Language and cognition in healthy aging and dementia

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Abstract

This dissertation investigates how changes in language performance in Alzheimer's disease (AD) and primary progressive aphasia (PPA) can help shed light on theories of language processing, the mental lexicon, and how language impairments in dementia can help give a more comprehensive understanding of the complex difficulties associated with the different diseases.

The dissertation is the first of its kind in Norway, focusing on language impairment in AD and PPA from a linguistic perspective. It contributes with new knowledge on deficits in lexical production and sentence comprehension in AD, PPA and healthy aging, shedding light on the structure of the mental lexicon in these populations. The results are in line with usage-based theories and interactive models of language processing, where the mental lexicon is seen a structured network of smaller and larger units at different levels of abstraction, sensitive to effects of frequency, age of acquisition and cognate status. Furthermore, they support a notion that theories of language should consider the multilingual mental lexicon as default. The results also indicate that there may be two different variants of the logopenic subtype of PPA.

The dissertation illustrates the advantages of using a range of different methods for assessing language, to get a detailed picture of possible impairments. By means of eye-tracking, subtle differences in processing speed between healthy adults and persons with dementia could be detected that were not seen in a parallel offline task. A free word association task detected differences that were not captured with traditional naming tasks.

Currently, language assessment plays a minor role in diagnosing dementia. However, this dissertation indicates that language data can add to diagnostic criteria for AD and PPA. While language difficulties in healthy aging and dementia can be seen as a continuum, the use of new methods and better assessment tools may contribute to both diagnosis and suggestions for possible treatment.

Sammendrag

Studiene i denne avhandlinga undersøker hvordan endringer i språkbruk hos personer med Alzheimers sykdom og primær progressiv afasi (PPA) kan gi ny kunnskap om språkprosesseringsteorier, det mentale leksikonet og hvordan språkvansker ved demens kan gi en bedre forståelse av de komplekse symptomene som følger av disse sykdommene.

Dette er den første avhandlinga i Norge som fokuserer på språkvansker ved Alzheimer og PPA fra et lingvistisk perspektiv. Den tilfører ny kunnskap om leksikalsk produksjon og setningsforståelse for personer med Alzheimer og PPA, og ved normal aldring, samtidig som den undersøker strukturene til det mentale leksikonet hos disse gruppene. Resultatene gir støtte til bruksbaserte språkteorier og interaktive prosesseringsmodeller, der det mentale leksikonet betraktes som et strukturert nettverk av større og mindre enheter, organisert på ulike abstraksjonsnivåer. Videre støtter resultatene teorier som går ut fra at det flerspråklige mentale leksikonet er grunnleggende. Resultatene peker også i retning av at det finnes to typer logopenisk PPA.

Studiene viser også hvor viktig det er å ta i bruk flere ulike metoder når man utreder språkvansker, for å få et mer detaljert bilde av mulige vansker. Ved bruk av eye-tracker ble det funnet forskjeller i prosesseringshastighet mellom personer med og uten demens, som ikke ble fanget opp av en samtidig, "offline" oppgave. Analyser av frie ordassosiasjoner viser at det er ulikheter mellom gruppene som ikke kommer fram i tradisjonelle benevnelsestester.

Språkkartlegging er ikke en sentral del av demensutredninga i Norge, men resultatene fra denne avhandlinga viser at språkdata kan fungere som tillegg til diagnosekriteriene for Aalzheimer og PPA. Språkvansker ved normal aldring og demens kan sees på som et kontinuum, og bruk av nye metoder og bedre kartleggingsverktøy kan bidra til både diagnose og mulig behandling.

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Oslo, October 2019

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Contents

List of Figures

List of Tables

Part I

Synopsis

1 Introduction

This dissertation investigates how language skills are affected in healthy aging and by dementia, more specifically Alzheimer's disease and primary progressive aphasia. The focus is on both theoretical linguistic and clinical implications for change in language function in the two diseases. The dissertation consists of four research papers preceded by a summarizing text.

This chapter introduces the field of study, beginning with a short background section in 1.1 and an introduction to the motivation and purpose of the study in 1.2, where the research questions are also introduced. Section 1.3 introduces the field of study, dementia, and the two diseases in focus, Alzheimer's disease (AD) and primary progressive aphasia (PPA). Section 1.4 outlines what we can learn about language processing by studying language impairment. Finally, the structure of the remaining chapters is outlined in 1.5.

1.1 Background

As the world's population grows older, more people are at risk of developing dementia. The World Health Organization (WHO) postulates a growth of 10 million new dementia cases per year worldwide (WHO, 2016b). With rising numbers of dementia cases in the world, more research is needed on areas of life that are affected by this disease.

Cognitive and neural decline in dementia can be explained as a more "exaggerated" manifestation of what is found in healthy, non-pathological aging. This decline will affect all areas of cognition, including language production and comprehension. In this dissertation, I investigate the changes that occur in language production and comprehension in non-pathological aging and in Alzheimer's disease (AD) and primary progressive aphasia (PPA).

Many aspects of language do not change as we age. However, there are changes in language use and behavior which are related to aging. The most prominent change in language behavior with increasing age are difficulties with lexical retrieval and sentence processing in comprehension (Obler & Pekkala, 2008). Most of the existing research in the field has been conducted in English, and with this dissertation I hope to bring in perspectives from a lesser studied language — Norwegian. This can help broaden the general clinical picture, and support findings from other studies, as well as inform about the language specific issues that can be of interest to clinicians in Norway.

Language skills are often poorly or inadequately assessed during screening for dementia. This is because dementia assessment needs to incorporate several elements to gain a complete picture of the complex impairments on different levels — cognitive, daily living, depression, personality, language — and tests in each domain by itself only touch on the surface. Another reason is that the language assessment tools are not sensitive enough, nor have they been specifically developed to account for degenerating language impairment.

In this dissertation I will explore issues related to word-finding difficulties and sentence comprehension in two different kinds of dementia — AD and PPA — as well as in healthy aging. The dissertation has two main goals; 1) to study how language manifestations in the different diseases can help contribute to theories about language organization in the brain, and 2) to see how the study of language impairment can help shed light on the clinical picture of AD and PPA.

1.2 Motivation and purpose

As previously mentioned, language function is often poorly assessed when diagnosing dementia, even though most types of dementia will affect language production and/or comprehension. A more thorough understanding of the language changes that follow as a result of different dementia diseases will not only give the persons who receive such a diagnosis (and the people around them) more knowledge about what can be expected as the disease progresses, but can also contribute to differential diagnosis between different dementia types. Furthermore, there are theoretical-linguistic reasons to study language impairment following disease in, or damage to, the brain. Studying impaired language can give us valuable insight into how language is organized in the brain.

This dissertation is based on work from one overarching project, titled *Language and cognition in healthy aging and dementia*, which includes four separate studies, each with a different focus. These studies will be outlined in detail in chapters 4 and 5. Each study resulted in a paper intended for scientific publication, these can be found in part II of this dissertation.

The first article, study I (Ribu, Under revision), is a literature review of how different psycholinguistic properties affect lexical access in both production and comprehension. Study II (Ribu, Norvik, Lehtonen, & Simonsen, submitted), looks at how a test of free word associations can supplement traditional tasks for lexical access in assessment and research of language in dementia. The third study (Ribu & Kuzmina, submitted) is concerned with sentence comprehension in AD and PPA, and employs eye tracking methodology to study how different sentence types are processed in real time. The focus in study IV (Lind et al., 2018) is on longitudinal changes in language production in PPA. This is a single-case study of lexical retrieval skills over time, and in different languages for one person with a diagnosis that is most likely the logopenic variant of PPA.

Language impairment in dementia is often assessed by means of picture-based tests — though these are often not comprehensive enough to identify all aspects of language and communication that can be affected by dementia. In many countries, tests are merely translated from the original to the local language without any adaptations. New tools and methods, as well as good adaptations of already existing tools for studying language processing and retrieval, may help shed light on both clinical and theoretical aspects of language decline in healthy aging and dementia. It is important to note that translation equivalents of words are not always comparable across languages. Not only because contexts differ, and concepts that are expressed with one lexeme in one language might correspond to two or more different lexemes in another, but also because underlying psycholinguistic variables (such as frequency, age of acquisition, imageability, etc.) differ between languages (see 2.1.2).

To date, there is not much research that looks at the longitudinal changes in language behavior during the course of a dementia disease. This makes it difficult for persons with dementia and their next of kin to know what to expect as the disease progresses. Learning more about the longitudinal aspects of language impairment in AD and PPA will also be of value to speech-language therapists, clinical linguists, doctors and other medical personnel who work with these patients.

Most of the research on language in healthy aging and dementia is based on studies of oral language production. However, language comprehension is just as important for successful communication; yet we know far less about comprehension deficits than we know about production deficits in dementia. Single-word comprehension is often not impaired to the same extent as single-word production. Sentence comprehension deficits may be the result of general cognitive impairment, but the exact underlying difficulties are debated.

AD is the most common cause of dementia, and the more we learn about the different deficits that accompany this disease, the easier it will be to distinguish the cases that are in fact AD from the cases that are not. Unfortunately, some cases of rarer dementia diseases, such as PPA, are sometimes misdiagnosed as AD because of physiological similarities and lack of knowledge of the finer details that separate the diseases. Furthermore, there is some uncertainty surrounding the diagnostic criteria for the subtypes of PPA, which makes it important to continue to study the language manifestations in the different PPA subtypes to keep adding to the knowledge about these diseases.

In this dissertation, I will focus on the following three aspects, and answer research questions related to each:

1. **Linguistic aspects:** How do different psycholinguistic variables influence naming and comprehension in AD and PPA? (study I). What can word associations reveal about lexical retrieval difficulties in AD and PPA? (study II). How is sentence comprehension impaired in AD and PPA? (study III). How can data from language impairments in AD and PPA inform about theories of language processing? (studies I, II, III, and IV).

2. **Methodological aspects:** How can the use of different test methodologies to study language production and comprehension give a deeper insight to the language impairments in AD and PPA? (studies II, III, and IV).

3. **Clinical aspects:** How can language data be used to differentiate between dementia diseases? (studies I, II, III, and IV). How do naming impairments in dementia change over time? (study IV).

With this dissertation I hope to bring more knowledge about how language(s) is organized in the brain, and how it is affected in individuals with dementia.

1.3 Dementia

Dementia is a syndrome characterized by biological mechanisms that damage brain cells, resulting in cognitive decline and functional impairment. The first symptoms are often seen in episodic memory, but also in complex mental tasks. Early behavioral decline is gradual, and most basic abilities such as language and motor functions are relatively spared early on in the disease. This may make it difficult to date the real onset of the clinical symptoms (Lezak, Howieson, Bigler, & Tranel, 2012). Executive functioning deficits in early/mild stage dementia includes impairments in planning, reasoning, foresight and impulse resistance. Patients will have more problems with complex tasks involving planning and flexibility of thinking as the disease progresses (Lezak et al., 2012; Bayles & Tomoeda, 2007).

Contrary to common belief, dementia is not *one* disease, but rather a syndrome[1] that can be caused by a number of different diseases that lead to atrophy of the brain cells, and impairment in multiple cognitive domains. Depending on which areas of the brain are most affected by atrophy, the dementia disease will affect cognitive abilities differently.

[1]In medicine, a syndrome is a constellation of signs and symptoms associated with a morbid process, a set of symptoms that occur together (Bayles & Tomoeda, 2007)

Most diseases that cause dementia are progressive and not reversible. This means that a person who is diagnosed with dementia will progressively get worse as time passes. The most common disease that causes dementia is AD (see 1.3.1 below), followed by different kinds of fronto-temporal diseases, including PPA (see 1.3.2). Throughout the remainder of this thesis, dementia will be used as a collective term to refer to both Alzheimer's disease and primary progressive aphasia.

1.3.1 Alzheimer's disease

Alzheimer's disease (AD) is the most common cause for dementia, accounting for approximately 60-70% of all cases (WHO, 2016a). AD is most commonly recognized by impaired episodic memory, difficulty with learning, and difficulty with recalling recently learned information. In some cases, other domains are more affected than memory initially, these are so-called non-amnestic presentations of AD (McKhann et al., 2011). In these cases, the most common dysfunctions are found in language, visuospatial skills and executive functioning.

AD often originates in areas of the brain that are most commonly associated with episodic memory, especially in hippocampus and the basal forebrain (Braak, Braak, & Hohl, 1993). Once the disease progresses, working memory and semantic memory are also affected. The motor cortex is often spared (Farkas et al., 1982), which means that speech is fluent without signs of apraxia of speech or dysarthria (Bayles & Tomoeda, 2007).

In a study where caregivers were asked to specify which changes in language behaviour they noticed in the patient before the diagnosis of AD was made, they reported word-finding problems (anomia), difficulty naming objects, impaired comprehension of instructions, difficulty sustaining a conversation and problems completing sentences among others (Bayles & Tomoeda, 1991). A more detailed description of how language is affected in AD will be provided in 3.2.

1.3.2 Primary progressive aphasia

Primary progressive aphasia (PPA) is a neurodegenerative disease with, in most cases, semantic degeneration as the core symptom. Three different subtypes of PPA have been identified, and these can be distinguished from each other on the basis of language manifestations and underlying neural pathology (Gorno-Tempini et al., 2011). The three subtypes are: A logopenic variant of PPA (lvPPA); a non-fluent, agrammatic variant of PPA (nfavPPA); and a semantic variant of PPA (svPPA). The variant which is most often linked to AD, is lvPPA. svPPA and nfavPPA are more often associated with frontotemporal dementias.

In the remainder of this dissertation, extra emphasis is made on lvPPA as this subtype is more similar to, and often closely linked to, AD than the other two variants, and because all participants with PPA who took part in this project have lvPPA.[2] The terms lvPPA and PPA are therefore used more or less interchangeably, with lvPPA used when extra emphasis of the subtype is needed.

PPA is not to be confused with stroke-induced aphasia, as the underlying causes are different. In PPA, there is no lesion or brain trauma that causes the language impairment, but rather progressive cortical atrophy to a more or less confined region of the brain (Gorno-Tempini et al., 2011). The language decline in PPA stems from these progressive neuroanatomical changes, and not from injury.

The onset of PPA is slow, and manifests itself as a gradual, progressive impairment of language production, object naming, syntax or word comprehension, that is apparent in conversations as well as in speech and language assessment (Gorno-Tempini et al., 2011). A more thorough description of the language impairments in PPA is supplied in 3.3.

1.3.2.1 The types of PPA

In recent years, there has been some discussion regarding the classification of the PPA subtypes. Some researchers report that as many as 40% of all PPA cases are unclassifiable into any of the three types (Sajjadi, Patterson, Arnold, Watson, & Nestor, 2012; Machulda et al., 2013; Utianski et al., 2019). In many cases, the unclassifiable observations will later go on to develop lvPPA or nfavPPA. This indicates that there is some uncertainty related to at least these two PPA subtypes (Machulda et al., 2013).

Some effort has been made to challenge the current sub-classification system of PPA (Vandenberghe, 2016). Vandenberghe (2016) and Leyton, Ballard, Piguet, and Hodges (2014) argue that there is evidence for two types of lvPPA: one that resembles the non-amnesic variant of AD, with initial language manifestations; and one that resembles the originally described version of lvPPA (Vandenberghe, 2016; Leyton, Ballard, et al., 2014). Similar patterns have also been described by Rohrer et al. (2013) and Teichmann et al. (2013). Matias-Guiu et al. (2019) recognized two different types of lvPPA based on both language profiles and imaging data from a cohort of 68 patients with mild PPA (all three subtypes). These issues will be discussed again in more detail in chapter 6 (see 6.3.3).

1.4 What can we learn from studying language impairment?

Research on language deficits and impairment in dementia may contribute to the development of linguistic theories. Many theories of language processing build on evidence from language-impaired speakers, mainly on data from speakers with post-stroke aphasia.

Historically, the study of how language is impaired after a focal brain injury has served as

[2] The participant in study IV has a more uncertain diagnosis, but it is reasonable to assume that lvPPA is the correct diagnosis (more on this in chapter 5 and in the article).

evidence for left-hemisphere dominance for language. It is believed that the deficits observed in speakers with an acquired language disorder reflect the underlying cognitive architecture consisting of sub-components that may be selectively impaired by an injury or disease (Meuter, 2009).

A central question within neurolinguistics is: *if certain aspects of language are damaged and others not, following damage to or disease in the brain, what can this tell us about the organization of language in the brain*? Studying the language impairments that follow from an injury or disease in the brain can say something about this organization, as a common trait for persons who acquire aphasia or dementia is that they had a fully mature language system before they experienced either a sudden (aphasia), or gradual (dementia) deterioration. The assumption is that language impairment following damage to, or disease in the brain, is not random but depends on constraints determined by the structure of the premorbid system (Caramazza, 1986).

Studying the language of speakers with different kinds of dementia allows us to study the relationship between language and cognitive processes. The pattern of dissociation in dementia can provide valuable information of the dependencies between language and cognition (Obler & Gjerlow, 1999). Language impairments rarely occur in isolation, and are usually accompanied by impairments in memory, executive functioning or other cognitive domains. Cognitive and linguistic functioning should therefore be assessed together, to examine the relationship between language and other cognitive functions.

Traditionally, theorists have assumed that the mental lexicon (see 2.1.1) is monolingual by default, with an option for bilingual storage and processing. However, recently the tables have been turned (Goral, 2019; G. Libben & Goral, 2015). In later years, there has been a growth in studies of bilingual[3] dementia. Parallel to the studies of "monolingual" dementia, these studies have been used to contribute to knowledge on the bilingual organization of language.

Furthermore, there is also an ongoing debate about the bilingual advantage: the claim that persons who speak more than one language have larger cognitive reserve, and that this may delay the onset of dementia (Bialystok, Craik, & Freedman, 2007; Bialystok, Craik, & Luk, 2012).This discussion is outside of the scope of this dissertation, but is important to acknowledge it in a dissertation which focuses on language and cognition in aging and dementia.

1.5 Outline of the dissertation

This dissertation is divided into three parts; part I is a summarizing text that introduces the field of study, theoretical background, previous research, methods and materials used in the different studies, analysis and discussion. Part II consists of the four articles that were written to answer the research questions, and reach the goals outlined above. All appendices are collected in part III.

[3]In the remainder of this dissertation, I will use the term ‘bilingual’ rather than ‘multilingual’ to refer to speakers of more than one language, regardless of whether the number of languages the individual speaks is two or more.

The remainder of part I is structured as follows: The next chapter introduces the theoretical framework of the studies, and the third chapter summarizes previous research on language abilities in healthy aging, AD and PPA. In chapter 4, the methods, materials and plans for analysis of the four studies are outlined. chapter 5 introduces the research studies found in part II, highlighting some of the main findings from each. Chapter 6 offers discussions and conclusions related to the clinical and theoretical implications that can be taken away from the studies in relation to the research questions.

2

Usage-based linguistics and language processing

To properly account for language impairment in aging, we need a good theoretical framework that can explain how language is organized, stored and processed. Based on such a framework we can postulate models for language production and comprehension, and changes in language behavior throughout the lifespan.

In this chapter, I first outline the theoretical framework which serves as grounding for this project (section 2.1), then I introduce some hypotheses about language and aging (section 2.2), and follow on with some models of language processing (section 2.3).

2.1 A usage-based theory of language

The theoretical framework adopted in this dissertation is a cognitive, usage-based approach to language. The main features of usage-based theories of language are: that language is understood as domain-general, neurocognitive capacities that are shaped by individual usage-patterns and experiences; that there is no separation between lexicon and grammar; and that language is a dynamic system, in which various aspects of a language user's linguistic knowledge are constantly reorganized and restructured through use (Langacker, 1987; Taylor, 2002; Bybee, 2010; Diessel, 2017). Each of these aspects will be discussed below.

The first feature, that language is domain-general, implies that there are no brain regions that are involved in language processing alone — the brain areas that are involved in language processing are also involved in other cognitive processes, such as memory, attention, learning and motor planning, to name a few (Dick et al., 2001). All aspects of language are integrated parts of cognition, and rely on the same general mechanisms. This means that the processes which underlie language structure are not specific to language, but applicable to several cognitive domains, which makes language domain-general, rather than domain-specific (Bybee, 2010). Language is acquired and processed by means of general cognitive skills, such as the ability to categorize our experiences based on perceived similarities, and through a vast memory capacity (Bybee, 2001; Taylor, 2002; Langacker, 1987).

Furthermore, in usage-based linguistics there is no distinction between the lexicon and grammar. The lexicon is central, and grammatical structures are abstract representations derived from a language user's experiences with particular words or utterances (Bybee, 2010). To understand these abstractions, we first need to understand how the lexicon is built up and shaped through patterns of usage.

Language users store *tokens* of language — these can be single words, *chunks* of words or whole utterances — as *exemplars* in a rich mental network. This network is organized by *form*, *meaning*, *usage patterns* and the connections between these. Connections are formed between exemplars which are perceived as similar in form or meaning. These perceived similarities between exemplars give rise to hierarchical relationships between general *schemas* and their more specific *instances*. These generalizations are based on different levels of abstraction, within phonology as well as semantics (Langacker, 1987; Taylor, 2002; Bybee, 2010).

All tokens are stored in one rich memory, and map onto other exemplars that are similar to it in form and/or meaning. Representations of tokens are further *entrenched*, or strengthened, by other exemplars that map onto it because of these perceived similarities (Bybee, 2010). One important condition for this entrenchment is frequency of occurrence. Frequency strengthens the representations of linguistic units in the memory, and facilitates the activation and processing of words, chunks and *constructions*, which are "learned pairings of form with semantic or discourse function, including morphemes or words, idioms, partially lexically filled and fully general phrasal patterns" (Goldberg, 2006, p.3).

Following Bybee (2006), cognitive representations of grammar are organized into constructions which are partially schematic, conventionalized sequences of morphemes with a direct semantic representation. Langacker (1987) claims that there is no distinction between syntactic, morphological or phonological constructions, rather they are all emerging from generalized abstractions. When the formation of grammatical constructions are regular, these regularities are expressed in the grammar by a schematic symbolic unit (Langacker, 1987). Grammatical structures are entrenched patterns of usage, and motivated by frequency just like other exemplars in the lexicon (Martínez-Ferreiro, Bastiaanse, & Boye, 2019).

Since all exemplars are stored in one rich memory system, storage and processing becomes efficient, as we do not rely on the application of rules (i.e., for phonotactics and/or verb morphology) to select the correct output, but we can retrieve words, chunks, and constructions as whole units (Taylor, 2002; Langacker, 1987).

At every level of language, from phonology to syntax, there is evidence for rich memory representations: exemplar strength (mediated by frequency) means that constructions can easily be accessed and used for analogical extensions, or for the creation of new exemplars. (Bybee, 2010).

The third feature relates to how language is shaped by usage patterns and experiences over the lifespan. Throughout life, language will develop and change. For instance, the memory system expands when new exemplars are acquired and mapped on to existing exemplars, leading to a larger vocabulary. Change in the vocabulary is not only related to the number of words, but also to the content of words. Words will not only be more entrenched with experience, but also attract richer semantic representations, with more connotations and stronger network connections to other words (Simonsen, Lind, Hansen, Holm, & Mevik, 2013).

The mental lexicon belongs to individuals, and not to individual languages. Since the lexicon is individual, a range of factors will influence how the lexicon is shaped, for instance the level of education and the number of languages, dialects and social registers a person speaks can affect the architecture of the lexicon (Street & Dąbrowska, 2010; M. Libben, Goral, & Libben, 2017). This means that the mental lexicon is fully capable of handling more than one language at a time (G. Libben & Goral, 2015). Storage and processing in the mental lexicon are further discussed in the next section.

2.1.1 The mental lexicon

The mental lexicon should be conceptualized as a (dynamic) process, rather than a (static) entity, meaning that the mental lexicon is a manifestation of human capacity for lexical action and ability (G. Libben & Goral, 2015; Jarema & Libben, 2007). Lexical ability is fluid and variable, and there are substantial individual differences in the functional architecture of the mental lexicon which will be related to patterns of change across the lifespan, patterns of use and education, and related to the specific languages each individual maintains at all times. Thus, the mental lexicon accommodates different languages, dialects and situational social restrictions (G. Libben & Goral, 2015).

Word comprehension and production (both spoken and written) are lexical activities which take place in the mental lexicon (Jarema & Libben, 2007). Processing relates to how we activate items in the lexicon, and prepare them for production or comprehension. When a concept in the lexicon is activated for production or comprehension (lexical retrieval), this activation spreads to other semantically or phonologically related words. This spreading activation is an important premise for many usage-based theories of language processing (e.g., the *Spreading-Activation*

Theory (Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997), and in interactive theories of language and aging, such as the *transmission deficit hypothesis* (Burke & Shafto, 2004, 2008), see sections 2.2 and 2.3 below).

Grammatical structures, just like lexical ones, vary across registers, languages, contexts, groups of individuals and even within individuals. Usage-based theories of language propose one common storage system for everything from morphemes to complex syntactic structures. Languages are seen as communication instruments, and all grammatical structures are perceived as functional. This means that grammar is not autonomous from semantic and pragmatic function, but that grammar is conceptualization. Syntax is iconically motivated by function. For instance, constituency is a product of what belongs together semantically and what belongs together at the expression level (Martínez-Ferreiro et al., 2019). Furthermore, grammar emerges from generalizations over exemplars, and is maintained and shaped by usage. Grammar, like language in general, draws on domain-general neurocognitive capacities involved in social cognition, conceptualization and memory (Ishkhanyan, Sahraoui, Harder, Mogensen, & Boye, 2017; Boye & Harder, 2017; Martínez-Ferreiro et al., 2019).

Usage-based theories emphasize that heuristic and probabilistic factors account for language structure, rather than (morpho)syntactic rules and operations (Gahl & Menn, 2016). An example of one such probabilistic factor is verb bias. Some verbs are biased to appear in certain structures; verbs that typically appear in *passive* sentence constructions are so-called *passive-biased*. Passive sentences with passive-biased verbs (i.e. 'the candidate elected for government was pleased')[1] will be easier to process than active sentence with passive-biased verbs (i.e. 'The candidate elected to change the topic') (Gahl & Menn, 2016). This means that it is not necessarily the structure (active vs. passive) which makes processing difficult, but rather the context in which the verbs occur. In other words, both word and construction frequency are important for processing of different sentence structures.

Individual factors can also affect the entrenchment of exemplars; for instance, the level of education has been found to influence the capacity for syntactic comprehension of low-frequency structures. People with a higher level of education are better at understanding low-frequency sentence structures compared to people with a lower level of education. That is, low-frequency structures might be more entrenched for highly educated people (Dąbrowska, 2015).

2.1.2 Psycholinguistic variables

Several factors, or underlying psycholinguistic variables, pertaining to the form, meaning and usage patterns of words will influence how they are stored in, and accessed from the mental lexicon. This section introduces a few variables of importance, namely *frequency*, *age of acquisition*, *imageability* and *cognate status*. This is not an exhaustive list of all variables which can influence

[1]Examples borrowed from Gahl and Menn (2016).

lexical retrieval, since a thorough review of all psycholinguistic variables is beyond the scope of this dissertation. The variables which are introduced here are variables that have an important influence on both language production and comprehension in healthy aging and dementia, and thus are important for the discussion of the results of the four studies in this dissertation. The influence of these factors on naming and comprehension is further reviewed in 3.2 and 3.3. This is also the main focus in study I (Ribu, Under revision).

Psycholinguistic variables can affect lexical-semantic processing at different levels of the mental lexicon — i.e., at the conceptual, lemma or lexeme level (Vonk et al., 2019). These variables are to a large extent language-dependent, meaning that for example, frequency for one word might not be similar for a translation-equivalent of the same word in another language (see table 3.2 in chapter 3 for some examples). Likewise, age of acquisition and imageability may differ for the same concept across languages.

As previously mentioned, all language structures are results of entrenched usage patterns and entrenchment is a function of frequency, and thus of experience (Martínez-Ferreiro et al., 2019). Word and construction frequency are therefore critical variables which affect retrieval performance, as high-frequency items have stronger representations than low-frequency items and are therefore easier to retrieve from the lexicon (Bybee, 2001).

It is common to distinguish between *type* and *token* frequency. Type frequency refers to the number of different lexical items a certain construction is applicable to. Token frequency refers to how often specific items occur. Both types of frequency are important for processing; type frequency is important for productivity of patterns in the lexicon (Bybee, 2001), and token frequency is recognized as one of the most critical factors which affect naming performance. Neurologically healthy speakers name words with high token frequency faster and more accurately than words with lower frequency (Oldfield & Wingfield, 1965; Balota & Chumbley, 1984; Balota, Burgess, Cortese, & Adams, 2002).

How early words are learned in childhood, the *age of acquisition* (AoA) of words, is also recognized as an important variable which affects lexical access. Words that are learned early in life tend to be more entrenched, and often more frequent than words learned later in life (Juhasz, 2005). One explanation for the higher entrenchment of early learned words is that all new words attach to already known words, strengthening the connections and further entrenching the known items. Words that are used more will develop richer semantic representations, which again leads to stronger entrenchment (A. W. Ellis & Lambon Ralph, 2000; A. W. Ellis & Young, 1977; Juhasz, 2005).

Two different AoA measures can be distinguished; objective and subjective AoA. *Objective AoA* of words can be obtained by following children's development over time. *Subjective AoA* is obtained by asking adults how old they think they were when they learned a given word. This last method may seem far-fetched, but there is a strong correlation between objective and subjective AoA, and both can be used as valid measures for how early or late words are acquired (Hansen, 2016; Łuniewska et al., 2016; Juhasz, 2005).

Another factor which influences lexical retrieval is a word's imageability. This is a conceptual feature of words, and refers to the ease of which a word gives rise to a sensory mental image (Paivio, Yuille, & Madigan, 1968). Similar to subjective AoA, imageability measures are obtained by asking peopple how easily different words evoke a mental image (Simonsen et al., 2013).

Imageability is often related to concreteness, but there is no one-to-one relationship between the two. Words with high imageability ratings are most of the time, but not always concrete. For instance, 'ghost is a word which has a high imageability rating for Norwegian (Lind, Simonsen, Hansen, Holm, & Mevik, 2013), but it does not denote a concrete entity. The opposite is also true: the word 'armadillo' is a concrete noun which often has a low imageability rating. Subjective measurements, such as for AoA and imageability, are highly dependent on individual variation, and individual experiences. For instance, research shows that imageability ratings for words increase with age, due to older adults' richer semantic networks (Simonsen et al., 2013).

One form-based variable which is of importance for the current project is word similarity across languages, or the cognate status of words. Cognates are words with similar form and meaning between languages. However, the similarity between form and/or meaning can be more or less overlapping; for instance, the Norwegian word 'katt' and the English 'cat overlap in both form and meaning, whereas the words 'sykle' and 'cycle' are more overlapping in form than in meaning, as the Norwegian meaning is more specific than the English one, and can only mean the verb 'to ride a (bi)cycle', and not the noun 'a cycle' in the sense of a set of elements recurring over an interval.

All of these variables, and many others, influence how items are stored in the mental lexicon, how they relate to each other and how they are processed. Variables like these affect the entrenchment of words and the connections between words in the mental lexicon. Frequency was mentioned in 2.1 as an important factor which influences processing. The other variables are also associated with storage and processing in different ways. AoA influences entrenchment, as new words map on to already existing ones and strengthen the connections between known words in the lexicon, and imageability is associated with the richer semantic connections and connotations between words.

2.2 Hypotheses on language and aging

Language processing in older adults, and by extension also dementia, must be seen in relation to age-related cognitive change. Some hypotheses try to explain the language changes observed in aging by relating them to other changes in cognitive abilities. For example, the *Inhibition deficit hypothesis* (IDH) assumes that aging weakens the inhibitory processes associated with task-irrelevant information (Hasher & Zacks, 1988; Zacks & Hasher, 1994). As a result, older adults activate more irrelevant information than younger adults, and suppress less irrelevant information once it is activated. This means that aging impairs inhibition in all cognitive systems — including memory, language and attention — and this disrupts the use of relevant information (Hasher & Zacks, 1988; Ortega, Gómez-Ariza, Román, & Bajo, 2012).

Evidence for this theory comes partly from older adults' tendency to produce speech which is perceived as off-topic, or irrelevant (Arbuckle & Gold, 1993). IDH explains this by stating that older adults have a reduced ability to inhibit irrelevant information, which in turn makes it almost impossible to suppress thoughts which digress from the current topic. This will result in production of unrelated information or personal observations (Zacks & Hasher, 1994; Arbuckle & Gold, 1993).

Problems with inhibition are also found in tasks which measure executive control, where older adults show more interference from the incongruent color base-word in the Stroop color-naming task, and from distracting words in picture naming and sentence reading tasks, than younger adults do (i.e. Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007; Ortega et al., 2012, for an overview).

Hasher and Zacks state that inhibition is an essential component of both language production and language comprehension, which would indicate that older adults should be impaired on tasks which tap both lexical comprehension and production (Hasher & Zacks, 1988; Zacks & Hasher, 1994). However, as will be discussed in sections 3.1.1 and 3.1.2, there is an asymmetry in lexical comprehension and production abilities associated with aging, which cannot be accounted for by a theory which assumes similar impairment in the two modalities.

Another view of age-related language change is found in the *transmission deficit hypothesis* (TDH), proposed by Burke and colleagues (Burke & Laver, 1990; Burke & Shafto, 2004, 2008). This hypothesis assumes that language production and perception depend on how fast, and how much priming can be transmitted across the connections between different nodes in the language-memory system. A node is selected for activation only if the priming-level for that node reaches a critical difference separating it from other nodes in the same domain. Connections become stronger with use, especially recent use, but will weaken over time if not frequently used. Aging it self can also weaken the strength between connections more generally.

The TDH assumes that there is only one connection between a phonological node and each lexical node, but many connections between different lexical nodes. This makes the phonological nodes more vulnerable to break-down (i.e., transmission deficit) than the lexical nodes. However, for comprehension, this means that upon hearing a word, priming transmits via the phonological nodes to the lexical nodes. Transmission of priming within the lexical system is aided by the many connections which link related concepts to each other (Burke & Shafto, 2008; MacKay & Burke, 1990). This hypothesis predicts small or no age-effects for language comprehension tasks, but a large age-related effect on production tasks (Burke & Shafto, 2008). The retrieval impairments observed in aging are thus explained as a deficit in retrieving phonological, rather than semantic, information.

2.3 Models of language processing

Most models of language processing operate with at least two levels of representation; one level for semantics and one for phonology/orthography. The main difference is in the way they conceptualize the relationships between these levels, either through serial or interactive activation. Serial models postulate that there is one-way activation between meaning and form, or the other way around. Interactive models, on the other hand, assumes that there is interaction in both directions. In the next sections, some common models for language processing which are relevant for this present thesis will be presented. First, some general models for production and comprehension are outlined in 2.3.1. Then, in the section regarding comprehension (2.3.2), I also introduce some theories of sentence comprehension, which is of particular importance for the third study in this dissertation. The final section (2.3.3) introduces a recent alternative language processing model which incorporates both production and comprehension.

2.3.1 Production models

One of the most influential models of language processing — called *A blueprint for the speaker* — was put forward by Levelt (1989). In this model, it is assumed that activation is unidirectional, with no feedback between different levels of processing. Following this model, language processing happens in different steps: In the *Conceptualizer* (the first step), the intended concepts are selected from the mental lexicon. In the second step, the *Formulator*, the phonological and grammatical form is selected, before the mapping of the phonological form to the concept takes place in the third step, the *Articulator*. The model is presented in figure 2.1.

Levelt's model is recognized as one of the most comprehensive models of speech processing, but it has been criticized for the uni-directional, top-down view of language processing (Dell, 1986). As an alternative to this serial model, Dell (ibid.) proposed a model based on the spreading activation principle. In this model, interaction spreads between the different levels of representation (i.e., phonological, semantic etc.), and the different levels are active at all times (Dell, 1986; Dell et al., 1997).

Since there is activation on several levels at the same time, activation at the phonological levels of the production system feeds back to the semantic level, which activates semantic representations which in turn reinforce activation of the phonological level (Dell et al., 1997). An illustration of how this activation spreads across levels is seen in figure 2.2.

Interaction is necessary to account for mixed-error effects (slips of the tongue where similarity in form tends to increase the probability for semantic substitutions in naming), which is taken as evidence for the simultaneous activation of semantic and phonological information. Activa-

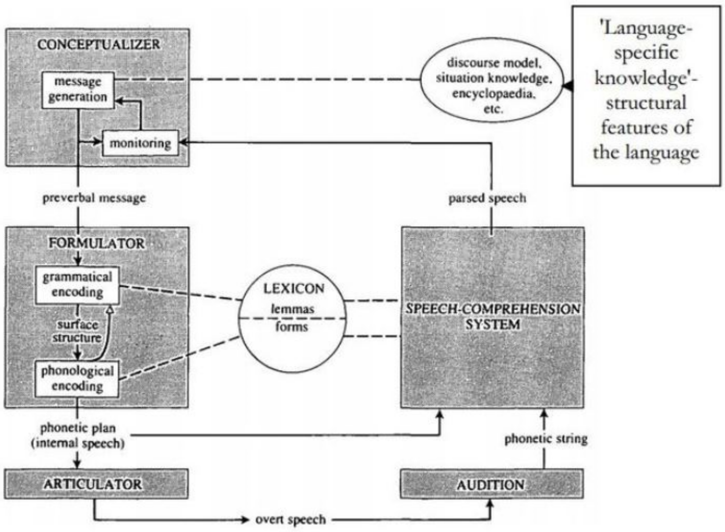


Figure 2.1: The blueprint for the speaker model (Levelt, 1989)

tion thus flows from target word nodes to phonemes, and then to mixed 'neighbors' (Dell et al., 1997).

Interactive models, where the structures are not predetermined, but shaped by feedback, are compatible with usage-based theories of language (Bybee, 2001).

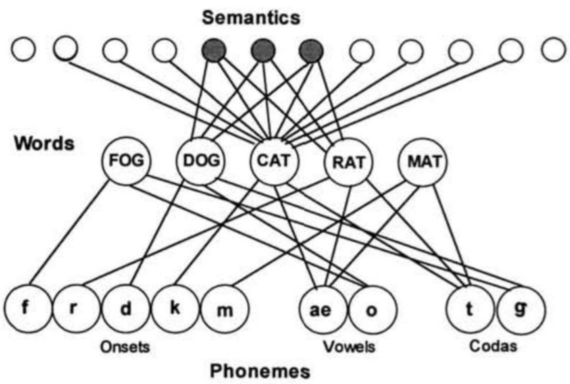


Figure 2.2: The spreading activation theory (Dell, 1997)

2.3.2 Comprehension models

Similar to models of speech production, models of speech comprehension can either be serial or interactive. For instance, the *Cohort model* (i.e., Marslen-Wilson & Welsh, 1978; Marslen-Wilson, 1980) assumes three stages of language comprehension that follow each other temporally: The *Access* level, *Selection* level and *Integration* level (see figure 2.3).

Phonemes are received on the access level, and all items which start with the same initial phoneme structure are activated, creating a cohort of candidate words. As more and more of the phonemes are received by the listener, the target word is selected by a process of elimination once competitor words that do not share the sound structure of the target word have been excluded.

At the second level (Selection), the listener uses context, semantics, recency of use and frequency to narrow down the candidates before choosing the word with the best fit on the third level (Integration). This model is uni-directional, and the higher levels do not interact with the lower levels, but rather rely on them for further processing (Marslen-Wilson, 1987).

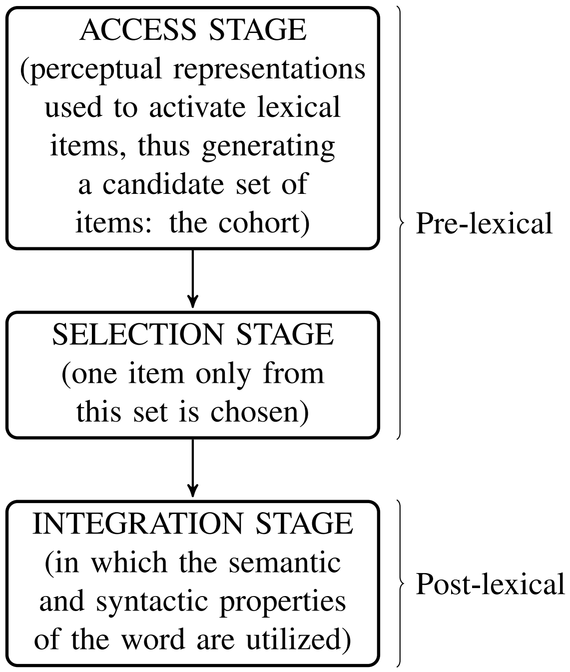


Figure 2.3: Schematic overview of the Cohort model

This feed-forward view of the Cohort model means that the model cannot account for how listeners recognize words which mismatch acoustically or contextually (Tanenhaus, Magnuson, Dahan, & Chambers, 2000), since later levels are dependent on the previous ones and there is no option for retracing and reactivation.

In contrast, the *TRACE model* (McClelland & Elman, 1986) is a dynamic processing structure made up of a network of units, which performs as the system's working memory as well as the perceptual processing mechanism. TRACE is also divided into three levels; the *Feature* level, *Phoneme* level and the *Word* level. Each of these levels relate to a particular perceptual object occurring at a particular point in time, relative to the beginning of the utterance (McClelland & Elman, 1986).

In this model, word elements are organized in a network. The likelihood of successful word recognition is influenced by excitatory connections at both lower levels (features and phonemes) and higher levels (sentential aspects) of representation. Selection of a target word is defined by competition between activated nodes. The node which receives most excitation will win out and be selected (McClelland & Elman, 1986). According to this model, the mind uses physical acoustic features, phonemic information and semantic information to match what has just been heard to a word in the mental lexicon (McClelland & Elman, 1986).

Speech recognition is complicated by the complex nature of speech signals. The model tries to account for the following "problems" with speech perception: 1) the temporal aspects of the speech signal, 2) overlapping phonemes and words, 3) context-sensitivity of cues, or the fact that articulation of phonemes is affected by the sounds that come before and after it, and 4) noise and indeterminacy in the speech signal (McClelland & Elman, 1986). These issues can be accounted for by interactive models which assume that the different processing levels affect each other, and that activation flows both upwards and downwards within the network.

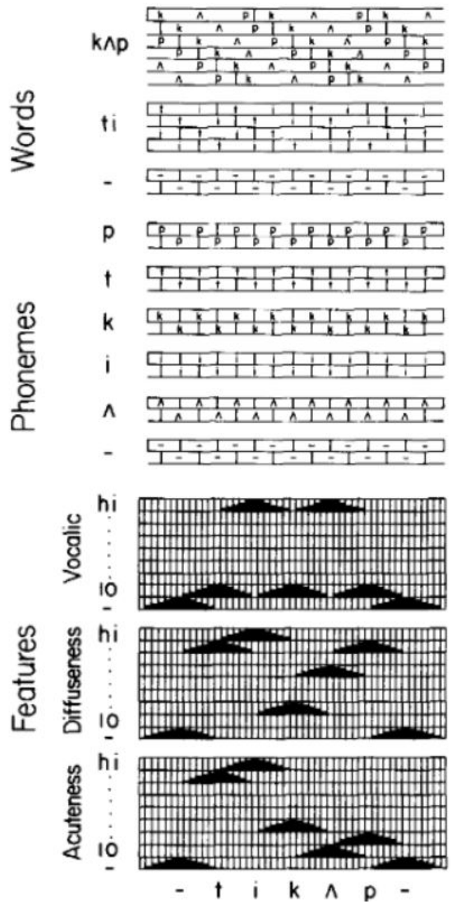


Figure 2.4: The TRACE model (McClelland and Elman, 1986)

Figure 2.4 shows a subset of the Units in the TRACE model, where each rectangle represents a different unit. The labels indicate what each unit represents. The horizontal edges of the rectangle indicate the portion of the TRACE which is covered by each unit. This specific image shows the feature specifications for the phrase "tea cup", preceded and followed by silence.

2.3.2.1 Sentence comprehension

Sentence comprehension is a complex task which requires comprehension of the individual words in the sentence, mapping of thematic (i.e., syntactic) roles onto grammatical structures, establishing the time-frame of the sentence, etc. In the following paragraphs, I introduce a few theories which try to explain how complex grammatical structures are comprehended and processed.

Some theories of sentence processing, for instance the *constraint-based model* (Trueswell & Tanenhaus, 1994) take statistical and probabilistic aspects of language, such as frequency of structures, into account when they explain how sentence processing is affected. Parallel to the frequency effects on the lexical level, the relative frequency of constructions affects sentence parsing (MacDonald, Pearlmutter, & Seidenberg, 1994; Jap, Martinez-Ferreiro, & Bastiaanse, 2016). Despite the fact that lexical frequency is recognized to be an important factor in language processing, frequency of grammatical constructions has not been incorporated into theories which explain comprehension of different syntactic structures in speakers with acquired language disorders, such as aphasia and dementia (Jap et al., 2016; Gahl & Menn, 2016).

Other models, such as the *Derived Order Problem Hypothesis* (DOP-H), assumes that sentences with derived word order require more processing capacities than sentences which follow base word order (Bastiaanse & van Zonneveld, 2006). The derived sentence order is, following Bastiaanse and van Zonneveld (ibid.), the result of syntactic movement operations. Since older adults and persons with dementia have reduced processing capacities compared to younger adults (see Park & Reuter-Lorenz, 2009), sentences with derived word order are expected to be even more difficult to process for them. An important premise for this hypothesis is that the derived sentences are harder, but not impossible, to process (Bastiaanse & van Zonneveld, 2006; Jap et al., 2016).

In a recently proposed statistical modeling account for language processing, Frank and Yang (2018) suggest that hierarchical syntactic operations (i.e., movement) are not necessary to explain sentence comprehension; relying on lexical properties of the stimulus will suffice (Frank & Yang, 2018). The authors argue that sentence comprehension requires at least some knowledge of word meaning, and constructing a sentence's hierarchical structure requires information about the word's possible syntactic categories (e.g., if a word can be a noun, a verb or an adjective in a given situation) (Frank & Yang, 2018). The only linguistic information which was available in Frank and Young's model resided on the lexical level, there was no phrase- or sentence level processing, only representation of lexical information (Frank & Yang, 2018; Frank & Christiansen, 2018).

This view is compatible with a usage-based view of language, where there is no distinction between the lexicon and grammar, and lexical items are seen as central. Models of sentence processing do not need to be based on a notion of movement and syntactic operations if statistical and probabilistic aspects of language, such as frequency of structures, are taken into account.

Statistical preferences for certain structures are used by the cognitive system for learning how to comprehend and produce utterances (Frank & Christiansen, 2018).

2.3.3 The Multilink model for production and comprehension

Not many models try to incorporate both production and comprehension, and even fewer do so while at the same time considering a bilingual mental lexicon as default. Most models of language processing see monolingualism as the norm, and define bi- and multilingual processing, and the bilingual mental lexicon, in relation to this monolingual default. But, as discussed above, the mental lexicon is driven by individual experiences, and is fully capable of handling more than one language at the same time (G. Libben & Goral, 2015).[2]

Studies of the bilingual mental lexicon have traditionally been based on the assumption that a multilingual speaker has two or more mental lexica which partially overlap. However, this hinges on the assumption of the monolingual norm and the bilingual exception. Recent advances in the study of multilingual processing claim that there is one mental lexicon which is shared for both or all languages, and that the bilingual mental lexicon thus includes the monolingual lexicon (G. Libben & Goral, 2015; M. Libben et al., 2017).

The *Multilink* model for language processing incorporates a unified account for (bilingual) word comprehension, lexical-semantic processing and word production (Dijkstra et al., 2019b). The model is the first to consider processing aspects of word production, comprehension and translation, and addresses how cognates can be processed (Goral, 2019). The model takes psycholinguistic variables into account, such as frequency, also when frequency is dependent on language proficiency and language exposure. Furthermore, it is also the first comprehensive model of language processing which explicitly states that the multilingual lexicon should be considered as the norm (Dijkstra et al., 2019b; Goral, 2019). This model is interactive, and postulates that different levels can be activated at the same time, and that activation spreads both forward and backward between levels (Dijkstra et al., 2019b).

Multilink is modelled as a lexical network where an input word activates various representations. These representations in turn activate their semantic and phonological counterparts, as well as associated language membership representations. All activation in Multilink is bi-directional (Dijkstra et al., 2019b). Figure 2.5 shows how this network is structured. One important aspect to note in this figure, is that the languages are represented as two separate nodes, even though the model argues for an integrated lexicon. Goral (2019) suggests that we do not yet have the proper experimental tools and/or the theoretical terminology to distinguish clearly between an "integrated one" and "interconnected two" lexical systems.

[2] In this dissertation, I assume that the multilingual lexicon is the default, and argue that the "monolingual" participants in the studies reported in part II are not, in fact monolingual, but rather use mainly one language for most purposes of their daily linguistic activity (see 4.3.1).

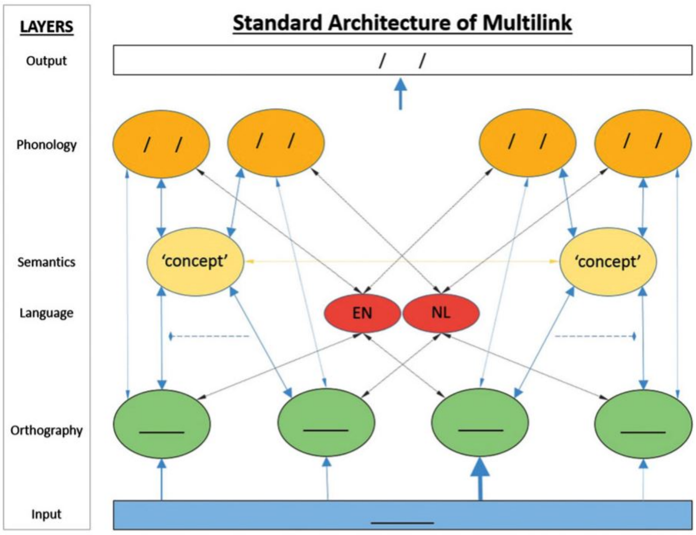


Figure 2.5: The Multilink model (Dijkstra, 2019)

Multilink simulates interaction between several codes (orthographic, phonological and semantic) at an interval measurement level. The model assumes that word retrieval involves language non-specific processing. The bilingual lexicon is integrated in the model, which means that there is only one storage for words from different languages. Furthermore, there is a link between translation equivalents only on the semantic level (Dijkstra et al., 2019b).

The model includes a task/decision system, which allows it to simulate word processing in psycholinguistic tasks such as lexical decision, orthographic and semantic priming, word naming and word translation production. The task/decision system checks the language membership of the input and output, and the degree of activation on phonological/orthographic and semantic levels as a requirement for the release of a response. Word naming and word translation happen when the phonological representation of the target language reaches a certain critical threshold. For word naming, the target and input languages are the same, whereas for word translation, target and input languages are opposite (Dijkstra et al., 2019b).

The input level is indicated by the blue line at the bottom, and orthographic representation by the green circles. Phonological representations are noted as slashes (/ /). Output is task dependent; in this illustration, the slashes indicate a phonological output in either language (L1 or L2). (see Dijkstra et al., 2019b, for more detailed information). The figure does not depict the production component in a satisfactory manner, but simulations of bilingual naming data performed on Multilink correlated well with empirical data (Dijkstra et al., 2019b).

Currently, Multilink is based on data from English and Dutch, and simulations have been run mainly on comprehension data rather than on production data, but the authors claim that other languages and language data can be implemented to further develop the model (Dijkstra et al., 2019b).

This model fits the theories outlined in sections 2.1 and 2.1.2, since it takes different underlying variables into account, especially frequency — even when this is influenced by language proficiency — and assumes that the multilingual lexicon should be seen as central. Furthermore, excitation between nodes spreads forwards and backwards in the system, giving activation at different levels of representation.

The model's merit lies in the fact that it assumes an integrated lexicon, and accounts for both production and comprehension. However, certain extensions and improvements can still be made: for instance, the model does not account for inhibition and suppression of non-target language representations, it is based on languages with very similar scripts and it lacks integration beyond the word-level. Furthermore, the primary infrastructure of the model is based on orthographic input, and there can be differences in written and spoken input which are not clearly accounted for in the model's current form (Goral, 2019; Ivanova & Kleinman, 2019; Van Hell, 2019; Dijkstra et al., 2019a).

The models and theories outlined in this chapter are all considered to be relevant for the studies in the current project. They will be discussed and evaluated in the discussion in 6.6.

3 Language and aging

In this chapter, previous research on language decline in healthy aging, AD and PPA is outlined in sections 3.1, 3.2 and 3.3 respectively. In section 3.4, I outline how language and cognition are traditionally assessed in dementia, both for diagnostic purposes and research.

It is important to note that when discussing language change in AD and PPA, these refer to generalized observations. Depending on the individual neural pathology, the impact of the language impairment will vary across patients, and two people with the same diagnosis may have different language profiles.

3.1 Language in healthy aging

Language abilities are said to not change much across the lifespan (Wingfield & Stine-Morrow, 2000), but some aspects of language processing are influenced by aging (Obler & Pekkala, 2008; Obler et al., 2010). Most notably, there is a change in naming abilities, and most adults will be familiar with the feeling of not being able to come up with the correct names for objects and persons. Furthermore, older adults may have more difficulty interpreting complex sentence structures compared to younger adults. This is normal in aging, and does not necessarily imply a cognitive or language impairment. However, as both naming impairments and sentence comprehension difficulties are common in AD and PPA, it is important to identify the changes that are considered "normal" in aging and those that can be indicative of an impairment.

Furthermore, general cognitive abilities, such as episodic and short-term memory, attention and inhibition will start to decline with advanced age (Park & Reuter-Lorenz, 2009; Goral, 2004). Changes in language as a result of aging may therefore be due to dependence on other cognitive factors that decline with age.

3.1.1 Language production in healthy aging

Though our vocabularies continue to grow throughout our lifespan, our lexical retrieval abilities reach a peak at around age 30 before they start to decline (Connor, Spiro, & Obler, 2004; Goral, Spiro, Martin, Obler, & Connor, 2007; Obler & Pekkala, 2008). Longitudinal studies have found the most drastic decline to happen after age 70 (Au, Albert, & Obler, 1989), but initial signs of decline have been found for people in their fifties (Au et al., 1995), and even as early as in the late thirties (Connor et al., 2004). This might be explained by a general slowing in processing with increasing age (Salthouse, 2010), or because it takes longer to search through a larger vocabulary (Vitevitch & Luce, 1998). When naming becomes difficult, one compensatory strategy can be to name a synonymous word, or overuse semantically "empty" words like ‘thing’ or ‘do’ to not interrupt speech flow (Adlam, Patterson, Bozeat, & Hodges, 2010).

Older adults are more prone to so-called "tip of the tongue states" (TOT) than younger adults (Astell & Harley, 1996; Burke, MacKay, Worthley, & Wade, 1991). This is the term used to explain the feeling of knowing a word without being able to articulate it. Results from naturalistic diary-keeping studies show that older adults have far more TOTs than younger adults (Burke & Shafto, 2008, 2004). TOTs can also be experimentally induced, often by asking trivia-like questions such as "What is the name of the river that runs through Rome?"

In a study by Burke and colleagues applying this latter paradigm (Burke & Laver, 1990; Burke et al., 1991), participants were asked questions about the real world, and to rate how certain they were that they knew the answer to the questions. They were also asked if they were able to recall the answer. The results showed that older adults had a significantly larger proportion of TOT states than younger adults, especially for proper nouns (Burke et al., 1991).

Decline in lexical retrieval skills is most often associated with proper noun retrieval, but difficulties have also been reported for other types of words and linguistic units (Obler & Pekkala, 2008). The main difficulty with lexical retrieval seems to be access to the phonological form, rather than impaired semantic knowledge. This can be seen in studies where cues are given to aid retrieval. Semantic cues are usually not very helpful for older adults, whereas phonological cues can be very beneficial and aide lexical retrieval (Obler & Pekkala, 2008).

Language production is more than just naming words in experimental settings, and it is important to study language in use to learn more about how the naming difficulties affect speech and communication. Research finds that sentence production is less affected by increasing age than naming in isolation, and syntax seems to be well preserved. If people experience difficulties with sentence generation, this is usually at the word level. (Kavé & Goral, 2016b; Peelle, 2018;

Kemper, 2012).

However, some changes have been observed in narrative production when comparing younger and older speakers. In tasks where people are asked to retell a recently heard story, older adults will often provide shorter answers than younger adults. In contrast, if they are asked to produce free narratives, older adults' narratives are longer than those of younger adults, but they contain fewer cohesive ties, more irrelevant information and are perceived by raters as less "dense" (Juncos-Rabadán, Pereiro, & Rodríguez, 2005).

The difference in story length can be related to speech fluency, and to more frequent and longer pauses. Researchers have found that older adults have an increased number of pauses in their speech, and that these are typically longer than for younger adults (Burke & Shafto, 2004; Tyler, Russell, Fadili, & Moss, 2001). This adds to the perception of older adults' slower and more hesitant speech. More frequent pausing can be seen as a compensatory strategy for older adults, to allow them self to search for appropriate alternatives when the initial word search is unsuccessful (Mack et al., 2015).

For speakers of more than one language, the same general picture is found as for monolingual speakers. However, the decreasing language abilities can develop later than for monolinguals, or they can affect one language more than the other(s) (Goral, 2013). Some people may experience *language attrition*, which is defined as the loss of one language, often the speaker's L1 (Schmid & De Bot, 2004).

In sum, lexical retrieval difficulties in production are apparent in older adults, especially in experimental settings where single words are assessed. Single word retrieval is also one of the issues that can be observed in naturalistic settings, and one that is reported on by speakers in diary studies. It is also clear that older adults do perform differently from younger adults on tasks that are based on more naturalistic speech output.

3.1.2 Language comprehension in healthy aging

Difficulties with language comprehension associated with aging are not observed on the single-word level, like we see for production difficulties. However, comprehension deficits in healthy aging have been reported on sentence and text level (Obler & Pekkala, 2008). These problems are often not exclusively language-related problems, but problems that originate from an interaction between language and other cognitive changes that are associated with aging — such as processing speed, attention and memory (Goral et al., 2011).

In studies that look at sentence structures that require a lot of inference, researchers find that such sentences are comprehended more slowly than sentences with less complex sentence structures. For instance, Kempler, Almor, and MacDonald (1998) and Ferreira (2003) found that older adults have more difficulty understanding complex sentences, for example, sentences that do not follow basic word-order, or longer sentences that include more than one finite verb. In some cases, the difficulty lies in processing pronouns, and deciding who is doing what to whom (Almor, Kempler, MacDonald, Andersen, & Tyler, 1999). Marked sentence types, such as passives, relatives or sentences with double negation, are especially difficult to comprehend (Caplan, 1996; Waters, Caplan, & Rochon, 1995; Rochon, Waters, & Caplan, 1994). In a study that compared older and younger participants who were matched on verbal and general intelligence and working memory, Zhu and colleagues found that older adults had significantly lower accuracy scores on a semantic and syntactic acceptability judgment task compared to younger adults (Zhu, Hou, & Yang, 2018).

When sentence processing becomes difficult, more executive functions are called upon (Goral et al., 2011), which begs the question of why sentence comprehension deficits are not more common in healthy aging, given the natural decline in memory functions during aging (Tyler et al., 2010).

Other issues that often affect language comprehension in older adults relative to younger adults, are hearing loss and reduced auditory acuity (i.e., difficulties with hearing certain sound frequencies). These issues often affect language comprehension in sub-optimal settings, such as noisy environments, or conversations including several participants (De Bot & Makoni, 2005).

To sum up, comprehension of syntactically complex sentences, and dense text material can be impaired in older adults, but single-word comprehension is usually not. However, it is difficult to disentangle the linguistic deficits from other cognitive deficits, such as reduced processing speed and changes in attention and memory. Physiological changes, such as hearing loss, may also contribute to deficits in spoken language comprehension.

3.2 Language in Alzheimer's disease

Changes in language behavior can be an early symptom in AD, specifically changes related to lexical retrieval. Anomia is often prominent early on in the disease, and other language abilities will be gradually affected as the disease progresses (Damico, Müller, & Ball, 2010). In the most severe cases of AD, patients' abilities to partake in meaningful communication are severely impaired, and in some cases almost impossible. The verbal output is often reduced to repetitions of their own or other's speech, production of meaningless sounds, and in extreme cases mutism (Sloot & Jonkers, 2011).

The first linguistic abilities that are affected are verbal fluency, auditory comprehension, and reading and writing comprehension (Tsantali, Economidis, & Tsolaki, 2013). Syntax seems to be relatively well spared, although this has mainly been investigated in oral production studies (Rochon et al., 1994; Lee, Yoshida, & Thompson, 2015).

3.2.1 Language production in Alzheimer's disease

Anomia is often apparent in both spontaneous speech and confrontation naming early on in the disease, and it often affects proper names before common names. The word finding difficulties will worsen throughout the course of the disease, making communication more and more difficult with time. In extreme cases, the anomia can even lead to mutism (Sloot & Jonkers, 2011).

Anomia in AD has been explained as either an underlying semantic impairment, or as an impairment in access to semantic information (Kavé & Goral, 2016a). An underlying semantic impairment could imply that some words are completely inaccessible from a speaker's mental lexicon, causing problems with both production and comprehension. However, if the impairment lies in access during production, speakers will still be able to recognize and comprehend words that they might not be able to articulate, and will still be able to provide descriptions of the word or produce synonyms and other semantically related words.

Some researchers find that persons with AD have more problems with naming nouns than verbs (White-Devine et al., 1996; Druks et al., 2006), while some find the opposite pattern (Williamson, Adair, Raymer, & Heilman, 1998; Hernández, Costa, Sebastián-Gallés, Juncadella, & Reñé, 2007). Almor and colleagues found that persons with AD have difficulties with pronouns (Almor et al., 1999). Others find a dissociation between animate (for instance, animals, fruits and vegetables) and inanimate objects (tools, furniture, vehicles etc.), where one category can be better preserved than the other (Zannino, Perri, Pasqualetti, Caltagirone, & Carlesimo, 2006; Cuetos, Arce, Martínez, & Ellis, 2017). All of these, and other underlying word properties (i.e. frequency, AoA, imageability and word structure, see 2.1.2) can influence how easy or hard words are to retrieve from the mental lexicon, both in terms of production and comprehension (Cuetos, Rodríguez-Ferreiro, Sage, & Ellis, 2012; A. W. Ellis & Lambon Ralph, 2000; N. C. Ellis, 2002).

Persons with AD tend to retrieve high-frequency words more easily than low-frequency words, and these are often more general, semantically empty words, such as 'thing' or 'do, or the use of superordinate category-names rather than more specific target words (i.e. 'bird' for 'penguin)[1] (Domoto-Reilly, Sapolsky, Brickhouse, & Dickerson, 2012). This can be attributed to the fact that their semantic network is impoverished, and more general lexemes are more easily retrieved due to their higher frequency and early AoA (Adlam et al., 2010).

On verbal fluency tasks, where one is instructed to name as many words they know belonging to a phonological or semantic category within a given time frame, persons with AD produce far fewer items than healthy participants, and the difference is greater for semantic than for phonemic fluency. Persons with AD also produce more repetitions of the same words, which may be related to a decline in working memory (Marczinski & Kertesz, 2006; Vita et al., 2014).

Analyses of speech samples show that persons with AD differ significantly from healthy

[1] Example from the picture naming task used in studies II and III.

controls on several measures: the respective amount of content words, nouns, and pronouns, as percentages of the total number of words (Kavé & Goral, 2016b); articulation rate; speech tempo and hesitation ratio (Hoffmann et al., 2010). Persons with AD produced fewer content words than controls, and a smaller percentage of the total words were nouns. Persons with AD also produced a higher number of pronouns than healthy controls. A finer analysis of the words produced by the two groups showed that persons with AD produced shorter words, and words of higher frequency than the control group did (Kavé & Goral, 2016b). The temporal measures can help distinguish both between persons with AD and healthy controls, but also between persons with mild, moderate and severe AD (Hoffmann et al., 2010; Martínez-Sánchez, Meilán, García-Sevilla, Carro, & Arana, 2013). More frequent, and longer, pauses in connected speech may be seen as compensatory mechanisms to overcome lexical retrieval difficulties (Pistono et al., 2019). Sentence production in AD is often short, slow and characterized by an overuse of empty words and a decline in relevant information content (Taler & Phillips, 2008; Fraser, Meltzer, & Rudzicz, 2015; Szatloczki, Hoffmann, Vincze, Kalman, & Pakaski, 2015).

In early stages of the disease, apraxia is not a common observation, but may develop in later stages. Dysfluencies, paraphasias, bizarre word combinations and intrusions are common mid-stage speech defects (Bayles & Tomoeda, 2007). In very late stages speech becomes non-fluent, repetitive, and largely non-communicative, with many patients displaying partial or pure mutism (Bayles, Kaszniak, & Tomoeda, 1987).

There is a growing body of research on bilingual dementia, but the results from this field show mixed results. In general, the majority of the studies on bilingual dementia show that persons with AD perform better in their dominant language on a range of tasks and measures. However, the pattern of performance across languages was similar for bilingual speakers with AD, suggesting that both languages are affected (Stilwell, Dow, Lamers, & Woods, 2016). It is important to note that the persons' first language is not always the dominant language. Both Gollan, Salmon, Montoya, and da Pena (2010) and Gómez-Ruiz, Aguilar-Alonso, and Espasa (2012) reported that their participants performed better in their L2 on measures where they had been more proficient in that language (i.e., literacy in the study by Gómez-Ruiz et al. (2012), and on the Boston Naming Test in Gollan et al. (2010)).

In sum, persons with AD show an early and gradual deterioration in lexical access abilities, which influences naming in isolation as well as in connected speech. Reduced lexical richness in context might be an indication of a cognitive impairment or early indication of AD, and these changes should be recognized as an important diagnostic feature for these patients. However, to date, there is no linguistic test or test battery that can successfully diagnose Alzheimer's disease on its own, and evaluation of linguistic parameters should be used in combination with other diagnostic measures (Szatloczki et al., 2015).

3.2.2 Language comprehension in Alzheimer's disease

Language production has been studied more extensively than language comprehension in AD. The study of language comprehension in AD has in recent years mainly been focused around syntactic comprehension, since single-word comprehension is less impaired than single-word production.

In most cases, semantic knowledge and word comprehension are spared early on in the disease. However, as the disease progresses, language comprehension may also deteriorate in line with other language and cognitive functions, such as auditory comprehension and reading (Bayles & Tomoeda, 2007).

Although most research concludes that single-word comprehension is spared in AD, some researchers found that persons with AD may have impairments in single-word recognition and/or comprehension relative to neurologically healthy persons (Hodges & Patterson, 1995; Hodges, Patterson, Graham, & Dawson, 1996; Cuetos, Herrera, & Ellis, 2010; Cuetos et al., 2017). These studies are based mainly on findings from lexical decision or word recognition studies.

Cuetos and colleagues too find some impairment in single-word comprehension (see Cuetos, Gonzalez-Nosti, & Martínez, 2005; Cuetos et al., 2017; Cuetos, Rodríguez-Ferreiro, & Menéndez, 2009), however, these impairments are less prevalent than sentence comprehension difficulties. Sentence comprehension can be affected by both a general processing decline (working memory impairment) or by a failure to comprehend the individual parts of sentences when these are presented in marked order (Croot, Hodges, & Patterson, 1999; Waters & Caplan, 1997; Caplan, 1996).

Some studies have shown that patients with AD have more difficulty comprehending more complex sentences (see Lee et al. (2015) for an overview), although the notion of what constitutes a complex sentence is not consistent across the studies. Some authors measure complexity by the number of words in the sentence (Tomoeda, Bayles, Boone, Kaszniak, & Slauson, 1990); some consider complex sentences to deviate from the base syntactic structure in the language (Rochon et al., 1994); while others discuss complexity by the number of propositions (finite verbs) (Croot et al., 1999; Waters et al., 1995). All of these issues do contribute to sentence complexity, often interacting with each other; shorter sentences with only one proposition in the active voice are easier to parse than longer sentences with more propositions and maybe even deviant syntactic structures, which will require more working memory capacity to parse correctly.

Meyer and colleagues (2012) found that it was the number of propositions (two or more) which made the sentences harder to comprehend, rather than what is often referred to as complex sentences, such as passives and other less frequent sentence structures (Meyer, Mack, & Thompson, 2012; Kempler, Almor, & MacDonald, 1998; Kempler, Almor, Tyler, Andersen, & MacDonald, 1998).

All of these studies show that language comprehension in AD is differently impaired relative to production. Production of sentences and connected language output is relatively spared in AD, but comprehension is impaired. The opposite is found for single-words, where the production seems to be impaired but the comprehension spared. This means that while persons with AD can still comprehend the individual parts of sentences, the syntactic parsing is difficult. Sentences that require a lot of inference rely more on cognitive capacities than when the sentences require less inference.

3.3 Language in primary progressive aphasia

The main diagnostic criterion for primary progressive aphasia (PPA) is an isolated and progressive language impairment for at least two years, with relative sparing of other cognitive functions (Gorno-Tempini et al., 2011; Mesulam, 2001; Gorno-Tempini & Miller, 2013). As previously mentioned, three variants of PPA have been identified: a semantic variant (svPPA), a non-fluent/agrammatic variant (nfavPPA) and a logopenic variant (lvPPA). There are no concrete numbers showing the distribution between the three subtypes, and some researchers claim that in as many as 40% of the cases it is not possible to make a correct classification (Sajjadi et al., 2012). The three variants are distinguished based on language manifestations and underlying neuro-pathological differences. Table 3.1 summarizes the main language features of the three PPA variants. The main focus of this and future sections on PPA will be on the logopenic variant of PPA (lvPPA), unless stated otherwise, because it is the variant that is most similar to AD in both underlying neural pathology and linguistic symptomatology.

In many cases, it is difficult to set a certain diagnosis until after a few years post-onset, as the diseases can be very similar (Gorno-Tempini et al., 2011; Henry & Gorno-Tempini, 2010). There is also some debate regarding the diagnostic unity for the lvPPA and nfavPPA subtypes (see 1.3.2.1 and 6.3.3), and some researchers argue that each of these two types can be further split into two different variants (Matias-Guiu et al., 2019; Vandenberghe, 2016).

3.3.1 Language production in lvPPA

The main language impairment found in lvPPA is one of lexical retrieval. This is especially apparent in experimental settings, such as picture naming. Word search is also present in spontaneous speech, resulting in slow speech, with frequent pauses allowing for word search. Some patients experience speech-sound errors both in confrontation naming and spontaneous speech. These are mainly phonemic paraphasias with speech-sound substitutions that are well articulated, without signs of agrammatism or impaired motor speech. This last point is one of the main differences between lvPPA and nfavPPA (Gorno-Tempini et al., 2011; Wilson et al., 2010; Henry & Gorno-Tempini, 2010; Mesulam, 2007).

Table 3.1: Main language manifestations in the three subtypes of PPA

	svPPA	nfavPPA	lvPPA
Production	**Impaired** confrontation naming **Spared** repetition and speech production (grammar and motor speech)	Agrammatism **and/or** effortful, halting speech with inconsistent speech-sound errors and distortions (apraxia of speech)	**Impaired** single-word retrieval in spontaneous speech and naming, repetition of sentences and phrases, (phonological) speech errors in naming and spontaneous speech **Spared** motor speech and absence of agrammatism
Comprehension	**Impaired** single-word comprehension and object knowledge for low-frequent or low-familiarity items	**Impaired** comprehension of syntactically complex sentences **and/or spared** single-word comprehension **and/or spared** object knowledge	**Spared** single-word comprehension and object knowledge

The operational criteria for lvPPA include: 1) presence of aphasia; 2) impaired sentence repetition and comprehension; 3) presence of anomia with evidence of relatively spared single-word comprehension; 4) evidence of phonemic paraphasias; 5) slowed rate of verbal expression due to pauses for word retrieval or verbal formulation; and 6) absence of agrammatic or telegraphic verbal output (Gorno-Tempini et al., 2011).

Noun naming is usually better spared than verb naming for lvPPA (Mack et al., 2015; Lind et al., 2018) and nfavPPA, but opposite for svPPA (Hillis, Tuffiash, & Caramazza, 2002; Hillis, Oh, & Ken, 2004; Hillis et al., 2006). High frequency, familiarity and low AoA have all been recognized as factors that aid lexical retrieval for persons with PPA (Hirsh & Funnell, 1995; Ukita, Abe, & Yamada, 1999; Vonk et al., 2019).

Persons with lvPPA often have frequent repetitions in their spontaneous speech, and difficulties with sentence repetition (Grossman et al., 1996; Hoffman, Sajjadi, Patterson, & Nestor, 2017; Louwersheimer et al., 2016), which can be an indication of impaired working memory (Meyer, Snider, Campbell, & Friedman, 2015; Silveri et al., 2014).

Bilingual PPA is still a young field of research, and there are not may studies that investigate the patterns of deterioration in both or all languages of bilinguals with PPA. In a review by Malcolm, Lerman, Korytkowska, Vonk, and Obler (2019) on all three PPA subtypes, the authors find two main patterns: either a parallel deterioration of all languages, or better sparing of L1.

In sum, the language impairments in lvPPA are similar to the ones observed in AD (i.e., impaired lexical retrieval and relatively spared sentence production), but with a relative sparing of general cognitive functioning. Two important clinical markers for lvPPA are impaired sentence repetition, and absence of agrammatism. However, there are some uncertainties about the lvPPA diagnosis, and the divergent results reported in the literature may in fact reflect the ongoing discussion about the possible division of lvPPA into two different subtypes.

3.3.2 Language comprehension in lvPPA

Since lvPPA is a relatively young diagnosis, it was the last one to be implemented in the PPA classification system (Gorno-Tempini et al., 2011; Henry & Gorno-Tempini, 2010), there is also less research on this sub-type of PPA compared to the two other types.

On a general note, single word comprehension and knowledge and grammatical abilities are usually well preserved throughout the course of the disease for lvPPA (Gorno-Tempini et al., 2011). Comprehension impairments have not been observed to the same degree as impairments in language production.

Two studies of sentence comprehension in PPA found that persons with lvPPA are more impaired on comprehension of longer sentences (Wilson, Galantucci, Tartaglia, & Gorno-Tempini, 2012; Charles et al., 2014). In the study by Wilson et al. (2012), persons with lvPPA performed well on short sentences, even passives, but showed impairment as the sentence length increased. Charles et al. (2014) could only identify a sentence comprehension deficit on sentences which included center-embedded clauses (‘the fox that followed the domesticated cat was fierce), and relate this to atrophy in fronto-temporal brain areas which are associated with sentence comprehension deficits, rather than an impairment in working memory or mapping of semantic and thematic roles.

However, since persons with lvPPA have impaired working memory, as evidenced by their impaired sentence and word repetition skills (Leyton, Savage, et al., 2014) and impaired phonological short term memory (Meyer, Snider, et al., 2015), it is reasonable to assume that sentence comprehension deficits similar to those observed in AD can be expected. Recent research also suggest that auditory acuity is impaired in PPA, which will influence language comprehension (Utianski et al., 2019; Hardy, Johnson, & Warren, 2019).

3.4 Dementia diagnostics

Since the main symptoms for most diseases that lead to dementia are primarily memory-related, language screening during the diagnostic process receives less focus. The diagnostic criteria developed by MacKhann and colleagues (McKhann et al., 1984; McKhann et al., 2011), which are recognized as a standard for dementia screening, suggests that language abilities should be assessed at the very least by naming, semantic similarity judgment and sentence repetition tasks. In cases of so-called non-amnesic debut, especially in cases where the patient's subjective claims are language-related, a more thorough language screening is necessary (McKhann et al., 2011).

The *Consortium to Establish a Register for Alzheimer's Disease* (CERAD) was founded in 1984 to develop a screening battery that could be implemented as a standard globally (Morris et al., 1989). This screening tool includes picture naming — 15 items from the *Boston Naming Test* (BNT), (Kaplan, Goodglass, & Weintraub, 1983) — verbal fluency and a word list to be learned and later recalled for assessment of verbal working memory. Changes in language behavior can also be an early indicator of cognitive decline, as found in non-amnesic mild cognitive impairment (MCI).[2] For differential diagnosis, especially between AD and lvPPA a more thorough language screening might be needed to offer the correct diagnosis.

Tests for general cognitive functioning, such as the *Mini-Mental State Examination* (MMSE) (Folstein, Folstein, & McHugh, 1975) usually include a section on language functioning. Such tests are meant for quick screening, and do not include more than a few items of picture naming (language production), reading (sentence comprehension), and sentence repetition.

Many tests for cognitive functioning rely on verbal information: for instance, tests for verbal episodic memory, such as the word list learning and recall test found in the protocol developed by CERAD (Morris et al., 1989). Despite the fact that the majority of cognitive and neuropsychological tests are language-based, there seems to be little recognition of the language impairments in AD and PPA during the diagnostic process, at least in a Norwegian context.

3.4.1 The Norwegian dementia screening protocol

The Norwegian register of persons assessed for cognitive symptoms (NorCog)[3] works to develop assessment tools for dementia in Norwegian, and to run quality control on these, and to ensure that patients are assessed according to the same protocol across the country.

The main screening protocol developed by NorCog follows the lines of the CERAD test battery, and includes the 15 item version from the BNT, verbal fluency for phonemes and categories, a subjective judgment of language fluency made by a neurologist during the screening process,[4] and a translated version of the word list for learning, recall and recognition from the original CERAD test battery, consisting of translation equivalents of the English word list items (Kirsebom et al., 2019).

[2]Mild cognitive impairment is a disorder characterized by memory impairment, difficulties with learning and reduced ability to concentrate. None of the symptoms are so severe that a diagnosis of dementia can be made (WHO, 2016a).

[3]*Norsk register for personer som utredes for kognitive symptomer i spesialisthelsetjenesten (NorKog)* is the Norwegian quality register for dementia which was opened in 2007 to increase knowledge about diagnostics, assessment and treatment of cognitive symptoms and dementia (https://www.aldringoghelse.no/norkog/).

[4]The judgment includes six yes/no-questions: *Does the patient have poor fluency? Does the patient produce repetitions in speech? Does the patient have dysarthria? Is the patient's speech coherent? Is the patient's comprehension poor? Does the patient have word finding difficulties?*

This protocol is not intended for language assessment, and the language tests included are therefore not very comprehensive. Furthermore, these tests are translated rather than adapted to Norwegian, which can potentially be problematic for language assessment. The BNT is usually not employed by speech-language therapists in Norway because there are no Norwegian norms available for this test. The version included in the NorCog battery is the same as the 15-item version extracted from the original test. However, for the (American) English version the items are arranged from the lowest to the highest frequency ("easier" words before "difficult" words). But, as mentioned earlier in section 2.1.2, underlying psycholinguistic variables are not always comparable across languages. A Norwegian translation equivalent of a "difficult" word in the original English version might have higher or lower frequency or familiarity, and therefore be easier or more difficult to name in Norwegian than in English. Table 3.2 shows how the frequencies differ between Norwegian and English for the 15 items in the short version of the BNT, based on recent frequency data from the Norwegian Web as Corpus (NoWaC) (Guevara, 2010) and the Corpus of Contemporary American English (COCA) (Davies, 2008).[5] This overview shows that there are certain items in the Norwegian version that should have been ordered differently compared to the original English version. Furthermore, among the Norwegian words there are more words with low frequency (under 1000 counts per million) than among the English words. The English word list contains more words of medium frequency (1000 - 3000 counts per million), even among the so-called ‘easy words’ (the five first items in the list).

Table 3.2: Frequency counts (per million) for items in BNT

	Item	Norwegian Frequency (NoWaC corpus)	English frequency (COCA corpus)
Easy	House	111407	316918
Easy	Comb	3525	2337
Easy	Toothbrush	971	1165
Easy	Squid	574	1765
Easy	Bench	12457	14026
Medium	Volcano	631	3042
Medium	Canoe	1204	3041
Medium	Beaver	580	2655
Medium	Cactus	323	2007
Medium	Hammock	206	1062
Difficult	Stethoscope	102	572
Difficult	Unicorn	386	676
Difficult	Trellis	48	565
Difficult	Sphinx	10	596
Difficult	Pallette	314	11

From a linguistic perspective, there are certain issues to be noted concerning the translated

[5] Both corpora give lemma frequencies in counts per million.

word list for learning and recall from the CERAD battery. These translations do not take underlying variables into account, and the words in the Norwegian version differ from the ones in the original English version in number of syllables and phonological structure. A greater number of longer words in the Norwegian version can potentially make the learning and recall even more problematic for persons with phonological short-term memory impairments.

Furthermore, translation equivalents may not always translate the full meaning of the source word. For instance, in the English version, the words 'letter', 'pole' and 'arm' have homonyms which are not covered in their Norwegian translations 'brev', 'stokk' and 'arm'.[6]

Even if words are translation equivalents of each other, they can be potentially different in cultural interpretation, familiarity or frequency of occurrence. These potential differences can result in different patterns of responses when used in different languages. If the purpose of the test is to measure linguistic and/or cognitive ability, a translation without consideration of functional, cultural, and frequency equivalence may introduce bias (Peña, 2007).

These issues can be used to argue for adaptation, or even creation of language-specific tests rather than an uncritical translation of tests between languages.

[6] 'Brev' can only mean a letter one sends in the post, and not the letters of the alphabet. A better translation for 'stokk' would be 'stick' or 'cane', whereas 'pole' could also denote magnetic/geographic poles, or wooden constructions which would better be translated to 'pol' and 'påle' respectively. The Norwegian word 'arm' can only refer to body parts, and never to weaponry.

4

Methods and materials

One way of learning as much as possible about language impairment in dementia is to use different methods to study the same phenomenon. In this dissertation, I have combined several tests that involve the same domains, and used both behavioral and experimental methods in the same experiments. This chapter is structured as follows: First the studies are introduced in section 4.1, followed by a more detailed description of the methods, participants and analysis of each of the studies (sections 4.2 to 4.5). Since there is some overlap between participants, materials and procedures in studies II and III, these issues are only reported on once, for study II, with some further specifications for study III. In section 4.6, some considerations regarding validity and reliability are discussed. Finally, some ethical considerations are discussed in 4.7.

4.1 The studies

Table 4.1: Overview of the studies

Study	**Type of study**	**Participants**
Study I	Literature review	N/A
Study II	Multi-case study to investigate lexical retrieval in healthy aging, AD and PPA	7 AD, 2 PPA 29 controls
Study III	Multi-case study of sentence comprehension abilities in AD, PPA and healthy aging	5 AD, 2 PPA 9 controls
Study IV	Single-case follow-up study of bilingual PPA	1 lvPPA?

Table 4.1 gives an overview of the four studies. More detail about each one can be found in the next sections of this chapter, in chapter 5 and in each of the individual papers.

4.2 Study I - Literature review

The main objective of this study was to identify which (psycho-)linguistic variables of words are most central for naming and comprehension success in AD and PPA, and whether these variables can be used to distinguish between different dementia types (AD and PPA), and between healthy and pathological aging. If that is the case, these variables and properties could and should be taken into account when constructing assessment tools for language impairment in AD and PPA. The variables under investigation were: word class, frequency, age of acquisition (AoA) and imageability (see 2.1.2).

4.2.1 Search criteria and selection

Three literature searches were conducted between November 2016 and March 2018 to ensure that the latest and most updated articles were included in the review. The searches were carried out searching for specific terms in the PubMed and Science Direct electronic databases.The two first searches were carried out using the following search terms: ‘Alzheimer’s disease’, ‘primary progressive aphasia’, combined with ‘lexical access’, ‘imageability’, ‘age of acquisition’, ‘word frequency’, and ‘word class’ In the third search, the terms ‘bilingualism’ and ‘multilingualism’ were added to specifically identify studies involving lexical retrieval in bilingual speakers — studies which might not have shown up in the first two searches. In total, the three searches returned 433 titles. After a thorough screening of the titles, abstracts, methodology and discussion of the papers, as well as removing duplicates and articles written in other languages than English, only 48 articles were included in the review. A schematic overview of the selection process is found in study I (Ribu, Under revision).

Papers that were included in the review were original, peer-reviewed research papers written in English. There was no restriction in regards to publication year. Articles that reported on other types of dementia than AD and/or PPA were excluded, unless they also reported on either one or both of the diseases in question.

Only papers reporting on behavioral data were included, since methodologies and results from structural and functional imaging studies, ERP and EEG studies, as well as eye tracking and other online methods, are difficult to compare to strictly behavioural data.

4.2.2 Analysis

The 48 articles that fulfilled the inclusion criteria were sorted based on which diagnosis they reported on — AD, PPA or both — and whether the main focus was on production or comprehension. Next, the methodologies that were employed in each study was considered, and the effect of the variables were studied in relation to the different tasks. This means that I could study the individual effects of, for instance, AoA on picture naming tasks or verbal fluency tasks.

Many of the studies included were written before the consensus on diagnostic criteria for PPA was made and implemented (Gorno-Tempini et al., 2011). Thus, a number of studies operated with fuzzy categorizations of the subtypes, or used names for the subtypes that are now outdated. No effort was made to try to classify the participants in each study following the 2011 criteria, since in most cases, there was not enough information provided in the original papers to properly do so. This of course means that there is some uncertainty about how the lexical variables affect the different subtypes of PPA.

The number of studies that investigated the same issues was often small, and it would be too difficult to perform robust regression analyses of these studies for a meta-analytic review, so the results from all studies were considered qualitatively.

4.3 Study II - Free word associations

In study II, 38 participants were recruited to investigate how free word associations (FWA) can be used as a supplement to more traditional tests of lexical access. For this purpose, a new picture naming and a word-to-picture matching test were also created, taking into account the psycholinguistic variables discussed in study I (see 4.3.5). The next sections focus on recruitment of participants, and selection and creation of different tests for cognitive and linguistic screening. The same tests were also used in study 3 (see 4.4).

4.3.1 Participants and recruitment

Participants with AD and PPA were recruited from the memory clinic at Oslo University Hospital (OUS), at Ullevål, Oslo, and control participants were recruited from personal networks and online information posts, or were spouses and/or family members of the participants with AD/PPA. The young adults came mainly from the student body at the University of Oslo (UiO) and personal networks. Posters with information about the project containing a QR-code that led to a sign-up website were hung in study halls, at the main libraries and around hallways at the University of Oslo's Faculty of Humanities. Three information posts with a link to the sign-up website were posted to Facebook, which were shared a total of 67 times. Despite the heavy activity in the comment sections of these posts, only a handful of people signed up after reading the information on the sign-up page.

Table 4.2 gives an overview of how many potential participants were contacted or initiated contact through the sign-up website, and how many of those that were, in turn, tested and finally included for the studies.

Table 4.2: Overview of participant inclusion

	AD	PPA	Older controls	Younger controls
Contacted	16	4	17	26
Declined / withdrew	9	2	1	9
Tested	7	2	16	17
Excluded	0	0	2	2
Total included	7	2	14	15

Participants with a pre-morbid language deficit (e.g., stroke-induced aphasia), or other neurological illnesses and disorders were not included in the study. Neither were left-handed participants; persons with a history of drugs or alcohol abuse; participants that the neuropsychologists at the memory clinic at OUS deemed to be unfit for long testing sessions.[1] Control participants with an MMSE score below 26/30 were also excluded.

Four participants were excluded from the control population as they did not fulfill the inclusion criteria; two participants from the older control group were had too low MMSE scores, one of the younger control participants was left-handed, and one reported having a known neurological condition.

A Wilcoxon rank-sum test showed that there was no significant difference between the neurologically healthy older control participants (HCE) and the AD and PPA groups with respect to age (AD vs. HCE: *W= 63.5, p= 0.291*, PPA vs. HCE: *W= 21.5, p= 0.258*) or education (AD vs. HCE: *W= 22.5, p= 0.0508*, PPA vs. HCE: *W = 5.5, p= 0.199*). However, the education levels between AD and HCE is close to significant; HCE participants had slightly higher education than AD participants. Table 4.3 gives information about demographic details at a group level for the four participant groups. The participants with PPA are reported individually, since calculating averages for two persons only is futile.

Education is reported in number of completed years, starting from first grade in elementary school. A majority of the younger control participants were still students, and most were tested mid-semester. In those cases, years were counted up until the last completed semester. Among the older control participants, approximately 2/3 had higher education corresponding to Master's level by today's standards. One participant with AD had no education after high school, one had four years of vocational training after (academic focused) high school, and the five others

[1]This last point only pertain to the participants with AD and PPA.

[2]In some cases biological 'sex' and social 'gender' do not coincide. In the current study, the participants' self-reported gender is recorded.

Table 4.3: Demographics of participants in study II

	AD (N=7)	PPA (N= 2)	Control (old) (N=14)	Control (young) (N=15)
Gender (M:F)	2:5	2:0	5:9	3:12 [2]
Age Age span	m: 74,85 (SD: 4,3) 66-79	75;81	m: 73,14 (SD: 6,3) 66-89	m: 24,8 (SD: 2,9) 19-30
Education Education span	m: 14,28 (SD: 2,49) 10-18	15;14	m: 16,60 (SD: 2,37) 15-20	m: 16,3 (SD: 1,8) 13-20

all had at least three years of university or college education. Both participants with PPA had an education level comparable to a Master's degree by today's standards.

All participants reported that Norwegian was their main language in daily life, and all considered themselves to be monolingual. However, all participants reported having learned at least one foreign language in school, and a majority of the participants had at some point in their lives used more than one language in their daily lives, either by living in a country where another language was spoken, or by studying one or more languages at a higher level. Only three participants reported not actively using any other language than Norwegian in their daily life (speaking, writing or reading), but all participants were regularly exposed to foreign languages — mainly English — through television shows, films and from listening to music/radio.[3]

Dementia diagnosis (AD or PPA) was made at the memory clinic at OUS by trained neurologists. The diagnosis follows the international guidelines for Alzheimer's diagnosis (McKhann et al., 2011), and is based on results from a range of standardized tests and supported by physiological findings, such as biomarkers in cerebrospinal fluid and neuro-imaging (MRI, SPECT or CT). One of the participants with PPA had initially been diagnosed with AD before this was later changed to PPA.

Persons who are diagnosed with a cognitive impairment in Norway are asked if they want to be registered in a national register for treatment and research — NorCog, see 3.4.1). All participants with AD or PPA in this study are also in this register. Ethical considerations regarding research with clinical populations are discussed in 4.7.

One of the main recruitment challenge was to find willing participants. This can be seen in table 4.2, as 16 persons with AD and 4 with PPA received an information package by mail and were contacted personally via telephone, but only 7 with AD and 2 with PPA consented to participate. Furthermore, 1 participant with AD initially consented to participate but withdrew the day before testing was scheduled. The same can be seen for the younger control participants, where 26 initially showed interest, but only 17 participated.

[3]Some participants provided responses on the verbal fluency task, the picture naming tests and the word association tests in other languages than Norwegian, although the test session was kept in a constant monolingual environment. This means that even "monolingual" persons show activation for several languages simultaneously, and can therefore not be called "pure" monolinguals.

It was surprisingly difficult to recruit participants to the older control group. Potential relevant participants were very active in the comment sections below most of the shared Facebook postings, but very few followed the link to the sign-up website. The project got a lot of online exposure in relevant environments, but the exposure did not translate into actual participants. Two possible reasons for this might be due to the long testing sessions (see 4.3.6), and geography; some potential participants from areas outside of South-Central Norway showed interest in the project, but were not interested in traveling to Oslo to participate. Furthermore, participation was voluntary, and no compensation beyond travel reimbursement was offered.

4.3.2 Cognitive test battery

To assess the functional cognitive level of all participants, everyone included in this project went through a comprehensive screening of cognitive and linguistic functioning. There is a substantial overlap between the test battery used at the memory clinics in Norwegian hospitals and the protocol used in this project. Patients who were referred from the memory clinic were therefore given a shortened version of the full battery that was used with control participants (see Appendix C). However, as the test battery from OUS is used for screening of cognitive function, and not language, some additional tasks were included (see 4.3.3).

Tests for screening of cognitive functioning rely heavily on linguistic as well as cognitive processing, and some cognitive tests have been proven to correlate more with language processing skills than others (MacDonald & Christiansen, 2002). For instance, set-shifting and sequencing problems are common for people with AD, which is often expressed through impairment in impulse resistance. This often results in slowness on the inhibition condition of the Stroop task (Lezak et al., 2012). Results on the inhibition sub-test of the Stroop task have also been found to correlate with the ability to suppress a contextually irrelevant language for speakers of more than one language (Bialystok et al., 2012), and to suppress irrelevant and personal responses on restrictive language activation tasks. This has implications for what kinds of responses one can expect on confrontation naming tasks (see Ribu et al., submitted).

The cognitive test battery included the *Mini-Mental State Examination* (MMSE) (Folstein et al., 1975), *Trail-Making Test A* and *B* (TMT-A+B) (Tombaugh, 2004), and a word-list learning, recall and recognition test, and a figure copying and recall test from *The Consortium to Establish a Registry for Alzheimer's Disease* (CERAD) (Morris et al., 1989); three different *Digit span* tasks (digits forward, digits backward and digit ordering); and the *Stroop* task.

The MMSE assesses orientation to time and place, memory recall and working memory, concentration, language and visuo-spatial drawing.

In the word-list task in CERAD, participants are presented with ten words, one at a time, printed in large letters on a piece of A4 paper, and asked to read each one out loud. The test administrator flips the pages to reveal the next word as soon as the participant has read the word on the current page. Immediately after reading the ten words, the participant is asked to recall as many words as they can remember. This procedure is repeated another two times with the same words, but in a different order of presentation. After 20-30 minutes, during which other, non-verbal tasks are completed, the participant is asked to recall the word list. Finally there is a word recognition list, including ten new words in addition to the ten words from the learned list. In the figure test, participants are first asked to copy four geometrical shapes, and after a series of non-visual tasks they are asked to recall these shapes.

The *Trail Making Test* (TMT) is a measure of visual conceptual and visuo-motor tracking, mental flexibility, visual attention and executive function (Lezak et al., 2012; Crowe, 1998). *TMT-A* consists of a page on which the numbers 1 through 25 are encircled and scattered around the page. The participant is asked to draw a line connecting the numbers in order as fast as they can. Errors are pointed out and can be corrected, but are not scored. In *TMT-B*, the page is filled with both numbers (1-13) and letters (A-L). In this task the participant is asked to draw a line alternating between numbers and letters (1-A-2-B-3-C etc.). The time it takes to complete TMT-A is subtracted from the time to complete TMT-B, which gives a total switching cost: a measure of mental flexibility, attention and switching.

Digit span tasks are also common tests for verbal working memory, and are often said to correlate with different measures of language proficiency (MacDonald & Christiansen, 2002). In the current study, participants were tested on digits forward, digits backward and digit ordering. In the first task, participants hear a series of numbers and are asked to repeat them back to the test administrator in the same order of presentation. In digits backward, the participants have to repeat the digits back in reversed order of presentation. The digit ordering task, where participants are asked to order digits from the lowest to the highest number, is supposed to be particularly difficult for persons with AD (MacDonald & Christiansen, 2002; MacDonald, Almor, Henderson, Kempler, & Andersen, 2001).

A two-panel version of the Stroop task (Delis, Kaplan, & Kramer, 2001) was used to measure executive functions. The two panels consisted of word reading (all words in black ink) and a color-word-interference panel (names of colors written in another colored ink than the color they represent). Time to complete the word reading panel was subtracted from the time it took to read the color-word-interference page, resulting in an inhibition cost score.

Table 4.4 gives an overview of the tests included in studies II and III and the cognitive and/or linguistic domains they measure. A superscript ^{0}, indicates that the test is also used in the test battery from the memory clinic.

4.3.3 Linguistic test battery

At the intersection between cognitive and linguistic tests are a sub-set of tests which assess both linguistic and cognitive abilities, such as tests for semantic knowledge and association — e.g.,

Table 4.4: Tests included in studies II and III

Test	**Measure**
MMSE [0]	Orientation to time and space, memory recall, working memory, concentration, language and visuospatial drawing
CERAD [0] word list learning and recall	Verbal learning and verbal working memory
CERAD [0] figure copying and recall	Constructional praxis, visuospatial drawing and -memory
Trail Making Test A + B [0]	Visual conceptual and visuo-motor tracking, mental flexibility, visual attention and executive function — especially shifting
Digit span Forward Backward Ordering	Working memory, attention, phonological storage and processing
Stroop	Executive functions — especially inhibition and speed of processing
Verbal fluency [0] (phonetic and semantic)	Verbal retrieval and recall, auditory attention, short-term memory, cognitive flexibility, and long-term vocabulary storage
Pyramids and Palm Trees and Semantische associatie test	Semantic knowledge and memory of objects and actions
Free word association	Semantic processing, lexical retrieval and semantic memory
Picture naming	Confrontation naming/lexical access
Word-to-picture matching	Lexical comprehension
Sentence-to-picture matching (Eye tracking)	Sentence comprehension
Cartoon description	Semi-spontaneous speech and narrative production

the *Pyramids and Palm Trees test* (PPT) (Howard & Patterson, 1992, 2005).

In the picture version of PPT knowledge about how objects belong together in the world is assessed through a procedure where participants match pictures to show their semantic knowledge. A similar test has recently been developed in the Netherlands for assessment of actions. This test, *De semantische associatie test* (SAT) (Visch-Brink, Stronks, & Denes, 2005), is used in this study together with the PPT to assess semantic memory and knowledge of actions and objects respectively. In both tests, the participant is asked to choose one picture that is related to another picture. In PPT the participants choose between two competing items, whereas they choose between three items in SAT.

A *verbal fluency* test, where participants are asked to name as many words as they know within a given time frame, is often used in neuropsychology as a measure of updating and verbal working memory (Lezak et al., 2012; Marczinski & Kertesz, 2006; Damico et al., 2010), but can also be used in linguistic screening as a measure of word generation/lexical retrieval. Both phonemic and semantic fluency was tested, and participants were instructed to name as many words they knew beginning with the sounds /f/, /a/ and /s/, as well as name as many animals they knew, in separate sessions of 60 seconds each.

Free word associations (FWA) can be used to study both lexical activation and lexical organization. The test included here is an oral test of 30 cue words to which participants have to freely associate. The test administrator reads a word from a list, and the participant is instructed to respond with the first word they can think of as a response to that word. A short introduction to how the FWA test was created is found below in 4.3.4.

Two different picture naming tests were included to assess lexical retrieval of both nouns and verbs. The Boston Naming Test (Kaplan et al., 1983) is the only test of language assessment that is included in the neuropsychological test battery from the memory clinic at the University hospital. BNT is not adapted to Norwegian, and the items are ranked in difficulty following frequency of the original test items in English (see 3.4.1). A second, locally constructed picture naming task was also included to investigate how test results may be influenced by taking underlying linguistic variables into account when constructing naming tasks. In the end, only results from the locally constructed naming task (henceforth the *Picture Naming Task*) were analyzed. This decision was made as there are no norms for the BNT, and it is neither translated nor adapted to Norwegian, and therefore not validated for use in a Norwegian context. In the Picture Naming Task, both verbs and nouns are assessed, and the total number of tested items is 60, compared to 15 nouns in the BNT. This makes the Picture Naming Task more comprehensive than the BNT.

The same items were also included in a word-to-picture matching task, for assessment of lexical comprehension. Inclusion of the same items in both a production and comprehension task was considered as one possible way to assess if knowledge of the items are spared even if access to the phonological form is impaired. How the items for these two tests were selected is detailed in 4.3.5.

A cartoon description task was included with the intention of analyzing word finding difficulties in narrative production (see below for study IV, 4.5.2), but was left out as it would make more sense to analyze these data in a separate study designated for that issue, this will be discussed more in 6.4.

Finally, sentence comprehension was tested with a sentence-to-picture matching task with an eye tracker (more on this in section 4.4).

4.3.4 Creation of the free word association test

A word list of 30 items (18 nouns and 12 verbs) was created based an already existing test for free word association (FWA) for Norwegian (Bøyum, 2016). This original test has been tried out on two cohorts of neurologically healthy participants: older adults (over 60 years) and younger adults (18-30 years). The FWA test in Bøyum (2016) differs in two main respects from the one included in the current study: First, the original test consists of 100 items. Secondly, the long list is developed as a written version, whereas this shortened version is presented to participants orally.

The 100-words list was initially reduced to 50 items by removing all adjectives, homophones, words that had low inter-rater agreement, and words that elicited more than 20% multi-word responses by participants older than 60 years in the 100-word study. Some words that triggered emotional reactions ("to miss", to fear", etc.) were also removed after trying out a pilot version of 50 words on a small set of participants. The FWA test should be fast and easy to administer, so the 50 words were then further reduced to the final version of 30 words. During the pilot testing it was also clear that the instructions had to be updated, as persons needed to be repeatedly reminded to reply with single words only.

The final selection included 20 words that had predominantly received meaning-based responses and ten words that received both meaning- and position-based responses in the 100-words version. Order of presentation was randomized using Microsoft Excel. The 30 items included in the final version with English translations can be found in Appendix E. Bøyum, Hansen, and Ribu (forthcoming) explains in more detail how both the 100 and the 30-word lists were created and how they both can be used for research purposes. The second paper in this dissertation investigates how the FWA test can contribute to knowledge on theoretical questions in linguistics, and can also be used in clinical assessment of AD and PPA.

4.3.5 Selection of items for Picture Naming and word-to-picture matching

To create the picture naming and matching tasks, the online database "Norwegian Words" (Lind et al., 2013) was consulted to select all nouns and verbs that were coded as having either high or low frequency, imageability and age of acquisition (AoA), excluding median values. This search returned a list of 1188 words: 747 nouns and 441 verbs.

First, a manual selection was made by removing homonyms (e.g., 'huske' *a swing* or *to swing* and even *to remember*, or 'et bein' *a leg* or *a bone*). Words with competing synonyms (with either similar AoA, imageability or frequency) were excluded (e.g., 'lege' and 'doktor' both translate to *(medical) doctor*, and have quite similar AoA and imageability ratings). Objects that were either too specific ('en ponni' *a pony*) or too general ('et dyr' *an animal*) were left out. Depictability was considered in cooperation with an artist, and words she considered to be too complex or difficult to draw in a simplistic style were left out. After this selection 431 words remained; 307 nouns and 124 verbs. Distribution across the three variables for the 431 words was explored in R ("R: A Language and Environment for Statistical Computing," 2019) with the Shapiro-Wilk test (Happ, Bathke, & Brunner, 2019).

AoA and frequency for the selected words were slightly skewed towards words with a high positive predictive value for lexical access — i.e., high frequency, and low AoA (see 2.1.2). This skewness was reduced by applying a logarithmic transformation (log(Xi)) to remove outliers and select words that had a normal distribution of these variables.

For imageability, the data had a slight negative skewness, with more words with a negative value (i.e., low imageability). This skewness was corrected by applying an exponential transformation (exp(Xi)). When the skewness was reduced, a total of 120 words were extracted from the two subsets (60 verbs and 60 nouns), trying to keep the selection normally distributed with regards to all three variables.

A Shapiro-Wilk test was applied for each word class to calculate the deviance from normal distribution. For the noun subset, all three variables showed normal distribution; however, in the verb subset there was a significant skewness towards words with low imageability, even after the necessary reductions and transformations ($w = 0.93$, $p = 0.002$). Verbs are in general less imageable than nouns (Bird, Howard, & Franklin, 2003), and this can therefore be expected.

Black-and-white line drawings for the 60 nouns and 60 verbs were prepared by the same artist who assisted in the selection process. A group of ten adult, native speakers of Norwegian (age range 29 – 78, mean: 40,9 SD: 16,26; education range 13 - 20 years, mean: 17,9 SD: 2,34) rated all of the 120 pictures in two separate sessions (60 images in each session). In both sessions they first named the picture (name agreement), and then rated on a five-point scale how well they felt the picture represented their mental image of that word (image agreement). Only the words with a 90% or higher name agreement and high image agreement (4-5 on the 5-point scale) were included in the final selection.

Figures 4.1 and 4.2 show the distribution of the final 60 words that were included in the naming test. A list of items that were included in the picture naming and word-to-picture matching task can be found in Appendix D, together with some examples of the illustrations.

A post-hoc Shapiro-Wilk analysis of the normal distribution of the final 30 nouns and 30 verbs show that the verb selection is still not normally distributed for imageability ($w = 0.90$, $p = 0.01$), meaning that the verbs in the naming and picture-matching tasks are generally of lower imageability than the nouns. This is seen in figures 4.1 and 4.2, where the majority of the words are clumped together on the left side of the x-axis. Note also that the scales of the x-axes are different; the imageability range is greater for nouns than for verbs.[4]

The figures show the words' frequency in color shading: a more purple color denotes higher frequency, and a more red color denotes lower frequency. On the x-axis, the words are scattered from lowest to highest imageability, and on the y-axis, the words are scattered from lower to higher age of acquisition. Verbs are in general less imageable than nouns (Bird et al., 2003, 2000), which is also visible in these figures.

There is a plan for further trialling and norming of this test, so it can hopefully be used more

[4]The scales run from 500-1100 for the nouns and 300-700 for the verbs, which is a result of the different transformations that were employed to ensure (near-)normal distribution of the values.

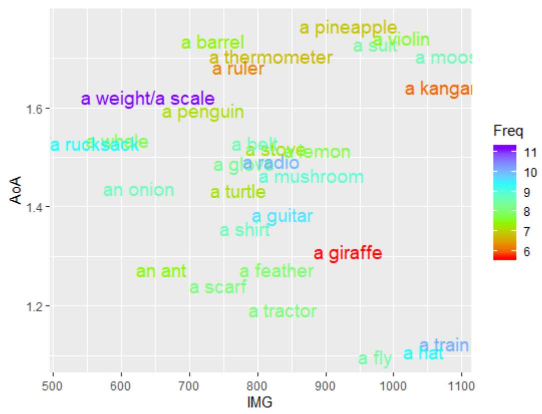


Figure 4.1: Final noun selection

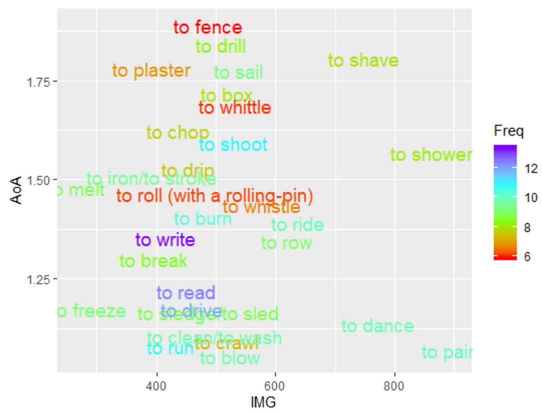


Figure 4.2: Final verb selection

widely.

4.3.6 Procedure

All participants with AD and PPA were assessed and diagnosed by a neurologist at the Oslo University Hospital, and asked if they wanted to be contacted about participation for this project. All participants with AD or PPA, and a majority of the (young and old) control participants were tested by myself, while 13 participants were tested by research assistants employed for this project. The research assistants received training in how to conduct the testing, and were instructed to always provide the same instructions for each testing session.

MMSE, CERAD, TMT A + B, verbal fluency and BNT were administered at the hospital as part of the diagnostic process, whereas the Pyramids and Palm Trees (PPT), De semantische associatie test (SAT), digit span tasks, Stroop and the Picture Naming, word-to-picture matching, free word association and cartoon description tasks were administered by the researchers involved in this project.

Participants were tested in one session of approximately two to three hours. Testing mainly took place in the Socio-Cognitive laboratory at MultiLing, Center for Multilingualism in the Society Across the Lifespan at the University of Oslo (UiO). In four cases, participants with AD received a home visit instead of coming to the University. One participant with AD was tested in two separate sessions of 90 minutes each.

The order of testing differed slightly between participant groups, because participants with AD and PPA were assessed with some of the tests at the memory clinic. A schematic overview of the order of testing can be found in 4.3.

To reduce test anxiety for the participants with AD and PPA, it was important to start the test session with an easy task. Furthermore, it was important to leave enough time between the picture naming and the word-to-picture matching tasks, for all participant groups. For control participants it was also important to leave enough time between the learning and recall tests from

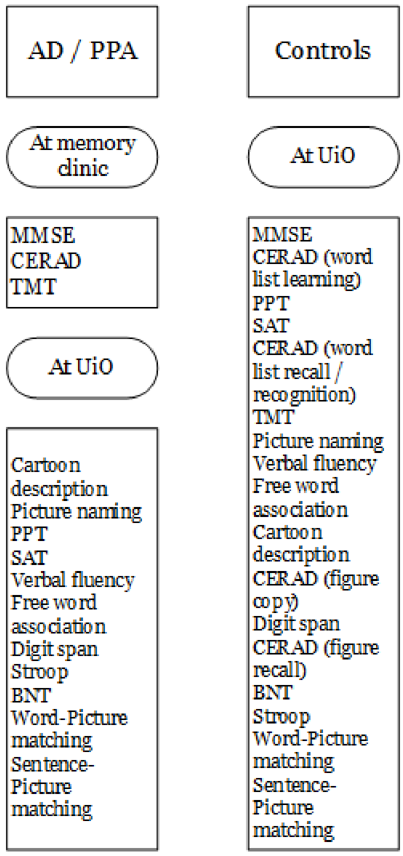


Figure 4.3: Order of tests per participant group

CERAD, and to have non-verbal tasks between the word list learning and recall sessions, and non-visual tasks between the figure copying and recall sessions. [5]

4.3.7 Analysis

In the following sections, I account for how the different tasks have been scored and analyzed.

To compare results between the participant groups, the Wilcoxon rank sum test has been used. This is computed in R ("R: A Language and Environment for Statistical Computing," 2019). The Wilcoxon sum rank test is a non-parametric test that is well-suited for operational statistics when the sample sizes are small. In this test the sums of the averages are ranked, rather than compared directly, which means it is less likely that the results are shifted because of outliers (Happ et al., 2019).

4.3.7.1 Accuracy

Responses in most tests were scored as either correct or incorrect, but for the Picture Naming and the FWA tasks, types of answers were recorded in order to investigate the relationship between

[5]This last point is of course also true for participants with AD and PPA, but the issue was resolved at the memory clinic.

the actual response and the target (for Picture Naming) or cue (for FWA).

Table 4.5 show the normative values for each of the tests included in this study. TMT and Stroop are timed, and each part is expected to be performed in less than 5 minutes. It is not possible to set a maximum performance score on these tests, and the column Max. (score) is therefore left blank. The same column is empty also for verbal fluency, as it is an individual measure for each participant. For these three tests, the average time and/or score for persons over 65 is given in the column Normative values. The FWA test is excluded from this table, since it does not operate with a numeric score, and results are not scored as correct or incorrect.[6]

Table 4.5: Max. scores and norms on the cognitive and linguistic tests

Test	**Max.**	**Normative values**
MMSE	30	26-30
CERAD WL-L	30	21,5/30
CERAD WL-R	10	7,2/10
CERAD F-C	11	10-11
CERAD F-R	11	8,51/11
TMT - A		34-40 sec.
TMT - B		80-104 sec.
Digits forward	16	
Digits backward	14	
Digit ordering	15	
Stroop 1		40,05 sec.
Stroop 2		135,50 sec.
Verbal fluency phon.		F: 15,8; A: 12,7; S: 17,5
Verbal fluency sem.		23,5
Pyramids and Palm Trees	52	98,7%
Semantische associatie test	20	93,43%
Word-to-picture matching	60	99-100%
Picture Naming, nouns	30	98,6%
Picture Naming, verbs	30	98,1%
Sentence-to picture naming	45	99-100%

The sentence-to-picture matching task have not been normed, but all 29 control subjects that participated in the study scored over 99% correct on this test, indicating that the test was not very difficult for most participants. The norms from the SAT are based on the percentile scores reported in Visch-Brink et al. (2005) for Dutch, and the norms from PPT in Howard and Patterson (2005). The word-to-picture matching task and the Picture Naming task were normed on an additional group of 20 neurologically healthy adults, aged 25-67 (see section 4.6).

Norms for verbal fluency among Norwegian-speaking adults are found in Egeland, Landrø, Tjemsland, and Walbækken (2006), and digit forward and backward in the Norwegian version

[6]CERAD WL-L = Word List Learning; CERAD WL-R = Word List Recall; CERAD F-C = Figure Copying; CERAD F-R = Figure Recall: Stroop 1 = control condition; Stroop 2 = inhibition condition

of WAIS -IV (Wechsler, 2008). CERAD and TMT norms come from Ivnik, Malec, Smith, Tangalos, and Petersen (1996), Kirsebom et al. (2019),and Tombaugh (2004). Norms for the Stroop test are based on data from Boone, Miller, Lesser, Hill, and D'Elia (1990). Considerations regarding the validity and reliability of these tests are discussed in section 4.6.

4.3.7.2 Scoring verbal fluency

Three rounds of phonemic and one round of semantic fluency was recorded for all participants. In the phonemic fluency task, words were scored if the initial sound was /f/, /a/ or /s/ — depending on which one was prompted. Common names and numbers, inflections of previously named words, series of compounds including the same first words, and repetitions were not counted. Dialectal variation was taken into account for words beginning with /s/. Participants who spoke a dialect where the initial sounds in the consonant cluster <sj> is pronounced /sj/ would get credit for words such as 'sjø' (*sea*), whereas the majority of the participants would not be credited for this, as the same word in their dialect would be pronounced with an initial /ʃ/. The total number of words generated for the phonemic fluency is the sum of items generated across all three trials.

Semantic fluency was only measured for one category: animals. All types of animals, living or extinct, were counted, but names of pets were excluded. Both supracategories (e.g., 'fish') and subcategories (e.g., 'salmon', 'cod' etc.) were accepted, so were different genders and parent/child categories of the same animal (e.g., 'cow', 'bull' and 'calf' would all be counted). Fantasy animals such as 'dragon' or 'unicorn' were also point-giving answers.

4.3.7.3 Scoring Free word association

Traditionally, free word association tasks have been scored using a binary system where responses are rated as either syntagmatic or paradigmatic in relation to the cue (Fitzpatrick, Playfoot, Wray, & Wright, 2015; Santo Pietro & Goldfarb, 1985; Eustache, Cox, Brandt, Lechevalier, & Pons, 1990). This dichotomous system is not always sensitive enough to capture the finer relationships between cues and responses, as many instances can be both syntagmatic and paradigmatic. For the FWA test used in this study, 11 scoring categories were used. Examples can be found in table 4.6. The high number of categories were included to better account for the detailed relationship(s) between cue and response words.

The word association data was scored individually by two raters, and disagreement was resolved through discussion between the two raters and a third consultant. For each cue word, all recorded responses were noted, and scoring was done based on the individual cue word, rather than per participant. This means that, for this study, it has not been possible to look at perseverations or priming. However, the individual responses are available for such studies at a later point: this topic is revisited in 6.4.

Table 4.6: Response categories for the word association task

Main category	Subcategory	Cue	Response	English translation
Meaning-based	Synonym	"sykehus"	"hospital"	*hospital → infirmary*
	Other semantic	"tolke"	"språk"	*interpret → language*
Collocation		"konsert"	"hus"	*concert → venue*
Form-based		"nyte"	"nype"	*enjoy → rosehip*
Mixed associations	Meaning + collocation	"avis"	"papir"	*newspaper → paper*
	Meaning + form	"håndtere"	"håndtak"	*to handle → a handle*
	Two-step	"tolke"	"Ringenes herre"	*interpret → Lord of the rings* (via J.R.R. Tolkien)
No association	Description	"hverdag"	"alle utenom lørdag og søndag"	*weekday → all but Saturday and Sunday*
	No answer	"Nyte"	"nei, det har jeg ikke noe ord til"	*enjoy → no, I don't have a word for that*
	Unrelated	"informere"	"hanske"	*inform → glove*
	Personal	"religion	"bra"	*religion → good*

4.3.7.4 Error analysis for picture naming

For the picture naming task, nine scoring categories were identified based on responses provided by participants in the norming sample. These categories were used to judge the participants' understanding of the tested items, and to evaluate if the persons with dementia have an impairment that is mainly due to accessing the correct item or if there are underlying semantic impairments which result in lexical retrieval difficulties. Table 4.7 gives an overview of the scoring categories and an example of each.

Results from the naming tests were scored by three different raters: one rater scored all 38 participants, and two raters scored 15 participants each — of which three overlapped between the two. Inter-rater reliability was calculated with Fleiss' exact kappa using the package *irr* in R. A kappa score is a number between 0 and 1, where numbers close to 0 indicates poor agreement between the raters, and a score closer to 1 indicates near perfect agreement between the raters. The reliability was good between the three raters: for Nouns, the kappa = 1, and for Verbs, the kappa = 0.926. Inter-rater reliability is considered acceptable for every number above 0.8 (McHugh, 2012).

Table 4.7: Response categories for the naming tasks

	Target	**Response**	**English translation**
Synonym	"brekke"	"knekke"	both *to snap, to break*
Hyponym	"flue"	"insekt"	*fly* → *insect*
Hypernym	"sekk"	"ryggsekk"	*bag* → *rucksack*
Description	"pingvin"	"sort og hvit fugl"	*penguin* → *black and white bird*
Code switch	"ananas"	"pineapple"	*English translation of target*
Different word class	"danse (v.)	"dans (n.)	*to dance* → *a dance*
Visual confusion	"palett"	"pensel"	*palette* → *paintbrush* (both in picture)
Semantic confusion	"hval"	"sel"	*whale* → *seal*
No answer	"løk"	"jeg vet ikke"	*onion* → "*I don't know*"

4.4 Study III - Sentence comprehension

The third study was designed to investigate sentence comprehension deficits in dementia as a factor of change in cognitive abilities, such as working memory and executive functioning. In this study, sentence comprehension was measured by means of an eye tracker, as well as behaviorally through judgment. This and the previous study rely on the same materials, therefore that information will not be repeated in this section.

The same participants as in the previous study were also included in this study. However, the number of participants was reduced. Several of the participants were excluded, as it was very difficult to obtain good eye tracking data from them.[7] The total number of participants reported on in this paper is thus 16. Due to the low number of young control participants with satisfactory eye tracking data, or enough recordings, this whole group had to be excluded from the study. Demographics of the included participants are found in table 4.8.

Table 4.8: Demographics of participants in study III

	AD (N=5)	PPA (N= 2)	Control (N=9)
Gender (M:F)	2:3	2:0	4:5
Age Age span	m: 74 (SD: 4,6) 66-79	75;81	m: 70 (SD: 4,34) 66-79
Education Education span	m: 13,8 (SD: 2,71) 10-18	15;14	m: 17,61 (SD: 0,73) 15-20

[7] It is not possible for me to determine the exact reason why the eye movements of these persons were unable to be tracked, as there can be many possible explanations for this. Reasons for poor tracking data can be droopy eyelids, glasses, eye makeup and other external factors (e.g., poor lighting conditions) which makes infra-red recording of the cornea difficult.

4.4.1 Visual world paradigm

Sentence comprehension was assessed by employing a sentence-to-picture matching paradigm combined with eye tracking methodology. Eye tracking allows us to study language processing "online", as it happens. By studying eye movements during a language comprehension task, one can pinpoint an individual's exact attention shifts as they happen, since gaze-shifts are considered to take place approximately 250 milliseconds (ms) after processing of the audio stimuli takes place. Eye tracking data can give some information about what is happening as language is processed, but it cannot tell us exactly what goes on in our brains. When (auditory) linguistic information is coupled with visual information, one can measure how the attention is driven by the sentence information in real time (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995).

The test paradigm used for studying sentence comprehension in study III is a so-called *visual world paradigm* (VWP) which includes both images and sound. In VWP, one usually measures how long it takes from when the participant hears a critical word until they direct their gaze towards the target picture (Tanenhaus et al., 1995). This paradigm is based on the so-called *eye-mind hypothesis*, which assumes that people automatically look towards what the brain is processing.

Three sentence types were tested in this experiment: active sentences, subject cleft sentences, and object cleft sentences. Cleft sentences have previously been identified as problematic for participants with AD and PPA (Croot et al., 1999; Thompson, Ballard, Tait, Weintraub, & Mesulam, 1997, see chapter 3). Each sentence was split into three *regions of interest* (ROI) for the eye tracking analysis (more on this in 4.4.4).

An example of each sentence type with its English translation is provided in table 4.9, while a full list of test sentences can be found in Appendix F.

Table 4.9: Regions of interest in the sentence comprehension experiment

ACTIVE (A)	*Norwegian* *English*	Gutten The boy	maler paints	jenta the girl
Region of interest		Region 1	Critical region	Region 2
SUBJECT CLEFT (SC)	*Norwegian* *English*	Det er gutten som It is the boy who	maler paints	jenta the girl
Region of interest		Region 1	Critical region	Region 2
OBJECT CLEFT (OC)	*Norwegian* *English*	Det er jenta It is the girl	gutten the boy	maler paints
Region of interest		Region 1	Region 2	Critical region

4.4.2 Selection of test items

The experiment consist of 45 reversible sentences - sentences that are still meaningful even when the subject and the object reverse roles (i.e. 'The boy paints the girl' in table 4.9 or in reversed order: 'The girl paints the boy'[8]). The sentences were constructed to fit 15 different verbs, divided into three experimental blocks, with 15 sentences in each block. In all three blocks, each sentence type appeared five times, but each verb only once.

Inspiration for the sentences included in the experiment and corresponding drawings was taken from the sentence comprehension subtest from the *Verbs and sentence test* (VAST) (Bastiaanse, Lind, Moen, & Simonsen, 2006). However, there were certain modifications made to make the test suitable for an eye tracking experiment. These modifications include: reduction from four competing pictures (one target and three distractors) to two (one target and one distractor); addition of an introductory 'context sentence' to familiarize the participants with the actors in the sentences and the pictures; and finally, creation of 15 new sentences based on the discarded distractor pictures to have enough sentences for an experimental setting.

A search in the NorGramBank, a syntactically annotated tree bank (Dyvik et al., 2016; Rosén, De Smedt, Meurer, & Dyvik, 2012), [9] was carried out to check how common each of the three sentence types are in Norwegian. This search returned a total of 781 356 hits divided over the three different sentence types. The distribution between the sentence types was as follows:

Table 4.10: Hits in the NorGramBank

Sentence type	No. sentences	percentage
Active (A)	744 358	95,3%
Subject cleft (SC)	32 342	4,1%
Object cleft (OC)	4 656	0,6%

After the stimuli items were selected, they were programmed into an eye tracking experiment using *Senso-Motoric Instruments* (SMI)'s software *Experiment centre* version 3.6. The sentences were audio recorded by a male professional voice actor. Afterwards, these recordings were manipulated to ensure that the verb in each sentence type came at a specific time slot depending on the sentence type. This time slot is referred to as the *critical ROI*, as it is upon hearing the verb that one can properly parse the sentences in question.

The pictures were quadratic black-and-white line drawings against a white background (550 x 550 pixles). The target alternated between the left and right side of the screen. A grey frame lay around both pictures to physically separate them from each other. All parts of the screen that

[8]Compare to 'The boy paints the apple' and 'The apple paints the boy', where the second sentence does not make sense when the roles are reversed.

[9]The tree bank is part of the Norwegian Infrastructure for the Exploration of Syntax and Semantics, INESS: http://clarino.uib.no/iness/page

are not either the target or the distractor image —that is, the grey frame, and anything outside it — is refered to as *white space*. An example of the test drawings can be seen in figure 4.4.

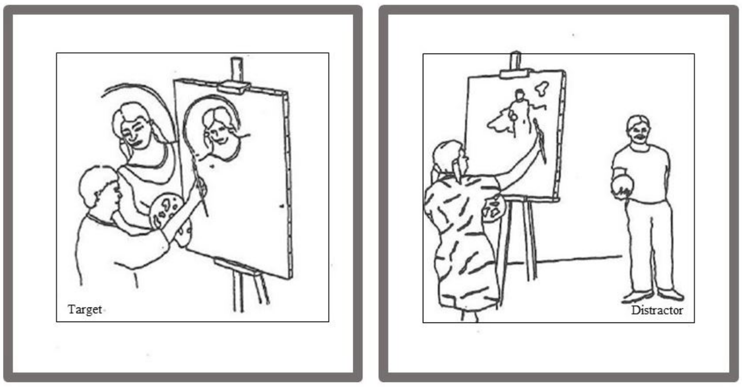


Figure 4.4: Example of a test pane from the Sentence-to-Picture matching task

An *area of interest* (AOI) was assigned to the target picture in each trial, covering a large proportion of the target image. A large AOI is good to capture gazes to target even if calibration is momentarily lost (in cases where participants blink or look away from the screen during testing), or if there is a lot of gaze drift.

Recordings were performed using the SMI RED 250 eye tracking device attached to an external screen linked to a laptop computer. The test administrator ran the experiment from the laptop, and participants saw the pictures on the external screen.

There are some eye tracking studies that have investigated sentence comprehension in healthy aging and in stroke-induced aphasia (Tanenhaus et al., 1995; Bickel, Pantel, Eysenbach, & Schröder, 2000) and single-word comprehension in AD and PPA (Seckin et al., 2016). Furthermore, there are some studies that have used eye tracking methodology to investigate general cognitive processes in AD. To my knowledge, there have not been any eye tracking studies of sentence processing in AD and PPA to date.

In general, studies show that cognitive impairments underlie the many changes in eye movements for patients with Alzheimer's disease. As the disease progresses, AD patients will develop impairments in visual cognition, in addition to the more well-known deficits in episodic and working memory (Ko & Ally, 2011). Researchers have recently directed their attention towards the slowed visual processing as an early indicator of AD, using eye trackers to study cognitive processes in general, and not specifically language processing (Pereira, Camargo, Aprahamian, & Forlenza, 2014; Ko & Ally, 2011; Molitor, Ko, & Ally, 2015).

4.4.3 Procedure

Participants were seated in front of a laptop computer with an SMI RED 250 Hz eye tracker attached to it. Recording frequency was set to 250 Hz. Three participants were mistakenly

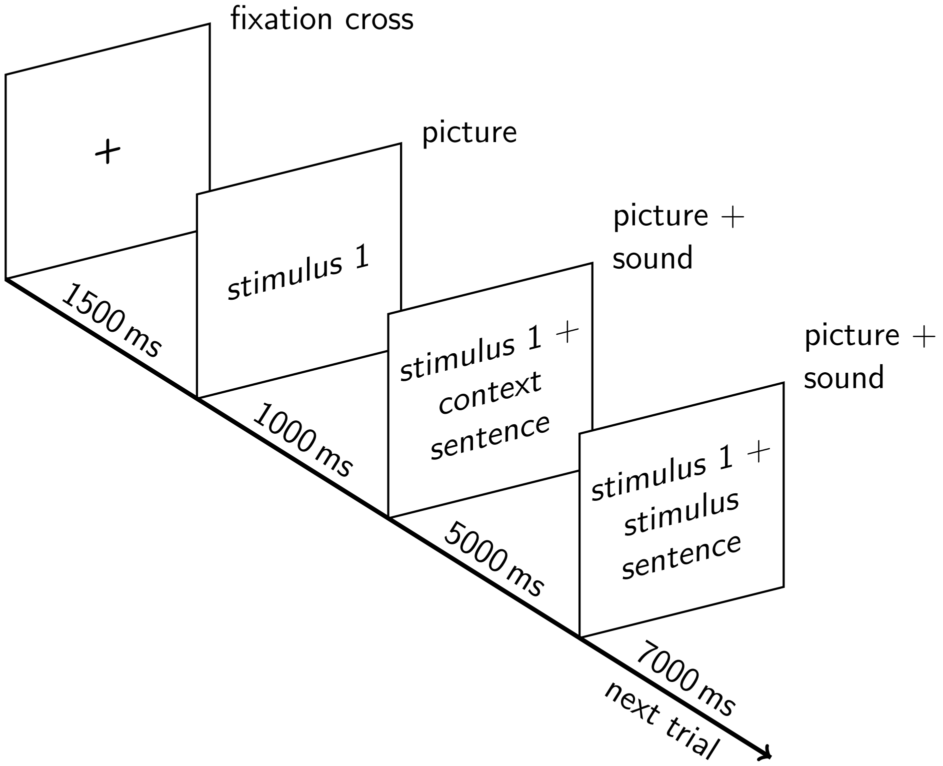


Figure 4.5: Test procedure eye tracking experiment

tracked at a sampling rate of 60 Hz, but this did not influence the data analysis. Between each experimental block there was a short break. Total testing time per participant was approximately 15 minutes for all three experimental blocks, including pauses.

Each trial began with a fixation cross in the middle of the screen, to direct the participants' gaze towards the center. After 1500 ms, two images (the target and the distractor) appeared on the screen. One second (1000 ms) later, the context sentence played (e.g., 'On these two pictures you can see a girl and a boy'). A pause of 2500 ms followed the offset of the context sentence, after which participants heard the stimulus sentence (i.e. 'The boy paints the girl'). After the stimulus sentence had been played, and the participants had indicated whether the left or the right picture corresponded to the stimulus sentence, there was a silence before the next trial automatically started. The full time from stimulus sentence onset until the next fixation cross was 7000 milliseconds. Stimuli were randomized across participants. The test procedure is schematically represented in figure 4.5.

4.4.4 Analysis

The data from the sentence-to-picture matching experiment were analyzed both online and offline. The online analysis includes the gaze data captured with the eye tracker. The offline measure was participants' accuracy in judging which picture corresponds to the spoken stimulus sentence.

The gaze data analysis was performed on the number of fixations from the critical ROI (from verb onset until 250 milliseconds after verb offset). It takes adults about 200 ms to launch a saccade, and 250 ms is a commonly used measure in visual world paradigm studies (Tanenhaus et al., 1995). Fixations after 300ms following the verb offset were considered to be the ones that were triggered by comprehension.

The independent variable for analysis was sentence type (active, subject cleft or object cleft), and within each critical ROI, the proportion of time the participants spent fixating on the target picture was calculated, and treated as the dependent variable. This was determined by applying the following formula:

$$\frac{Target}{(Target + Distractor + WhiteSpace)}$$

The total number of looks to target in a given ROI (sound) was divided by the number of looks to all AOIs in the images — target, distractor and white space —within that same ROI.

Each participants' scores on the MMSE, verbal fluency, Stroop, TMT A + B, and digit span were compared to their online and offline data, to investigate if comprehension is influenced by general cognitive functioning, executive functioning, short-term and/or working memory. All calculations were performed in R ("R: A Language and Environment for Statistical Computing," 2019).

4.5 Study IV - Longitudinal changes

The last study was conducted as part of a pilot project on multilingual dementia in Norway, and aimed to investigate lexical retrieval and naming strategies in the participant's two languages in a longitudinal perspective.

In this study, psycholinguistic elicitation techniques were combined with conversation analysis (CA) to study naming of nouns and verbs in different contexts. The focus here will be on the psycholinguistic part of the study.

4.5.1 Participant and recruitment

The focus in this study is on one participant, JJ, with a probable PPA diagnosis, and his performance on several lexical measures in different languages over the course of 18 months. The neuropsychological tests used in this study were performed at the participant's local hospital in Oslo during four different follow-up appointments. Additional tasks for general cognitive functioning, executive functioning and a linguistic assessment were conducted by members of the *MultiLing Dementia* research group on two occasions.

JJ was recruited through the conversation group for persons with dementia that he attended. The conversation group was organized by the local chapter from the *Nasjonalforeningen for folkehelsen*[10] dementia support group in Oslo. He received written information about the project, and both he and his wife gave written informed consent for him to participate.

JJ was an American national who had lived and worked in Norway for most of his adult life. He was 68 years old at the first test point (TP1), and nearly 70 at the second test point (TP2). JJ had higher academic education, attained in the US. At work, he used both Norwegian and English on a daily basis. He had learned most of his Norwegian through immersion, but also had some formal training. In his family, they spoke mainly English, but with some code-mixing between Norwegian, Swedish (his wife's first language) and English. His wife rated him as very proficient in Norwegian before the onset of his disease, and he spoke Norwegian with friends and neighbors, watched Norwegian television and read Norwegian newspapers. JJ reported that since the onset of his dementia, he had been using Norwegian less frequently.

JJ had been referred to a specialist in neurology at age 67 because of language problems. A *single-photon emission computerized tomography* (SPECT) scan showed bilateral reduced perfusion of large areas of the brain. According to his medical journal, his diagnosis was "A variant of Alzheimer's disease, frontal lobe dementia, primary progressive aphasia". I do not have access to any other information about the underlying pathology, and from the unclear description in his medical journal, it is impossible to say anything certain about the possible subtype of PPA. However, the results from the language testing, and the initial diagnosis as AD could suggest lvPPA.

His first two assessments on cognitive tasks performed at the hospital, show only a mild impairment. This indicates that his cognitive functioning is still intact early in the course of his disease, which is in line with the operational definition of PPA (Gorno-Tempini et al., 2011).

4.5.2 Materials

Cognitive tests in this study included the MMSE, TMT-A+B, the Erikson flanker task (Eriksen & Eriksen, 1974) and the *Rowland Universal Dementia Assessment Scale* (RUDAS) (Rowland, 2009; Wong, Martin-Khan, Rowland, Varghese, & Gray, 2012).

RUDAS and MMSE both measure general cognitive functioning, and assess mainly the same domains. The main difference is that RUDAS was developed as an alternative to MMSE, to be more sensitive in detecting cognitive decline in people with diverse cultural backgrounds. Similar to MMSE the total score is 30, and a score below 26 indicates mild cognitive impairment. RUDAS includes tests for the following domains: memory, spatial orientation, praxis, visuoconstructional drawing, judgment and language.

[10] *The National Association for Public Health* is a non-profit organization in Norway that works both with dementia and heart disease

The Flanker test measures the participants' abilities to suppress irrelevant information, and is generally seen as a measure of inhibition capacities (Eriksen & Eriksen, 1974). This is a computerized test where the participant sees five arrows on a screen. The arrows can either point in the same direction (congruent condition), or the central arrow can point in the opposite direction from the arrows flanking it (incongruent condition). The participant has to judge as quickly as possible, indicating by a key press, if the central arrow points to the left or to the right.

The linguistic battery included a subset of items for confrontation naming from the *Psycholinguistic assessments of language processing in aphasia* (PALPA) (Kay, Lesser, & Coltheart, 1996, 2009), and the *Verb and sentence test* (VAST) (Bastiaanse et al., 2006), and a cartoon description from the *Bilingual Aphasia Test* (BAT) (Paradis, 1998; Knoph, 2010). Recordings of spontaneous speech during a background interview and small talk with the participant are also available. Furthermore, JJ's wife filled in the *Communicative Effectiveness Index* (CETI) (Lomas et al., 1989, 2006), evaluating how she experienced his language impairment since the onset of his dementia.

To test word production through confrontation naming a sub-set of the test items from PALPA and VAST was used. Both tests originally consisted of 40 items each, however, only 30 items were included from each test in the current study to reduce testing load and time. An overview of the selected items can be found in Appendix G. The same set of pictures was used to elicit single verbs and nouns in both English and Norwegian.

The picture naming test was computerized to be able to measure reaction time for each item, programmed in E-prime version 2.0; (Schneider, Eschman, & Zuccolotto, 2002). However, this was not taken into account in the analysis because of poor timing quality. Nouns were elicited before verbs in both languages and at both test points.

The items were not matched for any underlying properties, but a post hoc analysis showed that 16/30 of the nouns and 15/30 of the verbs are cognates in English and Norwegian. A Wilcoxon rank-sum test showed that there was no significant difference in the frequencies of the words across languages. However, the selection of items is slightly skewed, with a few very high-frequency items in both the object and action naming subtests.

The cartoon description task was borrowed from the BAT (Paradis, 1998; Knoph, 2010). In this task, the participant is presented with a six-picture cartoon without any text, and is asked to use the pictures to tell a story. For scoring purposes, ten key content components of the cartoon's plot were identified; these are rendered in 4.5.4.

4.5.3 Procedure

JJ was tested on the language battery at two *test points* (TP), approximately one year apart. Each language was tested separately at the two TPs; first English, and a week later, Norwegian. RUDAS, flanker, picture naming and cartoon description were assessed by members of the MultiLing Dementia team. Before and between the two TPs JJ was followed up at his local hospital where he was also tested with the clock drawing task, TMT A + B and MMSE.

At each test session, two people were present with JJ in his home. To keep each test session as monolingual as possible, different research assistants were present at the different sessions, but the same main examiner (the second author, HGS) was present at all four test sessions.

Each session began with approximately 30 minutes of free talk between JJ and the examiners. In the first session, a biographical interview was conducted to learn as much as possible about JJ and his background, both socially and linguistically.

RUDAS and flanker tasks were only conducted during the English testing session, since this was his strongest language; CETI was filled out by his wife in Norwegian; and picture naming, cartoon description and small talk were recorded in both languages. Table 4.11 gives an overview of which tests and modalities were assessed at both TPs.

Table 4.11: Different recordings in each language at both TPs

Language	Test/Recording
ENGLISH	Interview/Small talk RUDAS Flanker Picture naming Cartoon description
NORWEGIAN	Small talk Picture naming Cartoon description CETI

4.5.4 Analysis

In this study, both qualitative and quantitative measures were employed to investigate JJ's naming skills and strategies in different task environments, though, the conversation analysis data will not be discussed in this dissertation.

For the picture naming task, items were scored as correct or incorrect using *composite scoring*. Composite scoring means that the responses were coded regardless of the language he used to respond (e.g., 'fish' was coded as correct for the Norwegian target 'fisk'). This was a strategy JJ employed frequently, especially for cognate words. The number of light verbs ('to do' or 'to make' etc) in the verb naming task were also counted.

For the cartoon description task, ten key content components that should be included to form a coherent story were identified. These components can be found in table 4.12. The cartoon description was further analyzed in terms of number of produced words and lexical density. The narratives were transcribed using conversation analysis conventions. Examples of transcribed excerpts can be found in paper IV (Lind et al., 2018).

Table 4.12: Content components for the cartoon description task

1	Introduction of the man (main character)
2	Introduction of the woman (main character)
3	Introduction of the birds (main characters)
4	The man climbs the tree
5	The branch snaps
6	The man falls down
7	The man's leg is broken
8	The ambulance arrives
9	The man is taken to the hospital
10	The mother bird cries as the chicks have died

4.6 Reliability and validity

Reliability and validity are considered to be the main measurement properties to assure researchers that a specific tool they use will give an accurate representation of what they wish to investigate. If a tool or an instrument is considered to be accurate, valid, interpretable, and provides robust results, it is suitable for use in clinical and research practice (Souza, Alexandre, & Guirardello, 2017). In this section, I present how the tasks that were specifically developed for the current project (FWA, picture naming, word-to-picture matching and sentence-to-picture matching) are considered to be reliable and valid for the purpose of this project.The validity of the project as such, is discussed towards the end of this section.

Reliability refers to the ability of reproducing consistent results over time, and by different observers. Reliability relies on the function of the instrument, of the population on which it is used, the circumstances it is used in, and on the context. Validity refers to whether the tool measures what it is supposed to measure (Souza et al., 2017).

To establish reliability for the 30-word FWA test, the short list has been tried out on an additional 154 adult L1 speakers of Norwegian, and compared to the responses on the same 30 words from the original 100-word list (Bøyum et al., forthcoming). Similar to the system employed in the current study, two raters each scored all responses, and a third consultant discussed the ratings with the two raters. Alternatively, two raters could have scored either all or a subset of items each, and an inter-rater reliability score could have been calculated.

The results from the comparison between the short and the long tests are slightly different from each other: More meaning-based responses were provided on the short than on the long test, and more form-based responses were given on the long, compared to the short test. This might be due to the different modes of presentation — recall that the long test was presented to participants in writing, and the short test was administered orally. It might be the case that form-based responses are more readily available when a person is presented with written cues than when they are presented with spoken cue words. However, the 30-word list is a reliable substitution for the 100-word list, and can be used in situations where testing time and load need to be reduced.

In addition to the participants included in the current project, the Picture Naming and the word-to-picture matching tests were also tried out on a set of 20 neurologically healthy L1 speakers of Norwegian, aged 25-65. Participants first named the pictures in the picture matching task, before they conducted the word-to-picture matching task. A full norming study of the two tasks was beyond the scope of this project.

However, the results from this small-scale validation study indicate that the Picture Naming test has high reliability, with the participants scoring 98,6% correct on average. For the word-to-picture matching task, all participants scored 100% correct, implying that the comprehension task was easier than the production task.

The results from this small-scale trial of the picture naming and word-picture matching tasks were only scored by one person, and no inter-rater reliability score has been obtained. However, for the larger population who participated in the study reported on in paper II, the inter-rater reliability between the three raters was very high for both verbs and nouns (see 4.3.7.4). High consensus between the raters can indicate that the scores reflect what the test was intended to measure (Mildner, 2013).

The original sentence-to-picture matching task from the VAST has been normed on a sample of both neurologically healthy persons, and persons with aphasia (Bastiaanse et al., 2006; Lind, Moen, & Simonsen, 2006). However, this test has been altered to fit the test paradigm employed in the current study. The version in the current experiment was not validated before testing commenced, but rather piloted on a small set of five volunteers. These volunteers, and all but one of the control participants in the current study scored 100% correct on the sentence-to-picture matching task. This indicates that the task was not particularly difficult for neurologically healthy participants. The task was somewhat more difficult for persons with AD and PPA, but their eye tracking data show less impairment.

An important question is whether this current experiment is in fact measuring sentence comprehension, or even compliance with task instructions. With only two pictures, there is a possibility that the recorded results are purely based on chance performance and guessing. However, both the online data and the offline judgments show that participants do chose the correct picture more than 90% of the time, which would strongly argue that participants are not guessing.

Although all four tests show high stability and reliability (the same results are reproduced for larger groups of participants), this does not automatically imply high validity. Validity is found when the test is proven to measure what it is supposed to measure. In this case, lexical retrieval for both production and comprehension, and sentence comprehension.

Picture naming, word-to-picture and sentence-to-picture matching tasks are some of the most common paradigms in language assessment. Picture naming tests often have high reliability, with test-retest correlations upwards of 0.9 (Howard, Patterson, Franklin, Morton, & Orchard-

Lisle, 1984). According to the Pearson correlation coefficient; 1 is considered perfect reliability, and everything above 0.9 is considered excellent reliability (Kirch, 2008). Regarding the word-to-picture and sentence-to-picture matching paradigms, these have been found to be a reliable tool for research and clinical assessment of comprehension of verbs and sentences (Bastiaanse, Edwards, Mass, & Rispens, 2003). Further research and trialling of the tests included in the current studies should add to the validity of these specific tests.

The aim has been to design a study with high internal, external and ecological validity, and at the same time being suitable for the population in question. Internal validity is strengthened by experiments that are well designed, carefully controlled and accurately measured, to ensure that any alternative explanation for the phenomena under consideration can be excluded (McDermott, 2011). Threats to the internal validity are experimental procedures, or the participants' experiences which influence the researcher's ability to draw correct inferences about the population under investigation based on the collected data (Creswell, 2009). In the current project, I have tried to control for confounding variables which can be a threat to the validity of the studies by keeping the test protocol similar for all participants within groups and collecting as much subject-relevant information as possible. However, there are some variables that it is not possible to control for, such as fatigue, test-wiseness or lack of interest or motivation, which can affect the participants' performance.

One way to assess the external validity of a study, is to replicate the study to see if the same results are obtained in different contexts and settings and with other participants. This strengthens the transferability of the results. The methods and procedures in the different studies have been described in detail in this chapter and in the specific papers. This is important to allow for replication of the studies. The ecological validity refers to the applicability of the experimental findings in the real world. The current project has a high degree of experimental control, which adds to the internal validity. However, this also means that testing at times becomes unnatural. To mimic more naturalistic language environments, production of full sentences and narratives was targeted in studies II and IV.

4.7 Ethical considerations

The different sub-studies were approved by the *Regional committees for medical and health research ethics*[11] with the following information: studies II and III, reference number *2016/1293*; study IV; reference number *2014/1993D*. Study IV was also approved by the Norwegian centre for research data (NSD), with reference number: *40523/3/HIT*.[12] Letters to the participants are found in Appendix A, and all approval notices are found in Appendix B. The data protection services at the University of Oslo also approved the project plan and plans for storage and treatment

[11] Regionale komiteer for medisinsk og helsefaglig forskningsetikk; https://helseforskning.etikkom.no
[12] Norsk senter for forskningsdata; https://nsd.no

of the collected data. In addition, the data protection officials at the Oslo University Hospital approved studies II and III. This was necessary to obtain information about the participants who were recruited from the NorCog register (see 3.4.1).

The participants with AD and PPA in studies II and III were recruited at the memory clinic after they had received their diagnosis, and agreed to be included in a national register for persons with cognitive impairments. The leader of the memory clinic contacted potential participants. Only if they agreed to be contacted to receive information about the project were their contact details given to me. Potential participants were first called to ask if they consented to receive an information package by mail. The information package contained an information letter about the purpose of the project and what participation would entail, a consent form and a response envelope. A follow-up phone call was made approximately one week after the participants were expected to have received the information package. Only the participants who returned the consent form, either spontaneously or after the follow-up phone call, were considered for inclusion.

The information letter was written in clear language, with short and precise sentences to enhance readability. Participants were informed that if they chose to participate, they were allowed to withdraw at any moment without having to provide a reason for this. The information letter had to be updated in the summer of 2018 to account for changes in the European data protection legislation and the introduction of the *General Data Protection Regulation* implemented by the EU (GDPR). All participants who had received an information letter before the implementations of the GDPR were sent a new letter with information about the new data protection guidelines, and a request to sign a new consent form. Updated consent was obtained from all relevant participants.

JJ (study IV) was recruited through the conversation group he attended. The leader of this conversation group approached him with a letter containing information about the purpose of the study, and he subsequently contacted us, agreeing to participate in the study. He signed a consent form at the beginning of the first session at each TP.

Obtaining consent from persons with dementia can be challenging. However, all participants in these studies had been evaluated by their physicians to be capable of giving consent. In early stages of the disease, participants are usually competent enough to give informed consent, but as the cognitive capacities decline, this might no longer be the case. It was therefore important to obtain consent from JJ again before the start of the second round of testing.

All participants included in the studies have been anonymized. However, in a country with a relatively sparse population, and participants recruited from the same geographical area, the question of anonymity is difficult; there is a risk that participants are recognizable based on only few cues, such as the combination of language background, age, gender and diagnosis — particularly for participants with rare diagnoses. Nevertheless, all participants have given their permission for the procedure and the results to be published in this dissertation, in scientific publications, in dissemination to relevant scientific fora and in presentations to students.

5

Main features of the studies

This chapter aims to further introduce the four studies. The main findings from each will be pointed out. After each introduction, there is a section including some commentary to each study. For a comprehensive discussion of the findings and results, see chapter 6.

5.1 Study I

The first study that is included in this dissertation is a systematic review of (psycho-)linguistic variables and lexical retrieval in AD and PPA. The main goals were to investigate which variables most affect production and comprehension of single words. A second aim was to investigate if an analysis of these variables can help distinguish between persons with dementia and control participants, and between AD and PPA. The variables under review were *word class*, *frequency*, *age of acquisition* (AoA) and *imageability*.

A majority of the reviewed studies found a dissociation between nouns and verbs (e.g., Druks et al., 2006; Kim & Thompson, 2004; Hernández et al., 2007), while one did not (Rodríguez-Ferreiro, Davies, González-Nosti, Barbón, & Cuetos, 2009). Among the studies that reported a dissociation between nouns and verbs, both a selective sparing for nouns (e.g., Druks & Weekes, 2013; White-Devine et al., 1996; Hillis et al., 2006; Lind et al., 2018; K. Robinson, Grossman, White-Devine, & D'Esposito, 1996) as well as a selective sparing for verbs (e.g., Hernández et al., 2007; G. Robinson, Rossor, & Cipolotti, 1999; Williamson et al., 1998; Hillis et al., 2004) were found.

There can be several possible reasons for these divergent results. Psycholinguistic variables affect words in different ways, and it is known that the variables *frequency*, *AoA* and *imageability* behave differently for nouns and verbs. There might be an interplay between the different variables that affect naming differences across word classes, rather than the word class membership per se. Another important point to make is that the way the different studies test for naming and comprehension impairment differs across the reviewed studies, which might also influence the results.

AoA was the variable that showed most stable effects across testing modalities and both in comprehension and production. This indicates that the words that are learned early in life are the words that are retained longest. Explanations for this include more entrenchment and plasticity of the neural system. Words that are encountered often will get more entrenched in the mental lexicon, and more entrenchment leads to more new words attaching to this word in later learning. When more words attach to a node, the nodes adapt to again accept more attaching words.

Another finding from this review is that anomia in AD and PPA seems to be primarily a difficulty with access to the phonological form, rather than an underlying semantic impairment. This implies that the semantic links in the mental lexicon are stronger than the phonological ones, and trigger enough excitation for lexical items to reach activation for production or comprehension. This is supported by the results of the majority of the reviewed studies, and by the fact that the main semantic variable under review (imageability) does not seem to affect lexical access in the same manner as AoA and frequency, which are variables that are associated with retrieval.

The results from this study suggest that the language impairments in AD and PPA are quite similar, despite the differences in underlying neural change. This finding is supported by the fact that in most cases, it is not possible to distinguish between AD and PPA on the basis of sensitivity of the studied variables in linguistic data. However, it is possible to use this data to differentiate between the different subtypes of PPA, and between healthy older adults and older adults with AD and/or PPA.

5.1.1 Comments to study I

This paper would have benefited from a more thorough methodological and theoretical discussion. Preferably, I should have included a section including information and discussion about *how* measures of the different variables are obtained. For instance, AoA and imageability are obtained by asking people how old they think they were when they learned a word (for AoA), or how easily they feel that a word gives rise to a sensory mental image (for imageability). Such subjective rating may seem far-fetched, but several studies show that the measures are reliable. Subjective AoA correlates very well with objective AoA as obtained respectively by parental reports and observational studies of children (Hansen, 2016; Łuniewska et al., 2016). Imageability and concreteness correlate to a great degree, but imageability gives more information about the conceptual experience of words that is otherwise missing from judgment of concreteness. There are also many other psycholinguistic variables that affect lexical retrieval, but that were not included in this review. For instance, concreteness, familiarity, word length and phonological variables such as similarity to other words, complexity, etc. to name a few.

Theoretically, a discussion of psycholinguistic processing models, and a closer tie between the findings and a discussion of such models, should have been included. Many theories of language processing are based on evidence from language impaired speakers. Language impairment in dementia is well-suited to use as evidence for psycholinguistic processing models, since it can be assumed that persons with dementia had an intact language system before onset of the disease.

It is quite difficult to make concrete statements about how the different variables influence lexical retrieval in PPA, since I cannot be certain about the type of PPA that is reported on in many cases. In the reviewed studies, there is not much information about which diagnoses the participants have. This is partly due to the large number of studies that were published before the consensus criteria for PPA were in place, but also and in some cases, the PPA subtype is not even reported.

Furthermore, only few articles included participants with lvPPA, either because these participants were left out by the authors (Fraser et al., 2014; Marcotte et al., 2014), or because the majority of the studies on PPA do not give enough information about the type of PPA studied. The most similar results are to be expected between lvPPA and AD, however a proper comparison between the results from the studies including participants with PPA to studies including participants with AD, becomes difficult when the grounds for comparison are lacking.

For a good review to be valid, it should be updated on a regular basis to account for the latest research in the field. A future update of this article should also include a thorough discussion of methodological considerations and theoretical implications.

5.2 Study II

The second study was concerned with how free word associations are affected by cognitive decline in AD and PPA; how different tests of lexical access and association affect naming abilities in PPA and AD; and how results from different tests can inform about lexical processing in general, and for individuals with AD and PPA specifically. The properties that were identified as particularly important for naming success in the literature review (frequency, AoA and imageability) were also taken into consideration in developing a naming and comprehension task included in this study.

Different tests for lexical access can yield different results, as the degree of restriction within the task influences the ease of lexical retrieval. In *picture naming* tasks, the participants are asked to name one specific target word, which makes the word search very restricted. In controlled word association tasks, like *verbal fluency*, the task is slightly less restrictive, as the participants are asked to name as many words belonging to a semantic category or starting with a particular sound; this somewhat restricts the word search. *Free word associations* are far less restrictive, and participant can in theory say any word as a response to a cue. Participants in this study were also assessed with the picture version of the *Pyramids and Palm Trees* test and *De semantische associatie test*, where the semantic associations are purely conceptual; participants have to retrieve information about the concepts and not the words. These tests are also considered restricted, as there is only one answer that is considered correct per trial.

Results from the traditional language assessment tests show that there is generally no dissociation between nouns and verbs for most participants, which is different from the findings regarding word class differences in study I.

Furthermore, the results from this study indicate that there are subtle differences in language behavior between persons with AD and PPA and neurologically healthy controls which cannot be captured by traditional, restrictive tests. In the free word association test, participants with AD provide more responses that are related to the cue words on multiple levels in terms of form, meaning and usage patterns. For instance, their responses can be both form and meaning-related to the cue, or both meaning-related and collocations. They also provide more pure collocations than do controls. These differences are found even in early or mild AD, such as for AD04 and AD06, whose scores on the neuropsychological tests show hardly any impairment.

With only two participants, it is of course not possible to establish a pattern of word association responses that can discriminate PPA from AD, or from neurologically healthy persons for that matter. However, there are marked differences between the two participants with PPA on several tests in this study. This might be related to the fact that PPA01's initial diagnosis was one of AD. Throughout, his scoring profile appears very similar to the participants with AD, but with more word-finding difficulties in his spontaneous speech. He also had more difficulty with the picture naming tests compared to PPA02.

Theoretical implications from this study include further support for an impairment in access rather than impairment in the semantic system per se. The findings also further support a hypothesis that there is interactive activation between nodes in the mental lexicon network (as opposed to serial processing). This study gives support to the *transmission deficit hypothesis* (TDH) (Burke & Shafto, 2004), rather than to the *inhibition deficit hypothesis* (IDH) (Hasher & Zacks, 1988).

The clinical implication found in this study, is that analysis of FWA results can point to some differences between neurologically healthy persons and persons with mild to moderate dementia. The differences between these two participant groups are subtle, and require a thorough analysis of the relationship between words.

5.2.1 Comments to study II

The results from this study show that the FWA task can be a valuable supplement to more traditional assessment tools, but it also provides additional information about the language deficits in dementia when used on its own. However, the scoring categories are broad, and with many categories there will always be a risk of ending up with several categories that receive too few responses for meaningful analysis.

An interesting question is why the participants with AD, and to some degree also the ones with PPA, seem to prefer collocation-based responses. One possible explanation for this could be that collocations are more automated, and are activated in the same way as chunks and prefabs in the mental lexicon.

An interesting observation is that the two participants with PPA behaved quite differently on several of the lexical, but also on the cognitive tasks. Since I do not have access to neuroimaging data from these two participants, I cannot make any assumptions as to whether the observed differences are due to differences in neuropathology. However, in line with current research on the matter (Matias-Guiu et al., 2019; Vandenberghe, 2016) there might be two different logopenic variants of PPA that can be distinguished based on which areas of the brain experience more atrophy, and also on results from different linguistic outcome measures.

Future research should include larger population samples, especially persons with PPA, to investigate if the findings from this study can be attributed to change associated with language impairment because of AD/PPA, or if it is an indication of individual differences.

The scoring system also needs to be discussed in greater detail. Two categories (syntagmatic vs. paradigmatic) are not enough to pick up on the many different relationships between cue and response, but too many categories will make the boundaries between the different categories unclear and confusing.

5.3 Study III

The third study moves beyond the single-word level, and investigates both online and offline sentence comprehension in AD, PPA and healthy aging. The focus of this study is on the comprehension of canonical and non-canonical sentences (i.e., active and clefts) in Norwegian. Sentence comprehension in dementia is far less studied than word production and comprehension, and it is therefore interesting to go more in depth on this issue.

Since lexical knowledge and comprehension appear to be spared in AD and PPA, the sentence comprehension deficits they experience do not stem from difficulties with comprehending the individual words of the sentences. Some previous studies have pointed to (working) memory impairments as the main cause for the sentence comprehension deficit in AD, but here it is contrasted with lexical skills in addition to results on tests for working memory and executive functioning.

Because of poor tracking ratio for a majority of the young participants from study II, the whole group was excluded from analysis. Further, five healthy older controls and two participants with AD had to be omitted for the same reason.

The results from the offline measures showed that the participants with AD in general fared better on this task than the participants with PPA, but neither group seems to indicate an impairment. However, the participants with PPA show better immediate attention to the target in the eye tracking data compared to the participants with AD. Furthermore, there is quite some individual variation between participants.

From the eye tracking data, it is clear that healthy older adults always detect the target picture within the region of interest, or right after, for all three sentence types — which is to be expected. As a group, the participants with AD show a similar gaze pattern as controls, however, they are slower and never reach a very high proportion of looks to target (between 55% and 75%). This indicates that these participants are less certain about which image is the target and which is the distractor, yet they have a preference for the target. The participants with PPA are also slower in detecting the target than controls, but their proportions of looks to target is higher than for participants with AD.

An interesting finding is that all three participant groups seem to prefer an agent-first parsing strategy, as they all initially look to the distractor image (almost 70% looks to the distractor for control and PPA participants, and 60% for AD participants) in the *object cleft* (OC) condition. Once more of the sentence becomes available to the listeners, their gazes shift towards the target, and control participants reach up to 90% looks to target by the end of the region of interest. For participants with PPA and AD, the proportion of looks to target in the OC condition is never over 70%.

Unfortunately, the eye tracking data from a large proportion of the participants were deemed to be unsuited for analysis, and the results can only indicate a trend at best. However, the trend is interesting, because it shows that persons with AD and PPA do comprehend even infrequent, non-canonical sentences, although with some uncertainty and longer response times than healthy controls.

5.3.1 Comments to study III

Just like with the previous study, the number of participants in this study is far too low to make sound generalizations about the results. This is extra problematic when a subset of participants were excluded due to poor eye tracking data, or because they expressed little interest in the task.

The technical difficulties with the eye tracking were in some cases related to poor quality of the calibration, especially for the older controls and the persons with AD. Some researchers have discussed how greater gaze drift for persons with AD may be of clinical relevance (Ko & Ally, 2011). More research on a bigger group of participants is needed to see if this is the same pattern observed in the current study.

There are two further methodological issues related to this study, which should have been taken into account when designing the experiment. First, there is no measure of reaction time for the offline judgment. When this measure is lacking, it is not possible to align the online and offline accuracy results (looks to target and pointing, respectively). Some of the participants with AD and PPA show two peaks of looks to target, one immediate and one delayed. If information about their offline reaction time had been available, this could have be aligned with the eye tracking data to see if the second peak of looks to target is related to looking back to the target picture after making the offline judgement, or if this second peak represents something else entirely.

Second, an addition would have been to include a test for sentence repetition, as this seems to be impaired in PPA and, to some degree, also in AD. Testing sentence repetition in addition to sentence-to-picture matching would have given us an even clearer picture of the sentence impairment for persons with these two diseases, which again would support both clinical and theoretical implications from this study.

Finally, more than half of the control participants were excluded due to poor eye tracking data. This means that when employing eye tracking methodology, one needs to be extra attentive to the huge amounts of potential data loss. In this case, I thought I would be safe with the number of participants that I had recruited for the lexical retrieval study, but should in fact have recruited at least double that number for this substudy.

5.4 Study IV

The last study was initiated to investigate how bilinguals with Alzheimer's disease fare on different naming tests, and how lexical retrieval problems are apparent in different modalities (free conversation, semi-structured narratives and experimental testing) and across languages. Our participant, JJ, was recruited through a conversation group for people with AD. However, after he had gone through two rounds of testing, it was clear that he did not in fact have AD, but rather PPA. The diagnosis is not clearly stated in his medical journal, where AD is listed as his main diagnosis and the doctor has made a note that it might be "a subtype of AD called primary progressive aphasia".

The main focus of this study is on longitudinal aspects of language decline in dementia, and on how one can use different methodologies to study lexical retrieval. Speech samples were elicited through picture naming, narrative production and personal interviews. The results show that JJ had similar issues with singular word activation in spontaneous speech as in confrontation naming.

JJ was tested in both his languages — English and Norwegian — on two separate occasions, approximately a year and a half apart. At the first test point (TP), roughly a year post diagnosis, JJ was very communicative and talked a lot. It was at this point possible to keep a conversation going with him, and he underwent the tests with few difficulties. One year later, his communicative skills had decayed and so had his spontaneous language production. It was no longer easy to guess what he was trying to convey. Confrontation naming and narrative production were also more effortful and difficult for him to perform than at the first TP.

At the first TP, JJ's naming skills were better in English than in Norwegian, and he named nouns better than verbs. His speech was halting with many pauses, and except for a few slips of tongue, always grammatically correct. His halting speech and naming errors made the cartoon description difficult, but the main story was conveyed. There were some instances of code switching to English during the Norwegian assessment, but never the other way around. This might be consistent with his language behavior before diagnosis, as reported by his wife, but there is no other data available on this issue.

At the second TP, 30 months post diagnosis, naming was poor in both languages on the confrontation naming test and even more so in spontaneous speech. At this point, it was almost impossible to keep a conversation going with JJ, especially in Norwegian. Verbs were still far more impaired than nouns in English, but, surprisingly, he performed marginally better on verb naming compared to noun naming in Norwegian. In the cartoon description, he provided very little content, despite producing more words than at the first TP. This was observed for both languages.

This study also supports the views of lexical activation put forward in the transmission deficit hypothesis (Burke & Shafto, 2004). Further, the indications of parallel decline in JJ's two languages is indicative of (at least) partially overlapping lexica for bilingual speakers. This study gives a good account of how language abilities deteriorate during the course of the disease.

5.4.1 Comments to Study IV

The spontaneous speech data in this paper has been analyzed using conversation analysis (CA), which is a good tool to describe the events that take place during conversation. This is a method that I do not have much experience working with personally, and since the main focus in this dissertation has been on psycho-linguistic methodologies, this part of the paper has not received much attention in the previous chapters. However, I see clear benefits of including CA analysis to better capture the word searches that take place in conversation and narrative production.

In this study, the naming data was analyzed only in relation to the words' frequency, and find that for noun naming in his L1, and both noun and verb naming in his L2, JJ experienced a frequency effect (better performance on high-frequency nouns). It would be interesting to also look at effects from other psycholinguistic variables, such as AoA and imageability. As information about these variables is available for the words tested in Norwegian through the

Norwegian Words database (Lind et al., 2013), these variables could have been taken into account in the results. However, it is uncertain how, for instance, AoA — as rated by first-language speakers of Norwegian — affect naming abilities for someone who learned the language as an adult.

JJ was tested in both his L1 and L2 with the same items and same pictures, meaning there could be a risk of familiarity and learning effects at the second session at each TP. However, as seen by the much poorer results in Norwegian compared to English, this does not seem to be the case.[1]

Using the same pictures to assess items in different languages means that items have not been controlled for underlying variables that might differ across languages. Preferably, the English versions of the same tests (PALPA and VAST) should have been used as well, to better assess individual items in each language. But as the Norwegian versions of these tests are based on the original English version (PALPA), and partly on the English translation of the VAST, the tests are, to a large degree, overlapping in the two languages. Norwegian and English also belong to the same language family, and none of the test items were culturally unique to Norwegian. It can therefore be justifiable to assess naming in English by means of tests that were originally adapted from English to Norwegian.

Another major point to discuss regarding this study, is the participant's diagnosis. It was initially communicated that he had AD, but in his medical journal it is noted that it might be PPA. Results on cognitive tests show only a slight cognitive impairment early in the disease, and the main symptom JJ experiences is one of language decline. JJ shows impairment in single-word production, both in confrontation naming and spontaneous speech, but not really impaired comprehension, which is in line with the profile found in lvPPA (see 3.1).

[1] English was tested before Norwegian at both TPs.

6

Discussion and conclusions

In this dissertation, I have studied the language abilities in speakers with Alzheimer's disease and primary progressive aphasia to reach two broad research goals:

1. What can data from persons with an age-related cognitive impairment tell us about how language is organized in the brain?

2. Can language data from persons with dementia aid dementia diagnostics, and can it help to distinguish AD from PPA, and both from healthy aging?

To reach these goals, I put forward research questions addressing three different topics which will be discussed in separate sections below: linguistic aspects in section 6.1, methodological aspects in section 6.2, and clinical aspects in section 6.3. Some limitations are outlined in section 6.4, and ideas for further research are introduced in 6.5. Section 6.6 concludes this dissertation.

6.1 Linguistic aspects

As introduced in chapter 2.1.2 and in chapter 3, there are variables associated with a word's form, usage pattern and meaning which influence how items are stored and processed in the mental lexicon (see section 2.3). In this section, the same issues are revisited, but with a focus on how the findings from the current project relate to these psycholinguistic variables (section 6.1.1) and to linguistic theories (section 6.1.2).

6.1.1 Psycholinguistic variables

Frequency is one of the most studied variables which affect lexical retrieval in naming, together with age of acquisition (AoA), imageability and linguistic variables such as word class and cognate status. The variables can affect language processing in different ways, and on different levels of processing (Vonk et al., 2019).

The results from three of the studies in the current project find frequency effects on different tasks, both word and construction frequency influence processing. In the literature review in study I (Ribu, Under revision), frequency is one of the most stable variables across testing modalities— both for production and comprehension. Frequency effects are also found in study IV (Lind et al., 2018), where JJ's naming is better on high-frequency items than on low-frequency items. In study III (Ribu & Kuzmina, submitted), we see that an agent-first parsing strategy, which is mediated by the frequency of structures where the agent occurs first in the sentence, is preferred for persons with and without dementia on object cleft sentences. These findings suggest that there is a frequency effect on several levels, from single words to sentence-sized constructions.

The literature review also lends support to another variable which is associated with lexical retrieval success, namely age of acquisition (AoA). AoA effects are found in a range of different test modalities — and both for production and comprehension — even when frequency effects are less pronounced. AoA effects can be seen as a consequence of the additive construction of semantic representations, whereby later acquired words are incorporated into a representation already containing earlier acquired words (Chang, Monaghan, & Welbourne, 2019). Early AoA words have richer, more embedded semantic representations than later acquired words (Li, Farkas, & MacWhinney, 2004; Brysbaert & Ghyselinck, 2006). Another view is that AoA effects are due to early plasticity on the learning of mappings between written, spoken and semantic forms of the vocabulary (A. W. Ellis & Lambon Ralph, 2000).

Different psycholinguistic variables were taken into account when developing the Picture Naming and word-to-picture matching tests in study II (Ribu et al., submitted), and this test was used partially to investigate the noun-verb dissociation which is often reported in the literature (e.g., Druks et al., 2006; Kambanaros & Grohmann, 2015). In the literature review selective sparing was found for both nouns and verbs, and it was therefore of interest to look deeper into this issue. On the Picture Naming task and the word-to-picture matching task, no difference between word classes was found (Ribu et al., submitted). However, word class differences were found in naming for both L1 and L2 in study IV (Lind et al., 2018), albeit only when composite scoring of the participant's two languages was employed. The conflicting results regarding word class dissociation in AD and PPA may imply that it is not the word class per se which complicates lexical retrieval, but rather an interplay between several different psycholinguistic variables, such as frequency and AoA, on the different test items.

JJ's naming success in his L2 is greatly influenced by the cognate status of the words in the naming task. He code switches regularly to English when naming pictures in Norwegian, which means that he activates words which are similar in both form and meaning, and that he has both his languages active at all times. Some participants, mostly the control participants, in studies II and III also respond with words in other languages than Norwegian on certain tasks. In most cases, they respond with words which are cognates between Norwegian and the language they switch to, suggesting that words which are similar in both form and meaning are especially easy to retrieve. This indicates that even "monolingual" speakers are in fact not monolingual, but have activation from several languages present at all times.

6.1.2 Theories of language and processing models

The findings from this dissertation fit well with usage-based theories of language, which emphasize the roles usage patterns, semantics and phonology play in language processing. Frequency effects are not only restricted to the single-word level, but are also found in sentence processing. AoA can be seen as a cumulative frequency effect, where words with early AoA will have stronger entrenchment than words with later AoA, which leads to stronger mental representations. Cognates also strengthen the connections between units in the lexicon since these words are similar in both form and meaning, which will influence processing of these words.

Usage-based theories of language presuppose that language is shaped and changed through usage patterns and experiences, and that there are differences across languages, communicative settings (including tasks and modalities), between groups of individuals and also between individuals. This makes it a good candidate to explain the variability across participants and tasks reported on in this dissertation.

The changes found in the three experimental studies looking at impairment in single-word naming and sentence comprehension can be seen as augmented manifestations of changes observed in healthy aging. This means that language changes can be scaled on a continuum from healthy to "pathological" changes, and that there might not be a need for a separate model that explains language impairment in AD/PPA contra healthy aging. A model which accounts for why lexical retrieval is compromised in healthy aging (the transmission deficit hypothesis, TDH, Burke and Shafto (2004), which predicts larger age-related changes in production than in comprehension, see 2.2) should also suffice to explain what happens when cognitive impairment enters the scene. The changes seen in AD and PPA are reinforced manifestations of the changes explained by the TDH.

In studies I, II and IV, I find support for an impairment in access rather than in underlying semantic knowledge. In study I, this is seen by the stronger effect from variables that are associated with retrieval (frequency and AoA), than variables related to semantics (imageability) (Ribu, Under revision). In studies II and IV, the access impairment approach is supported by the responses provided on different tests (Ribu et al., submitted; Lind et al., 2018). Synonyms and other semantically related responses on the Picture Naming task demonstrate that the participants have an understanding of the target object, but the phonological form is inaccessible. Similarly, JJ in study IV code switches between Norwegian and English in the Norwegian testing sessions, which indicates that he can activate the correct intended concept, but not its phonological form. His strategy is to produce an output form which is semantically overlapping, and phonologically similar to the target. Control participants in study II also provide code switching responses on the verbal fluency, picture naming and FWA tests (mainly to English and Scandinavian languages, but there is also one instance of a participant who named one animal in German[1] on the semantic fluency task), indicating phonological activation in a non-target language.

The instances of code switching are most likely not an impairment in inhibiting the non-target language: during the cognitive tasks, participants in the current study —both controls and participants with dementia— perform well on tests of inhibition. Both JJ and the participants in study II produce words in languages that they assume the test administrator knows, and this must be seen as a compensatory strategy, or as a playful display of language knowledge. Code switching as a compensatory strategy has also been found in another study specifically examining code switching patterns in dementia (Svennevig, Hansen, Simonsen, & Landmark, 2019). In studies II and III, the participants were aware of their code switches, and sometimes this production was fully intentional (e.g., pronunciation of 'kangaroo' with an exaggerated Australian accent). The instances of code switching on the Picture Naming task were often activation of cognates with the Norwegian target word (e.g., 'to ride' for 'å ri'). There is one exception which may indicate an inhibition deficit happened for two participants: They responded 'pineapple' instead of the Norwegian 'ananas' on a picture of a pineapple, but these cases were less common than cognate responses. On the FWA task, the non-Norwegian responses were always translation equivalents to the Norwegian cue word; these were scored as synonyms.

JJ's language profile in study IV shows similar change in the two languages over time. This may indicate a shared mental lexicon, especially for languages which are as closely related as Norwegian and English. The mental lexicon is fully capable of handling several languages at the same time, and a bilingual mental lexicon will also incorporate a monolingual mental lexicon. This fits well with the Multilink model for language processing (Dijkstra et al., 2019b), which presupposes that a bilingual mental lexicon is the default. This model also stresses the importance of psycholinguistic variables for processing, such as frequency, which makes it compatible with usage-based theories of language.

On the FWA test from study II, the free generation allows participants to select items which have a broader range of semantic and form-based relationships to the cue word, proving that units in the mental lexicon are connected along both semantic and phonological lines. Further-

[1] 'Kaninchen' ('rabbit'), rather than the Norwegian cognate 'kanin', seemingly to place emphasis on the diminutive in the German word

more, participants with AD produce more collocations, indicating a preference for automated, entrenched chunks of words. This can also be taken as an account of frequency-mediated storage and processing strategies, and is in line with usage-based theories of language. It also fits well with hypotheses of language processing which are interactive rather than serial in nature, since activation flows back and forth between phonological and semantic levels. This is because both form-based and meaning-based, as well as combinations of form and meaning-based responses are preferred for all participants.

6.2 Methodological aspects

The second focus in this project was to show how methodological triangulation can help broaden the knowledge obtained about language impairment in dementia. The three experimental studies in this dissertation employed several different methodologies. In studies II and IV, the same phenomenon, namely lexical retrieval, was approached from different angles using different tools and measures. In study III, both offline and online methods were used to study sentence comprehension.

6.2.1 Triangulation

Both Ribu et al. (submitted) and Lind et al. (2018) contrast restrictive tests of naming with freely produced data. The difference lies in the kinds of freely produced language data which are in focus. On the FWA task in Ribu et al. (submitted), the freely produced language output is still kept at the single-word level, whereas the cartoon description task and conversational data in Lind et al. (2018) were included to elicit connected speech samples. Both studies show that methodological triangulation — the use of more than one method to gather data — can provide a more thorough exploration of the complexity of lexical retrieval impairments, and reveal different patterns of impairments as well as their extent.

For instance, the FWA results suggest that the freely generated associations are different for people with and without dementia, which means that this test can be used to supplement traditional tests, such as picture naming. The test also provides valuable data if used alone, since it captures changes in linguistic behavior that cannot be captured by the means of restrictive tests. Combining both free and restrictive tests can give a comprehensive representation of a persons naming abilities.

Freely produced linguistic data is also crucial for detecting abnormalities in speech patterns and sentence construction. In study IV, the participant's speech was analyzed in terms of idea density and word retrieval in a narrative production task, and contrasted with picture naming tasks. JJ's poor sentence generation abilities may be linked to his low scores on the verb-naming test, since verb production plays an important role in sentence construction (de Diego Balaguer et al., 2006).

Combining online and offline methodologies is also useful, since one measure can identify changes that are not picked up on by another measure. This is found in the sentence comprehension task in study III (Ribu & Kuzmina, submitted), where the participants with AD and PPA are slower at detecting the target image than controls. Participants with dementia also show less automated processing than controls. This difference was not found in the offline data, but can clearly be seen on the eye tracking data. This is elaborated on in the next section.

6.2.2 Eye tracking

In the third study, there is no evidence for a sentence comprehension impairment based on the offline data alone. However, once the offline and the online data are combined, different processing strategies between neurologically healthy participants and participants with dementia become apparent.

In addition to measuring the proportion of looks to target, which is a measure of the participants' preference for the target image, the gaze data can also be used to measure time to detect target. It is on this last measure we find the greatest difference between participants with AD/PPA and healthy controls. This is in contrast to the reports from Tyler, Cobb, and Graham (1992), who state that online tasks tend to reveal more preserved knowledge than suggested by the offline tasks. In this study, four out of the seven participants with dementia show more uncertainties on the online measure than the offline.

The visual world paradigm, where audio and visual stimuli are combined, is recognized for its possibilities to study processing when it happens. The assumption is that it is not possible to control the rapid movements which take place between fixations, and once we are attending to an object on the screen, this is driven by attentional processes which we cannot override or control (Cooper, 1974; Tanenhaus et al., 2000).

By combining online and offline measures, we show that sentence comprehension ability is highly influenced by the measure used. In the offline task, pointing to the correct picture was used as a measure of post-interpretative processing. The task was time restricted, but the interstimulus interval was long enough to allow participants to make a judgment, which in most cases is correct. The online measure, however, demonstrates that most participants with AD, and one with PPA, show more uncertainty about which image is the target during the auditory stimulus presentation. This uncertainty follows an initial preference for the target image, a preference which cannot be captured on the offline task alone.

6.3 Clinical aspects

The first three studies investigate how language data can be used to distinguish AD and PPA from healthy aging, and (lv)PPA from AD (Ribu, Under revision; Ribu et al., submitted; Ribu & Kuzmina, submitted). In this section, the differences between persons with AD and controls will be discussed in relation to language assessment during diagnosis. Furthermore, study IV looks at how language impairments change over time for a person with PPA (Lind et al., 2018).

6.3.1 Assessment and diagnosis

There is often little importance attached to language assessment during screening for dementia, despite the fact that most types of dementia affect language behavior and use. Furthermore, most neuropsychological tests used in dementia assessment rely heavily on verbal information. Insufficient language testing can therefore also have implications for general test performance. If patients have subtle language impairments which are unnoticed due to poor assessment, it may affect their ability to perform well in a demanding testing session.

Traditional language assessment in dementia is often focused on production, and conducted by means of picture naming tests. Language comprehension is often not assessed. By combining tests for production and comprehension, researchers can investigate if a person has an impairment in semantic knowledge, or if there is an impairment in access to the phonological form.

The results from the literature review show that both AD and PPA can be distinguished from healthy aging based on language data. This is especially prominent in tests for lexical retrieval, such as verbal fluency and confrontation naming tasks (Ribu, Under revision). The same pattern was also found in the verbal fluency and confrontation naming tests in Ribu et al. (submitted), where healthy older adults scored better than participants with AD and PPA. There were also differences between persons with AD and controls on the FWA task, which cannot be found by employing (only) traditional, restrictive tasks such as picture naming (Ribu et al., submitted). This indicates that variations in language performance can help differentiate between healthy and pathological aging.

In study IV (Lind et al., 2018), JJ's naming of single words was contrasted with his word-searches in conversation and on semi-spontaneous speech samples. This comparison shows that JJ's poor sentence construction, especially in Norwegian, can be related to his poor verb naming skills on the confrontation naming task. Verbs play an important role in sentence generation, and hence also communication (de Diego Balaguer et al., 2006). This means that it is important to assess verbs as well as nouns to get a comprehensive picture of a person's full language impairment.

The difference between neurologically healthy participants and persons with AD and PPA was less pronounced in the sentence comprehension experiment in study III, especially for offline accuracy judgment. The results from the eye tracking data, on the other hand, show a temporal difference between persons with AD and healthy controls; the participants with AD and PPA are slower in detecting the target picture than the neurologically healthy controls. This indicates that comprehension is slower, especially on low-frequency sentence structures for persons with dementia. This is important to keep in mind when communicating with persons with dementia, or during dementia assessment, since many neuropsychological tests often have complex instructions, which may be harder to follow if not comprehended in their entirety.

Most of the participants with AD, the two with PPA, as well as one of the healthy controls make a few mistakes on the object cleft sentences, but not enough to state that these structures are impossible to comprehend. Some of the mistakes can be attributed to poorly drawn stimuli, for instance in some drawings it can be difficult to clearly see the difference between 'the man' and 'the woman' (see examples in Appendix F). Since the persons with AD and PPA perform relatively similarly to the neurologically healthy participants, this may reflect the assumption noted in the introduction to this dissertation, that language impairments in AD are exaggerated manifestations of the changes observed in healthy aging.

The above-mentioned observations suggest that a thorough assessment of language and language abilities can add to the clinical picture of both AD and PPA, and that linguistic tests should supplement other neurocognitive tests during the diagnostic process more than is the case in current assessment protocols. Results from the review paper also suggest that the patterns of language impairment in AD and PPA are quite similar. However, since only a few of the studies account for which subtype of PPA they studied, it is difficult to say if the different subtypes can be distinguished from AD based on analyses for psycholinguistic variables alone. As an alternative, an FWA task may be a valuable additional test to use for detecting language impairment in dementia.

6.3.2 Longitudinal change

Given the progressive nature of PPA, it is not surprising that there is a gradual decline in JJ's naming abilities over time (Lind et al., 2018). The decline is found in all three measures: confrontation naming, semi-spontaneous picture description and in conversation. The progressive decline in communicative skills were also documented by his wife's reports on the Communicative Effectiveness, CETI Index (Lomas et al., 1989, 2006).

JJ experienced different levels of naming difficulties both between his two languages and between the different tests at the first test point; however, these differences diminished over time. Two years post diagnosis, there was almost no difference between his scores on the picture naming tests in English (L1) and Norwegian (L2). The difference in decline was smallest in the cartoon description task, where his performance was quite poor in both languages already at test point 1. Even though it may seem like JJ's performance in his L1 is better spared than his L2 initially, there were indications in his narrative production and in the dissociation between naming performance on verbs and nouns that he experienced parallel impairments in both languages. JJ's dementia affects his less dominant language faster, but over time both languages became almost equally impaired.

English and Norwegian are closely related languages, and the parallel decline in the two languages may have been a result of deterioration of similar domains across lexically similar languages (e.g., the domains of lexical retrieval and comprehension). However, JJ's data follow a similar pattern found also for a person albeit with non-fluent, agrammatic PPA, who spoke Hungarian and English, two very different languages (Druks & Weekes, 2013).

These results indicate a slow and steady decline in several language functions, and both or all languages over time. However, some studies show that persons with PPA may have benefit from speech-language therapy (Croot et al., 2015; Meyer, Snider, Eckmann, & Friedman, 2015; Beales, Whitworth, & Cartwright, 2018), especially lexical retrieval intervention. Speech-language therapy is currently not a standard offer for people with PPA (or AD) in Norway.

6.3.3 How many types of lvPPA are there?

Since the identification of the three subtypes of PPA was published (Gorno-Tempini et al., 2011), several accounts of unclassifiable types of PPA have been identified. For instance, Sajjadi et al. (2012) found that as many as 41,3% of PPA cases were impossible to assign to any of the three established subtypes. The logopenic variant of PPA has proven especially difficult to correctly diagnose (Machulda et al., 2013; Sajjadi et al., 2012; Vandenberghe, 2016; Marshall et al., 2018).

In two important papers, researchers argue for a split of lvPPA into two different sub-classes. Vandenberghe (2016) proposed that lvPPA can be further divided into a left-hemisphere dominant lvPPA, which is very closely linked to non-amnesic AD with initial language impairment manifestations; and a temporoparietal transition zone lvPPA, with phonological working memory deficits, which is more closely linked to the original diagnostic criteria in Gorno-Tempini et al. (2011). The second type is restricted to phonological working memory impairments, and has a lower likelihood of AD compared to the first type (Vandenberghe, 2016).

Matias-Guiu et al. (2019) also argue for split of lvPPA into two subtypes, which they call Type 1 and Type 2. In their classifications, persons with lvPPA Type 1 performed more poorly on action naming tests than those with lvPPA Type 2. While lvPPA Type 1 is associated with atrophy in the left frontal lobe, Type 2 involves a more posterior region and the right parietotemporal lobe, similar to the regions identified by Vandenberghe (2016). Matias-Guiu et al. (2019) also fond clear gender differences betwen the two types; almost all patients with lvPPA Type 1 were female, while all participants that were classified with lvPPA Type 2 were male (Matias-Guiu et al., 2019).

Based on my own observations from the data collection sessions, I find that PPA01 (papers

II and III) and JJ's (paper IV) language profiles are more similar to each other than either of them are to PPA02 (papers II and III). Unfortunately, the three participants with lvPPA were not assessed with the same protocol, which can make it difficult to compare directly, yet there are some similarities which should be noted.

JJ and PPA01 have the same slow, halting and effortful speech pattern, whereas PPA02's speech is more fluent. PPA02 is equally impaired on action and object naming tests, while JJ and PPA01 perform better on object naming than on action naming. Furthermore, both JJ and PPA01 were initially diagnosed with Alzheimer's disease, whereas PPA02's diagnosis was a more straightforward example of lvPPA. This fits with the view where there is a subtype of PPA which is more associated with AD, and another subtype which is more clearly linked to the original diagnostic criteria proposed by Gorno-Tempini et al. (2011). Of course, it is not possible to state anything with certainty, based on only three participants.

It is further difficult to compare JJ, PPA01 and PPA02's results on tests for cognitive function, as not all the same tests were employed in the different studies. Moreover, both PPA01 and PPA02 were unable to perform some of the tests included in the cognitive test battery (PPA01 did not perform the figure copying test from CERAD,[2] and PPA02 did not perform the Stroop test due to poor color vision). Unfortunately, I do not have access to information about the neural atrophy for the participants with AD and PPA in this study. This means that I cannot conclude that the divergent language patterns are associated with distinct profiles of neural atrophy.

When PPA01 and PPA02 are compared to each other in studies II and III, it is clear that their profiles are quite different, and it is difficult to say if this is only due to individual differences. However, when JJ's scores on the comparable tests are also taken into account, it may look like we find two different patterns. Future studies should include a larger sample of persons with lvPPA to further investigate these patterns.

6.4 Limitations

There are certain methodological limitations related to this project which should be addressed. Specific limitations for each study are outlined in chapter 5 and in each of the four papers.

The main general limitation in this project is the small number of participants, both in terms of participants with dementia and control participants. The number of participants with dementia is especially low, and it is problematic to refer to them as a group. Therefore, in the papers Ribu et al. (submitted) and Ribu and Kuzmina (submitted) their results are mainly discussed on an individual level and compared to the control participants. There is also great variability between the participants, which can make it difficult to make judgments about the validity of the findings.

The low number of control participants is also problematic, especially in study III, where

[2] The test results were unavailable among the results obtained from the national register, and the research nurse who accessed the data could not provide a reason for this.

poor eye tracking measurements from several of the young participants had consequences for the whole group. The poor measurements were due to both technical difficulties with the apparatus and possible confounding factors, such as use of heavy eye make up, reflections from contact lenses and glasses etc., but also because some expressed little interest in the task and several did not want to complete all three test sets.

Small sample sizes are common in neurolinguistic and clinical linguistic research, due to the difficulties with recruiting a representative population. Sampling is often following a so-called *convenience sampling* principle, where participants who are available are included. *Purposive sampling* is another common way of obtaining participants, and it refers to how participants with certain predefined characteristics (e.g., persons with AD and PPA in the current experiment) are approached (Mildner, 2013). The number of participants is often limited also due to the high organizational demands of testing, since only one participant can be tested at a time, and testing sessions are often stretched out over several hours (Mertins, 2016).

A second general limitation is concerned with the use of non-standardized tests in the project. In studies II (Ribu et al., submitted) and III (Ribu & Kuzmina, submitted), tests for lexical retrieval were specifically designed (the FWA test and the Picture Naming test), and in studies III and IV (Lind et al., 2018), different adaptations to standardized tests were implemented. This was done because there is a lack of specifically developed material to test for language impairment in dementia in Norway. As briefly mentioned in 3.4.1, the translations of both the Boston Naming Test (Kaplan et al., 1983) and the word list from the Consortium to Establish a Register for Alzheimer's Disease (Morris et al., 1989; Kirsebom et al., 2019) may be insufficient to use in Norwegian in their current form, as they are uncritically translated and not adapted to Norwegian. One may even ask if they are in fact comparable to the original English versions. The Picture Naming test and the word-to-picture matching test that were specifically developed for this project need to be trialled further, both for persons with different dementia diagnoses and neurologically healthy participants, to establish the validity of these tests (see section 4.6).

6.5 Further research

The data collected during the test sessions includes a lot of material which has not yet been published, and which can be used to further study language in aging and dementia. In this section, I outline three possible research directions, based on the material which is still available from this project.

1. Study of connected speech samples
2. Typicality of words produced in association and verbal fluency tasks
3. Identification of lvPPA subtypes

To begin with, within the scope of this thesis, it was not possible to transcribe and analyze the cartoon description task and spontaneous speech samples collected for studies II and III. Building on the results from JJ in study IV, there might be interesting issues regarding idea density, number of words and kinds of words used in story retelling that might help distinguish between dementia and healthy aging. Furthermore, spontaneous speech data can also be used to investigate pauses, fluency and hesitations — all of which seem to be affected even in early stages of the different diseases (Mack et al., 2015). Samples of connected speech can also be used to study the relationship between word searches in discourse and in confrontation naming (Lind et al., 2018).

Next, the data from the word association test was, for the purpose of this study included here analyzed per cue word, rather than per participant. Some research suggests that persons with AD provide less typical responses than neurologically healthy participants (Eustache et al., 1990; Gollan, Salmon, & Paxton, 2006). Bøyum (2016) created norms lists from the participants in her study, giving a good account for which words can be expected as response words to a particular cue. For instance, more than 20% of the participants over 60 years old in her study responded ‘factory’ to the cue ‘industry’. Among the participants with AD and PPA in this study not one provided that same response word. In fact, only one person responded with a word which is also found in the norms list from the 100-word test, namely ‘virksomhet (‘enterprise’), which might also have been a perseveration of a cue word prompted just before the cue ‘industry’ (see Appendix E). A possible next step with this test can be to look at each participant’s responses in relation to the norms lists and investigate the typicality of responses, and also to look at the number of perseverations the participants with AD and PPA produce, which may be an indication of reduced working memory.

Lastly, based on the current trends in PPA research and in light of the divergent profiles found among the three participants with lvPPA included in this project, a natural next step would be to study these patterns in more detail. Future studies should include more participants with lvPPA, and also follow these participants over time to see if the different patterns are only visible initially and will converge over time, or if there are two different subtypes with a different underlying pathology and different progress throughout.

Since all three participants with PPA reported on in the studies in this dissertation are male, it is impossible to corroborate the gender difference found in Matias-Guiu et al. (2019) with data from my own research. Further investigation of the gender differences in lvPPA would be interesting, and more research on larger population samples is needed.

6.6 Conclusion

The findings from the studies included in this dissertation can be used for a discussion of both theoretical and clinical issues related to language impairment in dementia, and methodological issues regarding assessment and research.

The results from this dissertation are compatible with usage-based theories of language, and with interactive models of language processing. Language changes throughout the life span due to experiences, frequency and usage patterns. This can, for instance, be exemplified by the findings that older adults have larger vocabularies than younger adults, which leads to a higher number of semantically related, and especially synonymous, responses on the Picture Naming and word association tests.

Of the models of language and aging, the transmission deficit hypothesis (TDH) (Burke & Shafto, 2004) receives a great deal of support. This hypothesis suggests that the semantic knowledge is still intact, even if access to the phonological form is impaired. This is in line with the findings that older adults, and persons with dementia provide semantically related responses in lexical retrieval tasks.

Furthermore, responses in the FWA test show that there is interaction between phonological and semantic levels in production, fitting with interactive models of language processing, and not to serial models. Multilink (Dijkstra et al., 2019b) is an interesting model in this respect, since it also assumes a multilingual mental lexicon as the default, and there is indication of bilingual activation on a range of tests, even from the "monolingual" participants. This means that persons who think they are monolingual are in fact bilinguals, at least this is true for most Norwegians.

In this project, I have also shown the importance of employing different tools and methods to study the same topic. Methodological triangulation gives a more comprehensive account of the studied phenomena. For instance, without the combination of online and offline measures of sentence comprehension in study III, the difference between participants with and without dementia would not have been visible to the same degree.

There are subtle differences between persons with and without dementia on several tasks, which may be of clinical relevance. There is not one specific linguistic test which can distinguish healthy aging from dementia, or AD from PPA, but some linguistic markers can be very beneficial as additional clinical cues, and should not be neglected. For instance, the results from the FWA test show that this test can supplement traditional tests for lexical access to give a more nuanced picture of the differences between healthy aging and AD/PPA.

It can be difficult to distinguish between AD and lvPPA, and the differential diagnosis is further complicated by the possibility of two different subtypes as lvPPA. In some cases, persons with lvPPA are at risk of being misdiagnosed with AD, which might need different treatment and management. The studies included in this dissertation lend support to the hypothesis that there might be two types of lvPPA, and signify the importance of more research on language impairment in dementia.

The changes in language in dementia are similar to the changes observed in healthy aging, albeit more pronounced. Older adults experience difficulties on confrontation naming tests, and to some degree also with sentence comprehension. These difficulties are even more evident for persons with dementia. This means that language impairment in later life can be seen as a continuum, from "non-pathological" aging at one end, to decline associated with cognitive impairment at the other (De Bot & Makoni, 2005). It is important to be aware of these changes when evaluating persons who seek help for cognitive complaints.

With this dissertation, I have tried to find ways of learning more about language impairment in AD and PPA, and shown how studying linguistic data can help shed light on the clinical manifestations of the two diseases. The studies show that there are linguistic markers — such as different response patterns on the FWA test — which can distinguish persons with AD and PPA from their neurologically healthy peers. This implies that language screening during the diagnostic process should not be taken lightly. Furthermore, there is a need for proper diagnostic tools which can capture the fine-grained differences which are associated with dementia.

References

Adlam, A. L., Patterson, K., Bozeat, S., & Hodges, J. R. (2010). The Cambridge Semantic Memory Test Battery: Detection of semantic deficits in semantic dementia and Alzheimer's disease. *Neurocase*, 193–207. doi:10.1080/13554790903405693

Almor, A., Kempler, D., MacDonald, M. C., Andersen, E. S., & Tyler, L. K. (1999). Why do Alzheimer patients have difficulty with pronouns? Working memory, semantics, and reference in comprehension and production in Alzheimer's disease. *Brain and Language*, *67*(3), 202–227.

Arbuckle, T. Y. & Gold, D. P. (1993). Aging, inhibition, and verbosity. *Journal of Gerontology*, *48*(5), 225–232.

Astell, A. J. & Harley, T. A. (1996). Tip-of-the-Tongue states and lexical access in dementia. *Brain and Language*, *54*(2), 196–215. doi:10.1006/brln.1996.0071

Au, R., Albert, M. L., & Obler, L. K. (1989). Language in normal aging: Linguistic and neuropsychological factors. *Journal of Neurolinguistics*, *4*(3–4), 347–364. doi:10.1016/0911-6044(89)90026-2

Au, R., Joung, P., Nicholas, M., Obler, L. K., Kass, R., & Albert, M. L. (1995). Naming ability across the adult life span. *Aging, Neuropsychology, and Cognition*, *2*(4), 300–311.

Balota, D. A., Burgess, G. C., Cortese, M. J., & Adams, D. R. (2002). The Word-Frequency mirror effect in young, old, and early-stage Alzheimer's Disease: Evidence for two processes in episodic recognition performance. *Journal of Memory and Language*, *46*(1), 199–226. doi:10.1006/jmla.2001.2803

Balota, D. A. & Chumbley, J. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception and Performance*, *10*(3), 340–357.

Bastiaanse, R., Edwards, S., Mass, E., & Rispens, J. (2003). Assessing comprehension and production of verbs and sentences: The verb and sentence test (vast). *Aphasiology*, *17*(1), 49–73.

Bastiaanse, R., Lind, M., Moen, I., & Simonsen, H. G. (2006). *Verb- og Setningstesten*. Novus.

Bastiaanse, R. & van Zonneveld, R. (2006). Comprehension of passives in broca's aphasia. *Brain and language*, *96*(2), 135–142.

Bayles, K. A., Kaszniak, A. W., & Tomoeda, C. K. (1987). *Communication and cognition in normal aging and dementia*. Google-Books-ID: RnZxz38BORgC. Little, Brown.

Bayles, K. A. & Tomoeda, C. K. (1991). Caregiver report of prevalence and appearance order of linguistic symptoms in Alzheimer's patients. *The Gerontologist*.

Bayles, K. A. & Tomoeda, C. K. (2007). *Cognitive-Communication Disorders of Dementia* (1 edition). San Diego: Plural Pulishing Inc.

Beales, A., Whitworth, A., & Cartwright, J. (2018). A review of lexical retrieval intervention in primary progressive aphasia and alzheimer's disease: Mechanisms of change, generalisation, and cognition. *Aphasiology*, *32*(11), 1360–1387.

Bialystok, E., Craik, F. I., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia*, *45*(2), 459–464.

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences*, *16*(4), 240–250. doi:10.1016/j.tics.2012.03.001

Bickel, C., Pantel, J., Eysenbach, K., & Schröder, J. (2000). Syntactic comprehension deficits in Alzheimer's Disease. *Brain and Language*, *71*(3), 432–448. doi:10.1006/brln.1999.2277

Bird, H., Howard, D., & Franklin, S. (2000). Why is a verb like an inanimate object? Grammatical category and semantic category deficits. *Brain and Language*, *72*(3), 246–309. doi:10.1006/brln.2000.2292

Bird, H., Howard, D., & Franklin, S. (2003). Verbs and nouns: The importance of being imageable. *Objects vs. actions and nouns vs. verbs*, *16*(2–3), 113–149. doi:10.1016/S0911-6044(02)00016-7

Boone, K. B., Miller, B. L., Lesser, I. M., Hill, E., & D'Elia, L. (1990). Performance on frontal lobe tests in healthy, older individuals. *Developmental Neuropsychology*, *6*(3), 215–223.

Boye, K. & Harder, P. (2017). Konstruktionsgrammatik, regler og funktionsbaseret struktur i neurokognitiv belysning. *Ny forskning i grammatik*, *25*(24). doi:10.7146/nfg.v25i24.97244

Bøyum, M. (2016). *A New Word Association Test for Norwegian: Implications for theories on the mental lexicon, and on language and ageing* (Master's thesis, University of Oslo). Retrieved from https://www.duo.uio.no/handle/10852/52231

Bøyum, M., Hansen, P., & Ribu, I. S. (forthcoming). Assessing lexical processing with a free word association test: The roles of age, language proficiency and cognitive decline.

Braak, H., Braak, E., & Hohl, J. (1993). Staging of alzheimer-related cortical destruction. *European Neurology*.

Brysbaert, M. & Ghyselinck, M. (2006). The effect of age of acquisition: Partly frequency related, partly frequency independent. *Visual cognition*, *13*(7-8), 992–1011.

Burke, D. M. & Laver, G. D. (1990). Aging and word retrieval: Selective age deficits in language. In Eugene A. Lovelace (Ed.), *Advances in Psychology* (Vol. Volume 72, pp. 281–300). North-Holland.

Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the Tip of the Tongue: What Causes Word Finding Failures in young and Older Adults. *Journal of Memory and Language*.

Burke, D. M. & Shafto, M. A. (2004). Aging and Language Production. *Current Directions in Psychological Science*, *13*(1), 21–24. doi:10.1111/j.0963-7214.2004.01301006.x

Burke, D. M. & Shafto, M. A. (2008). Language and aging. In *The handbook of aging and cognition, 3rd ed* (pp. 373–443). New York, NY, US: Psychology Press.

Bybee, J. (2001). *Phonology and language use*. Cambridge University Press.

Bybee, J. (2006). From usage to grammar: The mind's response to repetition. *Language*, 711–733.

Bybee, J. (2010). *Language, usage and cognition*. Cambridge: Cambridge University Press.

Caplan, D. (1996). Syntactic Processing in Sentence Comprehension Under Dual-task Conditions in Aphasic Patients. *Language and Cognitive Processes*, *11*(5), 525–551. doi:10.1080/016909696387141

Caramazza, A. (1986). On drawing inferences about the structure of normal cognitive systems from the analysis of patterns of impaired performance: The case for single-patient studies. *Brain and cognition*, *5*(1), 41–66.

Chang, Y.-N., Monaghan, P., & Welbourne, S. (2019). A computational model of reading across development: Effects of literacy onset on language processing. *Journal of Memory and Language*.

Charles, D., Olm, C., Powers, J., Ash, S., Irwin, D. J., McMillan, C. T., … Grossman, M. (2014). Grammatical comprehension deficits in non-fluent/agrammatic primary progressive aphasia. *J Neurol Neurosurg Psychiatry*, *85*(3), 249–256.

Connor, L. T., Spiro, A. I., & Obler, L. K. (2004). Change in object naming ability during adulthood. *The Journals of Gerontology*.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology*.

Creswell, J. W. (2009). *Research design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage Publications.

Croot, K., Hodges, J. R., & Patterson, K. (1999). Evidence for impaired sentence comprehension in early Alzheimer's disease. *Journal of the International Neuropsychological Society: JINS*, *5*(5), 393–404.

Croot, K., Taylor, C., Abel, S., Jones, K., Krein, L., Hameister, I., … Nickels, L. (2015). Measuring gains in connected speech following treatment for word retrieval: A study with two participants with primary progressive aphasia. *Aphasiology*, *29*(11), 1265–1288.

Crowe, S. F. (1998). The differential contribution of mental tracking, cognitive flexibility, visual search, and motor speed to performance on parts A and B of the trail making test. *journal of clinical psychology*.

Cuetos, F., Arce, N., Martínez, C., & Ellis, A. W. (2017). Word recognition in Alzheimer's disease: Effects of semantic degeneration. *Journal of Neuropsychology*, *11*(1), 26–39. doi:10.1111/jnp.12077

Cuetos, F., Gonzalez-Nosti, M., & Martínez, C. (2005). The picture-naming task in the analysis of cognitive deterioration in Alzheimer's disease. *Aphasiology*, *19*(6), 545–557. doi:10.1080/02687030544000010

Cuetos, F., Herrera, E., & Ellis, A. W. (2010). Impaired word recognition in Alzheimer's disease: The role of age of acquisition. *Neuropsychologia*, *48*(11), 3329–3334. doi:10.1016/j.neuropsychologia.2010.07.017

Cuetos, F., Rodríguez-Ferreiro, J., & Menéndez, M. (2009). Semantic Markers in the Diagnosis of Neurodegenerative Dementias. *Dementia and Geriatric Cognitive Disorders*, *28*(3), 267–274.

Cuetos, F., Rodríguez-Ferreiro, J., Sage, K., & Ellis, A. W. (2012). A fresh look at the predictors of naming accuracy and errors in Alzheimer's disease. *Journal of Neuropsychology*, *6*(2), 242–256. doi:10.1111/j.1748-6653.2011.02025.x

Dąbrowska, E. (2015). What exactly is Universal Grammar, and has anyone seen it? *Frontiers in Psychology*.

Damico, J. S., Müller, N., & Ball, M. J. (2010). *The Handbook of Language and Speech Disorders*. Google-Books-ID: zQcdTCy0tm0C. John Wiley & Sons.

Davies, M. (2008). The corpus of contemporary american english: 450 million words, 1990-present.

De Bot, K. & Makoni, S. (2005). *Language and Aging in Multilingual Contexts*. MultiLingual Matters.

de Diego Balaguer, R., Rodrıguez-Fornells, A., Rotte, M., Bahlmann, J., Heinze, H.-J., & Münte, T. F. (2006). Neural circuits subserving the retrieval of stems and grammatical features in regular and irregular verbs. *Human Brain Mapping*, *27*(11), 874–888.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis Kaplan Executive Function System: Examiner's manual*. San Antonio (Tex.): Pearson.

Dell, G. S. (1986). A Spreading-Activation Theory of Retrieval in Sentence Production. *Psychological Review*.

Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*.

Dick, F., Bates, E., Wilfeck, B., Utman, J. A., Dronkers, N., & Gernsbacker, M. A. (2001). Language deficits, localization, and grammar: Evidence for a distributive model of language breakdown in aphasic patients and neurologically intact individuals. *Psychological review*.

Diessel, H. (2017). Usage-based linguistics. In *Oxford research encyclopedia of linguistics*.

Dijkstra, T., Wahl, A., Buytenhuijs, F., Van Halem, N., Al-Jibouri, Z., De Korte, M., & Rekké, S. (2019a). Modelling bilingual lexical processing: A research agenda and desiderabilia. *Bilingualism: Language and Cognition*, *22*(4), 703–713.

Dijkstra, T., Wahl, A., Buytenhuijs, F., Van Halem, N., Al-Jibouri, Z., De Korte, M., & Rekké, S. (2019b). Multilink: A computational model for bilingual word recognition and word translation. *Bilingualism: Language and Cognition*, *22*(4), 657–679.

Domoto-Reilly, K., Sapolsky, D., Brickhouse, M., & Dickerson, B. C. (2012). Naming impairment in Alzheimer's disease is associated with left anterior temporal lobe atrophy. *NeuroImage*, *63*(1), 348–355. doi:10.1016/j.neuroimage.2012.06.018

Druks, J., Masterson, J., Kopelman, M., Clare, L., Rose, A., & Rai, G. (2006). Is action naming better preserved (than object naming) in Alzheimer's disease and why should we ask? *Brain and Language*, *98*(3), 332–340. doi:10.1016/j.bandl.2006.06.003

Druks, J. & Weekes, B. S. (2013). Parallel deterioration to language processing in a bilingual speaker. *Cognitive Neuropsychology*, *30*(7-8), 578–596. doi:10.1080/02643294.2014.882814

Dyvik, H., Meurer, P., Rosén, V., Smedt, K. D., Haugereid, P., Losnegaard, G. S., … Thunes, M. (2016). Norgrambank: A 'deep' treebank for norwegian. In N. C. (Chair), K. Choukri, T. Declerck, S. Goggi, M. Grobelnik, B. Maegaard, … S. Piperidis (Eds.), *Proceedings of the tenth international conference on language resources and evaluation (lrec 2016)*. Portorož, Slovenia: European Language Resources Association (ELRA).

Egeland, J., Landrø, N. I., Tjemsland, E., & Walbækken, K. (2006). Norwegian norms and factor-structure of phonemic and semantic word list generation. *The Clinical Neuropsychologist*, *20*(4), 716–728.

Ellis, A. W. & Lambon Ralph, M. A. (2000). Age of acquisition effects in adult lexical processing reflect loss of plasticity in maturing systems: Insights from connectionist networks. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *26*(5), 1103–1123.

Ellis, A. W. & Young, H. D. (1977). Age-of-acquisition and recognition of nouns presented in the left and right visual fields: A failed hypothesis. *Neuropsychologia*, *15*(6), 825–828. doi:10.1016/0028-3932(77)90015-X

Ellis, N. C. (2002). Frequency effects in language processing. *Studies in Second Language Acquisition*, *24*(02). doi:10.1017/S0272263102002024

Eriksen, B. A. & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonserach task. *Perception and psychophysics*.

Eustache, F., Cox, C., Brandt, J., Lechevalier, B., & Pons, L. (1990). Word-association responses and severity of dementia in Alzheimer disease. *Psychological Reports*, *66*(3 Pt 2), 1315–1322. doi:10.2466/pr0.1990.66.3c.1315

Farkas, T., Ferris, S. H., Wolf, A. P., De Leon, M. J., CHristman, D. R., Reisberg, B., ... Reivich, M. (1982). 18F-2-deoxy-2-fluoro-D-glucose as a tracer in the positron emission tomographic study of senile dementia. *The American Journal of Psychiatry*.

Ferreira, F. (2003). The misinterpretation of noncanonical sentences. *Cognitive Psychology*, *47*(2), 164–203. doi:10.1016/S0010-0285(03)00005-7

Fitzpatrick, T., Playfoot, D., Wray, A., & Wright, M. J. (2015). Establishing the Reliability of Word Association Data for Investigating Individual and Group Differences. *Applied Linguistics*, *36*(1), 23–50. doi:10.1093/applin/amt020

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189–198.

Frank, S. L. & Christiansen, M. H. [Morten H]. (2018). Hierarchical and sequential processing of language: A response to: Ding, melloni, tian, and poeppel (2017). rule-based and word-level statistics-based processing of language: Insights from neuroscience. language, cognition and neuroscience. *Language, Cognition and Neuroscience*, *33*(9), 1213–1218.

Frank, S. L. & Yang, J. (2018). Lexical representation explains cortical entrainment during speech comprehension. *PloS one*, *13*(5), e0197304.

Fraser, K. C., Meltzer, J. A., Graham, N. L., Leonard, C., Hirst, G., Black, S. E., & Rochon, E. (2014). Automated classification of primary progressive aphasia subtypes from narrative speech transcripts. *Language, Computers and Cognitive Neuroscience*, *55*, 43–60. doi:10.1016/j.cortex.2012.12.006

Fraser, K. C., Meltzer, J. A., & Rudzicz, F. (2015). Linguistic features identify Alzheimer's disese in narrative speech. *Journal of Alzheimer*. doi:10.3233/JAD-150520

Gahl, S. & Menn, L. (2016). Usage-based approaches to aphasia. *Aphasiology*, *30*(11), 1361–1377. doi:10.1080/02687038.2016.1140120

Goldberg, A. (2006). *Constructions at work: The nature of generalization in language*. Oxford University Press.

Gollan, T. H., Salmon, D. P., Montoya, R. I., & da Pena, E. (2010). Accessibility of the nondominant language in picture naming: A counterintuitive effect of dementia on bilingual language production. *Neuropsychologia*, *48*(5), 1356–1366. doi:10.1016/j.neuropsychologia.2009.12.038

Gollan, T. H., Salmon, D. P., & Paxton, J. L. (2006). Word association in early Alzheimer's disease. *Brain and Language*. Language Comprehension across the Life Span, *99*(3), 289–303. doi:10.1016/j.bandl.2005.07.001

Gómez-Ruiz, I., Aguilar-Alonso, Á., & Espasa, M. A. (2012). Language impairment in catalan-spanish bilinguals with alzheimer's disease. *Journal of Neurolinguistics*, *25*(6), 552–566.

Goral, M. (2004). First-language decline in healthy aging: Implications for attrition in bilingualism. *Journal of Neurolinguistics*. Attrition, *17*(1), 31–52. doi:10.1016/S0911-6044(03)00052-6

Goral, M. (2013). Bilingualism, language and aging. In J. Altarriba & L. Isurin (Eds.), *Memory, Language and Bilingualism*. Cambridge University Press.

Goral, M. (2019). The bilingual mental lexicon beyond dutch-english written words. *Bilingualism: Language and cognition*.

Goral, M., Clark-Cotton, M. R., Spiro, A. I., Obler, L. K., Verkuilen, J., & Albert, M. L. (2011). The contribution of set shifting and working memory to sentence processing in older adults. *Experimental aging research*.

Goral, M., Spiro, A. I., Martin, L. A., Obler, L. K., & Connor, L. T. (2007). Change in lexical retrieval skills in adulthood. *The Mental Lexicon*.

Gorno-Tempini, M. L., Hillis, A. E., Weintraub, S., Kertesz, A., Mendez, M., Cappa, S. F., ... Grossman, M. (2011). Classification of primary progressive aphasia and its variants. *Neurology*, *76*(11), 1006–1014.

Gorno-Tempini, M. L. & Miller, B. L. (2013). Primary Progressive Aphasia as a model to study the neurobiology of language. *Brain and language*, *127*(2), 105. doi:10.1016/j.bandl.2013.10.008

Grossman, M., Mickanin, J., Onishi, K., Hughes, E., D'Esposito, M., Ding, X.-S., ... Reivich, M. (1996). Progressive Nonfluent Aphasia: Language, Cognitive, and PET Measures Contrasted with Probable Alzheimer's Disease. *Journal of Cognitive Neuroscience*, *8*(2), 135–154.

Guevara, E. (2010). NoWaC: A large web-based corpus for Norwegian. In *Proceedings of the NAACL HLT 2010 Sixth Web as Corpus Workshop* (pp. 1–7).

Hansen, P. (2016). What makes a word easy to acquire? The effects of word class, frequency, imageability and phonological neighbourhood density on lexical development. *First Language*, 0142723716679956.

Happ, M., Bathke, A. C., & Brunner, E. (2019). Optimal sample size planning for the wilcoxon-mann-whitney test. *Statistics in medicine*, *38*(3), 363–375.

Hardy, C. J. D., Johnson, J. C. S., & Warren, J. D. (2019). Auditory symptoms in primary progressive aphasia: A commentary on Utiansky et al. (2019). *Cortex*.

Hasher, L. & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In *Psychology of learning and motivation* (Vol. 22, pp. 193–225). Elsevier.

Henry, M. L. & Gorno-Tempini, M. L. (2010). The logopenic variant of primary progressive aphasia. *Current opinion in neurology*.

Hernández, M., Costa, A., Sebastián-Gallés, N., Juncadella, M., & Reñé, R. (2007). The organisation of nouns and verbs in bilingual speakers: A case of bilingual grammatical category-specific deficit. *Journal of Neurolinguistics*, *20*(4), 285–305. doi:10.1016/j.jneuroling.2006.10.002

Hillis, A. E., Heidler-Gary, J., Newhart, M., Chang, S., Ken, L., & Bak, T. (2006). Naming and comprehension in primary progressive aphasia: The influence of grammatical word class. *Aphasiology*, *20*(2-4), 246–256.

Hillis, A. E., Oh, S., & Ken, L. (2004). Deterioration of naming nouns versus verbs in primary progressive aphasia. *Annals of Neurology*, *55*(2), 268–275. doi:10.1002/ana.10812

Hillis, A. E., Tuffiash, E., & Caramazza, A. (2002). Modality-Specific Deterioration in Naming Verbs in Nonfluent Primary Progressive Aphasia. *Journal of Cognitive Neuroscience*, *14*(7), 1099–1108. doi:10.1162/089892902320474544

Hirsh, K. W. & Funnell, E. (1995). Those old, familiar things: Age of acquisition, familiarity and lexical access in progressive aphasia. *Journal of Neurolinguistics*, *9*(1), 23–32. doi:10.1016/0911-6044(95)00003-8

Hodges, J. R. & Patterson, K. (1995). Is semantic memory consistently impaired early in the course of Alzheimer's disease? Neuroanatomical and diagnostic implications. *Neuropsychologia*, *33*(4), 441–459. doi:10.1016/0028-3932(94)00127-B

Hodges, J. R., Patterson, K., Graham, N., & Dawson, K. (1996). Naming and knowing in dementia of Alzheimer's type. *Brain and Language*, *54*(2), 302–325.

Hoffman, P., Sajjadi, S. A., Patterson, K., & Nestor, P. J. (2017). Data-driven classification of patients with primary progressive aphasia. *Brain and Language*, *174*, 86–93. doi:10.1016/j.bandl.2017.08.001

Hoffmann, I., Németh, D., Dye, C., Pákáski, M., Irinyi, T., & Kálmán, J. (2010). Temporal features of spontaneous speech in Alzheimer's disease. *International Journal of Speech and Language*.

Howard, D. & Patterson, K. (1992). *The pyramids and palm trees test*. Thames Valley Test Company.

Howard, D. & Patterson, K. (2005). *Pyramide- og palmetesten*. Novus forlag.

Howard, D., Patterson, K., Franklin, S., Morton, J., & Orchard-Lisle, V. (1984). Variability and consistency in picture naming by aphasic patients. *Advances in neurology*, *42*, 263.

Ishkhanyan, B., Sahraoui, H., Harder, P., Mogensen, J., & Boye, K. (2017). Grammatical and lexical pronoun dissociation in French speakers with agrammatic aphasia: A usage-based account and REF-based hypothesis. *Journal of Neurolinguistics*.

Ivanova, I. & Kleinman, D. (2019). Multilink for bilingual language production. *Bilingualism: Language and Cognition*, *22*(4), 687–688.

Ivnik, R. J., Malec, J. F., Smith, G. E., Tangalos, E. G., & Petersen, R. C. (1996). Neuropsychological tests' norms above age 55: Cowat, bnt, mae token, wrat-r reading, amnart, stroop, tmt, and jlo. *The Clinical Neuropsychologist*, *10*(3), 262–278.

Jap, B. A., Martinez-Ferreiro, S., & Bastiaanse, R. (2016). The effect of syntactic frequency on sentence comprehension in standard indonesian broca's aphasia. *Aphasiology*, *30*(11), 1325–1340.

Jarema, G. & Libben, G. (2007). *The Mental Lexicon: Core perspectives*. Elsevier.

Juhasz, B. J. (2005). Age-of-Acquisition Effects in Word and Picture Identification. *Psychological Bulletin*, *131*(5), 684–712.

Juncos-Rabadán, O., Pereiro, A. X., & Rodríguez, M. S. (2005). Narrative speech in aging: Quantity, information content and cohesion. *Brain and Language*.

Kambanaros, M. & Grohmann, K. K. (2015). Grammatical Class Effects Across Impaired Child and Adult Populations. *Frontiers in Psychology*, *6*, 1670. doi:10.3389/fpsyg.2015.01670

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *Boston Naming Test*. Philadelphia: Lea & Febiger.

Kavé, G. & Goral, M. (2016a). Do age-related word retrieval difficulties appear (or disappear) in connected speech? *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, 1–20. doi:10.1080/13825585.2016.1226249

Kavé, G. & Goral, M. (2016b). Word retrieval in connected speech in Alzheimer's disease: A review with meta-analyses: Aphasiology: Vol 32, No 1. *Aphasiology*. Retrieved from https://www.tandfonline.com/doi/full/10.1080/02687038.2017.1338663

Kay, J., Lesser, R., & Coltheart, M. (1996). *Psycholinguistic Assessment of Language Processing in Aphasia*. Psychology Press.

Kay, J., Lesser, R., & Coltheart, M. (2009). *Psykolingvistisk kartlegging av språkprosessering hos afasirammede – norsk version*. Novus forlag.

Kemper, S. (2012). The interaction if linguistic constraints, working memory, and aging on language production and comprehension. In Naveh-Benjamin & Ohta (Eds.), *Memory and Aging*. CRS Press.

Kempler, D., Almor, A., & MacDonald, M. C. (1998). Teasing Apart the Contribution of Memory and Language Impairments in Alzheimer's DiseaseAn Online Study of Sentence Comprehension. *American Journal of Speech-Language Pathology*, *7*(1), 61–67. doi:10.1044/1058-0360.0701.61

Kempler, D., Almor, A., Tyler, L. K., Andersen, E. S., & MacDonald, M. C. (1998). Sentence Comprehension Deficits in Alzheimer's Disease: A Comparison of Off-Line vs. On-Line Sentence Processing. *Brain and Language*, *64*(3), 297–316. doi:10.1006/brln.1998.1980

Kim, M. & Thompson, C. K. (2004). Verb deficits in Alzheimer's disease and agrammatism - Implications for lexical organization. *Brain and language*, *88*(1), 1–20.

Pearson's Correlation Coefficient. (2008). In W. Kirch (Ed.), *Encyclopedia of public health* (pp. 1090–1091). Dordrecht: Springer Netherlands. doi:10.1007/978-1-4020-5614-7_2569

Kirsebom, B., Espenes, R., Hessen, E., Waterloo, K., Johnsen, S. H., Gundersen, E., … Fladby, T. (2019). Demographically adjusted cerad wordlist test norms in a norwegian sample from 40 to 80 years. *The Clinical Neuropsychologist*, 1–13.

Knoph, M. (2010). The Bilingual Aphasia Test – På norsk. *Norsk tiddskrift for logopedi*. Retrieved from https://www.mcgill.ca/linguistics/files/linguistics/Norwegian_BAT.pdf

Ko, P. C. & Ally, B. A. (2011). Visual Cognition in Alzheimer's Disease and Its Functional Implications. In S. De La Monte (Ed.), *The clinical spectrum of alzheimer's sisease: The charge toward comprehensive diagnostic and therapeutic strategies* (Chap. Visual Cognition in Alzheimer's Disease and Its Functional Implications). InTech.

Langacker, R. W. (1987). *Foundations of Cognitive Grammar: Theoretical prerequisites. Volume 1*.

Lee, J., Yoshida, M., & Thompson, C. K. (2015). Grammatical Planning Units During Real-Time Sentence Production in Speakers With Agrammatic Aphasia and Healthy Speakers. *Journal of Speech Language and Hearing Science*.

Levelt, W. J. (1989). *Speaking: From intention to articulation*. Cambridge, Mass.: MIT Press.

Leyton, C. E., Ballard, J., Kirrie, Piguet, O., & Hodges, J. R. (2014). Phonological errors as a clinical marker of the logopenic variant of ppa. *Neurology*.

Leyton, C. E., Savage, S., Irish, M., Schubert, S., Piguet, O., Ballard, K. J., & Hodges, J. R. (2014). Verbal repetition in primary progressive aphasia and in Alzheimer's disease. *Journal of Alzheimer's disease*.

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.) (M. D. Lezak, Ed.). Oxford: Oxford University Press.

Li, P., Farkas, I., & MacWhinney, B. (2004). Early lexical development in a self-organizing neural network. *Neural networks*, *17*(8-9), 1345–1362.

Libben, G. & Goral, M. (2015). How bilingualism shapes the mental lexicon. In J. W. Schwieter (Ed.), *The Cambridge Handbook of Bilingual Processing*. Cambridge University Press.

Libben, M., Goral, M., & Libben, G. (2017). The dynamic lexicon. In M. Libben, M. Goral, & G. Libben (Eds.). John Benjamins Publishing Company.

Lind, M., Moen, I., & Simonsen, H. G. (2006). Verb- og setningstesten (VOST): Et nytt redskap i den logopediske verktøykassa (del 1). *Logopeden*. Retrieved from https://www.mysciencework.com/publication/show/b13a47ac1ba048b21e7841109b5cd4f8

Lind, M., Simonsen, H. G., Hansen, P., Holm, E., & Mevik, B.-H. (2013). Norwegian Words: A lexical database for clinicians and researchers. *Clinical Linguistics & Phonetics*, 276–290. Retrieved from http://tekstlab.uio.no/ordforradet

Lind, M., Simonsen, H. G., Ribu, I. S., Svendsen, B. A., Svennevig, J., & de Bot, K. (2018). Lexical access in a bilingual speaker with dementia: Changes over time. *Clinical Linguistics & Phonetics*, *32*(4), 353–377. doi:10.1080/02699206.2017.1381168

Lomas, J., Pickard, L., Bester, S., Elbard, H., Finlayson, A., & Zoghaib, C. (1989). The Communicative Effectiveness Index: Development and psychometric evaluation of a functional communication measure for adult aphasia. *Journal of speech and hearing disorders*.

Lomas, J., Pickard, L., Bester, S., Elbard, H., Finlayson, A., & Zoghaib, C. (2006). *Spørreskjema for nærpersoner – CETI norsk versjon*. Bredtvet kompetansesenter.

Louwersheimer, E., Keulen, M. A., Steenwijk, M. D., Wattjes, M. P., Jiskoot, L. C., Vrenken, H., . . . Pijnenburg, Y. A. L. (2016). Heterogeneous Language Profiles in Patients with Primary Progressive Aphasia due to Alzheimer's Disease. *Journal of Alzheimer's disease: JAD*, *51*(2), 581–590. doi:10.3233/JAD-150812

Łuniewska, M., Haman, E., Armon-Lotem, S., Etenkowski, B., Southwood, F., Anđelković, D., . . . Ünal-Logacev, Ö. (2016). Ratings of age of acquisition of 299 words across 25 languages: Is there a cross-linguistic order of words? *Behavior Research Methods*, *48*(3), 1154–1177. doi:10.3758/s13428-015-0636-6

Lustig, C., Hasher, L., & Zacks, R. T. (2007). Inhibitory deficit theory: Recent developments in a "new view". *Inhibition in cognition*, *17*, 145–162.

MacDonald, M. C., Almor, A., Henderson, V. W., Kempler, D., & Andersen, E. S. (2001). Assessing Working Memory and Language Comprehension in Alzheimer's Disease. *Brain and Language*, *78*(1), 17–42. doi:10.1006/brln.2000.2436

MacDonald, M. C. & Christiansen, M. H. [Morten H.]. (2002). Reassessing working memory: Comment on Just and Carpenter (1992) and Waters and Caplan (1996). *Psychological Review*, *109*(1), 35–54, discussion 55–74.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological review*, *101*(4), 676.

Machulda, M. M., Whitwell, J. L., Duffy, J. R., Strand, E. A., Dean, P. M., Senjem, M. L., . . . Josephs, K. A. (2013). Identification of an atypical variant of logopenic progressive aphasia. *Brain and Language*, *127*(2), 139–144. doi:10.1016/j.bandl.2013.02.007

Mack, J. E., Chandler, S. D., Meltzer-Asscher, A., Rogalski, E., Weintraub, S., Mesulam, M.-M., & Thompson, C. K. (2015). What do pauses in narrative production reveal about the nature of word retrieval deficits in PPA? *Neuropsychologia*, *77*, 211–222. doi:10.1016/j.neuropsychologia.2015.08.019

MacKay, D. G. & Burke, D. M. (1990). Cognition and Aging: A Theory of New Learning and the Use of Old Connections. In F.G.A. Stone and Robert West (Ed.), *Advances in Psychology* (Chap. 5, Vol. Volume 71, pp. 213–263). North-Holland. doi:10.1016/S0166-4115(08)60159-4

Malcolm, T., Lerman, A., Korytkowska, M., Vonk, J. M. J., & Obler, L. K. (2019). Primary Progressive Aphasia in Bilinguals and Multilinguals. In J. W. Schwieter & M. Paradis (Eds.). Wiley Blackwell.

Marcotte, K., Graham, N. L., Black, S. E., Tang-Wai, D., Chow, T. W., Freedman, M., … Leonard, C. (2014). Verb production in the nonfluent and semantic variants of primary progressive aphasia: The influence of lexical and semantic factors. *Cognitive Neuropsychology*, *31*(7-8), 565–583. doi:10.1080/02643294.2014.970154

Marczinski, C. A. & Kertesz, A. (2006). Category and letter fluency in semantic dementia, primary progressive aphasia, and Alzheimer's disease. *Brain and Language*, *97*(3), 258–265. doi:10.1016/j.bandl.2005.11.001

Marshall, C. R., Hardy, C. J., Volkmer, A., Russell, L. L., Bond, R. L., Fletcher, P. D., … Rossor, M. N., et al. (2018). Primary progressive aphasia: A clinical approach. *Journal of neurology*, *265*(6), 1474–1490.

Marslen-Wilson, W. D. (1980). Speech understanding as a psychological process. In *Spoken language generation and understanding* (pp. 39–67). Springer.

Marslen-Wilson, W. D. (1987). Functional parallelism in spoken word-recognition. *Cognition*, *25*(1-2), 71–102.

Marslen-Wilson, W. D. & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. *Cognitive psychology*, *10*(1), 29–63.

Martínez-Ferreiro, S., Bastiaanse, R., & Boye, K. (2019). Functional and usage-based approaches to aphasia: The grammatical-lexical distinction and the role of frequency. *Aphasiology*.

Martínez-Sánchez, F., Meilán, J. J. G., García-Sevilla, J., Carro, J., & Arana, M. J. (2013). Oral reading fluency analysis in patients with Alzheimer's disease and asymptomatic control subjects. *Neurologia (English Edition*.

Matias-Guiu, J. A., Días-Álvarez, J., Cuetos, F., Cabrera-Martín, M. N., Segovia-Ríos, I., Pytel, V., … Ayala, J. L. (2019). Machine learningin the clinical and language characterisation of primary progressive aphasia variants. *Cortex*.

McClelland, J. L. & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology*, *18*, 1–86.

McDermott, R. (2011). Internal and external validity. (pp. 27–40). Cambridge University Press Cambridge.

McHugh, M. L. (2012). Interrater reliability: the kappa statistic. *Biochemia medica*.

McKhann, G. M., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease Report of the NINCDS-ADRDA Work Group* under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology*, *34*(7), 939–939. doi:10.1212/WNL.34.7.939

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Kawas, C. H., … Phelps, C. H. (2011). The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *7*(3), 263–269. doi:10.1016/j.jalz.2011.03.005

Mertins, B. (2016). The use of experimental methods in linguistic research: Advantages, problems and possible pitfalls. *Slavic Languages in Psycholinguistics*, 15–33.

Mesulam, M.-M. (2001). Primary progressive aphasia. *Annals of Neurology*, *49*(4), 425–432.

Mesulam, M.-M. (2007). Primary progressive aphasia: A 25-year retrospective. *Alzheimer Disease and Associated Disorders*. doi:10.1097/WAD.0b013e31815bf7e1

Meuter, R. (2009). Neurolinguistic contributions to understanding the bilingual mental lexicon. In A. Pavlenko (Ed.). Multilingual Matters.

Meyer, A. M., Mack, J. E., & Thompson, C. K. (2012). Tracking passive sentence comprehension in agrammatic aphasia. *Journal of Neurolinguistics*, *25*(1), 31–43. doi:10.1016/j.jneuroling.2011.08.001

Meyer, A. M., Snider, S. F. [Sarah F.], Campbell, R. E., & Friedman, R. B. (2015). Phonological short-term memory in logopenic variant Primary Progressive Aphasia and mild Alzheimer's disease. *Cortex*.

Meyer, A. M., Snider, S. F. [Sarah F], Eckmann, C. B., & Friedman, R. B. (2015). Prophylactic treatments for anomia in the logopenic variant of primary progressive aphasia: Cross-language transfer. *Aphasiology*, *29*(9).

Mildner, V. (2013). Experimental and quasi-experimental research in clinical linguistics and phonetics. In N. Müller & M. J. Ball (Eds.).

Molitor, R. J., Ko, P. C., & Ally, B. A. (2015). Eye movements in Alzheimer's disease. *Journal of Alzheimer's disease: JAD*, *44*(1), 1–12. doi:10.3233/JAD-141173

Morris, J. C., Heyman, A., Mohs, R. C., Hughes, J. P., van Belle, G., Fillenbaum, G., … Clark, C. (1989). The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*, *39*(9), 1159–1165.

Obler, L. K., Albert, M. L., Spiro, A. I., Goral, M., Rykhlevskaia, E., Huyn, J., … Schnyer, D. (2010). Language Changes Associated with Aging. In M. Albert & J. Knoefel (Eds.), *Clinical Neurology of Aging* (Chap. 42). Oxford University Press. Retrieved from http://oxfordmedicine.com/view/10.1093/med/9780195369298.001.0001/med-9780195369298-chapter-042

Obler, L. K. & Gjerlow, K. (1999). *Language and the Brain*. Google-Books-ID: nhc36DgVM4UC. Cambridge University Press.

Obler, L. K. & Pekkala, S. (2008). Language and Communication in Aging. In *Handbook of the Neuroscience of Language* (Chap. 26, pp. 351–358). San Diego: Elsevier. doi:10.1016/B978-008045352-1.00034-3

Oldfield, R. C. & Wingfield, A. [A.]. (1965). Response latencies in naming objects. *Quarterly Journal of Experimental Psychology*, *17*(4), 273–281.

Ortega, A., Gómez-Ariza, C. J., Román, P., & Bajo, M. T. (2012). Memory inhibition, aging, and the executive deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(1), 178.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology*, *76*(1p2), 1.

Paradis, M. (1998). *The Bilingual Aphasia Test*. McGil University. Retrieved from https://www.mcgill.ca/linguistics/research/bat

Park, D. C. & Reuter-Lorenz, P. (2009). The Adaptive Brain: Aging and Neurocognitive Scaffolding. *Annual Review of Psychology*, *60*, 173–196.

Peelle, J. (2018). Language and aging. In de Zubicaray & Schiller (Eds.), *The Oxford Handbook of Neurolinguistics*. Oxford University Press.

Peña, E. D. (2007). Lost in translation: Methodological considerations in cross-cultural research. *Child development*, *78*(4), 1255–1264.

Pereira, M. F., Camargo, M. v. Z. A., Aprahamian, I., & Forlenza, O. V. (2014). Eye movement analysis and cognitive processing: Detecting indicators of conversion to Alzheimer's disease. *Neuropsychiatric Disease and Treatment*, *10*, 1273–1285. doi:10.2147/NDT.S55371

Pistono, A., Pariente, J., Bézy, C., Lemesle, B., Le men, J., & Jucla, M. (2019). What happens when nothing happens? An investigation of pauses as a compensatory mechanism in early Alzheimer's disease. *Neuropsychologia*.

R: A Language and Environment for Statistical Computing. (2019). R Core Team. Vienna, Austria. Retrieved from https://www.R-project.org/

Ribu, I. S. (Under revision). First in, last out: A systematic review of the effects of (psycho-)linguistic variables on lexical retrieval in Alzheimer's disease and primary progressive aphasia.

Ribu, I. S. & Kuzmina, E. (submitted). Tracking non-canonical sentence comprehension in Alzheimer's disease and Primary progressive aphasia.

Ribu, I. S., Norvik, M. I., Lehtonen, M., & Simonsen, H. G. (submitted). Free word association in Alzheimer's disease and Primary progressive aphasia.

Robinson, G., Rossor, M., & Cipolotti, L. (1999). Selective sparing of verb naming in a case of severe Alzheimer's disease. *Cortex*, *35*(3), 443–450.

Robinson, K., Grossman, M., White-Devine, T., & D'Esposito, M. (1996). Category-specific difficulty naming with verbs in Alzheimer's disease. *Neurology*, *47*(1), 178–182.

Rochon, E., Waters, G. S., & Caplan, D. (1994). Sentence Comprehension in Patients with Alzheimer's Disease. *Brain and Language*, *46*(2), 329–349.

Rodríguez-Ferreiro, J., Davies, R., González-Nosti, M., Barbón, A., & Cuetos, F. (2009). Name agreement, frequency and age of acquisition, but not grammatical class, affect object and action naming in Spanish speaking participants with Alzheimer's disease. *Journal of Neurolinguistics*, *22*(1), 37–54. doi:10.1016/j.jneuroling.2008.05.003

Rohrer, J. D., Caso, F., Mahoney, C., Henry, M., Rosen, H. J., Rabinovici, G., ... Gorno-Tempini, M. L. (2013). Patterns of longitudinal brain atrophy in the logopenic variant of primary progressive aphasia. *Brain and Language*, *127*(2), 121–126. doi:10.1016/j.bandl.2012.12.008

Rosén, V., De Smedt, K., Meurer, P., & Dyvik, H. (2012). An open infrastructure for advanced treebanking. In *Meta-research workshop on advanced treebanking at lrec2012* (pp. 22–29). Hajič, Jan.

Rowland, J. (2009). *Rowland Universal Dementia Assessment Scale*.

Sajjadi, S. A., Patterson, K., Arnold, R. J., Watson, P. C., & Nestor, P. J. (2012). Primary progressive aphasia: A tale of two syndromes and the rest. *Neurology*, *78*(21), 1670–1677. doi:10.1212/WNL.0b013e3182574f79

Salthouse, T. A. (2010). Influence of age on practice effects in longitudinal neurocognitive change. *Neuropsychology*.

Santo Pietro, M. J. & Goldfarb, R. (1985). Characteristic patterns of word association responses in institutionalized elderly with and without senile dementia. *Brain and Language*, *26*(2), 230–243.

Schmid, M. S. & De Bot, K. (2004). Language attrition. *The handbook of applied linguistics*, 210.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-prime 2.0*. Psychology Software Tools Inc. Pittsburgh.

Seckin, M., Mesulam, M.-M., Voss, J. L., Huang, W., Rogalski, E. J., & Hurley, R. S. (2016). Am I looking at a cat or a dog? Gaze in the semantic variant of primary progressive aphasia is subject to excessive taxonomic capture. *Journal of Neurolinguistics*, *37*, 68–81. doi:10.1016/j.jneuroling.2015.09.003

Silveri, M. C., Pravatà, E., Brita, A. C., Improta, E., Ciccarelli, N., Rossi, P., & Colosimo, C. (2014). Primary progressive aphasia: Linguistic patterns and clinical variants. *Brain and Language*, *135*, 57–65. doi:10.1016/j.bandl.2014.05.004

Simonsen, H. G., Lind, M., Hansen, P., Holm, E., & Mevik, B.-H. (2013). Imageability of Norwegian nouns, verbs and adjectives in a cross-linguistic perspective. *Clinical Linguistics & Phonetics*, *27*(6-7), 435–446.

Sloot, P. & Jonkers, R. (2011). Benoemen van acties door Alzheimerpatiënten: Effect van instrumentaliteit en naamsverwantschap. *Stem-, Spraak- en Taalpathologie*, *17*(2). Retrieved from https://sstp.nl/article/view/3277

Souza, A. C. d., Alexandre, N. M. C., & Guirardello, E. d. B. (2017). Psychometric properties in instruments evaluation of reliability and validity. *Epidemiologia e Serviços de Saúde*, *26*(3), 649–659.

Stilwell, B. L., Dow, R. M., Lamers, C., & Woods, R. T. (2016). Language changes in bilingual individuals with Alzheimer's disease. *International Journal of Language & Communication Disorders*, *51*(2), 113–127.

Street, J. A. & Dąbrowska, E. (2010). More individual differences in language attainment: How much do adult native speakers of English know about passives and quantifiers? *Lingua*. Asymmetries in Language Acquisition, *120*(8), 2080–2094. doi:10.1016/j.lingua.2010.01.004

Svennevig, J., Hansen, P., Simonsen, H. G., & Landmark, A. M. D. (2019). Code-switching in multilinguals with dementia: Patterns across speech contexts. *Clinical linguistics & phonetics*, 1–22.

Szatloczki, G., Hoffmann, I., Vincze, V., Kalman, J., & Pakaski, M. (2015). Speaking in Alzheimer's Disease, is That an Early Sign? Importance of Changes in Language Abilities in Alzheimer's Disease. *Frontiers in Aging Neuroscience*, *7*. doi:10.3389/fnagi.2015.00195

Taler, V. & Phillips, N. A. (2008). Language performance in Alzheimer's disease and mild cognitive impairment: A comparative review. *Journal of Clinical and Experimental Neuropsychology*, *30*(5), 501–556.

Tanenhaus, M. K., Magnuson, J. S., Dahan, D., & Chambers, C. (2000). Eye movements and lexical access in spoken-language comprehension: Evaluating a linking hypothesis between fixations and linguistic processing. *Journal of psycholinguistic research*, *29*(6), 557–580.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science (New York, N.Y.) 268*(5217), 1632–1634.

Taylor, J. R. (2002). *Cognitive Grammar*. Oxford: Oxford University Press.

Teichmann, M., Kas, A., Boutet, C., Ferrieux, S., Nogues, M., Samri, D., … Migliaccio, R. (2013). Deciphering logopenic primary progressive aphasia: A clinical, imaging and biomarker investigation. *Brain, Journal of neurology*.

Thompson, C., Ballard, K., Tait, M., Weintraub, S., & Mesulam, M.-M. (1997). Patterns of language decline in non-fluent primary progressive aphasia. *Aphasiology*, *11*(4-5), 297–321.

Tombaugh, T. N. (2004). Trail Making Test A and B: Normative data stratified by age and education. *Archives of Clinical Neuropsychology*, *19*(2), 203–214. doi:10.1016/S0887-6177(03)00039-8

Tomoeda, C. K., Bayles, K. A., Boone, D. R., Kaszniak, A. W., & Slauson, T. J. (1990). Speech rate and syntactic complexity effects on the auditory comprehension of alzheimer patients. *Journal of Communication Disorders*, *23*(2), 151–161. doi:10.1016/0021-9924(90)90019-U

Trueswell, J. C. & Tanenhaus, M. K. (1994). Toward a lexicalist framework of constraint-based syntactic ambiguity resolution.

Tsantali, E., Economidis, D., & Tsolaki, M. (2013). Could language deficits really differentiate Mild Cognitive Impairment (MCI) from mild Alzheimer's disease? *Archives of Gerontology and Geriatrics*, *57*(3), 263–270. doi:10.1016/j.archger.2013.03.011

Tyler, L. K., Cobb, H., & Graham, N. (1992). *Spoken language comprehension: An experimental approach to disordered and normal processing.* The MIT Press.

Tyler, L. K., Russell, R., Fadili, J., & Moss, H. E. (2001). The neural representation of nouns and verbs: PET studies. *Brain: A Journal of Neurology*, *124*(Pt 8), 1619–1634.

Tyler, L. K., Shafto, M. A., Randall, B., Wright, P., Marslen-Wilson, W. D., & Stamatakis, E. A. (2010). Preserving Syntactic Processing across the Adult Life Span: The Modulation of the Frontotemporal Language System in the Context of Age-Related Atrophy. *Cerebral cortex*.

Ukita, H., Abe, K., & Yamada, J. (1999). Late Acquired Words in Childhood Are Lost Earlier in Primary Progressive Aphasia. *Brain and Language*, *70*(2), 205–219. doi:10.1006/brln.1999.2152

Utianski, R. L., Botha, H., Martin, P. R., Schwartz, C. G., Duffy, J. R., Clark, H. M., … Josephs, K. A. (2019). Clinical and neuroimaging characteristic of clinically unclassifiable Parimary Progressive Aphasia. *Brain and Language*.

Van Hell, J. G. (2019). Words only go so far: Linguistic context affects bilingual word processing. *Bilingualism: Language and Cognition*, *22*(4), 689–690.

Vandenberghe, R. (2016). Classification of the primary progressive aphasias: Principles and review of progress since 2011. *Alzheimer's Research and Therapy*.

Visch-Brink, E., Stronks, D., & Denes, G. (2005). *Semantische Associatie test (SAT)*. Pearson.

Vita, M. G., Marra, C., Spinelli, P., Caprara, A., Scaricamazza, E., Castelli, D., … Quaranta, D. (2014). Typicality of words produced on a semantic fluency task in amnesic mild cognitive impairment: Linguistic analysis and risk of conversion to dementia. *Journal of Alzheimer's disease: JAD*, *42*(4), 1171–1178. doi:10.3233/JAD-140570

Vitevitch, M. S. & Luce, P. A. (1998). When Words Compete: Levels of Processing in Perception of Spoken Words. *Psychological Science*, *9*(4), 325–329. ArticleType:

research-article / Full publication date: Jul., 1998 / Copyright © 1998 Association for Psychological Science. Retrieved from http://www.jstor.org/stable/40063346

Vonk, J. M., Jonkers, R., Hubbard, H. I., Gorno-Tempini, M. L., Brickman, A. M., & Obler, L. K. (2019). Semantic and lexical features of words dissimilarly affected by non-fluent, logopenic, and semantic primary progressive aphasia. *Journal of the International Neuropsychological Society*, 1–12.

Waters, G. S. & Caplan, D. (1997). Working Memory and On-Line Sentence Comprehension in Patients with Alzheimer's Disease. *Journal of Psycholinguistic Research*, *26*(4), 377–400. doi:10.1023/A:1025073902269

Waters, G. S., Caplan, D., & Rochon, E. (1995). Processing capacity and sentence comprehension in patients with alzheimer's disease. *Cognitive Neuropsychology*, *12*(1), 1–30. doi:10.1080/02643299508251990

Wechsler, D. (2008). Wechsler adult intelligence scale–fourth edition (wais–iv). *San Antonio, TX: NCS Pearson*, *22*, 498.

White-Devine, T., Grossman, M., Robinson, K., Onishi, K., Biassou, N., & D'Esposito, M. (1996). Verb confrontation naming and word-picture matching in Alzheimer's disease. *Neuropsychology*, *10*(4), 495–503.

WHO. (2016a). *The international classification of diseases, clinical modification: ICD-CM*. DHHS publication ; Washington, D.C.: U.S. Dept. of Health and Human Services, Public Health Service, Health Care Financing Administration : For sale by the Supt. of Docs., U.S. G.P.O.

WHO. (2016b). WHO Dementia Fact Sheet. Retrieved from http://www.who.int/mediacentre/factsheets/fs362/en/

Williamson, D. J., Adair, J. C., Raymer, A. M., & Heilman, K. M. (1998). Object and Action Naming in Alzheimer's Disease. *Cortex*, *34*(4), 601–610. doi:10.1016/S0010-9452(08)70517-3

Wilson, S. M., Dronkers, N. F., Ogar, J. M., Jang, J., Growdon, M. E., Agosta, F., … Gorno-Tempini, M. L. (2010). Neural correlates of syntactic processing in the non-fluent variant of primary progressive aphasia. *The Journal of neuroscience : the official journal of the Society for Neuroscience*, *30*(50), 16845–16854. doi:10.1523/JNEUROSCI.2547-10.2010

Wilson, S. M., Galantucci, S., Tartaglia, M. C., & Gorno-Tempini, M. L. (2012). The neural basis of syntactic deficits in primary progressive aphasia. *Brain and language*, *122*(3), 190–198. doi:10.1016/j.bandl.2012.04.005

Wingfield, A. [Arthur] & Stine-Morrow, E. A. L. (2000). Language and speech. In F. I. M. Craik & T. A. Salthouse (Eds.). Lawrence Erlbaum Associates Publishers.

Wong, L., Martin-Khan, M., Rowland, J., Varghese, P., & Gray, L. C. (2012). The Rowland Universal Dementia Assessment Scale (RUDAS) as a reliable screening tool for dementia when administered via videoconferencing in elderly post-acute hospital patients. *Journal of Telemedicine and Telecare*.

Zacks, R. T. & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory.

Zannino, G. D., Perri, R., Pasqualetti, P., Caltagirone, C., & Carlesimo, G. A. (2006). (Category-specific) semantic deficit in Alzheimer's patients: The role of semantic distance. *Neuropsychologia*, *44*(1), 52–61. doi:10.1016/j.neuropsychologia.2005.04.008

Zhu, Z., Hou, X., & Yang, Y. (2018). Reduced Syntactic Processing Efficiency in Older Adults During Sentence Comprehension. *Frontiers in Psychology*.

Part II

Papers

Ribu, I. S. (Under revision). First in, last out: A systematic review of the effects of (psycho-)linguistic variables on lexical retrieval in Alzheimer's disease and primary progressive aphasia

I

Ribu, I. S., Norvik, M. I., Lehtonen, M., & Simonsen, H. G. (submitted). Free word association in Alzheimer's disease and Primary progressive aphasia

II

Ribu, I. S. & Kuzmina, E. (submitted). Tracking non-canonical sentence comprehension in Alzheimer's disease and Primary progressive aphasia

III

Lind, M., Simonsen, H. G., Ribu, I. S., Svendsen, B. A., Svennevig, J., & de Bot, K. (2018). Lexical access in a bilingual speaker with dementia: Changes over time. *Clinical Linguistics & Phonetics*, *32*(4), 353–377. doi:10.1080/02699206.2017.1381168

IV

Part III

Appendices

List of appendices

Appendix A: Letters to participants

The next couple of pages include the information letters sent to participants in the different studies:

1. Information letter with consent form to persons with AD and PPA (Study II and III)
2. Additional information to persons with AD and PPA (Study II and III)
3. Information letter to control participants (Study II and III)
4. Information letter to JJ (Study IV)

Språk ved aldring og demens, informasjon og samtykke til primærdeltakere, 28709-2018. Versjon 4.0

UiO : **Universitetet i Oslo**
Humanistisk fakultet/Institutt for lingvistiske og nordiske studier

FORESPØRSEL OM DELTAKELSE I ET FORSKNINGSPROSJEKT OM SPRÅK, ALDRING OG DEMENS

Dette er et spørsmål til deg om å delta i et forskningsprosjekt for å undersøke hvordan språket utvikler seg når vi blir eldre og eventuelt får vansker med hukommelsen eller en demensdiagnose.

Du blir spurt om å være med i denne studien siden du nylig har vært til utredning ved hukommelsesklinikken på Ullevål sykehus.

Universitet i Oslo er ansvarlig for studien, men samarbeider med hukommelsesklinikken på Ullevål Sykehus. Vi rekrutterer også personer som har vært til utredning for litt lenger tid tilbake, og som har opplyst om at de vil delta i forskning.

FORMÅLET MED PROSJEKTET

Prosjektet undersøker språklige ferdigheter hos personer med og uten demens og i forskjellige livsfaser. I norsk sammenheng finnes det veldig lite forskning på språkbruk og språkferdigheter i et livsløpsperspektiv.

Når vi blir eldre vil mange oppleve at det er vanskelig å komme på de riktige ordene, eller det kan være vanskelig å følge med på historier andre forteller. Dette er normalt ved aldring, men det kan også forverres hvis man får en demensdiagnose. Ulike demenssykdommer kan også påvirke språkevnen ulikt.

I dette prosjektet prøver jeg å finne ut av hva som er normale språkendringer ved aldring, og om det finnes ulike «språkprofiler» for ulike demenssykdommer.

HVA INNEBÆRER PROSJEKTET?

Deltakelse i prosjektet innebærer at vi møtes én til to ganger, enten på Universitetet i Oslo, hjemme hos deg eller et annet sted du ønsker. Vi skal da gjøre noen oppgaver sammen, både på datamaskin og ved hjelp av penn og papir. I en oppgave vil jeg også filme øyebevegelsene dine ved hjelp av et lite kamera på en datamaskin. Til hvert møte setter vi av ca. 2 timer, og det er mulig å ta mange pauser underveis.

Under oppgavene vil jeg gjøre lydopptak, og noe av det du sier vil senere bli skrevet ned sånn at det kan brukes i forskningsartikler og i oppgaven min. Når materialet brukes i artikler, vil all informasjon om deg bli slettet, og ingen vil kunne kjenne deg igjen.

Jeg vil også gjennomføre et kort intervju med deg, der jeg spør litt om bakgrunnen din og om hvilke språk du snakker og har lært oppgjennom livet.

I prosjektet vil vi innhente og registrere opplysninger om deg. Hvis det ble tatt bilder av hjernen din, eller prøver av spinalvæske som ledd av utredningen, vil jeg få skriftlige beskrivelser av funnene fra disse testene fra en forskningssykepleier på Ullevål Sykehus. Jeg vil ikke få de faktiske prøvene eller bildene. Denne informasjonen oppbevares trygt på en innelåst server, og ingen andre enn meg får tilgang til denne informasjonen om deg.

Prosjektet avsluttes i august 2019, men informasjonen vil oppbevares trygt fram til juli 2024, deretter blir all informasjon om deg slettet.

MULIGE FORDELER OG ULEMPER

Det er ikke forbundet noen risiko med denne studien. Men oppgavene kan ta litt lang tid og du kan bli sliten underveis. Det er derfor viktig at du sier tydelig ifra når du ønsker pauser.

FRIVILLIG DELTAKELSE OG MULIGHET FOR Å TREKKE SITT SAMTYKKE

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Du kan når som helst be om å stoppe lydopptak under testingen, eller si at du ikke vil gjennomføre enkelte oppgaver. Du kan når som helst trekke deg fra studien uten å oppgi noen grunn.

Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder Ingeborg Sophie Ribu på e-post i.s.b.ribu@iln.uio.no eller telefon 48 10 56 59.

HVA SKJER MED INFORMASJONEN OM DEG?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert.

Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger gjennom en navneliste. Det er kun prosjektleder (Ingeborg Ribu) som har tilgang til denne listen.

Prosjektleder har ansvar for den daglige driften av forskningsprosjektet og at opplysninger om deg blir behandlet på en sikker måte. Informasjon om deg vil bli anonymisert eller slettet senest fem år etter prosjektslutt.

OPPFØLGINGSPROSJEKT

Hvis du synes det er greit vil jeg gjerne be om muligheten til å kontakte deg igjen ved en senere anledning for å delta i nye prosjekter senere.

FORSIKRING

Universitetet i Oslo er selvassurandør. Det er ikke forventet at det kan oppstå skade forbundet med deltakelse i prosjektet, men hvis det skulle skje vil Universitetet i Oslo dekke utgiftene.

GODKJENNING

Prosjektet er godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk, REK (2016/1293).

Etter ny personopplysningslov har behandlingsansvarlig og prosjektleder Ingeborg Ribu et selvstendig ansvar for å sikre at behandlingen av dine opplysninger har et lovlig grunnlag. Dette prosjektet har rettslig grunnlag i EUs personvernforordning artikkel 6.1a og 9.2a om samtykke.

Du har rett til å klage på behandlingen av dine opplysninger til Datatilsynet.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet kan du ta kontakt med Ingeborg Ribu på telefon 48 10 56 59 eller e-post i.s.b.ribu@iln.uio.no .

Du kan ta kontakt med institusjonens personvernombud dersom du har spørsmål om behandlingen av dine personopplysninger i prosjektet. Maren Magnus Voll er personvernombud ved Universitetet i Oslo. Hun kan nås på e-post personvernombud@uio.no eller telefon: 22 85 97 78

SAMTYKKE TIL DELTAKELSE I PROSJEKTET

JEG ER VILLIG TIL Å DELTA I PROSJEKTET

Sted og dato | Deltakers signatur

Deltakers navn med trykte bokstaver

Jeg samtykker til at det gjøres lydopptak som også kan brukes i senere forskning Ja____ Nei____

Jeg samtykker til å bli kontaktet igjen senere for deltakelse i andre studier Ja____ Nei____

STEDFORTREDENDE SAMTYKKE

Dersom primærdeltaker ikke lenger har samtykkekompetanse, kan pårørende gi samtykke på vedkommende sine vegne.

Som nærmeste pårørende til _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (Fullt navn) samtykker jeg til at hun/han kan delta i prosjektet.

Sted og dato | Pårørendes signatur

Pårørendes navn med trykte bokstaver

Jeg bekrefter å ha gitt informasjon om prosjektet

Sted og dato | Signatur

Rolle i prosjektet

UiO **Universitetet i Oslo**
Humanistisk fakultet/Institutt for lingvistiske og nordiske studier

Informasjon om studien «Språk og kognisjon i et livsløpsperspektiv»

Mitt navn er Ingeborg Ribu,
Jeg er språkforsker og jobber ved Universitetet i Oslo. Der skriver jeg en doktorgrad om hvordan språket utvikler seg gjennom livet, og hvordan det kan påvirkes av hukommelsesvansker. Prosjektet har arbeidstittel «Språk og kognisjon i et livsløpsperspektiv»

Når vi blir eldre vil mange oppleve at det er vanskelig å komme på de riktige ordene, eller å følge med i samtaler der mange deltar. Dette er vanlig ved aldring, men noen opplever mer av dette enn andre. For å få god oversikt over hvor vanlig dette er, undersøker vi språkferdigheter hos ulike deltakergrupper. I studien vil det derfor inngå personer i ulike aldersgrupper, og personer med og uten hukommelsesvansker.

I undersøkelsen vil vi gjøre ulike språklige oppgaver sammen. De fleste gjennomføres med penn og papir, men det er også en oppgave på datamaskin. Det er derfor fint om deltakerne kan komme til Universitetet i Oslo for å gjennomføre undersøkelsen, men vi har også mulighet til å møtes andre steder.

Undersøkelsen tar ca. 2,5 til 3 timer, inkludert pauser underveis. Noen synes det er greit å gjennomføre alt i løpet av ett møte, mens andre vil gjerne dele det opp. Det er opp til den enkelte deltaker hvordan man ønsker det.

Det blir gjort lydopptak av alle undersøkelsene, men det er kun for at testleder skal slippe å notere så mye underveis. Noe vil også bli transkribert, men da blir all informasjon om personen som har sagt det anonymisert, så ingen kan kjenne igjen deltakeren hvis dette brukes i publikasjoner senere.

Hvis du først har sagt ja til å delta i studien, men så ombestemmer deg, er det helt OK. Husk å gi beskjed sånn at jeg får slettet all informasjon som er samlet inn om deg.

Ta kontakt dersom du har spørsmål angående studien.

Håper du ønsker å delta!

Med vennlig hilsen,

Ingeborg Ribu
Doktorgradsstipendiat
Forskergruppe for klinisk lingvistikk og språktilegnelse
Universitetet i Oslo

Tlf: 48 10 56 59
E-post: i.s.b.ribu@iln.uio.no

Postadresse: Postboks 1102 Blindern 0317 Oslo
E-post: i.s.b.ribu@iln.uio.no
Telefon: 48 10 56 59
www.uio.no

UiO **Universitetet i Oslo**
Humanistisk fakultet/Institutt for lingvistiske og nordiske studier

FORESPØRSEL OM DELTAKELSE I ET FORSKNINGSPROSJEKT OM SPRÅK, ALDRING OG DEMENS

Dette er et spørsmål til deg om å delta i et forskningsprosjekt for å undersøke hvordan språklige ferdigheter endres i løpet av livet, sammenlignet med hvordan språket kan bli påvirket ved en demensdiagnose. For deltakelse i prosjektet er vi interessert i å komme i kontakt med voksne personer over 65 år, uten en kjent demensdiagnose, samt yngre voksne mellom 18 og 30 år.

FORMÅLET MED PROSJEKTET

Prosjektet undersøker språklige ferdigheter hos personer med og uten demens og i forskjellige livsfaser. I norsk sammenheng finnes det veldig lite forskning på språkbruk og språkferdigheter hos eldre personer.

Når vi blir eldre vil mange oppleve at det er vanskelig å komme på de riktige ordene, eller det kan være vanskelig å følge med på historier andre forteller. Dette er normalt ved aldring, men det kan også forverres hvis man får en demensdiagnose. Ulike demenssykdommer kan også påvirke språkevnen ulikt.

I dette prosjektet prøver jeg å finne ut av hva som er normale språkendringer ved aldring, og om det finnes ulike «språkprofiler» for ulike demenssykdommer.

HVA INNEBÆRER PROSJEKTET?

Deltakelse i prosjektet innebærer at vi møtes en gang på Universitetet i Oslo. Vi skal da gjøre noen oppgaver sammen, både på datamaskin og ved hjelp av penn og papir. I en oppgave vil jeg også filme øyebevegelsene dine ved hjelp av et lite kamera på en datamaskin. Vi setter av ca. tre timer til gjennomføring av oppgavene, og det er satt av tid til opptil flere pauser underveis.

Under oppgavene vil jeg gjøre lydopptak, og noe av det du sier vil senere bli skrevet ned sånn at det kan brukes i forskningsartikler og i oppgaven min. Når materialet brukes i artikler, vil all informasjon om deg bli slettet, og ingen vil kunne kjenne deg igjen.

Du vil også motta et spørreskjema som du sender tilbake i posten. I skjemaet er det noen spørsmål om bakgrunnen din og om hvilke språk du snakker og har lært oppgjennom livet.

Prosjektet avsluttes i august 2019, men informasjonen vil oppbevares trygt fram til juli 2024, deretter blir all informasjon om deg slettet.

MULIGE FORDELER OG ULEMPER

Det er ikke forbundet noen risiko med denne studien. Men oppgavene kan ta litt lang tid og du kan bli sliten underveis. Det er derfor viktig at du sier tydelig ifra når du ønsker pauser.

FRIVILLIG DELTAKELSE OG MULIGHET FOR Å TREKKE SITT SAMTYKKE

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Du kan når som helst be om å stoppe lydopptak under testingen, eller si at du ikke vil gjennomføre enkelte oppgaver. Du kan når som helst trekke deg fra studien uten å oppgi noen grunn.

Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder Ingeborg Sophie Ribu på e-post i.s.b.ribu@iln.uio.no eller telefon 48 10 56 59.

HVA SKJER MED INFORMASJONEN OM DEG?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert.

Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger gjennom en navneliste. Det er kun prosjektleder (Ingeborg Ribu) som har tilgang til denne listen.

Prosjektleder har ansvar for den daglige driften av forskningsprosjektet og at opplysninger om deg blir behandlet på en sikker måte. Informasjon om deg vil bli anonymisert eller slettet senest fem år etter prosjektslutt.

OPPFØLGINGSPROSJEKT

Hvis du synes det er greit vil jeg gjerne be om muligheten til å kontakte deg igjen ved en senere anledning for å delta i nye prosjekter senere.

FORSIKRING

Universitetet i Oslo er selvassurandør. Det er ikke forventet at det kan oppstå skade forbundet med deltakelse i prosjektet, men hvis det skulle skje vil Universitetet i Oslo dekke utgiftene.

GODKJENNING

Prosjektet er godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk, REK (2016/1293).

Etter ny personopplysningslov har behandlingsansvarlig og prosjektleder Ingeborg Ribu et selvstendig ansvar for å sikre at behandlingen av dine opplysninger har et lovlig grunnlag. Dette prosjektet har rettslig grunnlag i EUs personvernforordning artikkel 6.1a og 9.2a om samtykke.

Du har rett til å klage på behandlingen av dine opplysninger til Datatilsynet.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet kan du ta kontakt med Ingeborg Ribu på telefon 48 10 56 59 eller e-post i.s.b.ribu@iln.uio.no .

Du kan ta kontakt med institusjonens personvernombud dersom du har spørsmål om behandlingen av dine personopplysninger i prosjektet. Maren Magnus Voll er personvernombud ved Universitetet i Oslo. Hun kan nås på e-post personvernombud@uio.no eller telefon: 22 85 97 78

SAMTYKKE TIL DELTAKELSE I PROSJEKTET

JEG ER VILLIG TIL Å DELTA I PROSJEKTET

Sted og dato Deltakers signatur

Deltakers navn med trykte bokstaver

Jeg samtykker til at det gjøres lydopptak som også kan brukes i senere forskning Ja____ Nei____

Jeg samtykker til å bli kontaktet igjen senere for deltakelse i andre studier Ja____ Nei____

Jeg bekrefter å ha gitt informasjon om prosjektet

Sted og dato Signatur

Rolle i prosjektet

MultiLing Dementia – en studie av kommunikasjon hos flerspråklige

Kjære deltaker,

Når man blir eldre kan man ofte oppleve at det er vanskelig å finne de riktige ordene eller setningene, og at det påvirker kommunikasjon med andre. Dette er veldig vanlig for personer med demens, men det er også normalt for personer uten demens. Per i dag finnes det ikke noe verktøy som enkelt kan skille mellom vanlige og uvanlige språkvansker hos eldre. Vi er derfor interessert i å undersøke språket hos personer med og uten demens. Ansatte i helsevesenet og pårørende til personer med demens vil også ha nytte av å lære mer om språkvansker hos personer som har en demensdiagnose.

I den sammenheng ønsker vi å gjøre opptak av en- og flerspråklige personer, både med og uten demens. For de flerspråklige personene trenger vi opptak på norsk og på morsmålet. Deltakerne i undersøkelsen vil bli bedt om å fortelle en historie, og å svare på noen oppgaver. Det vil også bli avholdt et intervju med deltakerne og deres pårørende. Det kan hende vi trenger å treffe deg mer enn en gang.

Hvis du er interessert i å delta i undersøkelsen, vil vi gjerne at du signerer samtykkeskjemaet under og sender det tilbake til oss.

All informasjon er konfidensiell og vil bli anonymisert i formidling fra prosjektet. Det gjelder også alle opptakene vi gjør. Data fra prosjektet vil bli analysert og gjengitt på en slik måte at ingen kan kjennes igjen, og ingen kan vite hvem som har deltatt i undersøkelsen. Alt vi samler inn vil kun være tilgjengelige for forskere tilknyttet prosjektet. Alle dokumenter vil slettes etter prosjektslutt for å ivareta konfidensialitet.

Prosjektet avsluttes i løpet av 2015. De redigerte opptakene vil bli oppbevart i inntil 20 år etter prosjektslutt for sammenlikning med senere studier.

Din deltakelse i prosjektet er svært verdifull for oss for å forstå mer om hva som skjer med språket når vi blir eldre. Dette vil være med på å øke vår teoretiske kunnskap rundt temaet, samtidig som det kan være til nytte for personer som av profesjonelle eller personlige grunner har daglig omgang med personer med en (mulig) demensdiagnose.

Prosjektet er meldt inn til Personvernombudet for forskning, Norsk Samfunnsvitenskapelig Datatjeneste. Hvis du skulle ha noen spørsmål rundt undersøkelsen, eller vite noe om resultatene fra prosjektet, er det bare å ta kontakt med prosjektgruppa via adressen nederst på arket. Deltakelse i prosjektet er frivillig, og du kan når som helst (fram til prosjektslutt) trekke deg uten å måtte oppgi noen grunn om du ikke lenger ønsker å ta del i undersøkelsen. Dette gjøres på e-post eller telefon til prosjektleder Professor Bente Ailin Svendsen. Dersom du ønsker å trekke deg vil all data om deg bli slettet.

Tusen takk!

Vennlig hilsen (på vegne av forskerteamet)

Forskerteam:	
Prosjektleder:	Professor Bente Ailin Svendsen (Universitetet i Oslo)
Medlemmer av teamet:	Professor Hanne Gram Simonsen (Universitetet i Oslo)
	Professor Jan Svennevig (Universitetet i Oslo)
	Dr. Art. Marianne Lind (Statped)
Prosjektassistent:	Ingeborg Sophie Ribu (Universitetet i Oslo)

Bente Ailin Svendsen
MultiLing, Institutt for lingvistiske og nordiske studier, Universitetet i Oslo
Postboks 1102, Blindern
0317 Oslo
b.a.svendsen@iln.uio.no
22856966

Appendix B: Notification to the data protection officials

On these pages, the responses from the data protection officials are included:

1. Acceptance for studies II and III from the Regional committees for medical and health research ethics
2. acceptance after changes to the project plan for studies II and III were implemented
3. Remit Assessment from the Regional committees for medical and healthy research ethics for study IV. The committee deemed the project to not be approved by them, but by the Norwegian Centre for Research Data.
4. Approval from the Norwegian Centre for Research Data (NSD)

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Mariann Glenna Davidsen	22845526	20.12.2016	2016/1293 REK sør-øst B
			Deres dato:	**Deres referanse:**
			10.11.2016	

Vår referanse må oppgis ved alle henvendelser

Ingeborg Sophie Ribu
Universitetet i Oslo

2016/1293 Demens og språklig aldring

Forskningsansvarlig: Universitetet i Oslo
Prosjektleder: Ingeborg Sophie Ribu

Vi viser til tilbakemelding på ovennevnte forskningsprosjekt. Tilbakemeldingen ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 30.11.2016. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

Prosjektleders prosjektbeskrivelse
Prosjektets formål er å undersøke hvordan språk påvirkes av normal og patologisk aldring, både når det gjelder produksjon og forståelse av ordforråd og grammatikk i talt språk. Prosjektet har fire forskningsspørsmål: 1- Hvordan påvirkes forståelse ordforråd og grammatikk av en aldersrelatert kognitiv svekkelse (f.eks. demensdiagnose)? 2- Hvordan påvirkes produksjon av ordforråd og grammatikk av en aldersrelatert kognitiv svekkelse? 3- Planlegger personer med og uten demens tale annerledes? 4- Kan ulike lingvistiske trekk brukes som klinisk markør ved aldersrelatert kognitiv svekkelse? Det vil bli utført psykolingvistiske tester med ulike deltakergrupper for å undersøke ordgenerering og spontantale, og for å måle forståelse og gjenkjenning av ord.

Saksgang
Komiteen behandlet søknaden første gang i møte den 17.08.2016. I sitt brev datert 14.09.2016, skrev komiteen at den utsatte å treffe et endelig vedtak i saken da den ønsket utfyllende opplysninger på enkelte punkter. Prosjektleder sendte inn en tilbakemelding mottatt den 10.11.2016, inkludert revidert protokoll samt reviderte informasjons- og samtykkeskriv.

Komiteens vurdering ved første gangs behandling (gjengitt fra vedtak av 14.09.2016)
Komiteen forstår det slik at man i dette prosjektet ønsker å undersøke forskjeller i språkprosessering mellom personer med og uten kognitiv svikt. Det skal rekrutteres 90 personer fordelt på 3 grupper (personer over 65 år med og uten demens, samt unge voksne som utgjør kontrollgruppen).

Metoder
Det skal innhentes tidligere helseopplysninger fra pasientjournal om demensdiagnose, enten fra fastlege eller utreder ved hukommelsesklinikk («journal fra demensutredning»). Alle deltakerne vil gjennomgå 4 språkoppgaver for å samle inn data om produksjon og forståelse av enkeltord og setninger. Det skal brukes eye-tracker i noen oppgaver for å registrere øyebevegelser og blikkvarighet. Under oppgaveløsningene gjøres lydopptak. Disse anonymiseres og vil kunne bli gjort tilgjengelige for andre forskere gjennom

databasen "Disordered Speech Bank". I tillegg skal deltakerne screenes med tanke på global kognitiv funksjon (Mini-Mental State Evaluation), eksekutivfunksjoner og arbeidsminne. De skal også besvare spørreskjema om hukommelse, kommunikasjon og språkbakgrunn.

Komiteen kan ikke se det er beskrevet nærmere i protokoll hvilke metoder som skal benyttes for testing av eksekutive funksjoner og arbeidsminne. Det er også uklart hva som skal innhentes av informasjon fra pasientjournal.

Rekruttering
Det vises til at deltakere med demens vil rekrutteres gjennom sykehjem og dagsentere i Oslo, samt gjennom kontakt med hukommelsesklinikk og Nasjonalforeningen for folkehelsen samt demenskoordinatorer i de bydelene som har det. De eldre deltakerne uten demens vil i stor grad rekrutteres gjennom personlige nettverk og andre interesse-nettverk. De yngre deltakerne vil rekrutteres gjennom personlige nettverk og oppslag ved Universitetet i Oslo.

Det er ikke tydelig beskrevet i protokoll hvordan og hvem som skal vurdere samtykkekompetanse når det gjelder rekruttering av pasienter med demens diagnose.

Informasjon- og samtykkeskriv
Det er beskrevet at alle deltakerne vil bli gitt skriftlig og muntlig informasjon, samt at alle skal gi skriftlig samtykke til å delta i studien (for noen deltakere vises det til at pårørende skal spørres).

Det er kun vedlagt ett informasjon- og samtykkeskriv. Det kan synes som dette informasjonsskrivet skal dekke alle de tre deltakende gruppene. Det er i så fall ikke tilstrekkelig. Det må utarbeides egne, tilpassede informasjons- og samtykkeskriv til hver av gruppene da de har ulike forutsetninger for deltakelse.

Før komiteen tar endelig stilling til prosjektet vil det være nødvendig å få en nærmere redegjørelse av følgende:

1. Rekrutteringsprosedyren/ hvem skal vurdere samtykkekompetanse

2. Hvilke metoder som skal benyttes for testing av eksekutive funksjoner og arbeidsminne

3. Hvilke info skal hentes fra journal.

4. Utarbeide infoskriv til alle de deltakende gruppene. Disse må sendes komiteen for gjennomgang

Komiteens beslutning
Vedtak i saken utsettes. Komiteen tar stilling til prosjektet ved mottatt svar.

Prosjektleders tilbakemelding
Prosjektleders tilbakemelding av 11.10.2016 gjengis i sin helhet:

1. Samtykkekompetanse: Dersom forsøkspersonene med en demensdiagnose har manglene samtykkekompetanse, vil dette framkomme av informasjon fra utredende lege. Jeg har inngått et samarbeid med hukommelsesklinikken ved Oslo Universitetssykehus, Ullevål om at de kan gi informasjon om prosjektet, og henvise aktuelle kandidater til mitt prosjekt. Disse personene vil være utredet ved hjelp av et større klinisk verktøy, og utredende lege vil vurdere personenes samtykkekompetanse. I det nye samtykkeskjemaet (vedlegg 1) er det også satt av plass til at pårørende gir samtykke.

2. Kognitive funksjoner og arbeidsminne: I samarbeid med hukommelsesklinikken ved Oslo Universitetssykehus, Ullevål, har jeg utarbeidet en protokoll basert på deres testmateriale og utredningsprotokoll (vedlegg 2 og 3). Testene som inngår i testprotokollen for kognitive ferdigheter vil være Mini Mental State Evaluation, 10-ordstest fra CERAD, verbal flyt, forkortete Boston Naming Test, test for abstrakt tenking (likheter mellom ord), Klokketegning, figurkopiering, Trail Marking A+B. Videre bruker jeg en elektronisk versjon av Flanker (Eriksen, 1972) og Stroop (D-KEFS), tallrangering og baklengs *tallhukommelse, to tester for prosesseringshastighet (letter comparison og "boxes"), og pluss/minus-regning for set-shifting.*

Det er også blitt gjort endringer når det gjelder de språklige testene. Som før vil jeg benytte meg av en bildebeskrivelsesoppgave for å ellisitere spontantale/narrativproduksjon, men bildet er byttet ut. I den opprinnelige søknaden var det tenkt at jeg skulle bruke "kaketyveriet" fra Boston Naming Test, men jeg

har nå bestemt meg for "fuglehistorien", en tegneserie fra Bilingual Aphasia Test. Bildebenevnelsestesten forblir den samme, men jeg har lagt til en Time-Reference test (TRT) for produksjon av setninger. TRT innebærer grammatisk manipulasjon av setninger, fra fortid til framtid og omvendt.

Ordgjennkjennelsesoppgaven er byttet ut med en ord-og-bildematchingsoppgave for å undersøke forståelse av enkeltord, mens eye-trackingoppgaven forblir som tenkt i den opprinnelige søknaden. Videre har jeg lagt til to tester for å undersøke semantisk kunnskap, nemlig en ordassosiasjonstest der deltakerne blir forelagt 90 ord og skal skrive ned det første ordet de tenker på til hvert ord, og Pyramide- og palmetesten som ofte brukes for å undersøke semantisk kunnskap hos personer med afasi. I pyramide- og palmetesten får deltakerne se tre bilder, og de må avgjøre hvilke to som hører sammen.

3. Informasjon fra journal: Siden jeg har inngått et samarbeid med hukommelsesklinikken ved Ullevål sykehus, og de vil hjelpe meg med å finne personer som kan være med i studien, kan jeg være nokså sikker på at alle forskningspersonene som inngår i gruppa med demens har vært utredet med det samme verktøyet. Informasjon jeg vil få tilgang til fra journalene deres er hva slags demensdiagnose de har fått og når denne ble stilt, informasjon om hvilke tester de er blitt utredet med og resultatet på disse. Dersom det foreligger spinalprøver og MR-bilder, vil jeg få beskrivelse av resultatene fra disse, men jeg vil ikke få tilgang til de faktiske bildene og prøveresultatene. Jeg vil også søke NorKog om å få tilgang til pasienter som er registrert i dette registeret. Det etter oppfordring fra Hukommelsesklinikken ved OUS Ullevål.

4. Nye informasjonsskriv og samtykkeskjemaer er vedlagt. Vedlegg 1 er et nytt samtykkeskjema til gruppen med demenspasienter, og deres pårørende. Vedlegg 4 er et nytt samtykkeskjema til de to gruppene med forsøkspersoner uten demens, og vedlegg 5 er et informasjonsskriv som følger med samtykkeskjemaene og leveres til alle deltakere. Det er tenkt som mer informasjon enn det som framkommer i samtykkeskjemaene, og kan derfor fungere fint som supplement også til pårørende av forsøkspersonene som deltar i demensgruppen.

Komiteens vurdering
Komiteen mener prosjektleders tilbakemeldinger er tilfredsstillende besvart, men vil kommentere at samtykkeskrivene bør følge REK sine anbefalte maler. Det vil ikke være nødvendig med egne avkrysninger i samtykkeskrivet for annet enn spørsmål om å bli kontaktet for andre prosjekter i fremtiden. Komiteen setter dermed følgende vilkår til prosjektet:

1. Utbedre informasjon- og samtykkeskriv slik at de følger REK mal. I tillegg fjerne unødvendig avkryssingsalternativer.

Vedtak
Komiteen godkjenner prosjektet i henhold til helseforskningsloven, med forutsetning om at ovennevnte vilkår oppfylles, jf. § 9 og § 33.

Når vilkåret er oppfylt gjelder godkjenningen under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden.

Tillatelsen gjelder til 14.04.2019. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 14.04.2024. Opplysningene skal lagres avidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder ”*Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og* *omsorgssektoren"*.

Sluttmelding og søknad om prosjektendring
Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Prosjektet skal sende sluttmelding på eget skjema, se helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

Klageadgang
Komiteens vedtak kan påklages, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst B. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Komiteens avgjørelse var enstemmig.

Med vennlig hilsen

Grete Dyb
professor, dr. med.
leder REK sør-øst B

Mariann Glenna Davidsen
rådgiver

Kopi til:
- *Universitetet i Oslo ved øverste administrative ledelse*

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Ingrid Dønåsen	22845523	15.06.2018	2016/1293 REK sør-øst B
			Deres dato:	**Deres referanse:**
			16.05.2018	

Vår referanse må oppgis ved alle henvendelser

Ingeborg Sophie Ribu
Universitetet i Oslo

2016/1293 Demens og språklig aldring

Forskningsansvarlig: Universitetet i Oslo
Prosjektleder: Ingeborg Sophie Ribu

Vi viser til søknad om prosjektendring datert 16.05.2018 for ovennevnte forskningsprosjekt, samt e-post med supplerende opplysninger mottatt 14.06.2018. Søknaden er behandlet av sekretariatet i REK sør-øst på delegert fullmakt fra REK sør-øst B, med hjemmel i helseforskningsloven § 11.

Endringene innebærer:
- Endring i inklusjonskriterier: "*Fra mai 2018 vil også pasienter med diagnosen Primær progressiv afasi (PPA) inngå i studien dersom de har patologi som tilsvarer Alzheimers sykdom.*". Prosjektleder opplyser at ved å inkludere pasienter med Primær progressiv afasi i tillegg til pasienter med Alzheimer vil man kunne finne ut mer om hvordan språkferdigheter påvirkes i de ulike diagnosene, og hvordan man eventuelt ved hjelp av språkprofiler kan skille dem fra hverandre.
- Ny test for semantisk assosiasjon: The Semantic Association test.
- Protokollen (mottatt på e-post 14.06.2018) er oppdatert i henhold til endringene
- Ny kontaktperson ved forskningsansvarlig institusjon: Gunn-Elin Aa. Bjørneboe

Vurdering
Sekretariatet i REK har vurdert de omsøkte endringene, og har ingen forskningsetiske innvendinger til endringene slik de er beskrevet i skjema for prosjektendring.

Vedtak
REK godkjenner prosjektet slik det nå foreligger, jfr. helseforskningsloven § 11, annet ledd.

Godkjenningen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknad, endringssøknad, oppdatert protokoll og de bestemmelser som følger av helseforskningsloven med forskrifter.

Klageadgang
REKs vedtak kan påklages, jf. forvaltningslovens § 28 flg. Eventuell klage sendes til REK sør-øst B. Klagefristen er tre uker fra mottak av dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering, jf. forskningsetikkloven § 10 og helseforskningsloven § 10.

Vi ber om at alle henvendelser sendes inn på korrekt skjema via vår saksportal: http://helseforskning.etikkom.no. Dersom det ikke finnes passende skjema kan henvendelsen rettes på e-post til: post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

Knut Ruyter
Avdelingsdirektør
REK sør-øst sekretariatet

Ingrid Dønåsen
Rådgiver

Kopi til: *i.s.b.ribu@iln.uio.no; universitetsdirektor@uio.no*

Emne: Sv: Demens hos flerspråklige - språklig kompetanse, praksis og forvaltning
Fra: post@helseforskning.etikkom.no
Dato: 10.11.2014 14:25
Til: b.a.svendsen@iln.uio.no
Kopi:

Vår ref.nr.: 2014/1993 D Demens hos flerspråklige - språklig kompetanse, praksis og forvaltning

Viser til skjema for framleggingsvurdering mottatt 30.10.2014. Henvendelsen er vurdert av komiteens leder på fullmakt.

Formålet med prosjektet er å undersøke språklig kompetanse og språklig praksis hos flerspråklige som nylig har blitt diagnostisert med demens.

Deltakerne i studien skal rekrutteres i samarbeid med NAKMI, og utvalget vil bestå av fire personer med demensdiagnose og fire personer uten noen slik diagnose. Halvparten av deltakerne skal være flerspråklige.

Prosjektet søker å svare på hvordan demens manifesterer seg språklig hos enspråklige og flerspråklige personer, hva som kjennetegner samtaler der en av deltakerne har demens, og hvordan personer med demens og deres pårørende forholder seg til endringer som oppstår som følge av sykdommen, blant annet i møter med det offentlige, f. eks. helsevesenet

Basert på opplysningene som gis, oppfatter REK at formålet med prosjektet ikke er å gi ny kunnskap om sykdom og helse som sådan. Prosjektet faller dermed utenfor helseforskningsloven, som forutsetter at formålet med prosjektet er å skaffe ny kunnskap om helse og sykdom.

Prosjektet kan derfor gjennomføres uten godkjenning av REK. Det er forskningsansvarlig institusjons ansvar på å sørge for at prosjektet gjennomføres på en forsvarlig måte med hensyn til for eksempel regler for taushetsplikt og personvern.

Jeg gjør oppmerksom på at konklusjonen er å anse som veiledende jf. Forvaltningsloven §11. Dersom du likevel ønsker å søke REK vil søknaden bli behandlet i komitémøte, og det vil bli fattet et enkeltvedtak etter forvaltningsloven.
Med vennlig hilsen
Anne S. Kavli
Førstekonsulent
post@helseforskning.etikkom.no
T: 22845512

Regional komité for medisinsk og helsefaglig forskningsetikk REK sør-øst-Norge (REK sør-øst)
http://helseforskning.etikkom.no

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Bente Ailin Svendsen
Institutt for lingvistiske og nordiske studier Universitetet i Oslo
Postboks 1102 Blindern
0317 OSLO

Vår dato: 11.12.2014 Vår ref: 40523 / 3 / HIT Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 30.10.2014. All nødvendig informasjon om prosjektet forelå i sin helhet 08.12.2014. Meldingen gjelder prosjektet:

40523	*MultiLing Dementia - competence, practices, policies*
Behandlingsansvarlig	*Universitetet i Oslo, ved institusjonens øverste leder*
Daglig ansvarlig	*Bente Ailin Svendsen*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 31.12.2015, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

Hildur Thorarensen

Kontaktperson: Hildur Thorarensen tlf: 55 58 26 54
Vedlegg: Prosjektvurdering

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Avdelingskontorer / *District Offices*:
OSLO: NSD. Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. nsd@uio.no
TRONDHEIM: NSD. Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim. Tel: +47-73 59 19 07. kyrre.svarva@svt.ntnu.no
TROMSØ: NSD. SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. nsdmaa@sv.uit.no

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 40523

BAKGRUNN

Prosjektet er forhåndsvurdert av REK sør-øst (ref. 2014/1993), som oppfatter det slik at prosjektet faller utenfor helseforskningslovens virkeområde.

Prosjektet er en internasjonal samarbeidsstudie. Universitetet i Oslo er behandlingsansvarlig institusjon for den norske delen. Personvernombudet forutsetter at ansvaret for behandlingen av personopplysninger er avklart mellom institusjonene. Vi anbefaler at det inngås en avtale som omfatter ansvarsfordeling, ansvarsstruktur, hvem som initierer prosjektet, bruk av data og eventuelt eierskap.

MultiLing Dementia søker å forene psykolingvistiske og sosiolingvistiske tilnærminger til studiet av demens hos flerspråklige personer. Hovedfokuset ligger på tre temaer: 1: Flerspråklig kompetanse (hvordan manifesterer demens seg språklig?), 2:Flerspråklig praksis (Hvordan preges samtaler av at en deltaker har demens?), og 3: Forvaltning av flerspråklighet (Hvordan opplever og forholder personer med demens og deres pårørende seg til livsendringene som sykdommen medfører, i familien og i møter med helsevesenet?

UTVALG

Utvalget vil bestå av eldre personer med demens og deres pårørende. Ansatte vil også bli intervjuet om sin erfaring med gruppen som helhet, men ikke om enkeltpersoner.

INFORMASJON OG SAMTYKKE

Utvalget informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse. Informasjonsskriv mottatt 08.12.2014 er godt utformet.

Det oppgis at enkelte av brukerne vil kunne ha noe redusert samtykkekompetanse. Personvernombudet finner at opplysninger innhentet fra personer uten full samtykkekompetanse, kan behandles med hjemmel i personopplysningsloven § 8 d) og § 9 h).

Det anses ikke som potensielt belastende for vedkommende å delta i prosjektet. Det opplyses at vedkommende vil bli gitt tilpasset informasjon, samt at hjelpeverge/nærmeste pårørende informeres om prosjektet, og eventuelt gir en uttalelse om hvorvidt opplysninger om vedkommende kan anvendes i studien.

Det vurderes at den valgte fremgangsmåten for inklusjon av personer uten full samtykkekompetanse, bidrar i betydelig grad til å redusere personvernulempen ved deltakelse. Det vurderes videre at opplysningene vil kunne komme gruppen som helhet til gode. På bakgrunn av dette finner personvernombudet at samfunnsinteressen i at behandlingen finner sted, overstiger ulempen den medfører for den enkelte registrerte.

INFORMASJONSSIKKERHET

Personvernombudet legger til grunn at forsker etterfølger Universitetet i Oslo sine interne rutiner for datasikkerhet. Dersom personopplysninger skal lagres på mobile enheter, bør opplysningene krypteres tilstrekkelig.

PROSJEKTSLUTT
Forventet prosjektslutt er 31.12.2015. Ifølge prosjektmeldingen skal innsamlede opplysninger fra dem som har samtykket til dette da lagres i 20 år for oppfølgingsstudier. Data fra dem som ikke samtykker til lagring vil bli anonymisert.

Vi gjør oppmerksom på at all ny bruk av datamaterialet må meldes til personvernombudet.

Appendix C: Test protocols for the studies II and III

1. The short protocol for persons recruited via the memory clinic

2. The long protocol for all control participants

Date: Age: Tested by:		ID:
Semantic association test		
Pyramids and palm trees		
Free word association		
Picture naming	Nouns: Verbs:	
Verbal fluency	F: A: S: Animals:	
BAT cartoon description		
Digit span forwards	Longest: Score:	
Digit span backwards	Longest: Score:	
Digit span ordering	Longest: Score:	
Word-Picture matching	Nouns: Verbs:	
BNT short		
Stroop	Errors 1: corrected 1: time 1: Errors2: corrected 2: time 2:	
Sentence comprehension (visual world)	Active: Subject cleft: Object cleft:	

Date: Age: Tested by:					ID:
MMSE					
CERAD 10-words	1:	2:	3:		
Semantic association test					
Recall CERAD 10-ord	A:	B:			
Pyramids and palm trees					
Trail making	A:	B:			
Free word association					
Picture naming	Nouns:	Verbs:			
Verbal fluency	F: A:	S:	Animals:		
BAT cartoon description					
CERAD figure copying	1:	2:	3:	4:	
Digit span forwards	Longest:		Score:		
Digit span backwards	Longest:		Score:		
Digit span ordering	Longest:		Score:		
Recall CERAD figures	1:	2:	3:	4:	
Word-Picture matching	Nouns:	Verbs:			
BNT short					
Stroop	Errors 1: Errors2:	corrected 1: corrected 2:	time 1: time 2:		
Sentence comprehension (visual world)	Active:	Subject cleft:	Object cleft:		

Appendix D: Items for the picture-naming and word-to-picture matching tests in studies II and III

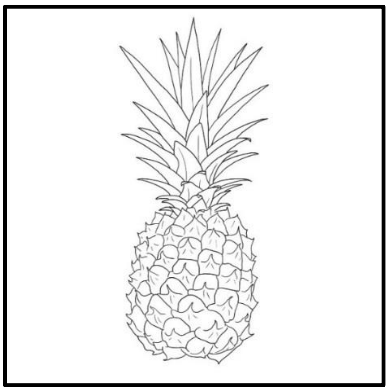
1. The final list of nouns for the Picture Naming task and the word-to-picture matching task
2. The final list of verbs for the Picture Naming task and the word-to-picture matching task
3. Example images from the Picture Naming task
4. Example images from the word-to-picture matching task

Norwegian	English (translation equivalent)
Et belte	A belt
En sekk	A backpack
En kenguru	A kangaroo
Et tog	A train
En fiolin	A violin
En løk	An onion
En pingvin	A pinguin
Et termometer	A thermometer
Ei fjær	A feather
Ei vekt	A (pair of) scales
En elg	A moose
Ei tønne	A barrel
En radio	A radio
Et skjerf	A scarf
Ei flue	A fly
En linjal	A ruler
En dress	A suit
Ei skilpadde	A turtle
Ei skjorte	A shirt
En sopp	A mushroom
En gitar	A guitar
En hval	A whale
En sitron	A lemon
En hanske	A glove
En komfyr	A stove
En sjiraff	A giraffe
En ananas	A pineapple
En maur	An ant
En hatt	A hat
En traktor	A tractor

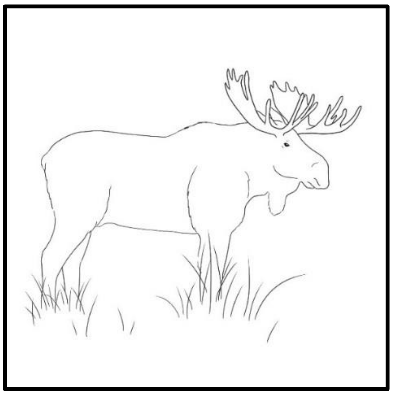
Norwegian	English (translation equivalent)
Å stryke	To iron
Å brenne	To burn
Å barbere	To shave
Å fekte	To fence
Å skrive	To write
Å skyte	To shoot
Å plystre	To whistle
Å spikke	To chisel
Å lese	To read
Å blåse	To blow
Å hugge	To chop
Å ro	To row
Å bore	To drill
Å ake	To sled
Å mure	To lay bricks
Å krabbe	To crawl
Å bokse	To box
Å danse	To dance
Å kjevle	To roll (dough)
Å dryppe	To drip
Å vaske	To clean
Å kjøre	To drive
Å smelte	To melt
Å male	To paint
Å brekke	To break / to snap
Å seile	To sail
Å dusje	To shower
Å løpe	To run
Å ri	To ride (horseback)
Å fryse	To freeze

Picture-naming: Nouns

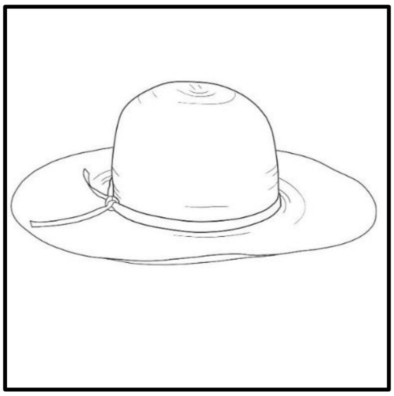
Ei fjær
(a feather)



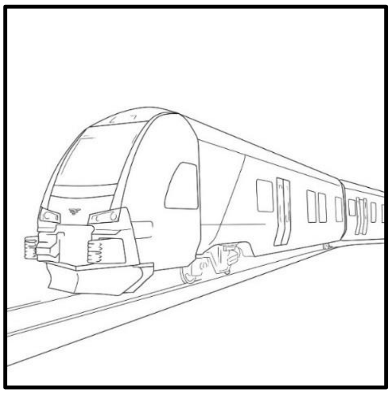
En annanas
(a pineapple)



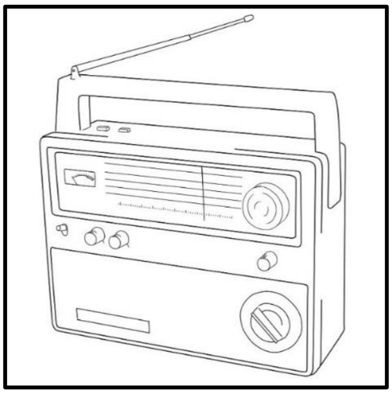
En elg
(a moose)



En hatt
(a hat)



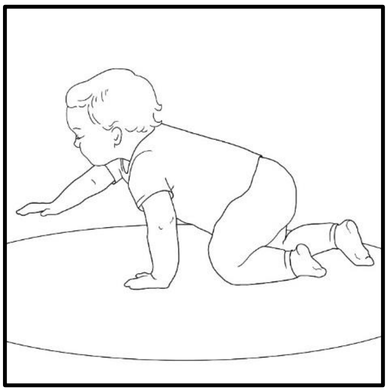
Et tog
(a train)



En radio
(a radio)

Picture-naming: Verbs

Å danse
(to dance)

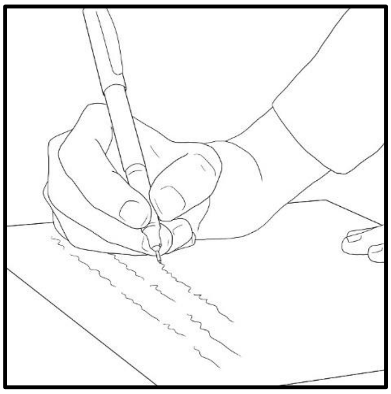


Å krabbe
(to crawl)

Å fryse
(to freeze)

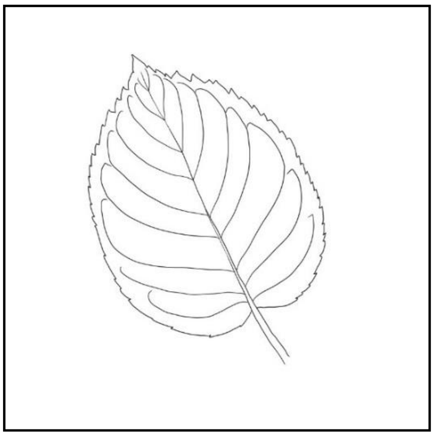
Å hugge
(to chop)

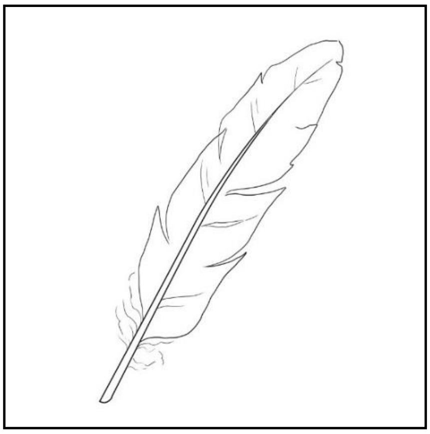
Å løpe
(to run)

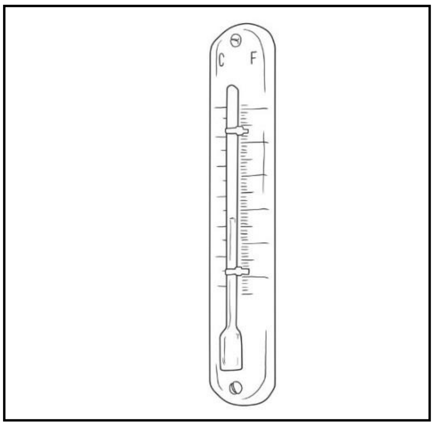


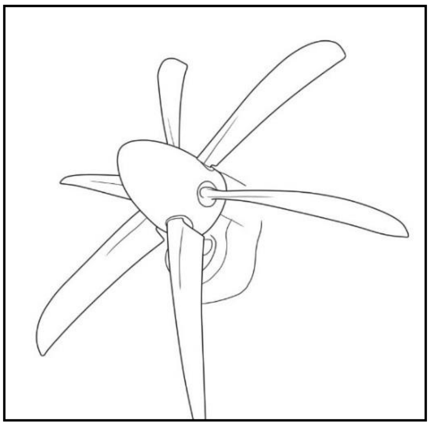
Å skrive
(to write)

Hvor er det en fjær?
Where is there a feather?



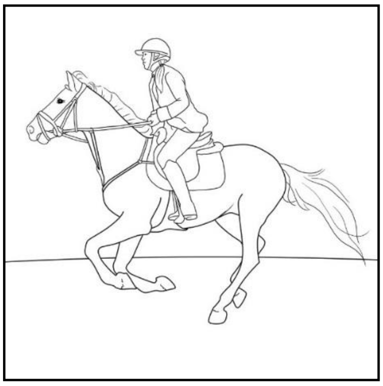
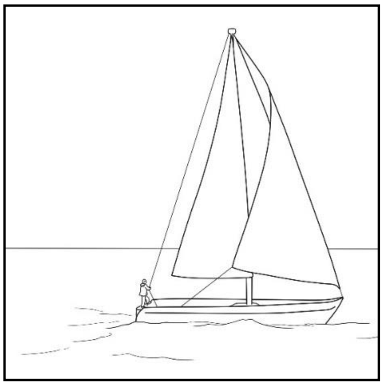






Hvor er det en som rir?
Where do you see someone riding?



Appendix E: Items on the free word association task in study II

Please say the first word that comes to mind when you hear the words I read aloud.

Please try to answer with only <u>one</u> word per response

Remember that there are no right or wrong responses.

sol – *sun* (N)

gå – *walk* (V)

hverdag – everyday (N)

forventning - expectation/anticipation(N)

ansette- employ (V)

servere- serve/wait/deliver (V)

håndtere- handle/ manage (V)

anledning – occasion/opportunity(N)

religion- religion (N)

sykehus – hospital (N)

virksomhet-firm/operation/activity(N)

konsert – concert (N)

innføre- introduce/ import (V)

tolke- interpret (V)

industri- *industry* (N)

gidde- be bothered (V)

nyte – enjoy (V)

konsentrere – concentrate (V)

understreke –emphasize/underline (V)

transport- transport (N)

avis- newspaper (N)

motstander- opponent (N)

litteratur- litterature (N)

drømme- dream (V)

overføre – transfer/transmit (V)

struktur- structure (N)

landbruk- agriculture/ farming (N)

middel – means/ resource (N)

økning- increase (N)

vindu- window (N)

informere – inform (V)

variant – variant/ version (N)

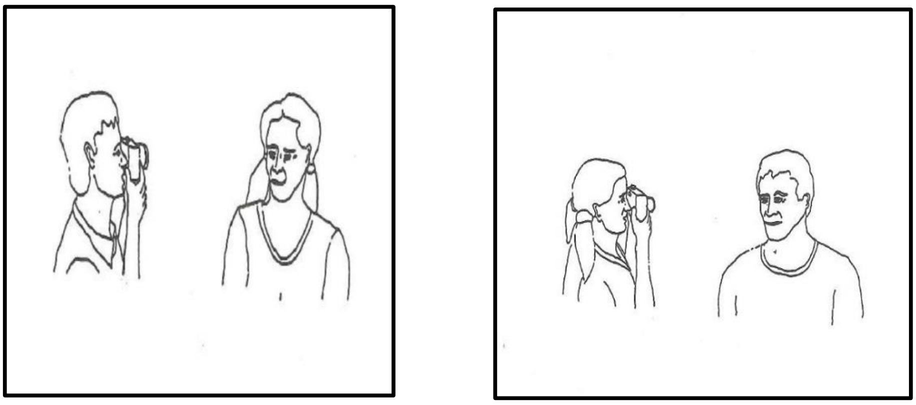
Appendix F: Items on the sentence-to-picture matching task in study III

Test set 1	
Norwegian	**English**
Jenta fotograferer gutten	The girl photographs the boy
Det er barnet damen dytter	It is the child the woman pushes
Det er kua som biter hesten	It is the cow that bites the horse
Jenta bærer mannen	The girl carries that man
Det er damen som truer mannen	It is the woman who threatens the man
Det er gutten jenta kveler	It is the boy the girl strangles
Jenta dytter gutten	The girl pushes the boy
Det er kua hesten biter	It is the cow the horse bites
Det er damen som vasker barnet	It is the woman who washes the child
Mannen klyper damen	The man pinches the woman
Det er hesten som sparker kua	It is the horse that kicks the cow
Det er jenta som filmer gutten	It is the girl who films the boy
Jenta kysser mannen	The girl kisses the man
Det er mannen damen redder	It is the man the woman rescues
Det er gutten jenta fotograferer	It is the boy the girl photographs
Mannen slår damen	The man hits the woman
Det er gutten jenta maler	It is the boy the girl paints
Det er jenta som klorer gutten	It is the girl who scratches the boy

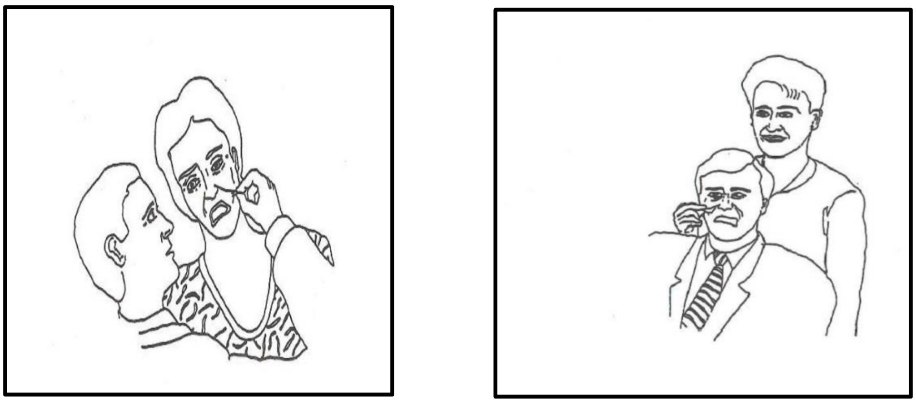
Test set 2	
Norwegian	**English**
Mannen redder damen	the man rescues the woman
Det er barnet damen dytter	It is the child the woman pushes
Det er mannen som bærer damen	It is the man who carries the woman
Mannen truer damen	The man threatens the woman
Det er gutten som kveler jenta	It is the boy who strangles the girl
det er barnet damen vasker	It is the child the woman washes
Gutten klorer jenta	The boy scratches the girl
Det er hesten kua sparker	It is the horse the cow kicks
Det er barnet moren slår	It is the child the mother hits
Hesten biter kua	The horse bites the cow
Det er jenta som fotograferer gutten	It is the girl who photographs the boy
Det er jenta som kysser mannen	It is the girl who kisses the man
Gutten maler jenta	The boy paints the girl
Det er jenta som klyper gutten	It is the girl who pinches the boy
Det er damen mannen filmer	It is the woman the man films

Test set 3	
Norwegian	**English**
Damen vasker barnet	The woman washes the child
Det er jenta gutten klyper	It is the girl the boy pinches
Det er mannen barnet kysser	It is the man the child kisses
Damen kveler mannen	The woman strangles the man
Det er mannen som redder damen	It is the man who saves the woman
Det er damen mannen truer	It is the woman the man threatens
Jenta fotograferer gutten	The girl photographs the boy
Det er gutten som dytter jenta	It is the boy who pushes the girl
Det er gutten som maler jenta	It is the boy who paints the girl
Kua sparker hesten	The cow kicks the horse
Det er barnet mannen klorer	It is the child the man scratches
Det er damen som slår mannen	It is the woman who hits the man
Mannen filmer damen	The man films the woman
Det er jenta mannen bærer	It is the girl the man carries
Det er jenta som biter gutten	It is the girl who bites the man

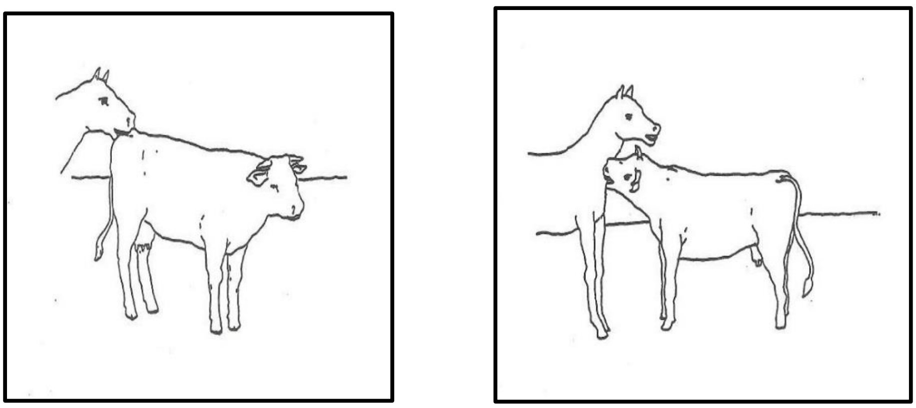
ACTIVE



The girl photographs the boy



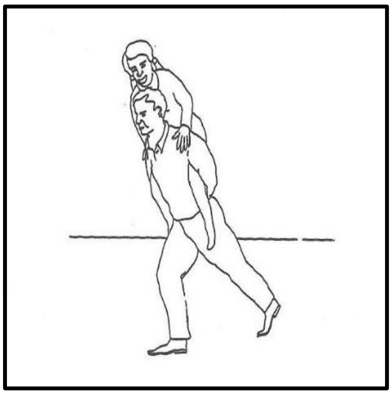
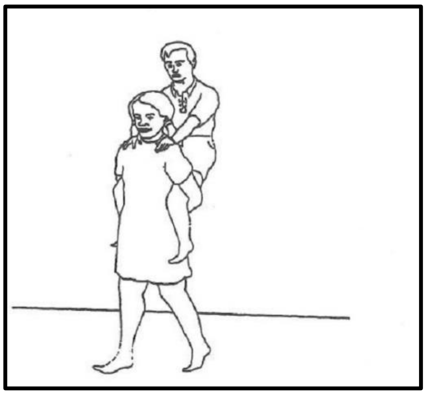
The man pinches the woman



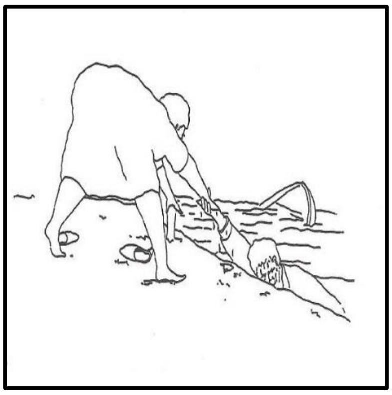
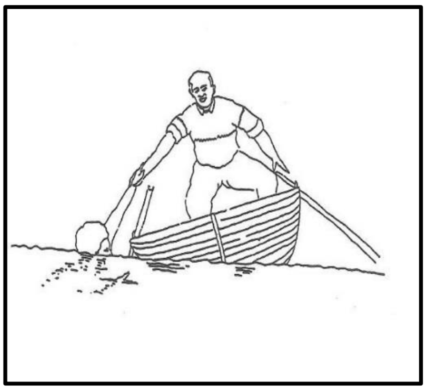
The cow bites the horse

SUBJECT CLEFT


It is the woman who pushes the child

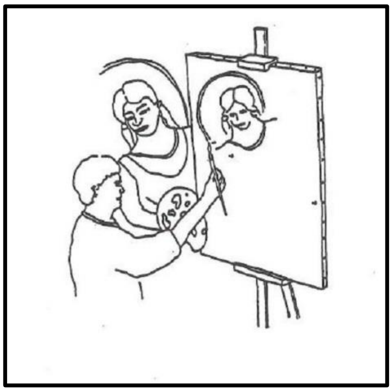
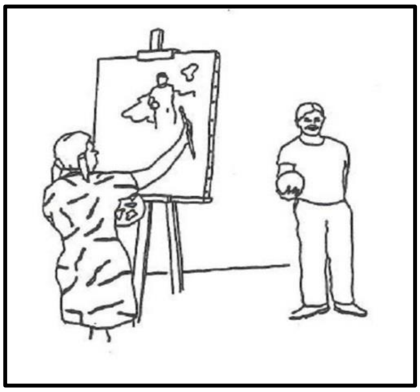



It is the girl who carries the man

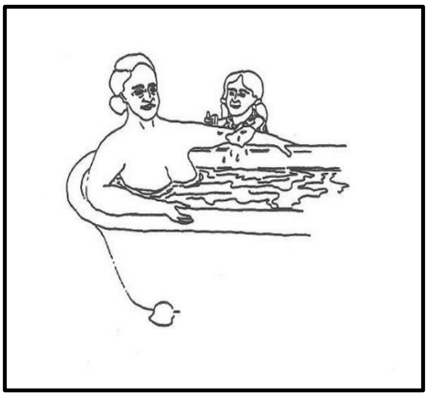



It is the woman who saves the man

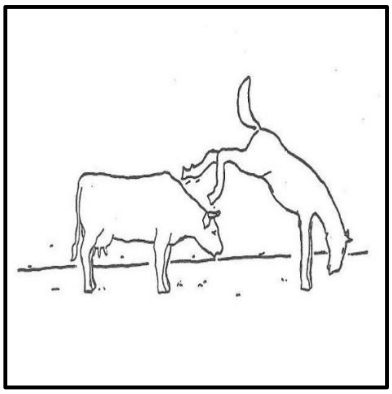
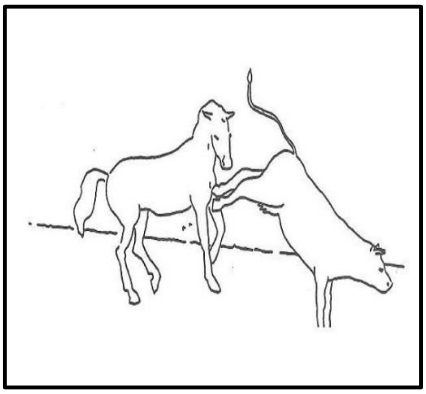
OBJECT CLEFT

It is the boy the girl paints

It is the child the woman washes

It is the horse the cow kicks

Appendix G: Background questionnaire for studies II and III

Questionnaire linguistic and social background

ID:_______________

(Added by test leader)

Date:______________

1. Gender: Are you **male** or **female**? (encircle)

2. Date of birth:

3. Are you **right handed** or **left handed**? (encircle)

4. What is you highest completed education?
   a. Elementary school (7 years)
   b. Middle school (10 years)
   c. High school (12 or 13 years)
   d. Vocational high school (3 or 4 years after middle school)
   e. Undergraduate
   f. Postgraduate
   g. PhD
   h. Total years of schooling______

5. What is your current profession (last profession, if retired)

6. Do you have normal hearning?
   Yes
   No
   a. If no, do you use a hearing aid?
      Yes
      No
   b. If yes, is your hearing normal with hearing aid?
      Yes
      Nno

7. Is your vision normal?
   Yes
   No
   a. If no, do you wear glasses or contact lenses?
      Yes
      No

b. If yes, is your vision corrected to normal with glasses/contact lenses?
   Yes
   No

8. Are you color blind?
   Yes
   No

9. Do you have difficulties with understanding and processing numbers or mathematics?
   Yes
   No

10. Do you have difficulties with reading/writing?
   Yes
   No

11. Have you ever had a brain injury?
   Yes
   No
   a. If yes, what kind of injury?

12. Do you have any known neurological diseases (epilepsi, MS etc.)?
   Yes
   No
   a. If yes, what kind?

13. Do you currently use psychofarmace?
   Yes
   No

14. What is your mothertongue?
   a. Norwegian
   b. Other

   c. If other, which?

15. In which country did you grow up?
   a. Norway
   b. Other

   c. If other, which?
   d. If other, how old were you when you moved to Norway?

16. Have you ever lived in another country than Norway for a period of six months or more?

a. Yes
b. No

c. If yes, which country, for how long and when was this?

17. Which language did you speak in your household when you grew up?
    a. Norwegian
    b. Other

    c. If other, which language and to whom did you speak this?

18. Have you learned any foreign languages in school?
    Yes
    No
    a. If yes, which one(s)?

19. Have you ever learned a foreign language outside of school (i.e., by living in a country where the language is spoken, self studies, language games or programs)
    Yes
    No
    a. If yes, which one(s) and in what manner?

20. Do you ever **speak** other languages than Norwegian in your daily life?
    Yes
    No
    a. If yes, how often?
       Every day
       A couple of times a week
       A couple of times a month
       less

21. Do you ever **read** other languages than Norwegian in your daily life?
    Yes
    No
    a. If yes, how often?
       Every day
       A couple of times a week
       A couple of times a month
       less

22. Do you ever **write** in other languages than Norwegian in your daily life?
    Yes
    No

a. If yes, how often?
   Every day
   A couple of times a week
   A couple of times a month
   less

23. Do you ever **hear** in other languages than Norwegian in your daily life?
    Yes
    No
    a. If yes, how often?
       Every day
       A couple of times a week
       A couple of times a month
       less

24. Range your skills in Norwegian, on a scale from 0-10 for the following activities (tick the box you feel corresponds to your skill level)

	1	2	3	4	5	6	7	8	9	10
Speak										
Understand										
Read										
Write										

25. Compared to a native speaker, range your skills in your foreign languages on a scale from 0-10:

Language:

	1	2	3	4	5	6	7	8	9	10
Speak										
Understand										
Read										
Write										

Language:

	1	2	3	4	5	6	7	8	9	10
Speak										
Understand										
Read										
Write										

Language:

	1	2	3	4	5	6	7	8	9	10
Speak										
Understand										

Read										
Write										

Appendix H: Items on the picture-naming task in study III

Norwegian	English (translation equivalent)
En gris	A pig
Ei dør	A door
En sopp	A mushroom
Ei pil	A dart
Ei geit	A goat
Et hjul	A wheel
En katt	A cat
En blyant	A pencil
Et belte	A belt
Ei tunge	A tounge
Et eple	An apple
En kylling	A chick(en)
En buss	A bus
Et hjerte	A haert
Et tog	A train
Et skjell	A shell
Ei bok	A book
Et brød	A bread
En hval	A whale
En fisk	A fish
Ei flaske	A bottle
En elefant	An elephant
Ei saks	A pair of scissors
Ei tavle	A back board
En vante	A mitten
En kikkert	Binoculars
Ei høne	A hen/chicken
En kjole	A dress
En skilpadde	A turtle
En banan	A banana

Norwegian	English (translation equivalent)
Å klippe	To cut
Å sove	To sleep
Å sitte	To sit
Å huske	To swing
Å stupe	To dive
Å sage	To saw
Å (spille) fløyte	To (play the) flute
Å flette	To braid
Å sykle	To ride a bike
Å filme	To film
Å melke	To milk
Å drikke	To drink
Å plukke (blomster)	To pick (flowers)
Å massere	To give a massage
Å støvsuge	To vacuum clean
Å fiske	To fish
Å danse	To dance
Å file (negler)	To file (nails)
Å bade	To bathe
Å fryse	To freeze
Å kjøre	To drive
Å bokse	To box
Å poste	To mail
Å hoppe	To jump
Å skrive	To write
Å fekte	To fence
Å kjevle	To roll (dough)
Å sy	To sow
Å stryke	To iron
Å trylle	To do magic