2009). Better performance with nouns has been attributed to stronger relationships

within this word class; however, psycholinguistic effects are unclear, as verbs tend to be more frequent than nouns, but are acquired later in life (Mätzig et al., 2009; Steyvers & Tenenbaum, 2005).

Findings including those reviewed in Chapter 2 also demonstrate that lexical-semantic changes are apparent in discourse produced by pwAD. Consensus findings indicate that they produce more verbs and fewer nouns than controls in both picture descriptions and spontaneous speech (Fraser et al., 2016; Kavé & Dassa, 2018; Blanken et al., 1987; Bucks et al., 2000). Declines in quantities of nouns produced are accompanied by increased reliance on pronouns, which function as less specific noun substitutes (Bucks et al., 2000; Fraser et al., 2016; Kavé & Dassa, 2018). Findings from picture descriptions suggest that pwAD also use a less diverse range of words than controls in discourse (Fraser et al., 2016; Kavé & Dassa, 2018). These changes in reliance on words by part of speech (POS) and in lexical diversity are accompanied by changes in the psycholinguistic properties of words produced. In picture descriptions and story retellings, pwAD have been found to rely on simple, generic words including copulas and verbs and nouns of higher frequencies than those used by controls (Kim & Thompson, 2004; Kintz & Wright, 2022; Slegers et al., 2018). Findings on AoA have not indicated reliance on simpler words by pwAD (Fraser et al., 2016; Yeung et al., 2021). However, consensus findings on word use have led to suggestions that breakdowns in semantic representations of “advanced,” or less well-connected, verbs and nouns in AD lead to their replacement with easily accessible, more well-connected, but less specific alternatives (Fraser et al., 2016; Kim & Thompson, 2004). This process would result in frequent reuse of less advanced verbs and nouns and increased use of pronouns, suggesting that changes in POS reliance, lexical diversity, and psycholinguistic properties of words produced by pwAD are related (Fraser et al., 2016; Kavé & Dassa, 2018).

In everyday communication, this combination of changes would contribute to perceptions of speech by pwAD as uninformative, inaccurate, or vague. However, little information is available on

lexical diversity or psycholinguistic properties of words produced by pwAD in spontaneous speech. Where reported, these findings have rarely been broken down by POS. Findings on lexical diversity include just one report of reduced overall diversity ($n = 8$ pwAD) and one of reduced diversity among both nouns and verbs ($n = 10$ pwAD) (Bucks et al., 2000; Blanken et al., 1987). Despite the findings of effects of word frequency and AoA on performance in single-word tasks, these measures have not been considered previously in analyses of spontaneous speech, either overall or by POS (Boschi et al., 2017). Breakdowns of diversity, frequency, and AoA of nouns and verbs produced in spontaneous speech would reveal whether the differential effects seen in discrete word production manifest in communicative situations. This knowledge would be useful in the design of targeted interventions. POS breakdowns would also help determine the extent to which overall changes in diversity, frequency, and AoA are attributable to changes in POS quantities. This is of interest especially considering the likely overuse by pwAD of a limited number of high-frequency, low-AoA pronouns.

The present study therefore aims to investigate whether pwAD exhibit significant differences from controls in the use of words of different POS in conversational speech. Five hypotheses are investigated. H1 predicts that pwAD will use significantly fewer nouns and significantly more verbs and pronouns than controls, with these changes resulting in significantly lower N/V ratios. H2 predicts that pwAD will exhibit significantly decreased lexical diversity compared to controls on three measures—overall, for nouns, and for verbs. H3 predicts that pwAD will produce significantly more copulas than controls. H4 predicts that pwAD will use nouns and verbs of significantly higher frequencies than controls. H5 predicts that pwAD will use nouns and verbs of significantly lower AoAs than controls.

3.2 Methods

3.2.1 Dataset

Language data used in this study come from the Carolinas Conversations Collection (CCC), a digital archive of recorded interviews with American men and women aged 65 and older (Pope & Davis, 2011; Davis, 2005). Data collection was approved by Institutional Review Boards at institutions where it was collected, and participants provided informed consent, as per the Declaration of Helsinki. The CCC is divided into two cohorts of conversational speech samples collected by a body of contributing researchers. One cohort consists of interviews with participants diagnosed with dementia by a physician (Davis, 2005). Prior to collecting these data, researchers agreed not to carry out further cognitive testing of participants or to consult physicians; however, pwAD are uniformly described as being in moderate to late disease stages (Davis, 2005). The other cohort consists of interviews with participants who were screened to rule out dementia (Pope & Davis, 2011). All conversations revolve around daily life and health. The interviewer first discloses their own typical daily activities before asking the interviewee to do the same. Where an interviewee refers to a health condition, the interviewer responds with a set of semi-structured questions. Recorded conversations were transcribed by trained medical transcribers according to a protocol established in conjunction with researchers (Pope & Davis, 2011).

3.2.2 Participants and language samples

The CCC includes a data management package with search filters for role, condition, and native language. These were used to search the corpus for data for this study. Participants were considered for inclusion in the AD group only if they met the following criteria: conversational role specified as interviewee; dementia specified as AD; native language specified as English; date of birth available; date of conversation available; sex- and age-matched control available.

These criteria resulted in a pool of 16 potential participants with AD. For each, the earliest dated intelligible audio-recorded conversation was selected for editing and coding according to CHAT guidelines (MacWhinney, 2000). After this process, speech samples of pwAD varied in length from 224 to 1,899 words. Noting uncertainty around the word count necessary for a connected speech sample to realistically reflect language production, Sajjadi et al. (2012) found 150- and 600-word transcripts comparable for analyses of connected speech by pwAD. However, longer texts are preferable when using lexical diversity to draw conclusions on a speaker’s vocabulary (Covington & McFall, 2010; Tuldava, 1995). As such, four transcripts with fewer than 500 words were excluded. The twelve remaining transcripts (Table 3.1) were cut to the end of the utterance that included the participant’s 560th word, matching the length of the shortest transcript.

Participants were considered for inclusion in the control group only if they met the following criteria: conversational role specified as interviewee; not reported to have AD or other neurological or psychiatric condition; native language specified as English; date of birth available; date of conversation available. A control group was selected to match the group of pwAD in number, sex, and age. Groups were not matched on education because this was provided in 4-year ranges, which were judged to be too broad to facilitate meaningful matching. Conversations for the control group were extracted, edited, coded, and cut down using the above process.

Table 3.1

Group Matching

Measure	Group comparison		
	pwAD (<i>n</i> = 12) Group mean (<i>SD</i>) Range	Controls (<i>n</i> = 12) Group mean (<i>SD</i>) Range	<i>t</i> (<i>p</i>)
Sex	10 f, 2m	10 f, 2m	
Age	82.2 (7.1) 68, 94	80.6 (9.2) 71, 101	0.47 (0.64)

Overall tokens	564.4 (5.53) 560, 579	562.8 (2.76) 560, 569	0.89 (0.39)
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3.2.3 Language analysis

Transcripts were analysed using CLAN, software designed for analyses of transcriptions in the CHAT format (MacWhinney, 2000). Initial POS tags generated in CLAN were reviewed and inaccuracies that would affect analyses were corrected—for example, *hog* tagged as a verb when in context it had been used as a noun.

H1-H3 are on noun, verb, and pronoun quantities and N/V ratios, lexical diversity overall and for nouns and verbs, and copula use. Noun, verb, and pronoun quantities are measured via token counts. Noun tokens include gerunds, *~ing* verb forms functioning contextually as nouns and tagged as such in CLAN. Noun tokens do not include pronouns. Noun token counts were generated with default CLAN code. For consistency with CLAN’s default calculation of N/V ratios, verb tokens include lexical verbs, copulas, and participles. Inclusion of copulas and participles in verb token counts requires a modification to default code. Pronoun token counts and N/V ratios were generated with default CLAN code. Lexical diversity of overall speech samples, of nouns, and of verbs are measured via type-token ratios (TTRs). TTR comparisons across samples may be affected by differences in sample size—samples with more words may have lower TTRs due to increased likelihood of word re-use (Fergadiotis et al., 2015; Heaps, 1978). Speech samples in this study, while matched for overall token count, vary naturally in noun and verb counts. CLAN offers two alternative lexical diversity measures: moving average type-token ratio (MATTR; Covington & McFall, 2010) and VocD (Malvern et al., 2004). However, due to limitations in CLAN functionality for deriving these measures by POS, noun and verb diversity are measured via TTRs in this study. For consistency and because overall sample size is not a confound here, overall lexical diversity is also measured via TTRs. All TTRs used here are lemma-based (Fergadiotis et al., 2013), so that, e.g., *brother* and *brothers* are counted as

two occurrences of the same word rather than as different words. Generation of lemma-based TTRs in CLAN requires a modification to default code. Overall TTRs consider all words in a speech sample. Noun TTRs consider all nouns and verb TTRs consider all verbs included in token counts. Copula production is measured via copula counts and ratios. Lexical verb, copula, and participle counts were generated with default CLAN code and used to calculate copula-to-verb ratios as $\text{copula} / (\text{lexical verb} + \text{copula} + \text{participle})$.

H4 and H5 are on noun and verb frequency and AoA. Wordlists were generated with default CLAN code and used to obtain frequency and AoA measures from external databases. Wordlists included all tokens appearing in token counts except for gerunds, which were excluded due to discrepancies between the word form's POS in speech samples and the lemma's POS in databases. Word frequencies were obtained from WebCelex, the web-based interface to the CELEX lexical database (Baayen et al., 1995). Frequencies are reported as lemma appearances per million words. Regarding AoA data, few datasets account for distinctions between multiple POSs of a given word form, for example *walk* used as a verb or a noun. Viably scaled datasets that do this tend to be small (Brysbaert and Biemiller, 2017). This study reports group-level statistics based on means of AoAs extracted from the 30,121-word dataset of Kuperman et al. (2012), which does not distinguish word forms by POS. Kuperman et al. (2012) asked participants to estimate AoA as the age at which the participant believed they had learned the word. Ratings range from 1.5 to 25 years old and are rounded to two decimals. This study also reports advanced statistics based on ratings from the 2,694-word dataset of Bird et al. (2001), the largest viably scaled dataset that accounts for POS (cf. Brysbaert and Biemiller, 2017; see also Section 4.1.2). Bird et al. (2001) asked participants to estimate AoA on a 7-point Likert scale where each point corresponded to a period of two years including the age at which the participant believed they had learned the word (e.g., a rating of one indicating an age between 0 and 2 years old), with a rating of seven for any age over 13. Those authors then multiplied mean ratings by 100, so that final ratings are between 100 for a low AoA and 700 for a high AoA.

3.2.4 Statistical analysis

The statistical software environment R (R CoreTeam, 2021) was used for all statistical analyses. H1-H3 were addressed using two-tailed independent samples *t*-tests that compared group mean noun, verb, and pronoun token counts, N/V ratios, TTRs overall and for nouns and verbs, and copula counts and ratios. Data used in these analyses met test assumptions. Alphas for *t*-tests were not adjusted for multiple comparisons because data analysed resulted from observations of natural phenomena (Rothman, 1990). Effect sizes were calculated using associated *t*-statistics and are reported in Cohen's *d* (Sullivan and Feinn, 2012). Due to effects of sample length on TTR (see Section 2.3), reporting on TTR comparisons considers results of token count comparisons. H4 and H5 were addressed using linear mixed effects models to test predictors of frequency and AoA of nouns and verbs used. Model structures were determined a priori based on predictors of interest for the present study rather than on a model selection process that may have resulted in the exclusion of these predictors from a model of best fit. Models included fixed effects of Group, POS, and Age. The continuous variable Age was centred but not scaled (Kraemer and Blasey, 2004). Sex was not included as a fixed effect because there were not enough males in each group to allow for reliable between-group comparisons of males. Participant and Word were included in models as nested random effects, with frequency values or AoA ratings for a given word appearing as many times as the word appeared in a participant's speech sample. Because plots of preliminary models did not meet statistical assumptions, dependent variables were converted to natural logarithms for analysis. Group-level comparisons of overall, noun, and verb frequencies and AoAs are included for descriptive purposes.

3.3 Results

3.3.1 Production by POS

Measures related to production by POS are presented in Table 3.2. pwAD were found to produce significantly fewer noun tokens than controls ($p < 0.01$). This result was associated with a very large effect size ($d = 1.31$). Group differences in pronoun use did not reach significance ($p = 0.08$). However, a strong inverse relationship was present between noun and pronoun production by pwAD ($r = -0.66$, $p = 0.02$). The groups produced similar verb token counts and N/V ratios (both $p > 0.05$). All non-significant comparisons of POS production were associated with medium effect sizes.

Table 3.2

Production by POS

Measure	Group comparison			
	pwAD ($n = 12$) Group mean (<i>SD</i>) Range	Controls ($n = 12$) Group mean (<i>SD</i>) Range	t (p)	d
Noun tokens	48.9 (10.5) 35–72	65.3 (14.2) 41–89	-3.22 (< 0.01)**	1.31
Verb tokens	95.1 (7.9) 81–103	100.3 (11.8) 75–119	-1.28 (0.22)	0.52
Pronoun tokens	119.2 (17.6) 87–153	106.4 (16.5) 67–129	1.83 (0.08)	0.75
N/V ratio	0.63 (0.21) 0.40–1.11	0.79 (0.27) 0.46–1.39	-1.64 (0.12)	0.67

* $p < 0.05$, ** $p \leq 0.01$

3.3.2 Lexical diversity

TTRs of pwAD and controls are presented in Table 3.3. Overall TTRs were found to be significantly lower for pwAD, indicating that they used a narrower range of words across all parts of speech than controls. This result was associated with a large effect size ($d = 1.02$). Given the

expected inverse relationship between sample size and TTR, decreased noun production by pwAD (see Sections 2.3 and 3.1) should be accompanied by higher noun TTRs than controls. However, the comparison of group noun TTR differences was not significant ($p = 0.47$), and pwAD produced lower mean noun TTRs than controls. Verb TTRs did not differ significantly between the groups, suggesting similar diversity in verb use. The non-significant comparisons of noun and verb diversity were associated with small effect sizes.

Table 3.3

TTRs

Measure	Group comparison			
	pwAD ($n = 12$) Group mean (SD) Range	Controls ($n = 12$) Group mean (SD) Range	t (p)	d
Overall TTR	0.29 (0.03) 0.24–0.33	0.32 (0.03) 0.28–0.39	-2.5 (0.02)*	1.02
Noun TTR	0.64 (0.08) 0.54–0.80	0.66 (0.08) 0.53–0.78	-0.74 ^a (0.47)	0.3
Verb TTR	0.39 (0.06) 0.33–0.51	0.40 (0.05) 0.34–0.49	-0.61 (0.55)	0.25

* $p < 0.05$, ** $p \leq 0.01$

^a Interpretation of these results should consider group differences in noun token production (see text).

3.3.3 Production of copulas

Two measures of copula production were analysed—copula counts and copula-to-verb ratios. pwAD produced an average of 23.9 copulas ($SD = 7.8$, range = 12 – 38) compared with controls' average of 22.6 ($SD = 5.8$, range = 10 – 32). Group differences were not significant for this measure ($t = 0.48$, $p = 0.64$, $d = 0.19$). pwAD produced an average copula-to-verb ratio of 0.25 ($SD = 0.08$, range = 0.15 – 0.4) compared with controls' average of 0.23 ($SD = 0.07$, range = 0.1 – 0.31). Group differences were not significant for this measure ($t = 0.75$, $p = 0.46$, $d = 0.31$). These non-

significant comparisons were associated with small effect sizes. Thus, pwAD did not rely more on copulas than controls.

3.3.4 Frequencies of nouns and verbs

Group-level statistics on the frequencies of words produced are presented in Table 3.4.

While pwAD exhibited a tendency to produce words of higher frequencies than controls, two-tailed independent samples *t*-tests indicated that group means did not differ significantly for overall words, nouns, or verbs ($p > 0.05$).

Table 3.4

Overview of Word Frequencies

Measure	Group comparison		
	pwAD ($n = 12$) Group mean (<i>SD</i>) Range	Controls ($n = 12$) Group mean (<i>SD</i>) Range	<i>t</i> (<i>p</i>)
Overall frequency	8956 (1069) 7188–11008	8661 (771) 7192–9968	0.77 (0.45)
Noun frequency	355 (148) 199–712	328 (160) 140–764	0.44 (0.66)
Verb frequency	11400 (3029) 6920–17066	10793 (2869) 5427–15014	0.5 (0.62)

* $p < 0.05$, ** $p \leq 0.01$

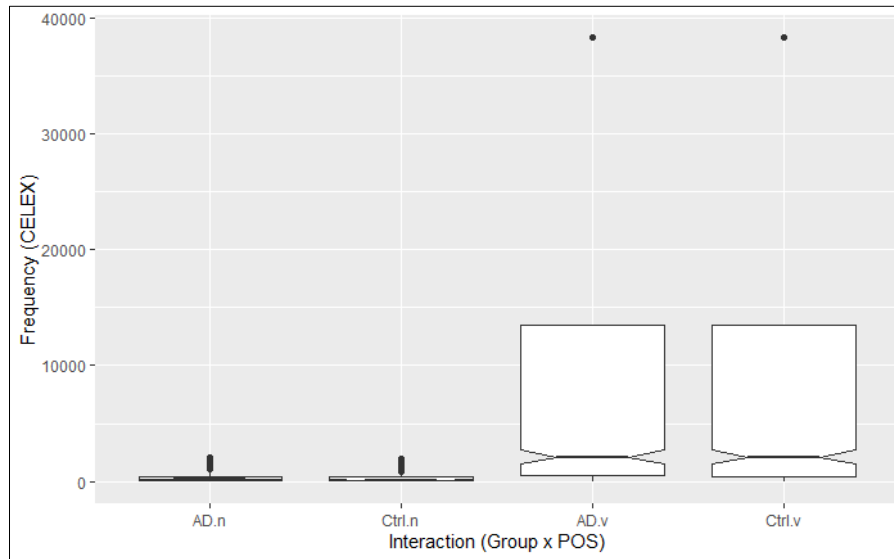
Frequency data were available for 3,664 of 3,716 nouns and verbs spoken by participants. These included 562 of 587 nouns and 1,139 of 1,141 verbs spoken by pwAD (mean frequencies per million words: nouns 354 ± 484 , verbs 11365 ± 15700) and 761 of 784 nouns and 1,202 of 1,204 verbs spoken by controls (nouns 310 ± 456 , verbs 10635 ± 15175)¹. Within both groups, frequencies were higher and variances greater for verbs than nouns (Figure 3.1). Qualitative inspection of the

¹ Means reported in the text differ from means reported in Table 3.4. Means reported in the text consider all nouns or verbs produced within a group, while means reported in Table 3.4 are group means based on participant means.

data indicated that several verbs, most notably *be* (38301 appearances per million words), were several times more frequent than both other verbs (next most frequent: *have*, 13494) and the most frequent nouns used within either group (pwAD: *one*, 2073; controls: *time*, 1971).

Figure 3.1

Frequency by POS and Group



Note. AD = pwAD, Ctrl = controls, n = nouns, v = verbs.

Frequency values were converted to natural logarithms for analysis due to heteroscedasticity in the residuals of a preliminary model that used actual values. As seen in Table 3.5, the linear mixed effects model using log frequency data resulted in a significant main effect of POS ($p < 0.01$). Main effects of Group and Age were not significant. Significant two-way interactions were present between Group and POS ($p < 0.01$) and Group and Age ($p < 0.03$). The two-way interaction between POS and Age did not reach significance ($p = 0.07$). The three-way interaction of Group, POS, and Age was significant ($p < 0.01$).

Table 3.5

Frequency Results

Predictor/interaction	Estimate	Standard error	<i>t</i>	<i>p</i>
Intercept	5.19	0.12	42.73	<0.01**

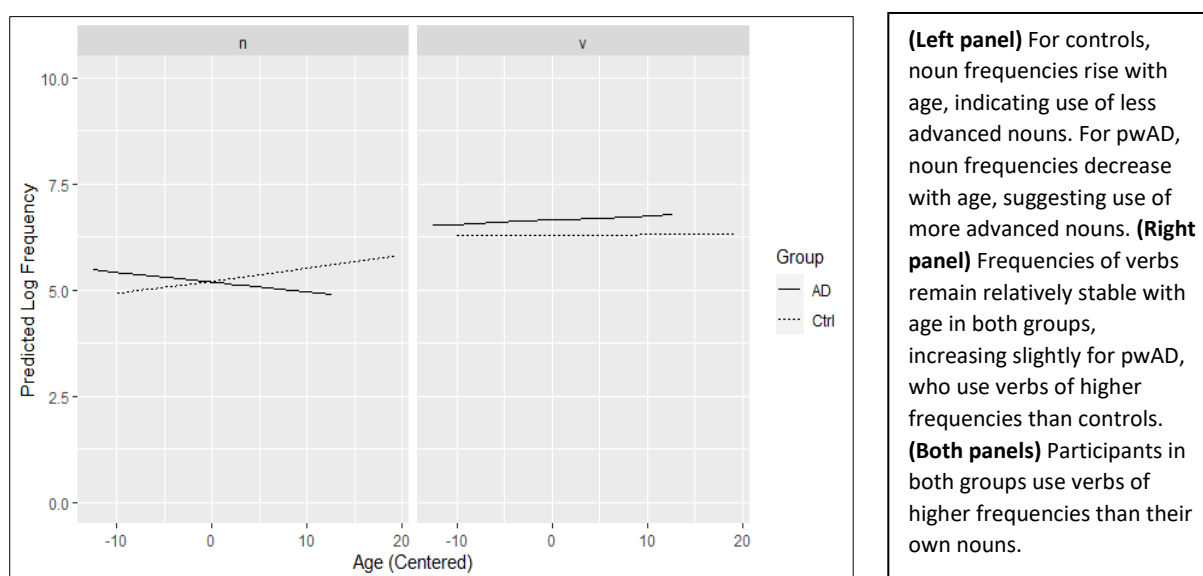
Group	0.03	0.16	0.16	0.87
POS	1.46	0.11	13.66	<0.01**
Age (centered)	-0.02	0.02	-1.22	0.24
Group x POS	-0.38	0.13	-2.84	<0.01**
Group x Age (centred)	0.05	0.02	2.36	0.03*
POS x Age (centred)	0.03	0.02	1.8	0.07
Group x POS x Age (centred)	-0.06	0.02	-3.05	<0.01**

* $p < 0.05$, ** $p \leq 0.01$

Model predictions are presented visually in Figure 3.2. Changes with age in frequencies of nouns used are apparent in both groups. For controls, noun frequencies rise with age, indicating use of less advanced nouns. The opposite is true for pwAD. Noun frequencies decrease with age, suggesting use of more advanced nouns. By contrast, frequencies of verbs remain relatively stable with age in both groups, increasing slightly for pwAD, who use verbs of higher frequencies than controls. Participants in both groups use verbs of higher frequencies than their own nouns.

Figure 3.2

Predicted Effects of Group, Age, and POS on Log Frequency of Words Used



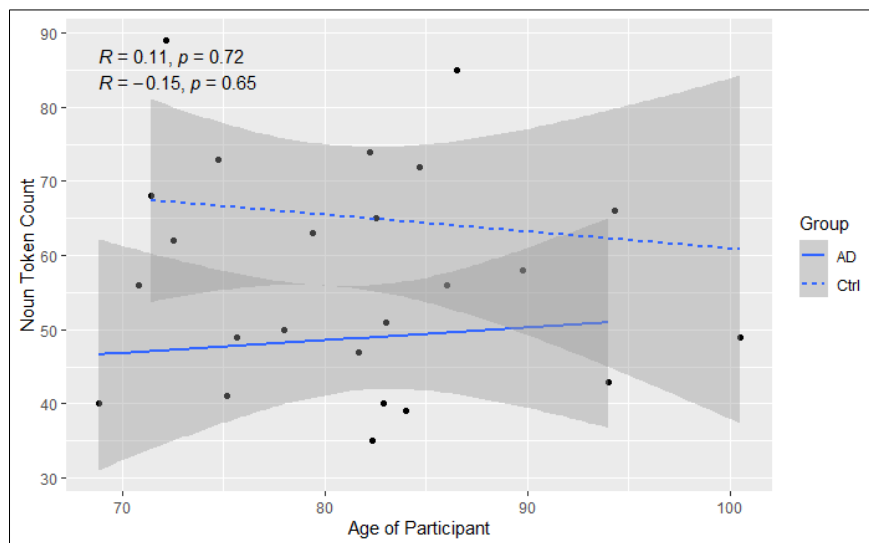
Note. AD = pwAD, Ctrl = controls, n = nouns, v = verbs.

Follow-up testing was carried out to explore the unexpected finding that controls used nouns of higher log frequencies with age, while pwAD used nouns of lower log frequencies. Of

specific interest was how these trends might relate to noun token counts, as well as any relationship between age and noun token production. As seen in Figure 3.3, changes with age in noun token production were not significant. Production decreased moderately for controls while increasing moderately for pwAD.

Figure 3.3

Effects of Ageing on Noun Token Production



3.3.5 AoAs of nouns and verbs

Prior to AoA analyses, a Pearson's correlation was conducted to assess the relationship between frequency and AoA of all words used in this study. This relationship, while significant, was weak ($r = -0.11, p < 0.01$).

Group-level statistics on the AoAs of words produced are presented in Table 3.6. On average, pwAD produced nouns and verbs of higher mean AoAs than controls, indicating use of more advanced words. However, two-tailed independent samples *t*-tests indicated that group means did not differ significantly for overall words, nouns, or verbs ($p > 0.05$).

Table 3.6

Overview of AoAs

Measure	Group comparison		
	pwAD (<i>n</i> = 12) Group mean (<i>SD</i>) Range	Controls (<i>n</i> = 12) Group mean (<i>SD</i>) Range	<i>t</i> (<i>p</i>)
Overall AoA	4.48 (0.11) 4.3–4.7	4.51 (0.15) 4.3–4.9	-0.65 (0.52)
Noun AoA	275.5 (19.1) 245–308	267.6 (14.4) 250–292	1.15 (0.26)
Verb AoA	279.6 (8.6) 266–295	276.6 (8.6) 265–298	0.87 (0.4)

Note. Overall AoA data come from the ratings of Kuperman et al. (2012). Noun and verb AoA data come from the ratings of Bird et al. (2001). See Section 2.3 for further information on these ratings datasets.

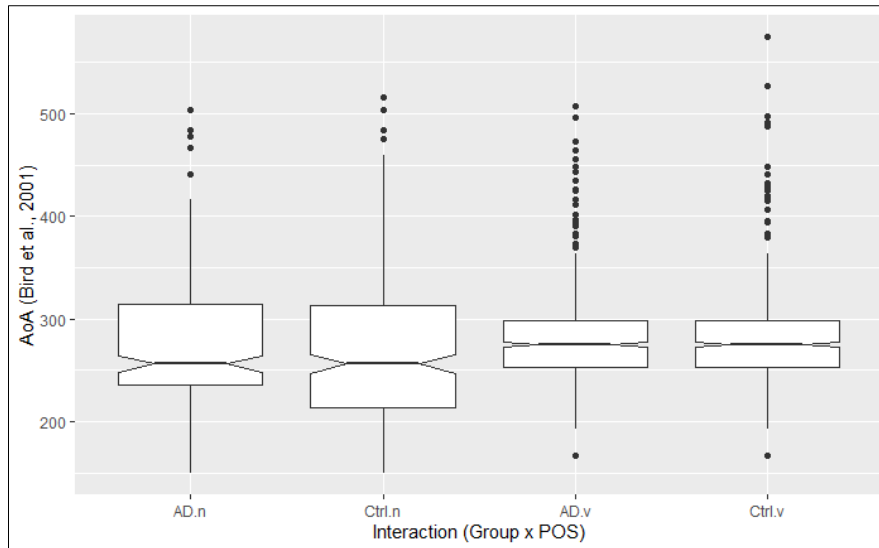
* $p < 0.05$, ** $p \leq 0.01$

AoA data were available for 2,722 of 3,716 nouns and verbs spoken by participants, including 276 of 587 nouns (AoA: 273 ± 72) and 1037 of 1,141 verbs (AoA: 280 ± 43) spoken by pwAD and 329 of 784 nouns (AoA: 268 ± 73) and 1080 of 1,204 verbs (AoA: 276 ± 43) spoken by controls². AoAs were similar between groups for the respective word classes (Figure 3.4), with variances greater for nouns than verbs.

Figure 3.4

AoA by POS and Group

² Means reported in the text differ from means reported in Table 3.6. Means reported in the text consider all nouns or verbs produced within a group, while means reported in Table 3.6 are group means based on participant means.



Note. AD = pwAD, Ctrl = controls, n = nouns, v = verbs.

AoA ratings were converted to natural logarithms for analysis due to a positive skew in the residuals of a preliminary model that used actual ratings. As seen in Table 3.7, the linear mixed effects model using log AoA data resulted in significant main effects of Group ($p < 0.01$) and POS ($p = 0.01$). The interaction between these terms was also significant ($p < 0.01$). The main effect of Age was not significant, and no interactions including the Age term were significant.

Table 3.7

AoA Results

Predictor/interaction	Estimate	Standard error	<i>t</i>	<i>p</i>
Intercept	5.64	0.01	406.4	<0.01**
Group	-0.10	0.02	-6.06	<0.01**
POS	-0.03	0.01	-2.48	0.01**
Age (centred)	0.00	0.00	0.75	0.46
Group x POS	0.13	0.02	8.27	<0.01**
Group x Age (centred)	-0.00	0.00	-0.81	0.43
POS x Age (centred)	-0.00	0.00	-1.14	0.26
Group x POS x Age (centred)	0.00	0.00	0.18	0.86

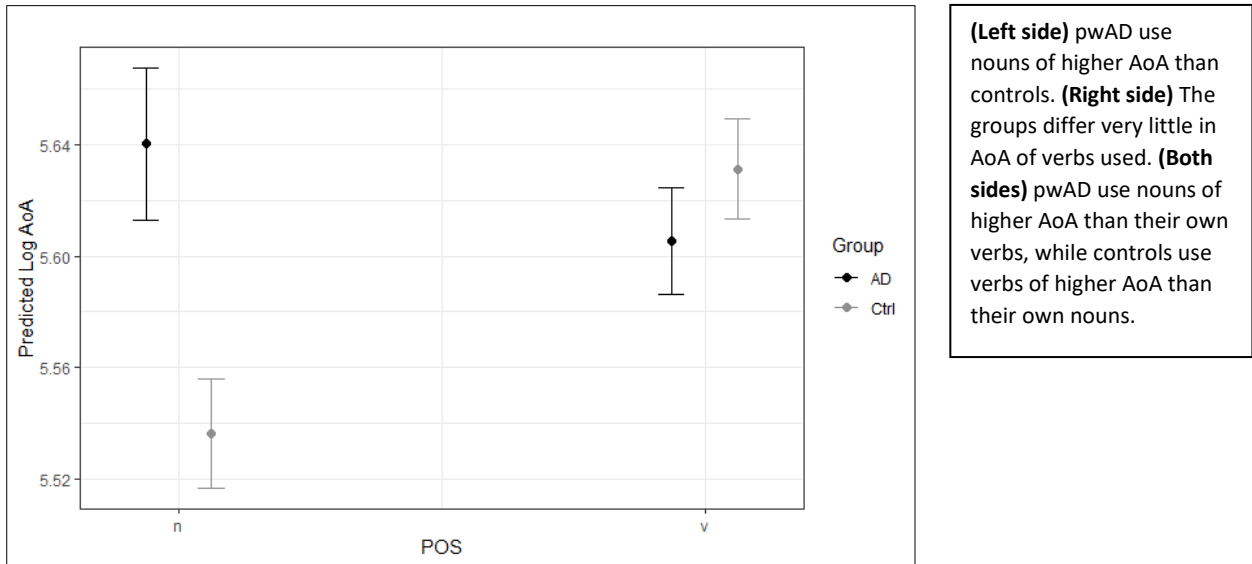
* $p < 0.05$, ** $p \leq 0.01$

Model predictions are presented visually in Figure 3.5. Between groups, pwAD use nouns of higher AoA than controls, while the groups differ very little in AoA of verbs used. Within groups,

pwAD use nouns of higher AoA than their own verbs, while controls use verbs of higher AoA than their own nouns.

Figure 3.5

Predicted Effects of Group and POS on Log AoA of Words Used



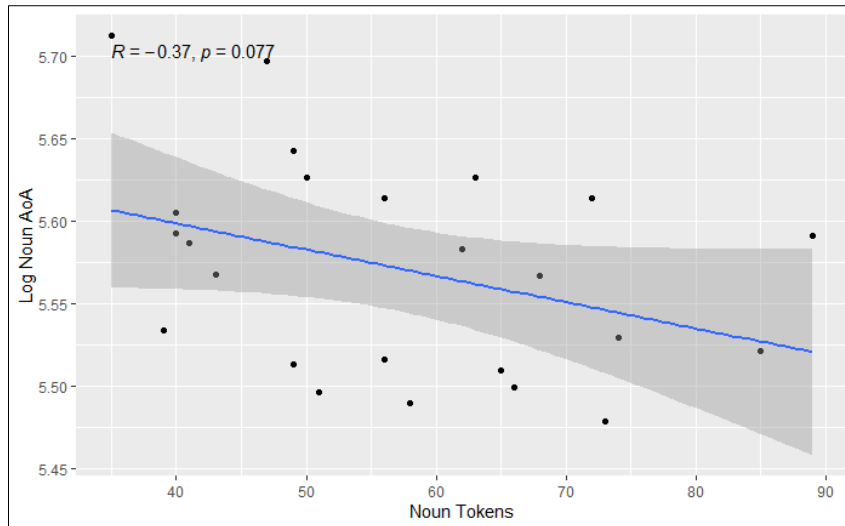
(Left side) pwAD use nouns of higher AoA than controls. **(Right side)** The groups differ very little in AoA of verbs used. **(Both sides)** pwAD use nouns of higher AoA than their own verbs, while controls use verbs of higher AoA than their own nouns.

Note. AD = pwAD, Ctrl = controls, n = nouns, v = verbs.

Follow-up testing was carried out to explore the unexpected finding that pwAD used nouns of higher log AoA than controls. Of specific interest was how this finding might relate to group differences in noun token counts. As such, relationships were examined between participants' noun token counts and the mean log AoA of nouns used. As seen in Figure 3.6, increased use of nouns was not significantly associated with decreases in log AoA of nouns ($p = 0.08$).

Figure 3.6

Relationship Between Noun Use and Log Noun AoA



3.4 Discussion

The aim of this study was to investigate whether pwAD differed from healthy age-matched controls in their use of words of different POS in conversational interviews. Speech samples of 12 pwAD and 12 controls were matched for overall word count and analysed for noun, verb, and pronoun quantities, N/V ratios, overall and noun and verb TTRs, copula counts and ratios, and frequencies and AoAs of nouns and verbs produced. pwAD produced significantly fewer nouns than controls. They also produced lower overall TTRs, while noun TTR comparisons were not significant despite the group differences in noun production. The groups did not significantly differ in verb token counts, N/V ratios, verb TTRs, or copula use. Frequency was predicted by a main effect of POS, two-way interactions between group and POS and group and age, and a three-way interaction between group, POS, and age. AoA was predicted by main effects of group and POS and a two-way interaction between group and POS.

Findings on nouns and verbs and their implications for research on language in ageing and AD are discussed in Section 4.1. Implications of these findings for communicative interventions are discussed in Section 4.2. Study limitations are discussed in Section 4.3.

3.4.1 Noun and verb use by pwAD and controls

3.4.1.1 H1-H3: Words produced and lexical diversity

The finding here of decreased overall lexical diversity in speech by pwAD, indicating use of a narrower range of overall words, is in line with consensus findings described in Chapter 2 and supported elsewhere (e.g., Bucks et al., 2000; Fraser et al., 2016). Evidence here indicates that this overall reduction is linked to changes in noun use. While direct comparison of noun TTRs suggested group differences were not significant, this result is likely attributable to differences in quantities of nouns produced, as TTRs are inversely related to token counts (Fergadiotis et al., 2015; Heaps, 1978). pwAD used significantly fewer nouns than controls, which should have resulted in higher mean noun TTRs if the diversity among nouns used by the groups was similar. Instead, the noun TTRs of pwAD were lower than those of controls despite their lower token counts, suggesting decreased diversity among nouns produced by pwAD. These findings of decreases in noun production and diversity are in line with prior findings on noun use in discourse by pwAD (Blanken et al., 1987; Fraser et al., 2016). The use of fewer nouns and of a decreased range of words overall, specifically of nouns, by pwAD are likely related through a process by which retrieval issues lead to the replacement of nouns, a wide-ranging, open word class, with a necessarily limited number of words from the closed class pronouns (Kavé & Dassa, 2018). Evidence of this replacement process is seen here in the inverse relationship between noun and pronoun use by pwAD. Effects of that process on overall lexical diversity are suggested in the combination of decreases in overall TTR and noun token counts alongside non-significant increases in pronoun use compared to controls. Further evidence that decreases in overall lexical diversity in AD are related to changes in noun and pronoun use can be seen in prior studies reporting similar combinations of findings (Bucks et al., 2000; Fraser et al., 2016; Kavé & Dassa, 2018). Further studies should explore how these changes in discourse relate to word retrieval issues.

In contrast to their changes in noun use, pwAD here did not differ from controls in verb token production, verb TTRs, or copula use. These findings contradict prior indications that in discourse, pwAD produce higher proportions of verbs, particularly generic verbs such as copulas, and a less diverse range of verbs than cognitively healthy controls (Blanken et al., 1987; Fraser et al., 2016; Kim & Thompson, 2004). Despite the combination here of decreased noun production by pwAD and non-significant group differences in verb production, N/V ratios did not differ by group. A non-significant decline in the use of verbs by pwAD likely factored into this finding. N/V ratios can be used to identify a retrieval issue for one of these two major word classes relative to the other (e.g., Breedin et al., 1998). However, the implication from the N/V ratio comparison reported here, that no such issue is present for these pwAD, contrasts with the findings on nouns and pronouns, which appear to suggest noun retrieval difficulties in discourse. Use of more direct measures to compare word use by POS—either quantities in standardised samples, as used here, or proportions or percentages of all words—may provide a better indication of POS-specific retrieval in discourse.

3.4.1.2 H4 and H5: Frequencies and AoAs of nouns and verbs

It was expected that pwAD would use words of higher frequencies and lower AoAs than controls. Words of lower frequency or higher AoA have been found to lead to difficulties for both the cognitively healthy and pwAD on discrete language tasks (Meschyan & Hernandez, 2002; Rodríguez-Ferreiro et al., 2009). This may relate to the role of these learning history variables in declarative memory and semantic connectedness (Steyvers & Tenenbaum, 2005; see also Chapter 2). Past findings have suggested that difficulty with more advanced words translates to reliance by pwAD on simple, generic alternatives in discourse (Fraser et al., 2016; Kavé & Dassa, 2018; Kim & Thompson, 2004). These findings are frequently derived from simple comparisons of group means (e.g., Kavé & Dassa, 2018; Kim & Thompson, 2004). Here, preliminary t-testing indicated no between-group differences in frequencies or AoAs of overall words, nouns, or verbs produced. Results of a linear mixed effects model also indicated little overall difference in the frequencies of

nouns or verbs used by group; however, age affected noun frequencies differently within each group. Frequencies of nouns used by pwAD decreased with age, suggesting the use of more advanced nouns, while frequencies of nouns used by controls rose with age. A separate linear mixed effects model found that pwAD produced nouns of higher AoA than controls regardless of age, seemingly indicating consistent use of more advanced nouns. These differences in findings by statistical method highlight the benefits of use of more robust tests. Use of mixed modelling here provided information on effects of not only age but also properties of individual words and their use within and across participants. Discussion below of psycholinguistic properties of words produced will focus on results of these models.

The trend of production of nouns of lower frequencies with age by pwAD, along with nonsignificant increases in noun production, may relate to differences in stages of decline within this group. The age range within the group (68-94) suggests the presence of both the common late-onset form of AD and of early-onset AD (EOAD), which is associated with more rapid cognitive decline and with different language symptoms (Lam et al., 2013; van der Vlies et al., 2009; Zhu et al., 2015). An informal cutoff age at diagnosis for EOAD is 65, though this is not for biological reasons and pwAD as old as 70 at diagnosis have been described as having EOAD (Ho et al., 2002; Zhu et al., 2015). People diagnosed with AD in their 60s and early 70s have a median life expectancy of seven to ten years post-diagnosis (Brookmeyer et al., 2002). Because the youngest three of these 12 pwAD were ages 68, 70, and 78, respectively, at time of conversation, it is possible that more advanced global decline at the lower end of the age spectrum contributed to a trend appearing to suggest improvements in noun production with age in pwAD. Unfortunately, the CCC lacks information relevant to this possibility. While all participants are described as being in moderate to late disease stages, information on disease stage at time of conversation was not available for individual participants. Demographic information useful in making inferences about disease stage or rate of decline, such as age at diagnosis, global cognition at diagnosis, or participant education level (Sona et al., 2012; Tchalla et al., 2018; Teri et al., 1995) was also not available. The present findings should thus be

interpreted with an awareness that age of pwAD is not indicative of disease progression. They reinforce findings of heterogeneity in AD (Lam et al., 2013) and indications discussed in Chapter 2 of the importance of accounting for disease stage during study design, recruitment, and data analysis. The lack of demographic information also leaves open the possibility that education played a role in this finding. It is possible that older pwAD here were more educated than younger ones, which might have resulted in a tendency to use nouns of lower frequencies (Tainturier et al., 1992).

In the present study, cognitively healthy adults over age 70 used nouns of higher frequencies with age in spontaneous speech. A nonsignificant trend also suggested possible use of fewer nouns with age. This combination of findings may hint at the appearance of changes in noun use in discourse production in advanced ageing. Healthy older adults are known to experience word retrieval difficulties on single-word tasks. However, it has been suggested that vocabulary growth with age compensates for retrieval difficulties on single-word and discourse tasks (Kavé et al., 2009; Shafto et al., 2017). Kavé et al. (2009) found that despite increasing noun retrieval difficulty on naming and fluency tasks, healthy speakers aged 20 to 85 produced less frequent nouns with age in picture descriptions. The authors attributed this to older speakers' larger vocabularies. The present findings are based on production of less constrained discourse by participants older on average than the oldest 30 participants in that study. These findings necessitate larger studies of changes to noun use not across the lifespan, but specifically in advanced ageing. They also underscore the usefulness of detailed reporting on performance by controls, which Chapter 2 indicated is at times lacking in studies that attribute language changes to AD. The follow-up frequency analysis used here focused on group disparities in trends in noun use rather than exclusively on the unexpected production of nouns of lower frequencies with age by pwAD. This revealed potential changes in healthy ageing that provided perspective on the apparent changes in pwAD. Future studies attributing language changes to AD should ensure they provide similar context by either including middle-aged comparison groups or analysing changes with age in healthy controls.

A follow-up analysis suggests the unexpected finding that pwAD used nouns of higher AoA than controls should not be taken at face value, as this finding may relate to significant group differences in noun token production. An inverse relationship was present in these data between the number of noun tokens produced by a participant and the mean log AoA of those nouns. A positive skew was also present in the AoA data, both overall and for nouns, prior to conversion for statistical analyses, suggesting heavy reliance on nouns acquired at earlier ages. Such a distribution is in line with Zipf's (1949) observation of speakers' general preference for less advanced words. While Zipf's observation was based on word frequencies, it also applies to AoA and, by way of these variables, to semantic connectivity (Mayor & Plunkett, 2010; Steyvers & Tenenbaum, 2005; van Egmond, 2011). Thus, the production of more noun tokens by a participant would likely include a higher proportion of nouns acquired at earlier ages, potentially explaining the finding here that controls used nouns of lower AoA than pwAD. Low numbers of noun tokens in AoA analyses may have also factored into this finding. Fewer than half the nouns appearing for each group in frequency analyses appeared in AoA analyses (frequency vs. AoA nouns: pwAD 562 vs. 276; controls 761 vs. 329). This likely had to do with the use of the AoA ratings set provided by Bird et al. (2001). While this may be the largest set of viably scaled AoA ratings to account for a word form's POS (see below), the inclusion of only 2,694 words in that dataset is a limitation that must be considered in interpreting the present findings. Another relevant consideration is the lack of information on participant education—it is possible that pwAD were more educated than controls, which might have contributed to their use of more advanced nouns.

Results of linear mixed effects models and t-tests suggest that frequencies and AoAs of verbs used differed little by group, with effects of age on frequency also less pronounced for verbs than nouns. Together, findings from H1-H5 suggest unimpaired verb production in spontaneous speech by pwAD while providing mixed evidence of noun production deficits. These differences in findings by POS are underscored by the significant main effects of POS in both frequency and AoA models. The findings on discrete word production reviewed in Chapter 2 also suggest POS effects in

performance by pwAD. However, in those tasks, pwAD seem to have greater difficulty with verbs than nouns. This combination of findings suggests that an advantage for nouns on single-word tasks does not translate to discourse. Findings that pwAD are no more impaired in describing actions than people or objects in pictures (Ahmed, de Jager, et al., 2013; Croisile et al., 1996) can be seen as further evidence of this. Poorer retrieval of verbs than nouns in single-word tasks has been attributed to weaker semantic organizations among verbs (Druks et al., 2006; White-Devine et al., 1996). Discourse contexts may mitigate verb retrieval deficits through the necessary interactions between verbs and words around them. These interactions recruit syntactic and morphological processes, which are relatively preserved in pwAD (Auclair-Ouellet, 2015; see also Chapter 2 or Williams et al., 2021). Task effects arising from differences in processing demands would likely relate further to the engagement of distinct neural areas depending on whether language is produced or comprehended in context or in isolation (Vigliocco et al., 2011). Potential effects of task type on retrieval of nouns and verbs by pwAD would be best investigated via within-participant comparisons of performance on single-word and discourse tasks. Analyses of functional imaging would provide further information on neural correlates of language processing and effects on performance resulting from changes to specific neural areas in AD.

Findings here on verbs are based on higher and more similar token counts than those on nouns, demonstrating that in addition to processing demands, verbs and nouns also differ in the extent to which they are relied upon in discourse. Speakers' heavier reliance on verbs, together with the larger number of nouns than verbs in the English lexicon, contribute to much higher mean frequencies for verbs than nouns. In the present data, for example, mean frequencies of verbs were 32 times higher than those of nouns (Table 3.4). Despite this, verbs are acquired later in life (Mätzig et al., 2009). POS differences in frequency and AoA have ramifications for interpretations of word use and lexical-semantic decline in AD. While findings here did not include group differences in overall word frequency, multiple discourse studies have reported higher overall frequencies for pwAD than controls (Slegers et al., 2018). An example is Kavé and Dassa (2018), who solicited picture

descriptions by pwAD nearly twice as long as those of controls. Their groups did not differ in percentages of words that were verbs, suggesting more verbs appeared for pwAD in analyses. pwAD also relied more on pronouns and less on nouns. Thus the finding of higher frequencies among words used by pwAD likely reflects an influence of group differences in numbers of nouns, verbs, and pronouns appearing in analyses. POS differences also apply to overall AoA comparisons. These were not significant here despite higher noun AoA for pwAD than controls. Yeung et al. (2021), though, reported use by pwAD of words of higher AoA than controls in Cookie Theft picture descriptions. Because words of lower AoA are more common in this task, the authors interpreted the finding as a sign that pwAD were more likely to make off-topic remarks. However, the authors also reference rate of noun and verb phrases as an explanatory factor in word-finding difficulties for pwAD. While further detail on this is not provided, group differences in noun and/or verb production may have contributed to the overall AoA finding. Accounting for this potential confound in studies of psycholinguistic effects in language production by pwAD would allow for more conclusive testing of hypotheses that pwAD replace advanced words of a given POS with less specific ones (Fraser et al., 2016; Kim & Thompson, 2004).

Differences between nouns and verbs in frequency and AoA are also relevant to the design of single-word studies. Stimuli in those studies are often matched for frequency and AoA, including at times across POS. Druks et al. (2006), for example, found both pwAD and controls to name objects faster and more accurately than actions. Object and action stimuli were matched for AoA, with frequencies only marginally higher for verbs. Since verbs tend to have much higher frequencies than nouns, a reduction in these differences may have resulted in the use of more advanced verbs, factoring into relative success with object stimuli. A better practice may be to match stimuli according to norms for the respective word classes, as in White-Devine et al. (1996), who found pwAD but not controls more accurate in naming objects.

More broadly, differences between nouns and verbs highlighted here—in frequency, AoA, proportion of words spoken, and context-dependent processing demands—are suggestive of deeper differences between these word classes. Those differences should be accounted for as potential confounds in the design stages of investigations of word-class specific impairments in pwAD. Studies investigating this possibility should refrain from drawing conclusions based strictly on within-group comparisons of performance across word classes. POS-specific impairments in pwAD should be framed within the context of any differences, or lack thereof, by word class for controls.

Differences were also present here across psycholinguistic variables. pwAD used nouns of similar frequencies but higher AoAs than controls. Age factored into predictions of frequency but not AoA of nouns used. Nouns were acquired earlier than verbs despite being less frequent in general usage. It has been suggested that frequency and AoA reflect the same information (Lewis et al., 2001), a claim supported by the tendency toward earlier acquisition of words of higher frequencies. However, the relationship between frequencies and AoAs of words used in the present study was weak, and conclusions that could be drawn on noun use from this study differ by measure. Sailor et al. (2011) also found differences in these measures, reporting that words produced on a semantic fluency task were of lower frequencies but lower AoAs than those produced on a letter fluency task.

While these findings could be seen to indicate that the measures are not proxies for one another, they may result from differences in data quality. Frequency values, including those used here, tend to be based on counts of appearances by a lemma in a large corpus. Lemmas correspond to meanings rather than word forms, thereby providing more specific information to corpus users. AoA measures frequently involve ratings based on adults' perceptions of their own or their child(ren)'s learning. While these methods allow for collection of large datasets, flaws related to subjectivity are inherent (see Wikse Barrow et al., 2019). More objective data collection methods such as recording or testing children are associated with separate issues, including greater difficulty obtaining large amounts of data. Regardless of collection method, AoA data often do not distinguish

between meanings of a word form, including multiple POS (Brysbaert & Biemiller, 2017). This is problematic considering differences here in AoA by POS. Brysbaert and Biemiller (2017) constructed a comprehensive set of acquisition norms for 44,000 word meanings, including multiple meanings of a word form, from which POS can be inferred. Construction of this dataset involved retrospective changes to data from the testing of US children beginning in grade 4, including the creation of a grade 2 norm. The authors provide a formula by which an AoA can be derived from a word's grade level of acquisition. While these norms attempt to address flaws in prior AoA datasets, the authors acknowledge crudeness in their scale, based as it is on grade, rather than age, of acquisition. The scale is divided into increments of two grades, or years, beginning at US grade level 2, or age seven. It therefore essentially provides a default AoA of seven for any word acquired by this age, at which children generally already possess a large vocabulary. The higher end of their scale is also problematic in that testing of adults was limited to students enrolled in thirteenth to sixteenth years of schooling, with words acquired after year 13 automatically assigned a grade level of 14. Among other potential uses, a large, objective, precisely scaled set of AoA norms that accounts for multiple word meanings would allow for improved understanding of relationships between frequency and word acquisition.

3.4.2 Implications for communicative interventions

The use by pwAD of nearly twice as many verbs as nouns, together with the potentially facilitative effects of context on verb production, necessitate future research on communicative interventions that target verbs. Such interventions have shown success in rehabilitation in post-stroke aphasia. Improvements experienced by people with aphasia following verb treatment include greater generalization across word, sentence, and discourse levels than is seen with noun treatments. Improvements appear to be independent of both the underlying verb deficit and the nature of the therapy, though they may be restricted by co-occurring syntactic deficits (Webster et al., 2015). Aphasia researchers have recommended not treating verbs in isolation (Bastiaanse et al.,

2006), with a focus instead on their argument structures and associated nouns. Such an approach may play to relative strengths of pwAD. AD should be considered less conducive to rehabilitative treatments than post-stroke aphasia because it is a progressive condition. However, prior findings on verb acquisition in AD (Grossman et al., 1997; Grossman et al., 2007) suggest some potential for targeting verbs in language maintenance or restoration. These studies found that, when attempting to learn a new verb, pwAD were able to acquire its grammatical features. They did not learn the verb's argument structure. This finding, however, may have related to aspects of the research methodology. As discussed in Chapter 2 of this thesis, that research group viewed argument structure as a semantic property, while the consensus among researchers is to regard it as a syntactic property. Given that syntax is relatively spared in pwAD, a syntax-based approach to acquisition of argument structure may facilitate production of both verbs and nouns in discourse. Study is needed of whether verb treatments for aphasia may, with or without modification, improve communication by pwAD.

Decreased noun production by pwAD highlights the need to address noun use as part of communicative intervention, since these decreases have broad implications for pwAD and their caregivers. Nouns are content words that convey meaningful detail, specifying for example the entity which has performed or received an action. Their replacement with less specific pronouns likely factors into perceptions of spoken discourse by pwAD as vague or empty (Fraser et al., 2016). The replacement of open-class with closed-class words also results in decreased lexical diversity. Adults have been shown to judge children exhibiting low lexical diversity in their speech as less appealing, mature, or talkative than those with higher lexical diversity (Burroughs, 1991). A question for future research is whether pwAD are also judged negatively based on decreased lexical diversity. Such judgments might lead caregivers to engage less in conversation with pwAD, contributing to social isolation and declining mental health for both parties (Byrne & Orange, 2005; Orange, 1991). Mental state and cognitive activity, including social interaction, can affect cognitive abilities (Joormann & Stanton, 2016; Schultz et al., 2015), so that this process may speed declines

experienced by pwAD, cyclically exacerbating language, communication, social, and mental health issues. Word retrieval in context and caregiver responses to simplified language production by pwAD are therefore potential intervention targets.

3.4.3 Limitations

This study has limitations of which the reader should be aware. As discussed above, severity of cognitive decline in pwAD could only be considered at a general level. While a uniform statement is available on the stages of CCC participants with AD, information is not provided for individuals. Education level, a predictor both of word use and of decline in AD (Tainturier et al., 1992; Teri et al., 1995), was not considered here, as this information was provided in broad ranges only. Due to small group sizes and specifically a lack of male participants, findings here are not broken down by gender, another predictor of decline in AD (Tchalla et al., 2018). Larger studies of the lexical-semantic measures investigated here should account for progression of cognitive decline, education, and gender. Speech samples were included based on a word count threshold and most were then artificially shortened. While this practice facilitated statistical analyses, it ignored potential contributors to variation among speech samples, which may include cognitive ability. These data are not controlled for interviewer or conversation topic. While this has the benefit of more closely simulating real-life communicative situations, these factors can influence the communicative participation and word choice of interviewees. Limitations related to the use of existing AoA datasets are discussed in Section 4.1.2. Despite its limitations, this study has provided information on lexical-semantic changes that may accompany ageing and AD while highlighting methodological considerations for improved investigation of these changes.

3.5 Conclusion

This study's purpose was to compare the conversational use of words of different POS by pwAD and healthy age-matched controls. Previous findings have suggested that breakdowns in semantic representations in AD lead to the frequent reuse of generic words, including pronouns,

copulas, and other high-frequency nouns and verbs. In the current study, pwAD produced fewer nouns and more pronouns than controls, leading to decreased lexical diversity. Frequencies of nouns produced did not differ by group, but age affected these differently. pwAD produced nouns of lower frequencies with age, which may have been attributable to advanced decline among younger pwAD. Controls produced nouns of higher frequencies with age, possibly suggestive of difficulty retrieving nouns in conversation in advanced ageing. pwAD used nouns of higher AoA than controls, a finding that may relate to group differences in noun quantities. The groups differed little in their use of verbs. Overall, aside from increased pronoun use, pwAD did not tend to produce less sophisticated words than controls. Across groups, POS significantly affected word frequency and AoA measures, with verbs having much higher frequency values than nouns. These findings highlight the importance of breaking down findings by POS when assessing language use. Future reporting on lexical diversity, frequency, and AoA in the speech of pwAD should account for POS effects. These findings also provide rationale for targeting both nouns and verbs in communicative interventions. Chapter 4 of this thesis further explores the language changes identified here within a larger group of older participants exhibiting varying levels of global cognitive ability, including both cognitively healthy participants and participants exhibiting signs of cognitive impairment.

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CHAPTER 4. MONTREAL COGNITIVE ASSESSMENT SCORE AND AGE AS PREDICTORS OF PART OF SPEECH QUANTITY AND SOPHISTICATION IN ADVANCED AGEING

Keywords and Abstract

Keywords

Cognitive decline, ageing, part of speech, lexical sophistication, word frequency, age of acquisition

Abstract

Introduction: Ageing is associated with increased risk of cognitive impairment but can also be accompanied by milder cognitive declines that are considered normal. Lexical-semantic changes have been found to result from common forms of age-related cognitive impairment, including Alzheimer's disease, as well as from healthy ageing. Distinction between lexical-semantic changes that accompany cognitive impairment and those that accompany healthy ageing are unclear.

Analyses of conversational word use by groups of participants ranging in cognitive function and age may clarify relationships between cognition, ageing, and lexical-semantic changes.

Methods: This study analysed noun, pronoun, and verb quantities and noun and verb frequencies and ages of acquisition (AoAs) in descriptions of childhood memories by 241 participants ranging from ages 64 to 91 and Montreal Cognitive Assessment (MoCA) scores of 14 to 30.

Results: Lower MoCA scores were significantly associated with use of fewer nouns and more pronouns. MoCA scores did not predict noun frequencies or AoAs or verb quantities, frequencies, or AoAs. Age did not predict noun or pronoun quantities or noun frequencies or AoAs. Similarly, age did not predict verb quantities or frequencies. However, increasing age was significantly associated with use of verbs of lower AoAs.

Conclusion: These findings provide further evidence that lower global cognitive ability is associated with use of fewer nouns and more pronouns in connected speech. These trends likely explain prior

findings of decreased overall lexical sophistication in cognitive impairment, since nouns are more sophisticated than pronouns and cognitive ability does not predict changes in sophistication within POS. Studies of use of pro-verbs, which function similarly to pronouns, may improve understandings of decreased lexical sophistication in cognitive impairment. Nonsignificant declines here in lexical sophistication measures with age suggest that further research on word use in groups of people over age 65 may improve understandings of language changes in healthy ageing.

4.1 Introduction

Age is associated with a range of cognitive changes, including changes affecting language. Age is, for example, the strongest predictor of Alzheimer’s disease (AD) (Plassman et al., 2007), which is marked by the lexical-semantic declines detailed in Chapter 2. As touched on in Chapter 1, though, healthy ageing is also believed to involve cognitive changes independently of AD or other disease processes (Salthouse, 2009). These include lexical-semantic declines that are less severe than those experienced by people with AD (pwAD) but appear despite a demonstrable increase in word knowledge across the lifespan (Kavé et al., 2009; Shafto et al., 2017). Clearer understanding of lexical-semantic changes in cognitive impairment and healthy ageing would help facilitate diagnosis of age-related major neurocognitive disorders (NCDs)—in particular AD, which accounts for about 70% of major NCD diagnoses (Plassman et al., 2007). Because 94% of AD diagnoses occur in patients over age 65 and incidence increases as age progresses beyond 70 (Zhu et al., 2015; Plassman et al., 2007), examinations of language use specifically by participants over 65 are necessary to differentiate these changes. However, as referenced in Chapter 1, distinguishing pathological from healthy language changes in this population may be complicated by undetected neuropathological processes in older participants classified as cognitively healthy (Harrington et al., 2018). The likelihood of exhibiting AD-associated amyloid pathology, for example, increases in adults with normal cognition as they progress in age from 50 to 90 (Harrington et al., 2018; Jansen et al., 2015).

A recent examination by Wisler et al. (2020) of relationships between language use and cognitive ability avoided uncertain binary classifications of cognition while focusing exclusively on participants of advanced age (64 to 97 years old). This study investigated the use of demographic measures and lexical and acoustic characteristics of spontaneous speech by 521 speakers to predict Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) scores ranging from 11 to 30. Overall, four of 108 variables significantly predicted the cognitive ability of participants. Age was the most significant predictor. Only one of 25 lexical measures, a measure of overall lexical diversity,

significantly predicted MoCA scores. Multiple other diversity measures across and within parts of speech (POS) did not predict scores, nor did proportionate use of infrequent words or infrequent verbs. Despite its relative lack of significant findings, this study's use of MoCA scores rather than broad classifications of cognitive ability, along with its inclusion of a large group of participants of a range of advanced ages, are useful practices in distinguishing language changes that may signify cognitive impairment from those appearing in healthy ageing.

Findings from Chapters 2 and 3 of this thesis indicate that inattention to particular effects of learning history and POS may have contributed to that study's lack of significant findings on predictors of cognitive ability. Noun frequencies or proportionate makeup of speech samples by POS, for example, were not considered despite suggestions from studies reviewed in Chapter 2 that learning history and POS affect retrieval by pwAD on single-word tasks. Higher frequency and earlier age of acquisition (AoA) of stimulus nouns and verbs have been shown to facilitate object and action naming by pwAD (Rodríguez-Ferreiro et al., 2009). Similar effects of learning history are apparent in performance on verb fluency tasks, where pwAD have been found to produce verbs of higher frequency and earlier AoA than cognitively healthy age-matched controls (Paek & Murray, 2021). The relative accuracy with nouns over verbs on naming tasks reported in Chapter 2 suggests differential effects by POS in retrieval by pwAD. Learning history may factor into POS effects, since nouns tend to be acquired earlier than verbs (Mätzig et al., 2009). However, as established in Chapter 3, verbs have much higher frequency values, clouding the contribution of learning history to this differential POS impairment.

Effects of learning history and POS appear to carry over to discourse production by pwAD. In connected speech, pwAD have been found to use a narrowed range of words of higher average frequencies than those used by controls (Fraser et al., 2016; Kavé & Dassa, 2018). The combination of decreased lexical diversity and higher average word frequency has led researchers to theorize that impairments in AD specifically affect advanced, or sophisticated, words, leading to frequent reuse of

less sophisticated substitutes (Fraser et al., 2016; Kim & Thompson, 2004). However, findings including those from Chapter 3 indicate that changes in lexical diversity and average word frequency may instead stem from changes in proportions of words used by POS, with nouns playing a key role. pwAD use fewer and less diverse nouns than controls, replacing them with words from the closed class pronouns while using similar or higher numbers of verbs (Blanken et al., 1987; Kavé & Dassa, 2018; see also Chapter 3). Because nouns tend to have lower frequency values than pronouns or verbs (Mätzig et al., 2009; Kavé & Dassa, 2018; see also Chapter 3), these changes in word use by POS likely factor into consensus findings of increased overall word frequency in pwAD. Meanwhile, between-group comparisons of noun sophistication have resulted in mixed findings (Fraser et al., 2016; Kavé & Goral, 2016), with Chapter 3 of this thesis including findings that pwAD produced nouns of similar frequencies and higher AoA than controls in spontaneous speech. This body of findings demonstrates the importance of accounting for POS and its effects in speech sample construction and sophistication measures when investigating lexical-semantic changes in AD.

In healthy ageing, findings on word frequency and POS in connected speech production, while mixed, suggest changes to noun use that differ from those seen in AD. Reporting that older but not younger adults experience increased difficulty retrieving lower-frequency words (Burke et al., 1991; Burke & Shafto, 2004) is contradicted by a Kavé et al. (2009) finding that participants aged 20 to 85 used nouns of lower frequencies with age. The authors attributed this to the larger vocabularies of older than younger people. Their finding that age did not lead to changes in numbers of nouns produced contrasts with recent reporting by Kintz and Wright (2022) that age led to significant, albeit weak, declines in the proportional production of nouns by 469 participants aged 20 to 89. While contradictory, these findings suggest that if noun production changes across the adult lifespan, these changes are minor. Reporting on noun use exclusively by participants of advanced ages is sparse. However, in Chapter 3, age was found to be associated with use of nouns of higher frequencies in twelve controls aged 71 to 100 who also exhibited nonsignificant declines in quantities of nouns produced. Overall, these findings indicate that, as opposed to the production of

fewer nouns by pwAD, people of advanced ages may produce relatively stable numbers of less sophisticated nouns as they continue to age.

Findings on verb production in both AD and healthy ageing are less clear. Reporting on frequency and AoA of verbs used appears to indicate marginal effects of either AD or ageing on verb sophistication. In Chapter 3, no group differences were present in frequencies or AoAs of verbs produced, and verb sophistication remained stable with age in healthy older people even as noun sophistication decreased. Fraser et al. (2016) similarly found no differences in verb AoA by group, though pwAD used verbs of higher frequencies. In contrast to findings based directly on frequency or AoA, investigations of the use of light verbs, a subset of highly frequent, semantically impoverished verbs, have found increased reliance on these in both ageing and AD (Kintz and Wright, 2022; Kim & Thompson, 2004). Overreliance on the lightest of these verbs, *be*, may distinguish pwAD from healthy older people. Kintz and Wright (2022), however, reported a high degree of overlap among the verbs used most often by pwAD and matched controls. These authors also reported that pwAD used more verbs than healthy older people. While adding to a lack of clarity on whether verb production increases in AD (Blanken et al., 1987; Kavé & Dassa, 2018; see also Chapter 3), these findings can be seen to confirm that it does not decline. In healthy participants, Kintz and Wright (2022) found no relationship between age and numbers of verbs produced, though age significantly predicted modestly decreasing proportions of verbs in speech samples. Overall, these findings on verbs suggest that, while their production in discourse may be less affected than noun production in ageing or AD, further investigation is needed.

The present study aims to investigate changes in the production of nouns, pronouns, and verbs in semi-structured interviews by older participants varying along continuums of global cognitive function and age. The study uses a subset of the Wisler et al. (2020) dataset. While that study investigated predictors of MoCA score, including age and language use, the focus of the

current study is on language use as predicted by MoCA score and age. The following hypotheses are investigated:

H1) The quantity of nouns produced in spontaneous speech will decrease significantly as MoCA score decreases, but there will be no significant effect of age.

H2) The quantity of pronouns produced in spontaneous speech will increase significantly as MoCA score decreases, but there will be no significant effect of age.

H3) The quantity of verbs produced in spontaneous speech will not change significantly as MoCA score or age changes.

H4) The lexical sophistication of nouns produced in spontaneous speech will decrease with age, but there will be no effect of MoCA score. H4a) Frequencies of nouns produced will increase significantly as age increases, and H4b) AoAs of nouns produced will decrease significantly as age increases.

H5) The lexical sophistication of verbs produced in spontaneous speech will not change as MoCA score or age changes. H5a) Frequencies of verbs produced will not change significantly as MoCA score or age changes, and H5b) AoAs of verbs produced will not change significantly as MoCA score or age changes.

4.2 Methods

4.2.1 Dataset

Data used in the present study are a subset of the dataset described by Wisler et al. (2020). In brief, that dataset consists of speech samples provided by 521 speakers of New Zealand English (335 females) between 64 and 97 years old. While some participants had histories of concussion, other head injury, transient ischemic attack, or other medical condition, these were not reported to have contributed to speech or language issues. Each participant underwent cognitive testing using

the MoCA, a brief tool used primarily in screening for mild cognitive impairment (Nasreddine et al., 2005), and participated in a semi-structured conversation. The conversation format consisted of five parts, during which the participant: 1) counted 1-10, 2) described a childhood memory, 3) reported what they had eaten for breakfast, 4) read a short passage, and 5) provided feedback on the participant experience. Wisler et al. (2020) analysed only the language produced in part 2, the participant's longest stretch of spontaneous speech. This was most often produced in response to the prompt, "Now tell me something funny that happened to you, or even a friend, when you were growing up." If a participant was unable to provide a response to this prompt, the interviewer followed up with the question, "What was New Zealand like when you were growing up?" Some participants still did not provide a substantial response. However, all responses were included in analyses on the rationale that the response attempt provided insight into the participant's cognitive ability.

4.2.2 Participants and language samples

The present study also examines only the memory descriptions from that dataset. However, analyses are limited to descriptions of at least 150 words. Prior research has established this as an acceptable minimum length for language analyses (Saffran et al., 1989; Sajjadi et al., 2012). Samples of this length also ensure the inclusion of multiple nouns, pronouns, and verbs from each participant, allowing conclusions to be drawn about participants' use of these POS. Thus, following the exclusion of three participants for whom complete demographic data was unavailable, speech samples were re-transcribed according to CHAT guidelines (MacWhinney, 2000). Descriptions of fewer than 150 words were excluded from further consideration. Those over 150 words were cut down to the participant's 150th word to ensure comparisons involved samples of a standardised length. The final dataset used here consists of speech samples produced by 241 participants (148 females) of an average age of 73.7 years old (sd 6.1, range 64-91) and an average reported education level of 13.3 years (sd 6.1, range 2-26) . The average MoCA score for these participants

was 26 (sd 2.9, range 14-30) of a maximum 30 points. 156 participants scored 26 or above, a scoring range associated with healthy cognition; 74 participants scored between 21 and 25, a range that may indicate MCI; 11 participants scored below 20, which may indicate dementia (Dautzenberg et al., 2020).

4.2.3 Language analysis

Transcripts were parsed and tagged using tools from CLAN (MacWhinney, 2000), software designed to work with data transcribed in the CHAT format. These tools were integrated into LaBB-CAT (Fromont & Hay, 2012), the data management package used to store and work with these transcripts. Words tagged as nouns, pronouns, or verbs were extracted and reviewed for accurate tagging, including the contextual accuracy of tags of *~ing* forms as nouns (gerunds) or verbs (participles). Inaccuracies that would affect analyses were corrected. Pronouns are of interest to this study as less specific noun substitutes that may result in vagueness. Therefore, pronoun types used where nouns would be ungrammatical or redundant were excluded from analyses. Pronouns included here were tagged by CLAN tools as personal, subject, object, demonstrative, existential, or indefinite. Pronouns excluded were tagged as interrogative (*Who* is she?), relative (He smokes, *which* is unhealthy.), reflexive (John really likes *himself*.), or possessive (That shirt is *mine*.) pronouns. Verbs are of interest to this study as words conveying semantic content. Therefore, verb types with a primarily grammatical function were excluded from analyses. Verbs included here were tagged as lexical verbs, copulas, or participles. Verbs excluded were tagged as auxiliary (I *have* eaten.) or modal (I *may* eat again.) verbs.

H1-H3, addressing POS quantities, were investigated using counts derived from final lists of nouns, pronouns, and verbs. Gerunds were counted as nouns and participles as verbs in these analyses, consistent with their tags. H4 and H5, addressing noun and verb sophistication, were investigated using frequencies and AoAs of noun and verb lemmas. Word frequencies are provided in LaBB-CAT as the overall number of lemma appearances in the CELEX lexical database (Baayen et

al., 1995). AoAs used here were extracted from the data of Bird et al. (2001), the largest viably scaled AoA dataset the author is aware of that accounts for a word form's POS (see Wikse Barrow et al., 2019 and Chapter 3 Sections 2.3 and 4.1.2 for discussions of existing AoA datasets and their limitations). Bird et al. (2001) asked participants to estimate AoA on a 7-point Likert scale, with each point corresponding to a period of two years including the age at which the participant believed they had learned the word. For example, a rating of one would indicate an age between 0 and 2 years old. A rating of seven was assigned for any age over 13. Bird et al. (2001) then multiplied mean ratings by 100, so that final ratings are between 100 for a low AoA and 700 for a high AoA. Gerunds were excluded from sophistication analyses due to discrepancies between the POS of word forms in speech samples and lemmas in frequency and AoA databases.

4.2.4 Statistical analysis

The statistical software environment R (R CoreTeam, 2021) was used for all statistical analyses. Each hypothesis was addressed using a regression model that included age and MoCA as predictors of interest and gender and education as covariates. These explanatory variables were included based on a specific interest in their effects rather than on a model selection process that may have eliminated predictors or relevant covariates from a model of best fit. Relationships between explanatory variables were examined prior to analyses. Continuous explanatory variables were centred but not scaled for analyses (Kraemer & Blasey, 2004). H1-H3 were investigated using multiple regression models with quantity of nouns, pronouns, and verbs, respectively, as outcome variables. H4 and H5 were investigated using four linear mixed effects models with noun frequency (H4a), noun AoA (H4b), verb frequency (H5a), and verb AoA (H5b) as outcome variables. Frequency and AoA ratings were converted to natural logarithms to address positive or negative skews, wide ranges of values, and, in verb frequency analyses, the influence of *be* in the original data. Speaker appeared alone as a random effect in these models due to convergence issues in preliminary models with Word as a nested random effect. Interactions of the predictor variables of interest, age and

MoCA, were included in preliminary models addressing all hypotheses, but were found non-significant and removed from all models. Where plots of final regression models did not meet statistical assumptions, models were subjected to nonparametric bootstrap analyses of 2000 iterations. Bootstrap results were used to calculate bias-corrected and accelerated (BCa) confidence intervals (Efron, 1987).

4.3 Results

4.3.1 H1: Noun quantities

An average of 27.3 nouns were produced per speaker (sd 5.8, range 15-47). A multiple regression model with noun quantity as the outcome variable showed that production of nouns was significantly lower for people with lower MoCA scores ($p = 0.045$, Table 4.1, Figure 4.1). The effect of gender on quantity of nouns produced was also significant, with men producing significantly more nouns than women ($p < 0.01$). Neither age nor education had a significant effect on numbers of nouns produced. Validation plots indicated this model met statistical assumptions.

Table 4.1

Quantity Results

Nouns					
Predictor	Estimate	Standard error	<i>t</i>	<i>p</i>	95% CI (BCa)
Intercept	26.36	0.49	54.22	< 0.01**	25.48, 27.34
Centered MoCA	0.3	0.15	2.02	< 0.05*	-0.01, 0.62
Centered Age	0.06	0.07	0.88	0.38	-0.09, 0.21
Gender	2.33	0.81	2.86	< 0.01**	0.8, 4.05
Centered Education	0.00	0.12	0.03	0.98	-0.22, 0.22
Pronouns					
Predictor	Estimate	Standard error	<i>t</i>	<i>p</i>	95% CI (BCa)
Intercept	20.8	0.41	50.66	< 0.01**	19.98, 21.62

Centered MoCA	-0.26	0.12	-2.09	< 0.05*	-0.46, 0.00
Centered Age	0.02	0.06	-0.39	0.7	-0.14, 0.09
Gender	1.65	0.69	-2.4	< 0.02*	-2.95, -0.30
Centered Education	-0.17	0.11	-1.64	0.1	-0.36, 0.04

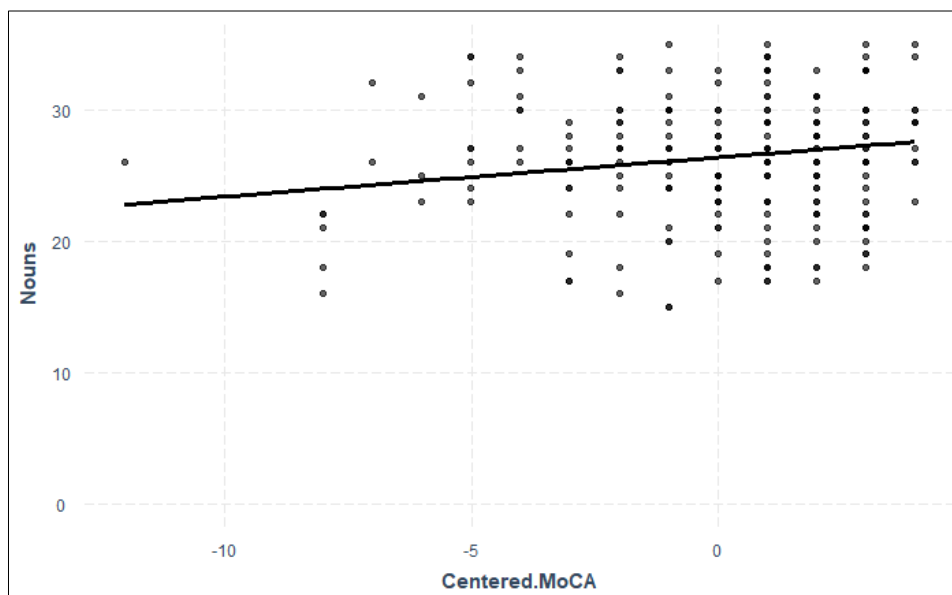
Verbs					
Predictor	Estimate	Standard error	t	p	95% CI (BCa)
Intercept	24.49	0.32	77.1	< 0.01**	23.85, 25.11
Centered MoCA	-0.11	0.1	-1.09	0.28	-0.3, 0.1
Centered Age	-0.03	-0.04	-0.69	0.49	-0.11, 0.05
Gender	-1.11	0.53	-2.08	< 0.04*	-2.18, -0.06
Centered Education	-0.05	0.08	-0.57	0.57	-0.21, 0.1

CI = confidence interval

* $p < 0.05$, ** $p \leq 0.01$

Figure 4.1

Relationship Between MoCA Score and Quantity of Nouns Produced



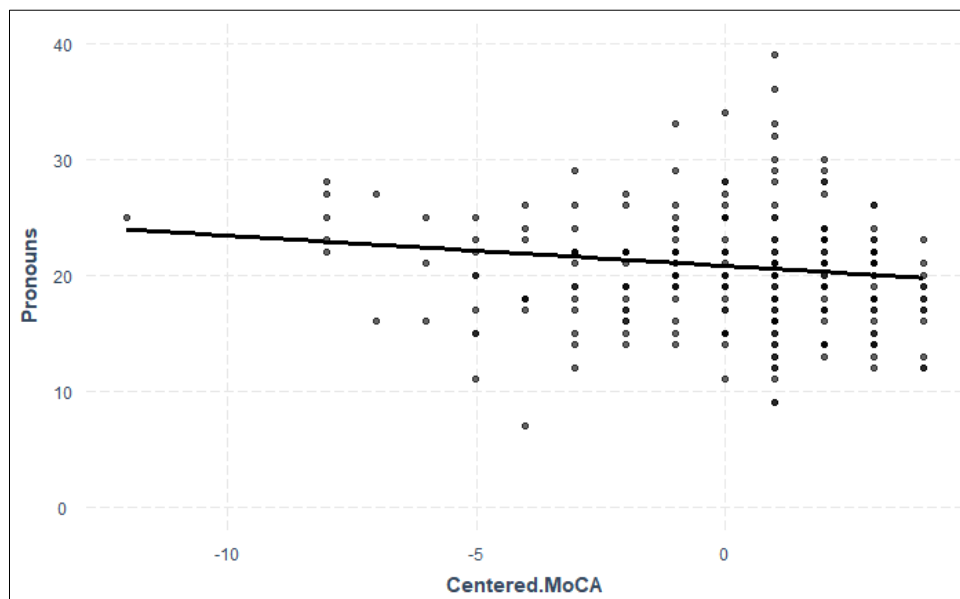
$p < 0.05^*$

4.3.2 H2: Pronoun quantities

An average of 20.2 pronouns were produced per speaker (sd 5, range 7-39). A multiple regression model with pronoun quantity as the outcome variable showed that production of pronouns was significantly higher for people with lower MoCA scores ($p = 0.038$, Table 4.1, Figure 4.2). The effect of gender on quantity of pronouns produced was also significant, with women producing significantly more nouns than men ($p < 0.02$). Neither age nor education had a significant effect on numbers of pronouns produced. Validation plots indicated this model met statistical assumptions.

Figure 4.2

Relationship Between MoCA Score and Quantity of Pronouns Produced



$p < 0.05^*$

4.3.3 H3: Verb quantities

An average of 24.1 verbs were produced per speaker (sd 3.8, range 14-35). A multiple regression model with verb quantity as the outcome variable showed that neither age nor MoCA significantly predicted verb production (Table 4.1). The effect of gender on quantity of verbs produced was significant, with women producing more verbs than men ($p < 0.04$). Education did not

have a significant effect on numbers of verbs produced. Validation plots indicated this model did not meet statistical assumptions. However, bootstraps of the model confirmed all results.

4.3.4 H4: Noun sophistication

Frequency data were available for 5464 of the 6570 nouns produced by speakers. The average CELEX frequency of these nouns was 5976 (sd 7772, range 1-37195). The average log frequency of nouns was 7.6 (sd 1.9, range 0-10.5). A linear mixed effects model with log frequency as the outcome variable showed that none of the predictors had a significant effect on the log frequency of nouns produced (Table 4.2). The nonsignificant effects of age and MoCA are represented visually in Figure 4.3. Validation plots indicated this model did not meet statistical assumptions. However, bootstraps of the model confirmed all results.

Table 4.2

Noun Sophistication Results

Frequency (log)					
Predictor	Estimate	Standard error	<i>t</i>	<i>p</i>	95% CI (BCa)
Intercept	7.62	0.05	151.09	< 0.01**	7.53, 7.72
Centered MoCA	-0.02	0.02	-1.39	0.17	-0.05, 0.01
Centered Age	0.00	0.01	0.53	0.6	-0.01, 0.02
Gender	0.03	0.08	0.34	0.73	-0.14, 0.17
Centered Education	0.01	0.01	0.75	0.46	-0.02, 0.03

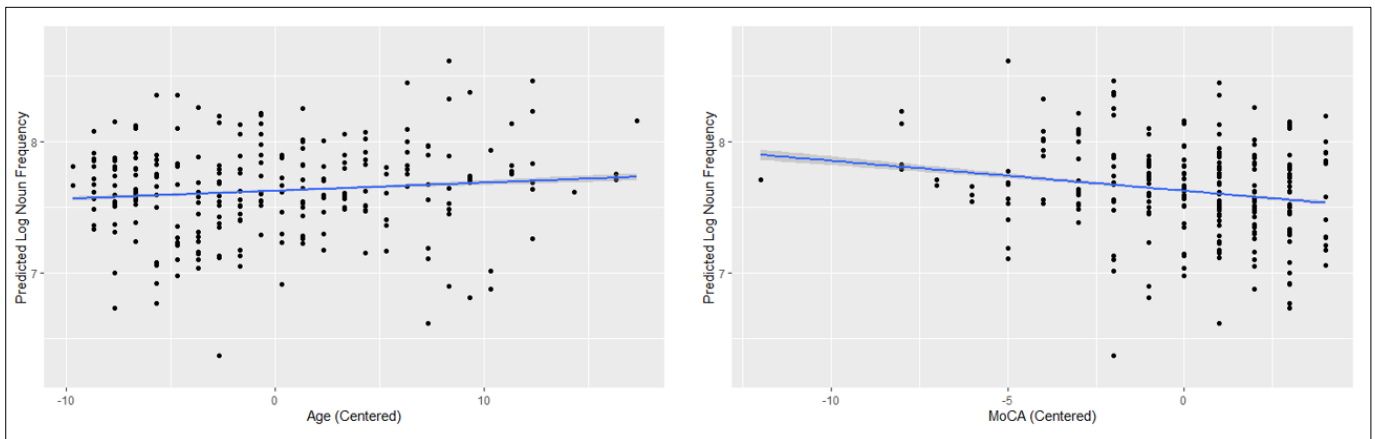
AoA (log)					
Predictor	Estimate	Standard error	<i>t</i>	<i>p</i>	95% CI (BCa)
Intercept	5.54	0.01	608.27	< 0.01**	5.52, 5.56
Centered MoCA	0.00	0.00	1.14	0.25	-0.00, 0.01
Centered Age	0.00	0.00	0.82	0.42	-0.00, 0.00
Gender	0.02	0.02	1.59	0.11	-0.01, 0.05

Centered	0.00	0.00	1.78	< 0.08	-0.00, 0.01
Education					

CI = confidence interval
 * $p < 0.05$, ** $p \leq 0.01$

Figure 4.3

Relationships Between Age and MoCA and Log Frequency of Nouns Produced

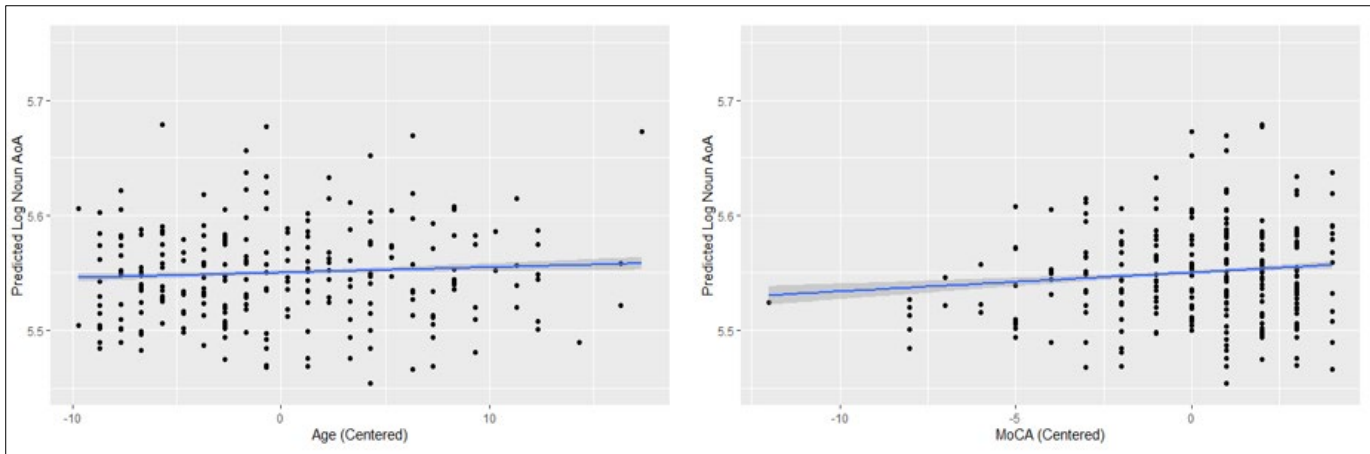


Age: $p = 0.6$; MoCA: $p = 0.17$

AoA data were available for 2224 of the 6570 nouns produced by speakers. The average AoA rating of these nouns was 266.4 (sd 73.3, range 150-823). The average log AoA of nouns was 5.6 (sd 0.26, range 5-6.7). A linear mixed effects model with log AoA as the outcome variable showed that none of the predictors had a significant effect on the log AoA of nouns produced (Table 4.2). The nonsignificant effects of age and MoCA are represented visually in Figure 4.4. The effect of education was marginally significant ($p < 0.08$). Validation plots indicated this model met statistical assumptions.

Figure 4.4

Relationships Between Age and MoCA and Log AoA of Nouns Produced



Age: $p = 0.42$; MoCA: $p = 0.25$

4.3.5 H5: Verb sophistication

Frequency data were available for 5782 of the 5799 verbs produced by speakers. The average CELEX frequency of these verbs was 201503 (sd 282851, range 2-687085). The maximum frequency value was that of the verb *be*, which was also the most frequently occurring verb in these data. The average log frequency of verbs was 10.5 (sd 2.3, range 0.7-13.4). A linear mixed effects model with log frequency as the outcome variable showed that neither age nor MoCA significantly predicted log frequencies of verbs produced (Table 4.3, Figure 4.5). The effect of gender was significant ($p < 0.05$), with women using verbs of higher log frequencies than men. The effect of education was not significant. Validation plots indicated this model did not meet statistical assumptions. Bootstraps of the model were inconsistent in confirming the relationship between gender and verb frequency—bootstraps of the model were performed multiple times, and in some cases, BCa confidence intervals for gender included 0.

Table 4.3

Verb Sophistication Results

		Frequency (log)			
Predictor	Estimate	Standard error	t	p	95% CI (BCa)

Intercept	10.51	0.05	219.25	< 0.01**	10.42, 10.61
Centered MoCA	-0.02	0.01	-1.47	0.14	-0.05, 0.01
Centered Age	0.00	0.01	0.51	0.61	-0.01, 0.02
Gender	-0.16	0.08	-1.98	< 0.05*	-0.31, -0.00
Centered Education	-0.00	0.01	-0.27	0.79	-0.02, 0.02

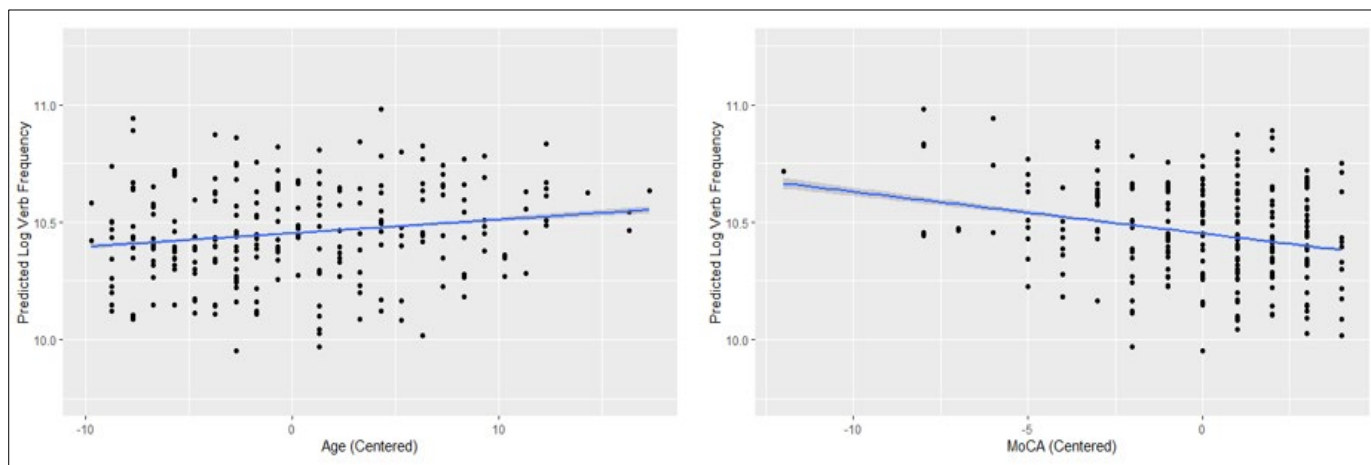
AoA (log)					
Predictor	Estimate	Standard error	<i>t</i>	<i>p</i>	95% CI (BCa)
Intercept	5.63	0.00	1823.02	< 0.01**	5.63, 5.64
Centered MoCA	-0.00	0.00	-0.7	0.48	-0.00, 0.00
Centered Age	-0.00	0.00	-2.03	< 0.05*	-0.00, 0.00
Gender	0.00	0.01	1.85	< 0.07	-0.00, 0.02
Centered Education	0.00	0.00	0.32	0.75	-0.00, 0.00

CI = confidence interval

* $p < 0.05$, ** $p \leq 0.01$

Figure 4.5

Relationships Between Age and MoCA and Log Frequency of Verbs Produced

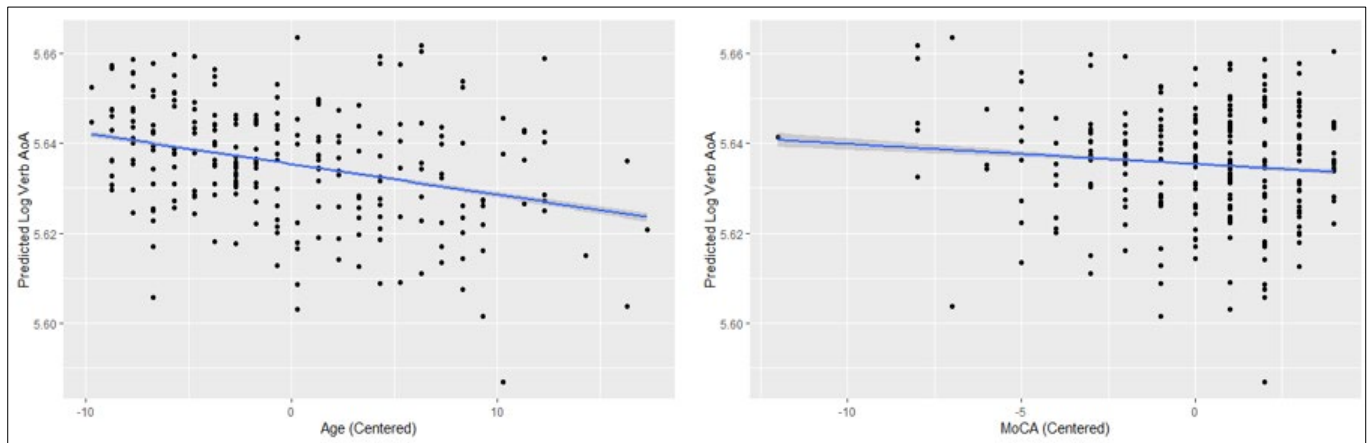


Age: $p = 0.61$; MoCA: $p = 0.14$

AoA ratings were available for 5053 of the 5799 verbs produced by speakers. The average AoA rating of these verbs was 283.1 (sd 42, range 167-570). The average log AoA of verbs was 5.6 (sd 0.14, range 5.1-6.3). A linear mixed effects model with log AoA as the outcome variable showed that age significantly predicted log AoA of verbs produced ($p = 0.04$, Table 4.3). Effects of MoCA and education were not significant (Figure 4.6), while the effect of gender was marginally significant ($p < 0.07$). Validation plots indicated this model met statistical assumptions.

Figure 4.6

Relationships Between Age and MoCA and Log AoA of Verbs Produced



Age: $p < 0.05^*$; MoCA: $p = 0.17$

4.4 Discussion

This study aimed to investigate effects of cognitive impairment and ageing on the production of nouns, pronouns, and verbs in spontaneous speech. Speech samples of 241 participants aged 64 to 91 were matched for overall word count and analysed for effects of MoCA score and age on noun, pronoun, and verb quantities as well as the frequencies and AoAs of nouns and verbs produced. Lower MoCA scores were significantly associated with use of fewer nouns and more pronouns, but did not predict noun frequencies or AoAs. MoCA score did not predict verb quantities, frequencies, or AoAs. Age did not predict noun quantities, frequencies, or AoAs. It did not

predict verb quantities or frequencies; however, increasing age was significantly associated with use of verbs of lower AoAs.

In line with findings from Chapter 3 and other research on the use of POS by pwAD (Fraser et al., 2016; Kavé & Dassa, 2018), these findings suggest that lower global cognitive ability is accompanied by use of fewer nouns and more pronouns. The present findings are based specifically on types of pronouns that can be used as less specific substitutes for nouns. Prior studies, including Chapter 3 and Kavé & Dassa (2018), have suggested that trends in noun and pronoun production result from retrieval issues in AD that lead to replacement of nouns with more easily retrieved, but less specific, pronoun substitutes. However, these studies did not report looking specifically at types of pronouns used as vague substitutes for nouns. These would include, for example, personal pronouns such as subject or object pronouns (e.g., *he, she, him, her*) but not interrogative or relative pronouns (e.g., *who, which*). One use of personal pronouns is to substitute for proper nouns, which pwAD are known to have difficulty with (Semenza et al., 2003). Relative pronouns, by contrast, are a sign of grammatical complexity (Chomsky, 1977). The distinct implications of use of different types of pronouns means that there is a need to distinguish between them when attempting to draw conclusions based on pronoun use. The findings presented here can thus be seen as strong evidence that people experiencing cognitive impairment replace nouns with vague, overlearned pronoun substitutes.

In data analysed for the present study, use of fewer nouns by people with lower MoCA scores was not accompanied by use of less sophisticated nouns. People with AD, the most common major NCD, are less accurate when required to use more sophisticated target words of a given POS to name pictures (Rodríguez-Ferreiro et al., 2009). pwAD also produce connected speech samples with fewer unique words and higher average frequencies among all words than cognitively healthy controls (Fraser et al., 2016; Kavé & Dassa, 2018). Based on these findings, researchers have theorized that semantic memory declines in AD cause breakdowns that affect sophisticated words

first, leading to their replacement with less sophisticated words in connected speech (Fraser et al., 2016; Kim & Thompson, 2004). These would include any grammatically valid, easily retrievable substitute, for example either pronouns or less sophisticated nouns in place of more sophisticated nouns (Almor et al., 1999). An alternative hypothesis attributes use of simplified vocabulary by pwAD to working memory problems (Almor et al., 1999). Under this hypothesis, representations of sophisticated words remain in semantic memory. However, in conversation, by the time of word selection, the working memory representation of the intended more sophisticated label has deteriorated to no longer include distinguishing features of that label, so that a general one becomes a better fit.

Both explanations assume that connected speech in AD is marked by use of more pronouns alongside fewer and less sophisticated nouns. However, a growing body of evidence suggests that noun sophistication does not significantly decline in AD. Reporting by Kavé and Goral (2016) of use of nouns of higher frequencies by 20 pwAD than 20 controls in picture descriptions is contradicted by findings from a larger picture description study (Fraser et al., 2016) and the study of conversational speech reported in Chapter 3. Each found nouns produced by pwAD not to differ in frequency or AoA from those produced by controls. The present study extends those findings, indicating no significant differences in frequency or AoA of nouns produced by people across a range of MoCA scores. All four studies report increased pronoun use by people with lower cognitive functioning. This combination of findings may indicate that past explanations have underestimated effects of either semantic or working memory impairments on communication by people with MCI and early AD. The extent of impairment may affect the use of less sophisticated nouns, resulting in decreased production of nouns across frequency or AoA spectrums. These findings may also be indicative of the degree to which people with MCI or mild to moderate AD compensate through intact syntactic processing (Taler & Phillips, 2008; see also Chapter 2 or Williams et al., 2021). While pronouns omit the distinctive semantic features of a concept, they capture grammatical features such as gender and number (Almor et al., 1999). Further work is needed toward understanding the

mechanisms and implications of replacement of nouns with pronouns but not less sophisticated nouns by people experiencing cognitive impairment.

Here, MoCA score did not predict verb quantity, frequency, or AoA. These findings are in line with reporting in Chapter 3 of no differences in quantities, frequencies, or AoAs of verbs produced in conversation by pwAD and controls. Findings from these studies contrast with reporting in reviews in Chapter 2 and by Taler & Phillips (2008) of significant effects of cognitive decline on verb processing in single-word tasks. This contrast supports the argument made in Chapter 3 that context may facilitate verb production. Findings here on verb quantity, like those in Chapter 3 and by Kavé & Dassa (2018), suggest no change in the proportional production of verbs by pwAD relative to other POS. This body of evidence contradicts earlier reports of increased reliance on verbs in AD (Fraser et al., 2016; Blanken et al., 1987; Bucks et al., 2000). The differences in findings may be partially attributable to inconsistent practices around inclusion of verbs in analyses, exacerbated by obscure documentation of these practices. For example, both Chapter 3 and the present study excluded auxiliary verbs—generally considered function words, conveyors of grammatical information, as opposed to content words, conveyors of semantic information. Both studies considered gerunds, verb forms that function syntactically as nouns, to be nouns for quantity analyses and excluded these from sophistication analyses. By contrast, Fraser et al. (2016), the largest study reporting increased reliance on verbs in AD, did not detail their decisions around inclusion of words in verb analyses. However, information in the study suggests that these authors likely included auxiliaries and gerunds as verbs in quantity and frequency analyses. This would have implications for conclusions on lexical-semantic processing by pwAD drawn based on findings of use of proportionally fewer nouns and more verbs, including verbs of higher frequencies. Future investigations of relationships between cognitive ability and verb use should detail decisions on words included as verbs in analyses.

While auxiliaries were excluded from this study, consensus findings of increased pronoun use by people with lower MoCA scores highlight a need to examine the use of auxiliaries specifically as pro-verbs. These are to verbs what pronouns are to nouns—they can replace verb or verb phrase referents (e.g., *She said to kick the computer, so I did*) to facilitate concise, cohesive communication. However, as with pronouns, use of pro-verbs creates the potential for vagueness. Bates et al. (1995) reported a nearly significant ($p < 0.06$) increase in use by pwAD of the pro-verb *do* on a video description task. The authors characterize this as an empty form and hypothesize that its increased use is related to heavy reliance on pronouns. Unfortunately, the study did not consider other pro-verbs, and the author is not aware of any research on use of pro-verbs in spontaneous speech in MCI or AD. Investigation of pro-verb use in spontaneous speech, including comparisons against lexical verb use, may provide generalizable information on use of pronouns and other semantically vague function words in place of more specific alternatives. It would also improve understandings of verb processing in people experiencing cognitive impairment.

Findings on quantity and sophistication in Chapters 3 and 4 of this thesis add to a growing body of research suggesting increased overall word frequency in speech by pwAD is caused by changes across, not within, POS. Reporting of increased overall word frequencies in connected speech by pwAD is based primarily on analyses of picture descriptions (Slegers et al., 2018; Boschi et al., 2017). A recent review by Slegers et al. (2018) identified three picture description studies reporting on word frequencies in AD: Kavé & Goral (2016), Fraser et al. (2016), and Kavé & Dassa (2018). Each reported overall increases. Each also reported increased use of pronouns and decreased use of nouns. Where reported, proportional verb use by pwAD was similar to or higher than that of controls. On average, pronouns and verbs have much higher frequency values than nouns (see Chapter 3 of this thesis; Baayen et al., 1995; Kavé & Dassa, 2018). Thus findings of increases in overall word frequencies in these studies are likely corollary to accompanying POS trends. Future investigations into overall word frequency should consider the effects of changes in proportions of words used by POS when reporting and interpreting their findings.

In contrast to the changes associated with MoCA scores, the current results generally indicate that advancing age did not significantly affect quantity or sophistication of words used by participants aged 64 and over, regardless of POS. Past studies of effects of lexical sophistication on word production by older people have reported on changes across the lifespan and may not be indicative of effects of advanced ageing. Little information has been available on how language use changes beyond the age of 65. In Chapter 3, twelve healthy controls aged 71 to 100 used more frequent nouns with age, in addition to using nouns of earlier AoA than those used by pwAD. However, information on the cognitive ability of participants was limited to binary designations as to whether AD or dementia were or were not present. Precise information on education, which is known to affect cognitive ability in older people (Alley et al., 2007), was also unavailable. Findings reported in this chapter are based on a higher number of participants and account for education and finer distinctions in global cognitive ability. Though findings here generally do not indicate significant changes with age, Figures 4.3 to 4.6 suggest that in addition to a significant change in AoA of verbs used, there was a general trend toward use of less sophisticated words. Further study of language changes as age progresses further past 65 would help pinpoint changes that are attributable to AD.

Gender appeared here to affect both POS quantities and verb sophistication. The findings of use of fewer nouns and more pronouns and verbs by females than males are in line with prior findings of gender differences in the use of these POS (Newman et al., 2008). Females here were also found to produce verbs of significantly higher frequencies and of earlier AoA at a level approaching significance ($p < 0.07$). These sophistication differences may be seen as surprising, given prior findings of no gender differences or a slight advantage for females in verbal ability (Hyde & Linn, 1988). Indeed, the findings should not be taken at face value. This study included more female than male participants. Their use of more verbs than males means more verbs were included for females in analyses. As discussed in Chapter 3 and by Zipf (1949), speech samples are made up of a disproportionate number of simple words. This means analyses here likely included more simple verbs for females than males, which may have affected results. Researchers investigating or

interpreting findings on lexical sophistication should consider the potential effects of quantity differences by group in sophistication analyses.

The use of MoCA scores to draw conclusions on degrees of cognitive decline is a weakness of this study. MoCA is intended as a screening tool for cognitive impairment. It is useful for excluding cognitive impairment or determining a need for further diagnostic assessment but is less suited to use as a stand-alone instrument for diagnostic purposes (Dautzenberg et al., 2020). It does not provide detailed insight into ability in specific cognitive domains. This limits its specificity for causes of cognitive impairment other than MCI, which may or may not convert to any of several dementias (Artero et al., 2006). The present findings should therefore be seen not to provide information on language use by pwAD but rather to document language use in an older population across varying levels of cognitive functioning. It has been argued that all MoCA items require substantial verbal ability (Demeyere et al., 2016), a confound that may have played some role in this study's findings of relationships between MoCA scores and language measures. Performance on MoCA and other cognitive screenings may also be influenced by age, gender, or education (Freitas et al., 2012), making it necessary to account for these as covariates. Despite these potential limitations, use of MoCA scores allows researchers to avoid broad, binary labels of cognitive status and provides insight into incremental changes across a range of global cognitive abilities (Wisler et al., 2020). The inclusion here of participants of a range of MoCA scores and ages has provided findings that should help distinguish effects of healthy ageing from impairments that may stem from disease processes.

This study has other limitations of which the reader should be aware. These include a lack of available options for AoA ratings. Limitations of existing AoA datasets are discussed in Wikse Barrow et al. (2019) and in Chapter 3 Sections 2.3 and 4.1.2. This study used the AoA ratings provided by Bird et al. (2001). While these distinguish between POS of word forms, the dataset is small. Language researchers would benefit from a large, objective, precisely scaled set of AoA norms that accounts for multiple word meanings. Another potential limitation of this study is its reliance on an

automated POS tagger. While automated language analysis tools facilitate work with large amounts of data, there is a tradeoff in coding accuracy. Automated POS tags for the present dataset were reviewed and inaccuracies identified were corrected, but inaccuracies may remain among tags of the 17,228 words analysed here. The prompt used to elicit these speech samples also appears to have led to production of high numbers of gerunds. These were classified as nouns for quantity analyses and were not assigned sophistication values, which would be based on usage as verbs. This practice led to differences in numbers of nouns included in quantity and sophistication analyses. Finally, the statistical significance of results presented here should not be equated with clinical or functional significance. Cognitive decline is heterogenous, and the clinical and functional significance of results such as these to a given individual should be determined through conversations between that individual, family and carers, and the clinicians working with them. Despite these limitations, this study has provided insight into changes in language use based on changes in age and cognitive ability while calling attention to methodological considerations that will improve investigation of these changes.

4.5 Conclusion

This study's purpose was to investigate changes in the production of nouns, pronouns, and verbs in conversational speech by older participants varying along continuums of global cognitive function and age. Ageing is often accompanied by cognitive declines. Some of these may arise due to disease processes that result in impaired cognition. However, healthy ageing may also involve modest cognitive declines. Lexical-semantic changes can appear in cognitive impairment or in healthy ageing. Analyses of word use by participants differing along continuums of cognitive ability and age, rather than in group membership, may help distinguish lexical-semantic changes that arise in healthy ageing from changes that signify disease processes. This study analysed noun, pronoun, and verb quantities and noun and verb frequencies and ages of acquisition (AoAs) in descriptions of childhood memories by 241 participants across a range of MoCA scores and ages. Lower MoCA

scores significantly predicted use of fewer nouns and more pronouns, but did not predict verb quantities or noun or verb frequencies or AoAs. Since nouns are more sophisticated than pronouns, these results suggest that changes in word use by POS contribute to findings of decreased overall lexical sophistication by cognitively impaired participants, while use of less sophisticated nouns or verbs does not. Consensus findings of increased pronoun use by people experiencing cognitive impairment necessitate investigations of the use of pro-verbs, which function similarly to pronouns but have been neglected in prior studies. Age did not predict noun quantities, frequencies, or AoAs. It did not predict verb quantities or frequencies but predicted their AoAs. While trends toward use of less sophisticated words with age were generally not significant, they suggest that further study of word use by people over age 65 may improve understandings of language changes in healthy ageing.

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CHAPTER 5: SUMMARY, LIMITATIONS AND FUTURE DIRECTIONS, AND CONCLUSION

5.1 Summary

The overall aim of this thesis was to investigate effects of lexical-semantic changes on the production of communicative speech by pwAD, with a focus on use of words across and within POS. Studies reviewed in Chapter 1 provided rationale for this investigation. Their findings indicated that AD is accompanied by communication difficulties that arise in part due to declines in informative content in speech produced by pwAD. Language changes in AD, most prominently lexical-semantic impairments, likely contribute to these declines. Evidence suggests that lexical-semantic impairments differ by POS. Studies of comprehension and production of individual words have indicated better processing of nouns than verbs by pwAD. This may relate to stronger semantic relationships and thus better connectivity among nouns. Findings from discourse tasks, while less extensive, have indicated that relative success in producing nouns may not carry over to connected speech. In discourse, pwAD produce fewer nouns and more pronouns than healthy age-matched controls. However, few of the findings on POS use are based on analyses of spontaneous speech, so that it is unclear whether AD leads to changes in the use of words across and within POS in communicative contexts. If present, such changes would likely contribute to declines in informative content and thus to communication issues.

Based on findings reviewed in Chapter 1, research for this thesis was guided by a broad hypothesis that pwAD would differ from healthy older people in their use of words across and within POS in spontaneous speech. To refine this hypothesis, information was needed on the processing of multiple POS by pwAD. However, a bias toward reporting on nouns was apparent in the findings described in Chapter 1. Reporting on verbs was scarcer and lacked cohesion, possibly stemming from the variety of tasks from which conclusions on verb processing had been drawn.

A systematic review was conducted to synthesize and clarify findings on verb processing and identify directions for future research. A PICOS framework was developed to guide the formulation of a search strategy to identify studies of verb comprehension and production by pwAD. This strategy was used to search Medline (Ovid), PsycInfo, and CINAHL in 2018; search results were updated in 2021. This process led to the identification of 57 studies reporting on verb processing in isolation, in individual sentences, and in discourse. Results of the systematic review of these studies are reported in Chapter 2. On single-word tasks, pwAD were impaired compared to controls in both comprehending and producing verbs. Comparisons across POS confirmed greater impairments for verbs than nouns. Frequency and AoA affected performance by pwAD on these tasks, suggesting a role for learning history in language changes in AD. These effects were present regardless of POS. Tasks assessing comprehension of individual sentences also suggested verb processing issues, as pwAD had difficulty with sentences that included multiple verbs or verbs with reversible thematic roles. Few studies reported on individual sentence production or on discourse comprehension. Discourse produced by pwAD tended to include similar or higher numbers of verbs than discourse produced by controls, in addition to fewer nouns and more pronouns. pwAD relied heavily on high-frequency words, including light verbs (e.g., *be*), and exhibited decreases in lexical diversity—use of a narrower range of words—compared to controls on discourse tasks. These changes to language were accompanied by an overall decrease in the informative content of discourse produced by pwAD. The review noted scarce reporting on POS use in spontaneous speech production by pwAD. A recurring issue in studies reviewed was inadequate reporting on controls, which limited interpretations of findings on performance by pwAD.

Findings from this systematic review motivated two subsequent studies of word use in spontaneous speech by older participants exhibiting varying levels of global cognitive ability. The overall aim of these studies was to determine whether changes in the use of words across and within POS occur with age-associated cognitive impairment. Changes across POS were investigated using measures of reliance on nouns, pronouns, and verbs. Changes within POS were investigated

using measures of the lexical sophistication of nouns and verbs used—their frequencies and AoAs. The primary interest of these investigations was language use by pwAD. However, a secondary objective was to establish an understanding of how the measures of interest were affected by more modest cognitive declines, particularly those associated with healthy ageing. This information was seen as necessary because the cognitive declines associated with ageing often resemble, but are less severe than, those appearing in age-associated cognitive impairment; however, little information is available on how healthy ageing affects the measures targeted in these investigations. Examining effects of ageing would thus facilitate accurate interpretations of analyses of language produced by people experiencing more severe declines, such as associated with AD.

In addition to the focal measures of word use across and within POS, the first of these corpus studies, reported in Chapter 3, followed up specifically on two findings reported in the systematic review. The first was on decreases in lexical diversity in discourse produced by pwAD. Similar findings were reported in studies that did not meet review criteria. The cause of these decreases was not clear from prior reporting. Changes in word use by POS, specifically the use of fewer nouns and more pronouns, could play a role due to a necessarily limited number of pronouns replacing a wider variety of nouns. This relationship was rarely discussed by researchers. Alternatively, decreases could arise from repeated use of a limited number of words of a given POS or multiple POS. However, lexical diversity within word classes had rarely been examined. A second review finding followed up on in this study was overreliance by pwAD on the copula. Studies reviewed had broadly found pwAD to rely heavily on light verbs or other generic, high-frequency verbs without specifically examining copula use. However, the only study that had investigated this, Kim and Thompson (2004), found that overuse of the copula had likely contributed to findings of heavy production of light verbs.

In line with prior reporting, findings from Chapter 3 included decreased noun production, increased pronoun production, and no significant differences in verb production by pwAD compared

to controls. Decreased lexical diversity was also present, overall and for nouns. These findings suggest that both replacement of nouns with pronouns and repetition of a limited number of nouns factor into decreases in overall lexical diversity in discourse production by pwAD. The use of fewer nouns and of a narrower range of nouns points to an impairment in noun production. However, findings here suggest that this impairment may not involve the lexical sophistication effects seen in the production of individual words. Nouns produced by pwAD did not significantly differ from those produced by controls in terms of frequency, and pwAD produced nouns of higher AoA. This AoA finding may suggest increased lexical sophistication, though it more likely reflects controls' production of more nouns, naturally resulting in an increased proportion of nouns of early AoA. Controls, though, also produced nouns of higher frequencies with age, suggesting decreasing lexical sophistication. Meanwhile, the groups did not differ in measures of verb use, including copula use, suggesting that pwAD are more impaired in producing nouns than verbs in discourse. In combination with findings from single-word tasks, these findings may suggest that context facilitates the production of verbs. This possibility highlights the potential of investigations of differences in performance by task type to provide insight into neurological and neurocognitive aspects of language processing.

Chapter 4 aimed to further the understanding of relationships between global cognitive ability and lexical-semantic changes in spontaneous speech gained in Chapter 3 by addressing limitations present in that study. Those related primarily to a lack of information in the dataset from which participants had been selected. Chapter 3 was specifically interested in effects of AD; however, the dataset chosen for use specified dementia aetiology for a limited number of participants. In combination with other selection criteria, this resulted in a group of 12 pwAD. Only two males were included, and education was provided in ranges only, so that gender and education could not be meaningfully accounted for as covariates. The dataset was broadly described as including participants in moderate to late stages of dementia. However, stages of individual participants or information from which these might be determined, such as cognitive assessment

scores, were not available. This restricted analyses of effects of cognition to binary group designations, with the group of pwAD likely encompassing varying extents of decline. Chapter 4 sought to investigate effects of cognitive ability with greater precision and in a larger group of participants while accounting for gender and education as covariates.

Based on findings from Chapter 3, the broad hypothesis guiding Chapter 4 was that ageing and differences in global cognitive ability would lead to differential effects on noun use in spontaneous speech. Lower cognitive functioning was expected to be accompanied by use of fewer nouns and more pronouns, but not to affect noun sophistication. Age was expected to lead to use of less sophisticated nouns—i.e., nouns of lower frequencies and higher AoAs—but not to affect noun or pronoun quantities. Measures of verb use were not expected to be affected by global cognitive ability or ageing. These hypotheses were tested through analyses of language produced by 241 participants (93 males) ranging in MoCA score from 14 (suggestive of a major NCD) to the MoCA maximum of 30 (healthy cognition) and in age from 64 to 91. As hypothesized, lower MoCA scores predicted use of fewer nouns and more pronouns, but did not predict noun sophistication. Age, however, did not predict noun frequencies or AoAs or noun or pronoun quantities. As hypothesized, MoCA scores did not predict verb quantities, frequencies, or AoAs. Age did not predict verb quantities or frequencies but predicted their AoAs. General trends, while not significant, indicated use of less sophisticated words with age. Findings here thus aligned with those on effects of cognitive ability from Chapter 3 while providing some support for that study's findings on effects of ageing.

Overall, the research presented in this thesis offers evidence of the benefits of analysing spontaneous speech by people experiencing cognitive declines, and specifically of breaking findings down by POS. Such breakdowns appear to help delineate effects of the cognitive declines associated with healthy ageing versus effects of cognitive impairment on language and communication. Findings here indicate that people experiencing cognitive declines more severe than those

associated with healthy ageing produce fewer nouns and more pronouns than people ageing healthily. However, cognitive impairment does not have effects over and above those of healthy ageing on the sophistication of nouns or verbs produced. These differences in language production in cognitively impaired versus healthy ageing could be exploited for use in the diagnosis, classification, and monitoring of age-related cognitive declines. Meanwhile, the production of verbs may be a relative area of strength in communication by people experiencing common forms of cognitive impairment, such as AD or MCI. This strength could be exploited to improve communication through modification of interventions currently employed to target verb use to improve holistic language production by people with aphasia.

5.2 Limitations and future directions

The research reported in this thesis has attempted to highlight both objects of inquiry and methodological considerations for future studies. However, limitations of this research should be considered when interpreting its findings. Limitations specific to individual studies have been discussed in writeups of those studies. The reader is referred to Chapter 3 Section 4.1.2 for discussion of limitations of existing AoA datasets, including the Bird et al. (2001) dataset used to generate findings appearing in Chapters 3 and 4. Additionally, findings in this thesis should be followed up on in studies that provide more detailed information on participant cognition, control for and investigate effects of task characteristics, and collect functional images during task performance. Rationale and guidance on these recommendations are provided below.

5.2.1 Participant cognition

Conclusions from findings presented here are limited by incomplete information on causes and stages of cognitive decline. Chapters 3 and 4 drew conclusions on effects that were attributed to healthy ageing. However, behavioural changes that appear to result from healthy ageing may be accompanied by disease processes in the brain that can only be detected via imaging. Chapter 3 grouped participants based on binary distinctions regarding AD diagnosis, with the group of pwAD

including participants in moderate to late disease stages. Further detail on cognitive ability was not available. Chapter 4 drew conclusions on cognition based on MoCA scores. Intended for use as a screening tool, MoCA provides limited information on specific cognitive domains and is not useful on its own to make diagnoses or determine NCD aetiology. Future studies of effects of cognitive decline on language production would do well to include results of thorough, domain-specific cognitive assessments of participants accompanied by structural neuroimaging and, where applicable, information on aetiology and stage of NCD.

5.2.2 Task characteristics

Chapter 2 identified a need for analyses of spontaneous speech produced by people experiencing AD and related cognitive declines. Chapters 3 and 4 addressed that need. However, collection of data analysed in Chapter 3 was not strictly controlled for topic of conversation or interviewer. Topic influences the words used in a conversation. The interviewer may in turn influence the topic and other outcomes, including the degree of participant engagement in conversation. The latter contribution is especially relevant where studies analyse only samples meeting a minimum word count threshold, as interviewer characteristics may play a role in a speech sample's exclusion from study. Data collection for Chapter 4 involved a smaller pool of interviewers, resulting in less variability in interviewer characteristics. A set prompt was used to elicit speech samples. However, that prompt was open-ended, resulting in no less variability among topics discussed. Language analysed throughout this thesis therefore likely reflects not only lexical-semantic abilities of participants, but also properties of topics they discussed.

Chapter 2 also highlighted a need to study language production by the same participants across multiple task types. Such studies would help determine whether deficits apparent in the production of words in isolation or in highly controlled discourse also appear when the participant has greater control over the language they produce, as in everyday communication. Chapters 3 and 4 offered further support for analyses of language production by the same participants across tasks.

In these studies, people experiencing cognitive declines appeared more impaired in producing nouns than verbs in context. This finding contrasts with results from tasks of single-word production reported in the review, where cognitively impaired participants had more difficulty producing verbs than nouns. Future studies of effects of cognition on language production should include multiple tasks. Where aspects of performance are found to differ by task, task demands and the neurocognitive abilities required in meeting them should be investigated.

Studies of performance across task types may provide insight into differential diagnosis of AD and PPA. As in AD, knowledge of semantic processing in PPA is heavily based on performance in single-word tasks (Gorno-Tempini et al., 2011). As in pwAD, word frequency affects performance by people with the semantic variant of PPA on these tasks (Gorno-Tempini et al., 2011). Evidence in this thesis indicates pwAD may not rely on words of higher frequencies in discourse. Future studies should examine effects of word frequency in performance on single-word tasks by pwAD and people with semantic variant PPA as well as the frequencies of words produced by the same participants in discourse. Results would help determine whether analyses of psycholinguistic properties of words produced in discourse would aid in differential diagnosis of these conditions.

5.2.3 Functional imaging

Research for this thesis did not include functional images of the neural processes that accompanied spontaneous speech production by participants. However, findings from studies incorporating the design recommendations discussed above—structural neuroimaging, details of domain-specific cognitive abilities, aetiology of NCD, and multiple task types—would be strengthened by inclusion of a functional imaging component. Functional imaging during task performance by neurologically healthy participants under the age of 65 would help to clarify task demands and their neural correlates. Comparisons of these to functional images of people aged 65 and older, ageing both healthily and in conjunction with various causes of cognitive impairment,

would help researchers better understand effects of these neurological processes on task performance.

5.3 Conclusion

This thesis investigated lexical-semantic changes that may accompany cognitive impairment and healthy ageing. Changes in the conversational use of nouns, pronouns, and verbs were of specific interest. Findings here demonstrated that while declines associated with AD more adversely affect the production of verbs than nouns in isolation, cognitive impairment—declines beyond those seen in healthy ageing—specifically affect the production of nouns in discourse. This results in increased reliance on pronouns but does not have effects over and above those of healthy ageing on noun sophistication or the production of verbs. Future studies of language changes accompanying cognitive impairment should investigate the use of pro-verbs, analyse performance across multiple tasks, and include structural and functional imaging. Research on the progression of lexical-semantic changes from 65 years old to more advanced ages would be especially useful in providing normative data against which to compare those findings.

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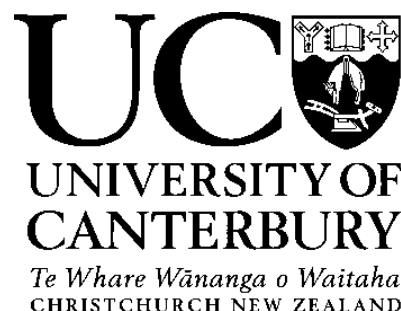
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APPENDIX A: Co-authorship form

Deputy Vice-Chancellor's Office
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Co-Authorship Form

This form is to accompany the submission of any thesis that contains research reported in co-authored work that has been published, accepted for publication, or submitted for publication. A copy of this form should be included for each co-authored work that is included in the thesis. Completed forms should be included at the front (after the thesis abstract) of each copy of the thesis submitted for examination and library deposit.

Please indicate the chapter/section/pages of this thesis that are extracted from co-authored work and provide details of the publication or submission from the extract comes:

Material covered in Chapter 2 has previously been published in:

Williams, E., McAuliffe, M., & Theys, C. (2021). Language changes in Alzheimer's disease: A systematic review of verb processing. *Brain and Language*, 223.
<https://doi.org/https://doi.org/10.1016/j.bandl.2021.105041>

Please detail the nature and extent (%) of contribution by the candidate:

Mr E Williams was responsible for the conceptualisation and design of work through to acquisition, analysis, and interpretation of data. His supervisors (McAuliffe & Theys) discussed the design, reviewed drafts, and provided mentorship throughout the process. Mr Williams was the primary and lead author, responsible for approximately 85% of the content, and nearly all of the conceptualisation. He also drafted and revised content prior to and following peer review, completed all work in the final approval of proofs for publication, and was the lead author and corresponding author. We acted as his advisors and mentors, but the work was lead, directed, and completed by Mr Williams.

Certification by Co-authors:

If there is more than one co-author then a single co-author can sign on behalf of all.

The undersigned certifies that:

- The above statement correctly reflects the nature and extent of the Doctoral candidate's contribution to this co-authored work
- In cases where the candidate was the lead author of the co-authored work he or she wrote the text

Signature: *Megan McAuliffe* Date: *17.07.2022 (on behalf of McAuliffe & Theys)*
Eric Williams, 19.07.22