

UNIVERZA V LJUBLJANI
SKUPNI INTERDISCIPLINARNI PROGRAM DRUGE STOPNJE
KOGNITIVNA ZNANOST
V SODELOVANJU Z UNIVERZO NA DUNAJU, UNIVERZO V
ZAGREBU, UNIVERZO KOMENSKI V BRATISLAVI IN
UNIVERZO EÖTVÖS LORÁND V BUDIMPEŠTI

KATARINA MARJANOVIČ

**PROCESIRANJE BESED IN PSEVDOBESED PRI
BOLNIKI Z DEMENCO**

Magistrsko delo

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KATARINA MARJANOVIČ

**PROCESSING OF WORDS AND PSEUDO-WORDS IN
PATIENTS WITH DEMENTIA**

Master's Thesis

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Zahvala

Posebej bi se rada zahvalila mojima mentoricama, Christini in Tatjani, za znanje, ki sem ga pridobila z njuno pomočjo, za vztrajno odgovarjanje na moja vprašanja, ter za neutrudno podporo in vodenje pri izdelavi naloge.

Hvala tudi udeležencem raziskave, ki so nekaj svojega dragocenega časa namenili naši raziskavi.

Hvala zaposlenim Nevrološke klinike UKC Ljubljana za vso pomoč pri težavnem iskanju udeležencev z demenco.

Mama, Aljoša, hvala za podporo in pozitivne misli takrat, ko sem jih najbolj potrebovala.

Hvala tudi sošolcem in soplesalcem za neomajni optimizem in spodbudne besede.

Hvala tatu, ki me je naučil vztrajnosti in pozitivnega pristopa k vsaki, še tako težavni, nalogi.

Katarina

PROCESIRANJE BESED IN PSEVDOBESED PRI BOLNIKI Z DEMENCO

Izvleček

V tej magistrski nalogi smo se posvetili procesiranju besed in psevdobesed pri bolniku z Alzheimerjevo demenco. Med zgodnjimi težavami bolnikov z demenco so namreč tudi težave s poimenovanjem in iskanjem besed, kar bi lahko kazalo na izgubo leksikalnih reprezentacij. Cilj magistrske naloge je bil zato ugotoviti, kako ta izguba napreduje.

Problema smo se lotili s pomočjo besed in psevdobesed, ki kršijo različna besedotvorna pravila slovenskega jezika. V ta namen smo uporabili nalogo prepoznavanja besed, ki smo jo predstavili kontrolni skupini mladih udeležencev, bolniku z demenco (Alzheimerjeva demenca) in dvema kontrolnima udeležencema.

Rezultati naše raziskave so pokazali, da je mentalni leksikon bolnice že prizadet in da je njeno poznavanje slovenskih besedotvornih pravil in posledično tudi slovenskega besedišča že v upadu. Kar pa je najpomembnejše, je dejstvo, da tega upada klasičen test za ocenjevanje demence, kot je Kratek preizkus spoznavnih sposobnosti (KPSS), ni mogel zaznati, kar kaže na pomembnost testov, kot je ta, ki smo ga razvili v tej študiji primera.

Ključne besede:

Demenca, jezik, leksikalne reprezentacije, besedotvorje, procesiranje besed, procesiranje psevdobesed, besednovrstne kršitve, kršitve udeleženskih vlog, vidske kršitve.

PROCESSING OF WORDS AND PSEUDO-WORDS IN PATIENTS WITH DEMENTIA

Abstract

In the thesis we focus on word and pseudo-word processing in patients suffering from dementia of Alzheimer's type. One of the early problems of patients with dementia is difficulty with naming and word finding, which could suggest a decay of lexical representations. The aim of the thesis is to find out how this decay progresses and to find out at which stage difficulties occur in patients with dementia.

We approach this issue by using an acceptability task for words and pseudo-words which violate various aspects of word formation in the Slovenian language. The task was presented to a young control group, one patient with dementia (Alzheimer's disease), and to two age- and sex-matched control participants.

The results revealed that the patient's mental lexicon is already in decay and her knowledge of Slovenian word formation rules and vocabulary is degraded. Most importantly, this degradation could not be detected by the standardized cognitive assessments tools, such as the Mini Mental State Examination (MMSE), which indicates that tests like the one developed in our case study could be of a significant importance for diagnostic purposes.

Keywords:

Dementia, Alzheimer's Disease, language, lexical representations, word formation, word processing, pseudo-word processing, thematic violations, aspectual violations, categorial violations.

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1 Introduction

In today's society, dementia has become a frequently diagnosed disease, preventing patients to lead a normal everyday life and affecting language abilities of an individual, which diminishes their possibilities for normal communication. Because of this reason and due to the fact that the number of patients will only grow in the future, dementia is a topic that needs to be studied thoroughly from every possible aspect, including the linguistic point of view. Furthermore, it is exactly the word loss and word processing that can tell us more about the disease course and in this way contribute to our following of the disease from its early stages onward.

For this reason, the main aim of our research was to find out how the decay of lexical representations progresses in patients with dementia. We approached this issue by creating a task with regular words of the Slovenian language and pseudo-words¹, which violate different aspects of the Slovenian word formation rules. With the help of this task, we tried to find the answers to the main questions. Firstly, we were interested in whether the patient will make a clear line between the pseudo-words that violate word formation rules of the Slovenian language and words that do not when compared to the controls. Secondly, we were interested in finding out whether all violated rules will have the same significance for the patient in comparison to the control participants, or whether there will be any signs of degradation of word formation rules and vocabulary.

The thesis is structured as follows. In section 2 the aim and rationale of our research are presented. In section 3 word formation is presented. The section starts with the subsection carrying basic information about morphology, and is followed by the subsection with the description of pseudo-words. At the end of section 3 the Slovenian word formation and its violations are described. The description of word and pseudo-word processing follows in section 4, divided into three subsections. The first two deal with word (subsection 1) and pseudo-word (subsection 2) processing and in the last one the semantic representations are presented. Section 5 deals with dementia. A short general introduction of dementia is followed by the description of Alzheimer's disease in subsection 1, in which language

¹ A pseudo-word is a word formation which resembles regular word of a certain language, but nevertheless has no meaning and is not lexicalized, e.g. **disblunkable* (more detailed explanation of the term will be further developed in section 3.2.).

difficulties connected with this type of dementia are also described. At the end of the section the evaluation of dementia is introduced in subsection 3. These descriptions are followed by section 6, in which the experiment is described. The section is divided into two subsections, the first one describes the first part of our experiment, the normative study, while the second one deals with our case study with the patient with Alzheimer's disease and presents the results and their discussion at the end of the section. In section 7, the general conclusion is presented.

2 Aim and Rationale of the Research

In today's society, dementia is getting more and more frequently diagnosed disease. The disease affects the patients on different levels of their lives, as it affects different cognitive domains, including the language domain (Henderson, 1996; Cummings & Cole, 2002; Grossman et al., 1996; Taler & Philips, 2007; Martin & Fedio, 1983; Altmann & McClung, 2008; Garrard, 2005; Martin & Fedio, 1983; Robinson et al., 1996). For this reason it is very important to study dementia from different points of view, including the linguistic one. Detailed knowledge about word loss and word processing can namely tell us more about the disease course and in this way contribute to our following of the disease from its early stages onward.

The aim of this research was, therefore, to focus on lexical representations in patients with dementia. We were interested in finding the answer to the question on how word loss progresses during the course of the disease. Our research on the progression of word loss in patients with dementia was guided by the following research questions:

- (1) Will the patient make a clear line between the pseudo-words that violate word formation rules of the Slovenian language and words that do not when compared to the control participants?
- (2) Will all violated rules have the same significance for the patient in comparison to the control participants? Are there any signs of degradation of word formation rules and vocabulary?

Following these research questions, we did not only gain an insight in the decay of lexical representations and word loss in patients with Alzheimer's disease, but also in pseudo-word

processing in healthy native Slovenian speakers. Furthermore, this study also represents the first attempt to use the Slovenian language as a diagnostic tool for dementia in Slovenian-speaking populations, which could contribute to the development of a diagnostic tool with higher sensitivity when compared to the one that is in use at the moment.

3 Word Formation

This section introduces the main principles of morphology, description of pseudo-words and their creation, and Slovenian word formation and violations of word formation rules of this language.

3.1 Morphology

Morphology is the area of grammar “concerned with the structure of words and with relationships between words involving the morphemes that compose them” (Carstairs-McCarthy, 2002: 25). The morphemes are the smallest parts of word, which are defined as “the minimal linguistic units with a lexical or grammatical meaning.” (Booij, 2005: 8-9). E.g. the English word *teacher* is composed of two different morphemes, *teach* and *er*. Morphemes are of two types; they can be root morphemes (*teach* in the word *teacher*) or non-root morphemes (*-er* in the word *teacher*). Root morphemes constitute the core of the word and carry the major component of its meaning; they typically belong to a lexical category (usually noun, verb, adjective) and are often free, i.e. they can stand on their own (e.g. as *bird*, *teach* in English). Non-root morphemes or affixes, on the other hand, are necessarily bound to the root with which they form a complex word. Affixes that precede the root are called prefixes (like *en-* in *enlarge*); affixes that follow the root are called suffixes (like *-ness* in *politeness*, and *-able* in *acceptable*) (see figure 1 for tree scheme of prefix, suffix and root morphemes).²

² Besides prefixes and suffixes, languages can also have infixes, which are morphemes that appear inside the word. In English they are relatively rare, but can be found in plural forms of some words, such as *passerby*, which is pluralized with infix *-s-*, *passersby*.

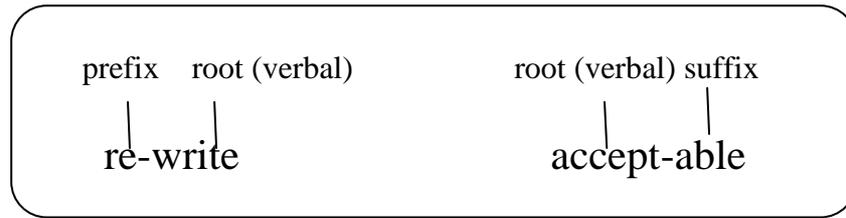


Figure 1: Non-free morphemes (prefix *re-* and suffix *-able*) and free root morphemes (verbal roots *write* and *accept*)

The element to which an affix is added is called the base. In many cases the base is also the root, e.g. in *teacher*, *teach* is a base for *-er* as well as the root. But if the affix is added to a unit larger than a root, then the root and the base do not coincide, e.g. in the word *teachers*, the base for the affix *-s* is *teacher*, which is not a root, but a combination of a root (*teach*) and an affix (*-er*).

3.2 Pseudo-Words

The term *pseudo-word* (sometimes also referred to as *jabberwocky stimuli*) refers to word formation which resembles regular words of a certain language, but nevertheless has no meaning and is not lexicalized.

An example of an English pseudo-words is **blunk*, which does not violate any phonotactic rules³ of English, but nevertheless has no meaning in the English language. Since the word does not violate phonotactic rules, we can also use it to derive a new pseudo-word out of it, following the process of addition or affixation (Matthews, 1993), in which we add affixes to the root, without any violation of the morphological structure of English, since the affixes have the ability of forcing a lexical category on nonexistent roots (Libben, 1994), such as **blunk*. Such example would be the pseudo-word **disblunkable*. The prefix *dis-* and the suffix *-able* can namely both be attached to verbs (Booij, 2005) and in our case of a pseudo-word **disblunkable*, **blunk* takes over a function of a verbal root to which the prefix *dis-* is

³ Phonotactic rules are language specific restrictions which “determine the sound sequences that can appear in a syllable and the positions in the syllable where particular sounds can occur” (Al-jasser, 2008: 95). An example of an English phonotactic rule is that a syllable cannot begin with the consonants *z* and *v* following one another (i.e. *zv-*).

attached (**disblunk*). After the prefix, the adjective-forming suffix *-able* is attached as well, (Booij, 2005, Carstairs-McCarthy, 2002), therefore the newly created word has a form of an adjective, and respects the word formation rules of English. Thus, we can also say that it has a morphological structure of an English word, as represented in the figure 2 (below):

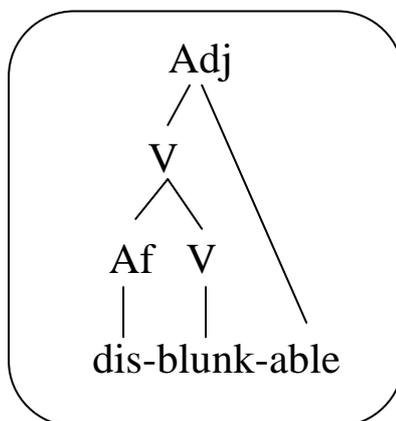


Figure 2: Morphological structure of a pseudo-word (Af- affix, V- verb, Adj - adjective)

On the other hand, pseudo-words can also be created in such a way that they violate word formation rules. An English example of such pseudo-word can be created out of the prefix (*re-*) and suffix (*-able*), which are attached to the noun base *-car-*, i.e. **recarable*. In this example, the base word (*car*) is a proper English noun, therefore the two affixes we used (prefix *re-* and suffix *-able*) cannot be attached to it if we follow word formation rules, since they can only be attached to verbs (Carstairs-McCarthy, 2002). This example from the English language corresponds to the Slovenian examples of pseudo-words with categorial violations, described in detail in section 3.3.1, paragraph (b), which we used in our acceptability task as one of the six different categories of stimuli.

3.3 Slovenian Word Formation

In this section, the focus is on Slovenian word formation rules and their violations, which result in creation of pseudo-words that we used in our off-line task.

Each language has its own word formation rules, which are rules that tell us how to form words in this particular language. In the Slovenian language, words are composed of morphemes and can be simple, i.e. composed of one morpheme, or complex, i.e. composed of

at least two morphemes. Simple words are the ones which cannot be divided into two parts, for example: *in* “and” and *le* “only”, whereas complex words can be divided into at least two constituent parts, e.g.: *mladost* – *mlad-* (root) + *-ost* (suffix) + \emptyset (case ending) “youth”.

There are different types of word formation processes in Slovenian⁴. The most common among them are derivation (and ordinary derivation by prefixation)⁵ and compounding. Derivation is a word formation process which forms a word with a meaning distinct from that of its base through the addition of an affix, e.g. *pis+ec* – *pisec* “writer”, *trdoglav+ost* – *trdoglavost* “stubbornness”. Compounding is a word formation process, where two bases are combined to form a new word, e.g. *zemlj+e⁶+pis* – *zemljepis* “geography”. As mentioned, there are also other types of word formation in the Slovenian language, which are less frequent and not as productive and therefore only briefly mentioned in this thesis (juxtaposition (e.g. *se ve, da* – *seveda* “of course”, “certainly”), truncation (e.g. *gledališč+ški* – *gledališki* “theatrical”), zero derivation (e.g. *dežurni učenec* “student on duty” – *dežurni*), and blends based on orthography – acronyms (e.g. *teritorialna obramba* “territorial army” – *TO*).

For the purpose of this thesis, we focus on one type of word formation – derivation, more specifically on the derivation of nouns with the suffix *-ec* that denote a masculine agent and are derived from verbal bases (e.g. *igralec* “actor”, “player”).

3.3.1 Slovenian Word Formation Violations

In Slovenian (as in morphologically similar languages), not all affixes can be attached to all bases, thus word formation rules have to be followed when a new word is being created, since these word formation rules reflect constraints which exist in a certain language (Manouilidou, 2007). Two examples of such constraints are thematic constraints, which involve word formation rules about relationships concerning agent roles (e.g. suffix *-er* can only attach to

⁴ For details on traditional Slovenian word formation processes and types, which slightly differ from our general description of word formation types, the reader is referred to (Toporišič, 2000).

⁵ In traditional Slovenian linguistics there is also another word formation type, named “ordinary derivation by prefixation” (Toporišič, 2000; Toporišič, 2001) which is a subtype of the classical derivation. In this type of word formation, according to Toporišič’s definition, one element of the word base is replaced with a prefix (e.g. *zelo star* – *prastar* “very old”, *višji škof* – *nadžkof* “archbishop”).

⁶ -E- is an affix with the help of which we connect the two combined bases.

verbal root of a verb in which the subject is also the agent⁷ (e.g. *reader*)), and categorial constraints, which provide word formation rules about lexical category of the base (e.g. the suffix *-able* can only attach to a verbal base, such as *drink* – *drinkable*, but not also to noun base, such as *car* – **carable*). It is important to note that, based on Manouilidou's research done for Modern Greek language (Manouilidou, 2007), the speakers of a certain language are not equally sensitive to these constraints, since, based on her research, thematic constraints are for native speakers of a certain language more violable than categorial ones; in other words, the speakers are more sensitive to categorial violations of word formation rules than to the thematic ones.

If we do not follow these rules, we build a word which might phonologically sound like a word of a certain language, but is in fact not a possible part of its vocabulary – in this case we can talk about word formation violations. In the thesis we focus on three types of these violations, limiting ourselves to the derivation of Slovenian nouns ending in the suffix *-ec*, which is one of the most common suffixes in this type of word formations (Stamljič-Breznik, 1994/95). These violations are: thematic (a), in which there are violations of the basic relationships concerning agent roles (Marvin, 2002), categorial (b), in which the lexical category of the base is inappropriate, and aspectual ones (c), in which specific word formation rules about verbal aspectuality⁸ are being violated (Marvin, 2002). We furthermore also focused on another type of the derivation of Slovenian nouns ending in the suffix *-ec*, which does not violate any word formation rule, but nevertheless still results in creation of pseudo-words, the so-called pseudo-words with blocking (d).

(a) Pseudo-words with thematic violations

Slovenian noun derivatives with the suffix *-ec* can only be derived from verbs in which the subject is the agent of the action described by the verb (Marvin, 2002). Since subjects of the

⁷ Agent of the verb is the person who performs the activity described by the verb, e.g. *reader* – *the person who reads*.

⁸ In the Slovenian language aspect is a property of individual verbs and can be expressed morphologically. In principle, every verb has a pair of a perfective and imperfective verb form. In the perfective verb form, the duration of the action described by the verb is limited in time, and in the imperfective, the duration of the action described by the verb is not limited in time (e.g. *preplavati* – to swim, perfective and *plavati* – to swim, imperfective).

verbs *umirati* “to die” and *viseti* “to hang” in our example are not agents⁹, no such nominalizations can be derived from the verbs of the type investigated in this thesis:

- (1) a. **umiralec* (somebody who is dying, *dyer)
 b. **viselec* (somebody who is hanging, *hanger)

(b) Pseudo-words with categorial violations

Slovenian noun derivatives with the suffix *-ec* can only be derived from a verbal root. In our examples we have *črka* “letter” and *telefon* “telephone”, which are noun roots and therefore violate this rule:

- (2) a. **črkilec* (*letter-er)
 b. **telefonilec* (*telephone-er)

Before continuing with the description of the last type of violation, it is important to note that there is a difference between the morphological analysis of Marvin (2002), which is the one we followed when creating the pseudo-words used for the purpose of this thesis, and Toporišič (2001) in stating to which roots can suffix *-ec* be attached. According to Toporišič (2001) there are several suffixes (*-alec*, *-elec*, *-ilec*, *-ec*), which can be attached to verbal root nouns (root morphemes), denoting the agent of the action (e.g. *igr* + *alec* “actor”, or *mor* + *ilec*, murderer), whereas according to Marvin (2002) the only suffix, which can be used for derivation of this kind of nouns, is *-ec*, which is attached to the verbal base. But in this case, the verbal base is not only a root morpheme, but an *l*-participle¹⁰ (e.g. *igr* + *ec*, “actor”, “player”, or *mor* + *ec* “murderer”).

⁹ Such verbs are unaccusative verbs, in which the syntactic argument of the verb is not a semantic agent of the verb, meaning that it does not carry any responsibility for the action of the verb. Therefore, this kind of verbs can only have non-agent subjects and can only describe involuntary human activities (i.e. *umirati* “to die”) or events, which affect inanimate objects (i.e. *stopiti se* “to melt”).

¹⁰ The term participle denotes a lexical item which is derived from a verb. It has characteristics of verbs as well as adjectives. In the Slovenian language we distinguish the participles that end in *-č* (e.g. *jokajoč* “crying”), *-ši/vši* (e.g. *pozabivši* “forgetting”), *-n* or *-t* (e.g. *skrit* “hidden”, *zamujen* “missed”, “lost”) and in *-l* (*skril* “hidden”) (Toporišič, 2000).

As the difference may not be of great importance when deriving nouns from the verbal base, the significance of it comes into consideration when deriving nouns from the noun base. When we created pseudo-words with categorial violations, denoting the agent of the event expressed by the root, we added the suffix *-ec* to pseudo-participles¹¹, such as for example *telefonil-* (see (2b)), and not to noun *telefon* “telephone”. This way we followed the analogy with the existing derived agentive nouns, where the productive pattern is attaching *-ec* to the verbal base in the form of an *l*-participle of the verbal root and not attaching *-ec* to the root, a pattern that is much rarely found in the language.¹²

(c) Pseudo-words with aspectual violations

In Slovenian, where in general aspect can be expressed morphologically by prefixation or suffixation, every verb has a pair of a perfective and imperfective verb form (e.g. *plavati* “to swim-imp” vs. *preplavati* “to swim-pf” – aspect is expressed by prefixation; *prepisati* “to copy-pf” vs. *prepisovati* “to copy-imp” – aspect is expressed by suffixation). The perfective verb form describes the action as finished or completed, while the imperfective form presents the action as on-going or repetitive. These verbal aspects must be taken into consideration when deriving nouns from verbs. Slovenian noun derivatives with the suffix *-ec* can only be derived from the imperfective forms (Marvin, 2002), such as e.g. *plavati* “to swim-imp” – *plavalec* “swimmer” and *moriti* “to murder-imp” – *morilec* “murderer”, but not from the perfective forms (*preplavati* “to swim -pf” and *umoriti* “to murder-pf”), as illustrated in (3):

- (3) a. **preplavalec* (*noun, derived from the perfective form of a verb to swim)
 b. **umorilec* (*noun, derived from the perfective form of a verb to kill)

¹¹ These pseudo-participles have the same form as regular participles, but the corresponding verbs do not actually exist (e.g. *jadril-*).

¹² When creating this type of pseudo-words, we decided to take the verbal base with the vowel *-i-* as a default form. The reason for this decision was due to the fact that a few verbal roots in a similar type of nominalization (denoting a kind of instrument used in the action denoted by the verb) take the theme vowel *-i-* instead of the one that we would expect them to take according to the verbal base (e.g. *barvati* – *barvilo* “to colour” – “pigment”, *rezati* – *rezilo* “to cut – blade”), making *-i-* a default theme vowel.

(d) **Pseudo-words with blocking**

In the thesis we did not only focus on different types of violations which are described above, but we also created another type of pseudo-words, which do not violate any word formation rule of the Slovenian language, but nevertheless do not exist in Slovenian vocabulary, since there is another word lexicalized and in usage to describe the particular masculine agent:

(4) a. **risalec* (could be a word for “a drawer”, but in the Slovenian language we have the word *risar* for this masculine agent)

b. **kuhalec* (could be a word for “a cook”, but in the Slovenian language we have the word *kuhar*).

The term blocking, used in our naming of this kind of pseudo-words, refers to linguistic situations in which existence of one form (in our case of a lexicalized word of Slovenian, e.g. *kuhar*), prevents the existence of another form, which would be otherwise expected (in our case, these are the pseudo-words with blocking, e.g. **kuhalec*) (Embick, 2007).

4 Word and Pseudo-Word Processing

4.1 Word Recognition and Word Processing

As this thesis deals not only with pseudo-words, but also with real words, a model of word recognition as proposed by Rumelhart and McClelland (1982) is presented in this section.

The findings suggest that word recognition is an automatic process which does not necessarily depend on conscious awareness (Cheesman & Merikle, 1984; cited in Eysenck and Keane, 2010). This assumption comes from the Stroop effect¹³ while performing the Stroop task¹⁴, which suggests that word meaning can be obtained even when people are consciously trying not to process it.

¹³ The Stroop effect is “the finding that naming of the colours in which the words are printed is slower when the words are conflicting colour words (e.g., the word RED is printed in green)” (Eysenck and Keane, 2010: 639).

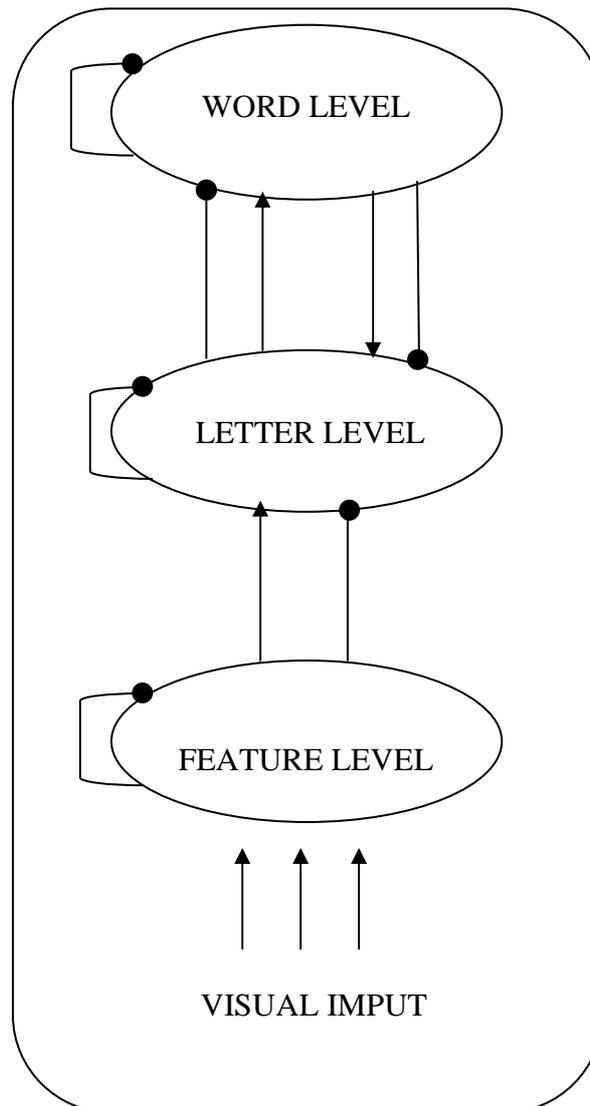
¹⁴ A Stroop task is “a task in which the participant has to name the colours in which the words are written” (Eysenck and Keane, 2010: 639).

Let us now turn to the description of this automatic process. Rumelhart and McClelland (1982) proposed a model of visual word processing, called *the interactive activation model*. The model is based on the assumption that bottom-up and top-down processes interact, thus enabling the information to flow in both directions at once: from lower to higher levels and from higher to lower levels. This proposal of information feedback explains how knowledge of a higher level unit (such as, for example, word), can affect the processing of a lower level unit (e.g. letter).

According to the interactive activation model, word processing is organised into three levels (1) *the feature level*, (2) *the letter level* and (3) *the word level*, each of them consists of a set of units (nodes) – one for each possible element at a particular level (e.g. word level consists of a set of word nodes, letter level consists of a set of letter nodes, one for each letter in each position within the words, and feature level consists of a node for each possible feature¹⁵ at each letter position). Each node is associated with a momentary activation, and the degree of the activation corresponds to the strength of the assumption that the presented input contains a particular unit. The more active node is and the less active other, mutually exclusive nodes, are, the more likely it is for the system to report that visual input contains a unit the node stands for. When a threshold of the activation level of a node is exceeded, this node excites other nodes with which it is consistent (e.g. an initial *n* is consistent with the word *node*) and inhibits all other nodes, with which it is not consistent.

The described system is activated when a string of letters is presented to the visual system. First, a feature in a letter is detected (level 1), and all letter units containing the feature, are activated and all other letter units are inhibited. At the second level (2) the letters are identified. When the identification takes place, the activation is sent to the third level (3) for all letter units of the appropriate length that contain the recognized letter at that particular position within the word, and inhibition is sent to all other word units. At this level – word level – words are recognized and activated word units increase the activation level in the level 2 (the letter level) for all the letters that form the recognized word (Rumelhart & McClelland, 1982).

¹⁵ A feature of a letter is, for example, a horizontal line at the left side of the letters N, H or M.



Scheme 1: Interactive Activation Model, scheme adapted from Rumelhart & McClelland (1982).

As the authors of the model suggested, there seem to be two different mechanisms responsible for word and pseudo-word processing: one, which they named “word mechanism”, which is engaged automatically if the presented visual stimulus is a word, and another one, “pseudo-word mechanism”, which is engaged only when pseudo-words are presented. However, their model gives no proposal how pseudo-words are processed. Therefore, for the purpose of this thesis, we adopt Libben’s model of pseudo-word processing (Libben, 1994), which is presented in more detail in the following section (4.2).

4.2 Pseudo-Word Processing

In this part we introduce Libben's model (Libben, 1994) of pseudo-word processing and we add the upgrade to the model as proposed by Manouilidou (2007). Libben (1994) proposes that pseudo-word processing occurs in four different stages. We will describe this four-stage process on the example of the English pseudo-word **disblunkable*, a pseudo-word which respects the word formation rules of English and is described in more detail in section 3.2.

At the first stage the scanning of the string from left to right takes place, during which all lexicalized substrings are being exposed (such as *dis-blunk-able*). Manouilidou adds that this is the stage at which all the non-words¹⁶ are being rejected (Manouilidou, 2007). At the second stage morphological computation takes place, at which interpretable structures are created from lexical substrings (*dis-[blunk-able]* and *[dis-blunk]-able*). According to Manouilidou (2007), this is the stage at which pseudo-words with categorial violations are being rejected. She also adds that between this Libben's stage and before his third stage, there is also a stage 2a, where thematic processing¹⁷ of a word takes place. At the third stage an interpretation for each of these representations occurs, in which the combination *[dis-blunk]-able* would evoke a meaning of “not to blunk”, while the combination *dis-[blunk-able]* would give no interpretation. The prefix *dis-* can namely only be attached to verbs, but not to adjectives; and in our example of the pseudo-word *blunkable*, the pseudo-word has the form of an adjective, therefore the combination with the prefix *dis-* fails to give an interpretation (cf. suffix *-able* in the first combination can be attached to verbs, and the pseudo-word *disblunk* has a form of a verb therefore the pseudo-word *disblunkable* evokes the meaning as described above). And lastly, at the fourth stage, the speaker chooses between the two interpretations: the speaker prefers *[dis-blunk]-able*, the combination that gave some kind meaning at the previous stage, rather than the other combination (Manouilidou, 2007).

¹⁶ The term non-word refers to words, which do not exist in the particular language and do not carry any meaning. They can either follow the phonotactic rules of a particular language and are thus pronounceable in that language (e.g. **blunk*) or they can violate the phonotactic rules (e.g. **ghxyzxd*).

¹⁷ Thematic processing denotes the assignment of thematic roles, such as agent, patient, or location, to the words, phrases or sentences.

LIBBEN	LIBBEN		MANOUILIDOU
STAGE	PROCESSING	EXAMPLE	
1	scan of the string from left to right; all lexicalized substrings are being exposed	<i>dis- blunk-able</i>	non-words are rejected
2	morphological computation takes place; interpretable structures are created from lexical substrings;	<i>dis-[blunk-able]</i> and <i>[dis-blunk]-able</i>	pseudo-words with categorial violations; stage 2a: thematic processing of a word
3	interpretation for each of these representations	<i>dis-[blunk-able]:</i> no interpretation VS. <i>[dis-blunk]-able:</i> not to blunk	
4	the speaker chooses between the two interpretations	<i>[dis-blunk]-able</i>	

Table 1: 4-stage model of pseudo-word processing, as suggested by Libben (1994) and upgraded by Manouilidou (2007).

Quite a lot is known about pseudo-word processing in healthy individuals, but not so much is known about this processing in dementia patients, who, as will be described in more detail in section 5.1.1., exhibit severe language difficulties. For exactly this reason, we focus on this particular area and try to find out whether these patients exhibit difficulties in pseudo-word processing, which could suggest a decay of lexical representations in these patients. In this way we combine the findings of neuroscience with the findings in the field of linguistics. Up until this point, our focus has been mostly on linguistics, but in the following paragraphs we move on to the field of neurology.

5 Dementia

Dementia is increasingly common diagnosis in today's aging society and due to the aging population the numbers are only expected to grow in the coming years (Grossman et al., 2006) and even to nearly quadruple in the next 50 years (Cummings & Cole, 2002). The essential feature of this disease, as defined by DSM-IV-TR (The Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders) diagnostic criteria (APA, 2000), is "the development of multiple cognitive deficits that include memory impairment and at least one of the following cognitive disturbances: aphasia, apraxia, agnosia, or disturbance in executive functioning." (APA, 2006: 148) This kind of cognitive decline and unusual behaviour, which marks the disease, prevents the patients from leading a normal life (Fadil et al., 2009).

Among common difficulties connected with dementia are also language difficulties. These appear early in the disease course and can be observed in different forms of dementia. In this thesis, we focused on language difficulties connected with one type of dementia, Alzheimer's disease, which will be described in more detail in the section 5.1.

5.1 Alzheimer's Disease

Alzheimer's disease (AD) is the most prevalent form of dementia (Henderson, 1996; Altmann & McClung, 2008). It is a progressive neurodegenerative disorder that gradually robs the patient of cognitive function and eventually causes death (Cummings & Cole, 2002, Fox et al., 1998), which typically follows 6-8 years after the diagnosis (Fox et al., 1998).

The distribution and progress of damage in this type of dementia varies considerably; however, a typical progression of it has been nevertheless defined (Altmann & McClung, 2008). At the early stage of the disease the damage can be noted in entorhinal cortex and hippocampus, areas which are involved in encoding of new memories (Braack, 1997; Thompson et al., 2003) With the progression of the disease, the signs spread to adjacent cortical structures – the inferior temporal lobe, the temporo-occipital junction, and the temporoparietal junction (Braack, 1997; Thompson et al., 2003), regions, impairments of which usually lead to the loss of word knowledge and concepts underlying these words

(Altmann & McClung, 2008), suggesting that semantic representations¹⁸ crucial for meaningful language are distributed also across these brain regions, whose damage (i.e. damage to one or more components of the semantic memory¹⁹) results in distinct impairments, which are notable in dementia and aphasia (Antonucci & Reilly, 2008).

Even if the typical progression of this type of dementia has been defined, different subtypes of Alzheimer's disease still exist, since the spread of the disease varies across individuals. Therefore, in some cases, the disease pathology results in visual variant AD, when it takes a slightly more posterior route. In this case the occipital region of the brain is more affected, which results in difficulties with visual perception and spatial cognition. In other cases, the brain damage is most severe in the perisylvian region, resulting in condition very similar to progressive nonfluent aphasia. Therefore, it is important to note, that, similarly to aphasia, different difficulties, connected with this type of dementia, depend on the location and on the extent of cortical damage (Altmann & McClung, 2008).

Nevertheless, typical difficulties can be marked for this type of dementia, as patients with Alzheimer's disease experience difficulties in various cognitive domains (Taler & Philips, 2007). The most notable symptoms are decline of the episodic memory (Altmann & McClung, 2008; Taler & Philips, 2007; Fox et al., 1998), executive function (Albert, et al., 2001; Daly et al., 2000), perceptual speed (Albert, et al., 2001; Fox et al., 1998), visuospatial skills (Albert, et al., 2001; Fowler et al., 2002), and attention (Rubin et al, 1998; Tierney et al., 1996; both cited in Taler & Philips, 2007).

5.1.1 Language Profile of Patients with Alzheimer's Disease

Virtually all patients with this type of dementia also exhibit language difficulties (Henderson, 1996), as the disease is marked also by progressive language disorder, which begins with anomia and progresses to fluent aphasia during the disease course (Cummings & Cole, 2002).

¹⁸ When talking about loss of word knowledge, concepts and the impaired access to word meaning (damage which is notable in, e.g. dementia or aphasia), the lexical knowledge is also semantic knowledge (Antonucci & Reilly, 2008).

¹⁹ Semantic memory stores our organized general knowledge about the world. Its content can be extremely varied, and it also includes information about language (Eysenck & Keane, 2010).

The language difficulties connected with this type of dementia can be observed in verbal fluency (Grossman et al., 1996; Taler & Philips, 2007), single word comprehension (Grossman et al., 1999; Martin & Fedio, 1983), repetition (Grossman et al., 1996), in category membership judgments of single words, and in discriminating between the target category and semantically related foils (Grossman et al., 1996). Furthermore, these patients also relatively frequently use semantic paraphasias (substitution of an intended word for another word, which is related to the intended word; e.g. using *cat* for *dog* – the intended word *dog* belongs to the same category as the substitution word *cat*), which affect open class words (nouns, verbs) (Kempler, 1987 in Altmann & McClung, 2008), and they also exhibit difficulties in confrontation naming (Taler & Philips, 2007; Henderson, 1996; Grossman et al., 1996), particularly of biological items (e.g. *cat* as opposed to *table*), where semantic knowledge plays an important role (see section 4.3 for more details on semantic knowledge and representations) (Martin & Fedio, 1983), whereas their difficulties with naming man-made objects, such as tools (e.g. *hammer*), is less severe (Garrard, 2005; Martin & Fedio, 1983).

These different processes which occur during the performance of a naming task can be disrupted either at linguistic or at nonlinguistic level (Henderson, 1995; cited in Henderson, 1996), however, most naming errors in patients with AD appear within lexical semantic domain (Martin & Fedio, 1983), and they typically occur early in the disease course (Cummings & Benson; 1989; Huff, 1990; both cited in Taler & Philips, 2007).

As some studies suggest, AD patients exhibit more significant deficit in naming verbs (e.g. *run*) compared to nouns (e.g. *table*) (Robinson et al., 1996). In his study (Robinson et al., 1996), Robinson proposes three possible explanations for this difference in impaired naming for verbs and nouns. The first proposed explanation is that this could be due to the difference between verbs and nouns in their meaning representation in semantic memory. Verbs are namely associated with more grammatical features than nouns, and this grammatical weight could selectively impair verb usage in a patient with AD. Other proposed explanations are that this difference could be due to impaired retrieval from the output lexicon, which is organized into major form classes, or due to a different mental representation of verb and noun meaning (Robinson et al., 1996).

Further language difficulties of patients with AD can also be observed on discourse level processing, while their syntactic and phonological abilities mostly remain preserved (Taler & Philips, 2007). Also their sentence comprehension is relatively well preserved, but they do

exhibit some difficulties with processing of grammatically complex phrase structures which appear in longer sentences (Grossman et al., 1996). Namely, in longer discourses, as pointed out by Altman and McClung (Altmann & McClung, 2008), sentence comprehension requires working memory, which is in AD impaired early in the disease course, because of the loss of neural connections between posterior language areas and frontal regions of the brain, which support working memory (Altmann & McClung, 2008).

5.2 Semantic Representations

The language difficulties exhibited by dementia patients, which were described in detail in previous section, usually result from the impairment of semantic/lexical representations. In this section we briefly explain how semantic representations are organised in our brain, before moving to a more detailed description of Alzheimer's disease and language difficulties, connected to this type of dementia.

Contemporary views on semantic representations claim that these representations and semantic memory in general are a dynamic system, whose multiple components are distributed across a large network of cortical regions (Altmann & McClung, 2008; Antonucci & Reilly, 2008). This complex network encodes everything a person knows about a particular concept, including information about language (Plaut, 1996; Eysenck & Keane, 2010).

Semantic features of the above described network follow a similar principle as neurons: if two different features are activated at the same time, a connection between them is formed. How strong this connection would be depends on the frequency of the two particular features being activated at the same time – the higher the frequency of simultaneous activation is, the stronger is the connection between the two features (Altmann & McClung, 2008). What is also important to note is that semantic features are often shared by different representations for different words, particularly of the words belonging to the same category (Plaut, 1996; Eysenck & Keane, 2010). Such example would be semantic representations for mammals. Most of them are likely to include the features such as *has legs*, *has ears*, *has fur*, therefore the connections between these features are strong, as they co-occur in many different words (Randal et al., 2004). This kind of connections and shared features are the basis for formation of semantic categories (Tyler & Moss, 2001; Altmann & McClung, 2008). However, shared features do not only include the same features, but also distinguishing features, which help in differentiating between related items within a specific category. Such example would be the

features *has a mane* and *has stripes*, which differentiate *lion* from *tiger* (Plaut, 1996, Altmann & McClung, 2008).

Alzheimer's disease affects these semantic representations on two different levels: at first the connections between features are weakened, followed by the loss of individual features as the disease progresses (Gonnerman et al., 1997; Altmann & McClung, 2008). This suggested pattern of loss of semantic/lexical representations is also supported with the fact that patients with AD often exhibit difficulties in naming biological items (see also section 5.1.1), compared to no or less severe difficulties in naming tools and other man-made things (Gonnerman et al., 1997; Martin & Fedio, 1983). Different studies have namely revealed that there is a smaller proportion of distinguishing features in representations of living things, whereas these features of tools and other man-made things have a bigger proportion of distinguishing features (Altmann & McClung, 2008). Therefore, when distinguishing features of biological items are lost, only shared features remain available, which leads to semantic errors (Altmann & McClung, 2008).

5.3 Evaluation of Dementia

In the last three sections we described language difficulties connected with dementia, but we did not mention how this disease is evaluated. Thus, the description of the most common evaluation of dementia is introduced in this section.

In the evaluation of dementia, the Mini-Mental State Examination (MMSE)²⁰ is widely and most commonly used. This test is very useful in detecting dementia in those patients in which cognitive impairment is suspected and it also aids in quantifying the severity of impairment as the disease progresses. Following the general rule, the scores in the range from 0 to 10 are marked as severe cognitive impairment, whereas scores between 11 and 20 correspond to moderate impairment, scores between 21 and 25 to mild impairment, and scores between 26 and 30 to questionable impairment or intact functioning (Mungas, 1991).

However, there have been some suggestions that even if the specificity of the MMSE examination is good, its sensitivity is poor, which means that the test will not be able to detect an important percentage of dementia patients (Cummings & Cole, 2002). This suggestion has

²⁰In Slovenian speaking populations the Slovenian version of MMSE is in usage under the name *Kratek preizkus spoznavnih sposobnosti* (KPSS) (Granda, Mlakar in Vodušek, 2003).

been supported also by evidence that 5% of probable Alzheimer's disease patients from the ADDTC (Alzheimer's Disease Diagnostic and Treatment Centres) database had a MMSE scores greater than 25. Even if this percentage is relatively small, it nevertheless indicates that solely a high MMSE score cannot rule out dementia in general nor can it rule out Alzheimer's disease in particular (Mungas, 1991).

So far we introduced the word formation and its rules, continued with words and pseudo-words processing and described Alzheimer's disease and language profile of the patients with this disease. We used all this theoretical background when designing the experiment, based on pseudo-word recognition, which is to be described in more detail in the following sections.

6 The Experiment

6.1 Rationale

The main goal of our research was focused on lexical representations in patients with dementia, since we were interested in investigating the question on how word loss progresses during the course of the disease. We have decided to focus on pseudo-word processing when pursuing this goal because a lot is known about pseudo-word processing in healthy individuals, but not so much is known about this processing in dementia patients. We believe that finding out whether these patients exhibit difficulties in pseudo-word processing could aid in understanding the decay of lexical representations in these patients.

6.2 Research Questions

Our research on progression of word loss in patients with dementia was guided by the following research questions:

(1) Will the patient be able to differentiate between pseudo-words that violate word formation rules of the Slovenian language (e.g. **umorilec*, **črkilec*) and words that do not violate any rules (e.g. **risalec*, *igralec*) when compared to healthy control participants?

(2) Will all the violated rules have the same significance for the patient in comparison to the control participants? Are there any signs of degradation of word formation rules and vocabulary?

6.3 Hypotheses

Based on the findings of a previous research for Modern Greek (Manouilidou, 2007), which dealt with processing of pseudo-words in healthy speakers of Modern Greek, we expected that the control group will show a continuum in the acceptance/rejection rates of pseudo-words, starting with massively rejecting pseudo-words with categorial violations (e.g. **črkilec*) and being more flexible in accepting pseudo-words with thematic violations (e.g. **viselec*) (i.e. positive answers that the pseudo-word could belong to the Slovenian vocabulary). What we also expected was that the participant would be equally flexible in accepting aspectual violations (e.g. **preplavalec*) as well, even if this assumption is not based on previous research (i.e. research for Modern Greek did not include this type of stimuli), since this category of violations is somewhat similar to thematic violations, as these violations are both based on the verbal category of the base.²¹ However, a different pattern was expected for the patient, who was expected to accept more pseudo-words as possible words, thus, making more errors, since his/her lexical representations will already be in decay.

To sum, the hypotheses were following:

(1) Hypothesis 1:

The control group of healthy elderly participants will show a continuum in the acceptance/rejection rates of pseudo-words, starting with massively rejecting pseudo-words with categorial violations (e.g. **jadrilec*, **črkilec*) and being more flexible in accepting pseudo-words with thematic (e.g. **bolelec*, **sovražilec*) and aspectual violations (e.g. **pogasilec*, **ulovilec*).

²¹ In aspectual violations we derived a noun ending with *-ec* from a perfective verb form, whereas, when following word formation rules of Slovenian, such nouns can only be derived from the imperfective forms. In thematic violations, we derived the noun from verbs in which the subject was not also the agent of the action described by the verb, whereas according to word formation rules these nouns can only be derived from verbs in which the subject is also the agent of the action.

(2) Hypothesis 2:

The patient with dementia is expected to accept more pseudo-words as possible, thus, making more errors, when compared to the control group.

6.4 Methodology

In order to test the above hypotheses and to find the answers to our research questions, we have decided to create an acceptability task in which we presented stimuli belonging to six different categories. The study was conducted in two phases. In the first phase, the normative study took place in order to decide about the final list of stimuli, based on judgments of native speakers of Slovenian. The results of this study were taken into consideration when performing the second phase of our research, the case study with the AD patient and two control participants. These two different phases are presented in detail in the following sections.

6.5 Phase 1: Normative Study

6.5.1 Aim

The aim of the first phase of our study was to test the selected stimuli. These were tested on a group of young participants, native speakers of Slovenian, for normative purposes: based on their judgements about words and pseudo-words and their belonging to the Slovenian language, we made a decision about the final list of stimuli, which was used in the second phase of the study.

6.5.2 Acceptability Task

The participants were presented with a list of 180 selected stimuli. For each of the stimuli, they had to provide a “yes” or “no” answer, indicating whether or not the presented word belongs to the Slovenian vocabulary. In case they thought it did, they were also asked to provide the meaning of this word. The example of the test, showing 6 different stimuli is presented in the table 2:

	DA	NE	POMEN
posekalec	DA	NE	
umiralec	DA	NE	
tekalec	DA	NE	
cepilec	DA	NE	
skakalec	DA	NE	
ležalec	DA	NE	

Table 2: An example of the test with 6 stimuli

6.5.3 Stimuli

Before creating the stimuli used in our acceptability task we studied the rules of Slovenian word formation for masculine agents (Toporišič, 2000; Stramljič-Breznik, 1994/95) and the related work in theoretical linguistics (Marvin, 2002), focusing on noun derivation for masculine agents with the suffix *-ec*. We have later broken these rules into three different levels, thus creating three different groups of words with thematic, categorial and aspectual violations (for a detailed explanation and examples of these violations, see section 3.3.1).

We also added a group of words, the so-called blocking words, which do not violate any of the above described rules, but nevertheless do not exist in Slovenian vocabulary (e.g. **risalec*, which could be a word for “drawer”, **kuhalec*, which could be a word for “cook”; see section 3.3.1, paragraph (d) for more detail). At the end we also added a group of common Slovenian words for masculine agents (e.g. *bralec* “reader”, *igravec* “actor”, “player”, *občudovalec* “admirer”), which do not violate any word formation rules, and also a group non-words, which sound similar as common words in the Slovenian language as they follow the phonotactic rules of Slovenian, but nevertheless do not exist in the Slovenian language and do not carry any meaning (e.g. *dovina*, *lastje*).

In each group we selected a pool of 30 items, which were chosen according to their frequency (we made sure that the arithmetic mean of the frequencies is more-or-less similar in all the

word groups), tested in the Corpus of the Slovenian language FidaPlus (Korpus slovenskega jezika FidaPLUS). This was of particular importance especially in the category of regular words for masculine agents, since it enabled us to include only the stimuli which are well known among all generations of the Slovenian speaking population and have a high frequency of usage in everyday language and thus no new words, e.g. connected to technology, were used. Since pseudo-words are not part of vocabulary of a certain language, we could not test them directly by inserting them into the corpus. Therefore, we used the closest lexicalized word on which the pseudo-word/violation was based.

Following this principle, we used the infinitive form of verbs to check out the stimuli belonging to the category of pseudo-words with thematic violations (e.g. for a pseudo word **umiralec*, “*dyer”, we looked up an infinitive form of a verb *umirati*, “to die”). The same verb form was used also to check out the stimuli, belonging to the category of words with blocking (e.g. for **risalec*, we looked up *risati*, “to draw”). But for the other two categories of violations we used nouns in the nominative case: in this way, we checked out the stimuli belonging to aspectual (e.g. for the pseudo-word **preplavalec*, we looked up the noun *plavalec*, “swimmer”) and categorial violations (e.g. for the pseudo-word **travilec*, we looked up the noun *trava*, “grass”). The frequencies for regular Slovenian words were tested easily, since we could test them directly by inserting them into the corpus, whereas for the non-words, we could not check their frequency, since they are non-existent and do not have a lexicalized word on which they could be based.

The pseudo-words, selected in the way described above, were used to form an acceptability task. In this task we focused on the patterns of rejection/acceptance for the presented pseudo-words, in which we took into consideration the type of violation. We showed the participants the list of words and pseudo-words and asked them whether the presented word is a Slovenian word or not. Samples of the stimuli, their characteristics and mean frequencies and roles can be found in Table 3:

<i>Type of stimulus</i>	<i>Characteristics</i>	<i>Example</i>	<i>Mean frequency</i>
Pseudo-words with thematic violations	violations of the basic relationships concerning agent roles	*počivalec (*rest-er) *rumenelec (*become-yellow-er)	2290,5
Pseudo-words with categorial violations	lexical category of the base is inappropriate	*črkilec (*letter-er) *travilec (*grass-er)	2366,53
Pseudo-words with aspectual violations	violation of specific word formation rules about verbal aspectuality	*preplavalec (*noun, deriving from a perf. form of a verb “to swim”) *umorilec (*noun, der. from a per. form of a verb “to kill”)	2090,27
Words with blocking	do not violate any of the above described rules; but do not exist in Slovenian vocabulary	*risalec (could be a word for “a drawer”, but a word <i>risar</i> exists for this meaning) *kuhalec (could be a word for “a cook”, but a word <i>kuhar</i> exists for this meaning)	2440,93
Words for masculine agents	words which are part of Slovenian vocabulary	<i>igralec</i> (actor) <i>občudovalec</i> (admirer)	2698,77
Non-Words	Nonexistent in Slovenian language	*dovina *lastje	0

Table 3: Samples of stimuli used in the study

6.5.4 Participants

In the first phase of our research we included 20 young Slovenians, selected by stratified sampling from the population of 18 to 40 years of age. Before taking the test, the participants

had to provide four basic pieces of information about themselves: age, gender, languages that they speak and years of their formal education. All of the young participants were aged from 19 – 40 (M age: 27.3), 11 of them were men and 9 women, all of them had 13 or more years of education (M years of education: 16.3).

6.5.5 Analysis and results

The data were first analysed in Microsoft Excel. We first sorted the stimuli according to their type, since they had been randomized before we presented them to the participants. The participants' correct answers ("yes" for real words and "no" for non-words and pseudo-words) were transformed into 1, and the wrong ones into 0 ("no" for real words and "yes" for non-words and pseudo-words). In this way we were able to calculate the percentage of acceptance for each presented word. We also calculated error percentage in each of the five different types of stimuli.

From the participant's answers, transformed in this manner, we used the Microsoft Excel program in order to calculate the acceptance rates (percentages of accepted words and pseudo-words as possible ones, see diagram 1), for six different types of presented stimuli. The results were as follows in Table 4:

	W-X	Pseudo-Block	Pseudo-Asp	Pseudo-Them	Pseudo-Cat	Non-W
young controls	98,40%	5,20%	2,10%	1,90%	0,86%	0,50%

Table 4: The acceptance rates for young controls

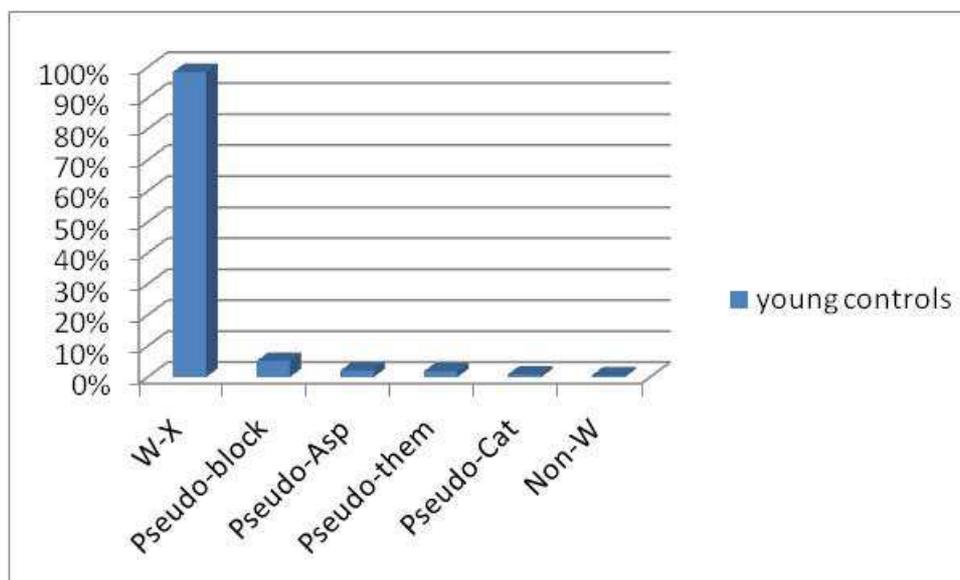


Diagram 1: Acceptance rates for young controls, tested for normative purposes

The acceptance rates (AR) revealed that the young controls accepted only real Slovenian words for masculine agents (e.g. *storilec*), and rejected all the pseudo-words with violations (see Table 4 for acceptance rates). The only exception was the category of words with blocking (e.g. **pekalec*) with no word formation violation, which had a slightly higher acceptance rate, and for which the statistically significant difference was revealed. We namely carried out a Paired Samples t-test at the end, which enabled us to compare the results of young controls between the six different categories of stimuli, and thus to compare the sensitivity of the young controls to different word-formatting rules. When comparing the results, we were comparing the correct answers, i.e. “no” for all the pseudo-words (pseudo-words with thematic, aspectual and categorial violations, pseudo-words with blocking) and non-words, and “yes” for the real words. The results were as follows in Table 5:

Compared categories	SD	Df	t-scores	p value
Non-W vs Pseudo-Block	1,531	19	-3,943	0,001
Non-W vs Pseudo-Asp	1,429	19	-1,252	0,226
Non-W vs Pseudo-Them	0,786	19	-1,422	0,171
Non-W vs Pseudo-Cat	0,788	19	-,567	0,577
Non-W vs W-X	0,616	19	-1,453	0,163
Pseudo-Block vs Pseudo-Asp	1,504	19	-2,826	0,011
Pseudo-Block vs Pseudo-Them	1,483	19	3,317	0,004
Pseudo-Block vs Pseudo-Cat	1,251	19	4,467	0,000
Pseudo-Block vs W-X	1,785	19	2,881	0,01
Pseudo-Asp vs Pseudo-Them	1,461	19	,459	0,651
Pseudo-Asp vs Pseudo- Cat	1,593	19	,842	0,41
Pseudo-Asp vs W-X	1,508	19	,593	0,56
Pseudo-Them vs Pseudo- Cat	1,089	19	-,616	0,545
Pseudo-Them vs W-X	1,508	19	,237	0,815
Pseudo- Cat vs W-X	1,119	19	-,400	0,694

Table 5: Comparison (Paired Samples t-test) of six presented categories of stimuli for young controls

6.5.6 Outcome

The presented results indicate that young controls made a clear line between pseudo-words that violate word formation rules of the Slovenian language (aspectual, categorial, and thematic violations) and words that do not (pseudo-words with blocking, non-words, and regular words of Slovene for masculine agents)²², thus indicating that all the violated rules have the same significance for young controls, while at the same time they are less sensitive to the pseudo-words that do not violate any word formation rules of Slovene (compare acceptance rates (AR): AR_{pseudo-them}: 1,90%; AR_{pseudo-cat}: 0,86%; AR_{pseudo-asp}: 2,10%; AR_{pseudo-block}: 5,20%).

Based on the results of the normative study we were able to apply some changes to the acceptability task, which was later presented to the AD patient and to control group for this

²² In this kind of division into two different groups of categories, we are referring to word formation violations.

patient. We excluded the stimuli which were accepted by the majority of young participants as real words from the task which was further used in the second phase of our case study.

6.6 Phase 2: A Case Study with a Patient with Alzheimer's Disease

6.6.1 Aim

The aim of the second phase of the research was to focus on the performance of the AD patient. We were interested in finding the answer to how the decay of lexical representations progresses in patients with dementia. Our research was thus guided by research questions whether the patient will make a clear line between the pseudo-words that violate word formation rules of the Slovenian language and words that do not and whether all the violated rules will have the same significance for the patient or whether there will be any signs of degradation of word formation rules and vocabulary.

6.6.2 Acceptability Task

The acceptability task was in general the same as in the first phase of our research (see section 6.5.2 for a detailed description of the task). Nevertheless, some changes were introduced into the task after taking into account all the results we obtained by performing the normative study. These changes concern the stimuli included into the task and are presented in more detail in the following section (see section 6.6.3).

6.6.3 Stimuli

As mentioned above, we did some changes to the task, which was presented to the elderly control group and to the patients with Alzheimer's disease. We replaced some words for masculine agents and reduced the number of the stimuli in the remaining categories.

Since some regular Slovenian words for masculine agents have been rejected by the young control participants, we have decided that words with three or more rejections (7 stimuli) should not be included into the task, which will be presented to the patient and to the control

group. Therefore, we replaced them with other words of Slovenian (see Table 6), with higher frequency of usage (tested in FidaPlus, corpus of Slovenian language).

Replaced words	Replaced with	Frequency
zdravilec	oblikovalec	4705
prosilec	napovedovalec	1003
cepilec	spremljevalec	2466
jemalec	ustvarjalec	2182
sporočevalec	stanovalec	911
pletilec	ponarejevalec	149
lovilec	oglaševalec	4705
pihalec	poznavalec	3575
jahalec	tekmovalec	4461

Table 6: List of replaced words for masculine agents, their replacements and frequencies of replacements

Furthermore, we also reduced the number of the stimuli to 20 per type of violation, with the exception of real Slovenian words (W-X) – we kept the same number as in the test presented to young controls (i.e. 30). When reducing the number of stimuli, we included the ones that were rejected by the young controls, since these appear to be non-problematic for the young Slovenian population, which uses the Slovenian language at all levels (as well in everyday communication situations as also for educational and work related purposes) on a daily basis. The only exception from this rule was the 20 pseudo-words with blocking. In this case we included the ones that were accepted by young controls, since they seemed to be closer to real words, thus, contributing to the uniqueness of this category, which does not violate any of the word formation rules.

These newly selected stimuli were later presented to the patient with Alzheimer's disease and to the control group for this patient.

6.6.4 Participants²³

The stimuli were presented to two different groups of participants: to a patient with Alzheimer's disease and to a control group for this patient. As well as the young controls, these participants also had to provide four basic pieces of information about themselves: age, gender, languages that they speak and years of their formal education. In the following two sections, these two groups of participants will be described in more detail.

6.6.4.1 Patient with Alzheimer's disease

The tested patient with AD was 87 years old, female, level of education: post-secondary (according to Slovenian levels of education), diagnosed with probable moderate Alzheimer's disease with late onset (based on DSM IV). Her MMSE (The Mini Mental State Examination) score was 21/30, her score on the language part of this test was 7/8 (she lost the point on the repetition task), suggesting almost intact linguistic knowledge.

6.6.4.2 Control Participants

The two control participants were matched on gender, age and level of education with the patient. The control participants were also given the MMSE test, to make sure they are

²³ The acceptability task was also presented to a patient with frontotemporal dementia. The tested patient was a 49 year old, male, his level of education was higher professional (according to Slovene educational levels), he was diagnosed with Frontotemporal dementia, with a clinical picture of symptoms of behavioural disorders in the foreground. However, due to behavioural disorders (very declinatory behaviour) the patient had no MMSE score, and his diagnosis depended mostly on his doctor's description and on the description of his closest family members, who stated that he is not disoriented and that his comprehension is intact, but he tends to refuse to do what he is being asked to do. He recalled information very well; however his attention and calculation seemed to be impaired. His repetition was intact; he even tended to repeat everything he heard (echolalia) and was inclined to fixation of repeated words (perseveration). He was still able to write, read and understand what he has read, but he refused to write or draw while being tested. Due to his very declinatory behaviour, the patient was unable to complete the task, and he stopped cooperating after 2/3 of the solved task. For this reason and also due to the fact that the patient had no score on the language part of the MMSE or any other score, we have decided that the patient's data will be excluded from the current research and are therefore not presented in this thesis. Since we have been, up to this point, unable to find any other patient with this kind of dementia, who would be willing to participate, this part of the research remains unanswered at this point.

cognitively unimpaired. The mean value of MMSE score for healthy elderly participants was 27.5/30, the mean value of score on the language part of the test was 8/8.

6.6.5 Analysis and Results

When we received the data from the two groups of participants, i.e. the patient with Alzheimer's disease and two control participants for this patient, the same procedure of analysis was followed as in the normative study. The data in the Microsoft Excel file was first sorted out from randomized order by 6 different categories of presented stimuli. Later, we calculated the acceptance rates for each category and for each participant. The acceptance rates for all the participants were later statistically compared via the Fisher's exact test for count data.

The acceptance rates given in Table 7 indicate how many times the participants said the presented stimulus is a word of the Slovenian language:

	Non-w	Pseudo-Asp	Pseudo-block	Pseudo-Cat	Pseudo-them	W-X
Control 1	0%	45%	90%	25%	76%	100%
Control 2	0%	55%	90%	20%	53%	100%
AD patient	5%	95%	100%	10%	65%	100%

Table 7: Acceptance rates for two control participants and patient with AD

In Diagram 2 (see below) the acceptance rates for presented stimuli of AD patient (blue) and two control participants (red and green) are presented:

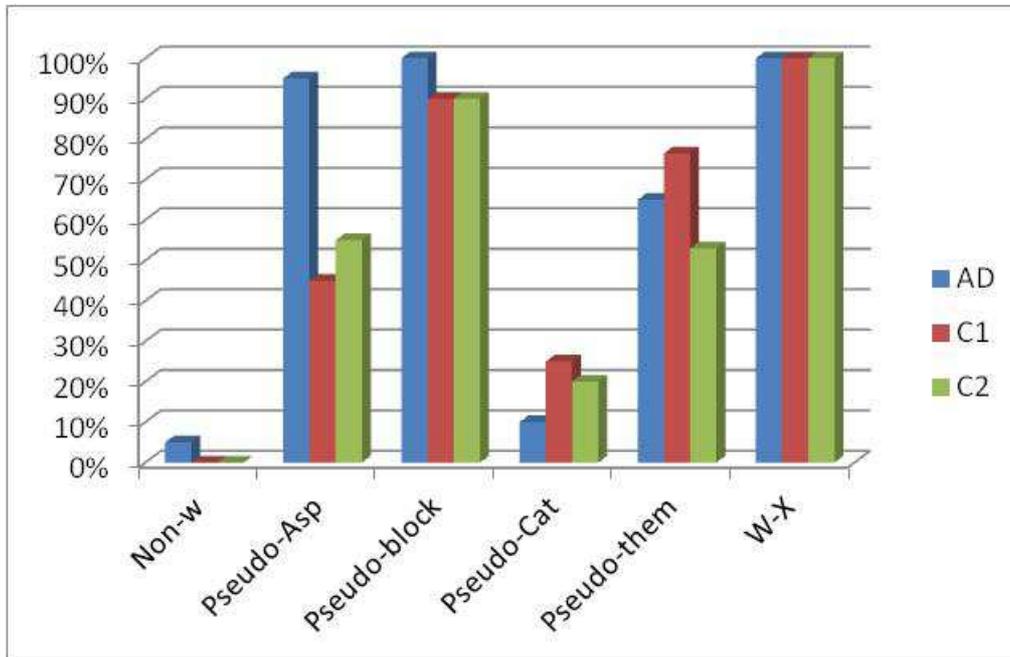


Diagram 2: Acceptance rates for patient with AD (AD) and two control participants (C1 and C2)

Since our sample was small, we were only able to perform the Fisher's exact test for count data to compare the patient's and controls' performance. Separate analyses were carried out on the data for the patient and each control participant. We first compared the performance of the two control participants among themselves, to check if there was any statistically significant difference in their performance and later we separately compared the patient's results with the first and the second control participant.

The analysis revealed that there was no significant difference in the performance of the two control participants when comparing their correct answers, i.e. "no" for the pseudo-words with thematic, aspectual and categorial violations, pseudo-words with blocking and non-words, and "yes" for the real words. The results of the comparison between the performance of the two control participants are presented in the Table 8:

Category of stimuli	Control 1 and control 2
W-X	P < 0,754
Pseudo-block	P < 0,698
Pseudo-Asp	P < 0,376
Pseudo-them	P < 0,141
Pseudo-Cat	P < 0,5
Non-w	P < 0,756

Table 8: Comparison of the two control participants

Nevertheless, focusing solely on the acceptance rates, we consider that our results support Hypothesis 1, proposing a continuum in the acceptance rates across categories of pseudo-words among the control participants, starting with massive rejection of pseudo-words with categorial violations and expressing more flexibility in accepting pseudo-words with thematic and aspectual violations.

Further comparison of the patient's and controls' performance revealed a significant difference in the category of pseudo-words with aspectual violations (pseudo-asp, e.g. **pogasilec*) in comparison with both, first ($p < 0,005$) and second ($p < 0,002$) control participant. However, for the other categories of presented stimuli, no significant difference was revealed. The results are given in the Table 9:

Category of stimuli	AD and control 1	AD and control 2
W-X	p < 0,377	P < 0,377
Pseudo-block	P < 0,122	P < 0,122
Pseudo-Asp	P < 0,005	P < 0,002
Pseudo-them	P < 0,177	P < 0,182
Pseudo-Cat	P < 0,1	P < 0,16
Non-w	P < 0,25	P < 0,25

Table 9: Comparison of a patient with AD and two control participants (α error = 2,5%)

When comparing the patient's results with the results of the control participants, a difference in the sensitivity to the rules for the patient with AD and both control participants was revealed.

Based on the controls' data, the rules about verbal aspectuality (violations of which result in Pseudo-Asp stimuli, e.g. **preplavalec*) and those about basic relationships concerning agent roles (Pseudo-Them stimuli, e.g. **ljubilec*) are most violable and the participants are equally sensitive to both of these rules, whereas the rules about appropriate lexical category of the base (Pseudo-Cat stimuli, e.g. **črkilec*) are the least violable (see Table 7). In most categories, the patient's sensitivity to the presented word formation rules does not differ from the control participants. The patient namely also shows the same sensitivity to the rule about basic relationships concerning agent roles, which is more violable than the rule about appropriate lexical category of the base. However, an important difference in the patient's sensitivity to the violated rules when compared to the controls can be noted in the category of aspectual violations, since for the patient the rules about verbal aspectuality are the most violable and differ significantly from the controls' sensitivity for these rules (for acceptance rates of all the participants see Table 7, for p values of the comparison of a patient and both controls, see Table 9).

When examining the results concerning the remaining three categories of stimuli (words for masculine agents (W-X, e.g. *tožilec*), non-words (Non-W, e.g. **nastovač*) and pseudo-words

with blocking (Pseudo-Block, e.g. **pekalec*)), that do not violate any word formation rules of the Slovenian language, no significant difference in the acceptance rates between the patient with AD and the control participants is observed (see Table 9 for p values).

The control participants, as well as the patient, accepted all regular words for masculine agents. The patient also accepted all the pseudo-words with blocking, which was slightly higher as in both control participants, but no statistically significant difference ($p < 0,12$) was revealed (for acceptance rates see Table 7 above). Whereas for the non-words, the control participants rejected all the presented stimuli, and in this category the patient's acceptance rate also did not significantly differ from the acceptance rate of the control participants ($p < 0,25$ in comparison with both control 1 and control 2; for acceptance rates of all the participants see Table 7).

These results partly support Hypothesis 2, stating that the patient with dementia is expected to accept more pseudo-words as possible and thus making more errors compared to the control participants. The patient namely accepted more pseudo-words within one category of pseudo-words (pseudo-words with aspectual violation), but in other categories of pseudo-words the patient's performance did not statistically differ from the controls' performance.

6.6.6 Discussion

The main goal of this research was to find out how the decay of lexical representations progresses in patients with dementia. We approached this issue by trying to find the answers to two main questions: we tried to examine whether the AD patient will make a distinction between the pseudo-words that violate word formation rules of Slovenian and words that do not violate any rules, and to figure out whether all violated rules have the same significance for this patient in order to detect any possible signs of word knowledge and rule degradation as a result of the disease. This was also achieved via a comparison between patient's performance and the healthy control group.

The analysis indicates that the control participants as well as the patient differentiated between pseudo-words with different types of word formation violations, suggesting that not all violated rules have the same significance for them (Hypothesis 1). This difference can be noted already when looking solely at acceptance rates. However, when comparing the patient with AD with the control participants, the results indicate different sensitivity to word

formation rules of the Slovenian language for the patient with AD. The patient is not sensitive at all to the rules about verbal aspectuality, since she was treating the presented pseudo-words with this type of violations as real words, which indicates that she has lost this rule completely (Hypothesis 2). Furthermore, she seems to be more sensitive to the rules about basic relationships concerning agent roles, and most sensitive to rules about the appropriate lexical category of the base, indicating that the representations of these two word formation rules are not yet in decay at this stage of the disease. The latest rule seems to be of the highest sensitivity also for the control participants, but in their case the other two rules seem to be of the same significance.

The fact that she is still sensitive to two word formation rules, while she is not at all sensitive to the rule about verbal aspectuality, could suggest that her knowledge of word formation rules is at the initial stage of decay. The reason for the decay to start with the loss of this particular rule about verbal aspectuality could be that this rule is somewhat more marginal compared to the other rules.

Furthermore, according to the acceptance rates of the categories of pseudo-words with thematic and categorial violations we could predict that as the disease progresses, the decay of the knowledge of word formation rules about basic relationships concerning agent roles will follow next, since the patient seems to already be less sensitive to this kind of violation, while the knowledge of word formation rules about appropriate lexical category of the base will remain preserved for the longest period of time, since the patient is still equally sensitive to this type of violation as the control group.

The analysis further indicates that the patient's representations of the real words and pseudo-words, which do not violate any word formation rules, remain preserved at this stage of the disease. This conclusion can be drawn from the patient's results for the categories of regular words for masculine agents, pseudo-words with blocking and non-words.

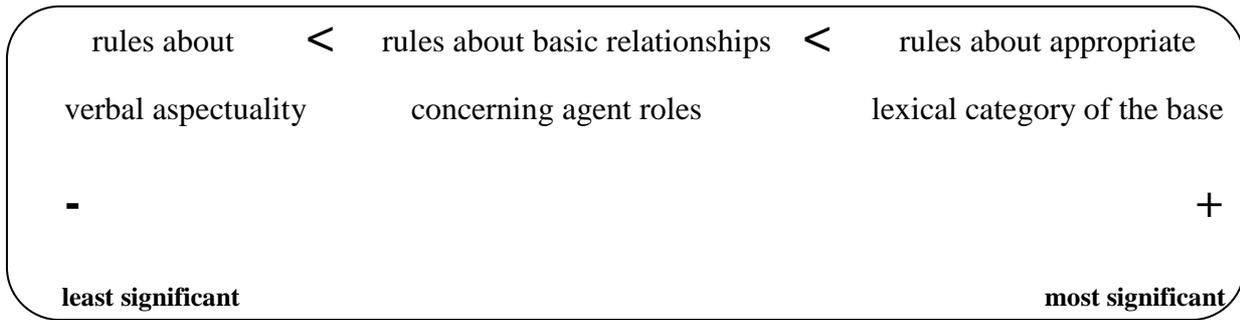
Namely, in the first category (W-X, regular words for masculine agents), the control participants accepted all the presented stimuli. The patient's results did not differ at all when compared to the controls' results, since the patient also recognised all presented words and made no errors when accepting them, revealing that her lexical representations of real words are not impaired at this stage of the disease. Thus, if we take into consideration the *interactive activation model* as proposed by Rumelhart and McClelland (1982) (see section 4.1 for more

detail), we can say that the patient's processing of real word recognition remains intact at all three levels of word processing at this stage of the disease progression.

The stimuli in the second category, pseudo-words with blocking, also do not violate any word formation rule and therefore the acceptance rate for this category of stimuli was higher than the acceptance rates for all other categories of pseudo-word stimuli in all groups of the participants (see Table 7 for acceptance rates), indicating that native speakers of Slovenian - the AD patient as well as the controls - do not treat these words as pseudo-words, since these stimuli could easily be regular words of Slovenian if there was not another word lexicalized and in usage for the same meaning (for more details see section 3.3.1 (d)). Therefore, for the patient with AD, these results indicate that her knowledge of Slovenian word formation rules, which results in the creation of possible Slovenian words without any violations, is preserved at this stage of the disease.

A similar conclusion can also be drawn for the category of non-words, which are just pronounceable word units that do not carry any meaning and are not familiar in any way (cf. pseudo-words used in our task, which were created by violating word formation rules of Slovenian, sound familiar to the native speakers of Slovenian). Therefore, all groups of participants rejected all the presented non-words, including the patient with AD. This result indicates that her processing of this kind of stimuli is preserved, since she was able to distinguish between the non-words with no meaning and pseudo-words which look and sound the same as regular words of the Slovenian language and also apply some lexical meaning.

Taking all these results into account, a tendency towards a difference in the sensitivity to the violated rules between the patient with AD and the control participants can be observed, in a way as presented in Scheme 2 below. This tendency was noted in the comparison of the AD patient with both control participants, and it can also be noted already when comparing solely the acceptance rates of the patient and the young controls – the latter namely very rigidly rejected all the presented stimuli that were not real words of Slovenian. Therefore, we think that detecting this difference could be a very important contribution, which should be investigated in more detail and with more participants in future research, since it indicates that in patients with AD the decay of lexical representations could start with the decay of the representation of the word formation rule about verbal aspectuality.



Scheme 2: Sensitivity to Slovenian word formation rules for the patient with AD.

Based on the gained results, we could also try to take into consideration the proposed model of four-stage pseudo-word processing (see section 4.2), to define at which stage of pseudo-word processing the patient exhibits difficulties. However, before doing so, we would like to point out that our data do not fit the proposed model completely, since the model is based on the results of an on-line study, while we only performed an off-line acceptability study, but we nevertheless think that this kind of implementation could offer an important assumption about pseudo-word processing in this patient. Since the patient is not sensitive at all when it comes to the rule about verbal aspectuality, while she seems to be more sensitive to the rules about basic relationships concerning agent roles, and most sensitive to the rules about the appropriate lexical category of the base, we could assume that her difficulties with pseudo-word processing start within Libben's second stage, or more likely right after or at Manouilidou's proposed stage 2a, where thematic processing takes place, since her sensitivity to rules about basic relationships concerning agent roles is already starting to decrease, but is not yet completely impaired.

Furthermore, these results also offer an explanation on why the patient scored very high on the language part of the MMSE test (7/8), even if her mental lexicon is already in decay and her knowledge of Slovenian word formation rules and vocabulary is degraded. This impairment is not detectable via a coarse measures such as MMSE, since this measure only includes words which do not violate any word formation rules, therefore, it only includes the stimuli in which the patient's performance is yet intact, but not also the stimuli which, based on our research, reveal the patient's impaired representations of Slovenian word formation rules and thus also vocabulary, which seem to be in decay at an earlier stage of the disease progress.

7 Conclusion

Based on previous research on pseudo-words and their processing we formulated specific research questions and two hypotheses. These were tested with the help of an acceptability task, presented to young controls for normative purposes and later to one patient with Alzheimer's disease and two control participants.

The results of our case study provided conclusions about pseudo-word processing in healthy participants and also, most importantly, in a patient with Alzheimer's disease. Regarding the latter, the results indicated a complete loss of sensitivity to one type of Slovenian word formation violation rule, indicating that the patient's knowledge of word formation rules are already in decay. Nevertheless, this decay cannot and was not detected via MMSE (Mini Mental State Examination), since this coarse measure only includes words which do not violate any word formation rules, therefore, it only includes the stimuli in which the patient's performance is yet intact, but not also the stimuli which could reveal the patient's impaired lexical representations and knowledge of Slovenian word formation rules, both of which seem to be in decay at this stage of the disease. Thus, our case study offers an important insight into Slovenian word and pseudo-word processing in patients with Alzheimer's disease and reveals potentially important data and results, which could serve as a good basis for future work and development of diagnostic tools for dementia, based on the Slovenian language.

On the other hand, it should be pointed out that the conclusions we reached are based on a case study which makes us cautious when making statements about pseudo-word and word processing and the decay of lexical representations in patients with Alzheimer's disease in general. However, since the patient's results were compared to two control participants separately, and both comparisons resulted in the same pattern, we can make an assumption that the same pattern can be expected also when performing the research on a bigger sample. The proposed pattern of decay is, thus, a good starting point for more in-depth research with more participants, but should not be considered as the finishing point of this research.

Furthermore, this study represents the first attempt to use the Slovenian language as a diagnostic tool for dementia in Slovenian-speaking populations and makes a contribution to the research of the loss of the lexical representation in patients with Alzheimer's disease and represents a good starting point for more in-depth research with more participants with different types of dementia.

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9 Appendices

9.1 Appendix 1: Master Thesis Summary in the Slovenian Language

(Daljši povzetek v slovenskem jeziku)

Procesiranje besed in psevdobesed pri bolnikih z demenco

1 Uvod

Demenca je vse bolj pogosta bolezen starejšega prebivalstva, ki med drugim prizadene tudi jezikovne sposobnosti bolnika. Nevroloških raziskav na to temo je vse več, zaradi hudih jezikovnih težav, ki spremljajo demenco, pa je nevrologijo smiselno združiti z jezikoslovjem. Ravno razvoj pri izgubi razumevanja besed nam namreč lahko pove marsikaj tudi o razvoju same demence ter na ta način pripomore, da se z boleznijo soočimo že v njenih zgodnjih fazah.

2 Besedotvorje

2.1 Psevdobesede

Izraz *psevdobeseda* se nanaša na besedne formacije, ki so podobne običajnim besedam nekega jezika, vendar pa kljub temu nimajo nobenega pomena in niso leksikalizirane. Primer slovenske psevdobesede, ki smo jo uporabili tudi v nalogi, zasnovani za to raziskavo, je na primer **umorilec*.

2.2 Slovensko besedotvorje in njegove kršitve

2.2.1 Besedotvorne vrste

V slovenščini poznamo različne besedotvorne vrste (za podrobnosti o tradicionalni delitvi glej Toporišič, 2000). Najpogostejši med njimi sta izpeljava in zlaganje. Pri izpeljavi novo besedo dobimo tako, da podstavi dodamo obrazilo (primer: *pis+ec*), pri zlaganju pa dve podstavi združimo v novo besedo (primer: *zemlj+e+pis*).

2.2.2 Slovenske besedotvorne kršitve

Vsak jezik ima lastna besedotvorna pravila, ki določajo, kako se tvorijo posamezne besede. Eden od načinov tvorjenja je, da podstavi dodajamo obrazila. Vendar pa vseh obrazil ne moremo dodati vsaki podstavi, temveč moramo pri tem postopku slediti pravilom, ki prinašajo določene omejitve (Manouilidou, 2007). Če teh pravil ne upoštevamo, dobimo besedo, ki sicer lahko zveni kot beseda nekega jezika, vendar ni del besedišča tega jezika – v tem primeru govorimo o besedotvornih kršitvah.

V nalogi smo se posvetili trem tipom tovrstnih kršitev, pri čemer smo se osredotočili na besedotvorni postopek izpeljave samostalniške besede na *-ec*, ki označuje vršilca dejanja (npr. *igralec*). Zanimale so nas t.i. udeleženske kršitve (a), kjer so kršena osnovna razmerja glede udeleženskih vlog, besednovrstne kršitve (b), pri katerih je neprimerna lekiskalna kategorija podstave, in vidske kršitve (c), kjer gre za neupoštevanje specifičnih besedotvornih zahtev glede glagolskega vida. Poleg teh kršitev pa smo se v tej nalogi posvetili tudi psevdobesedam, ki besedotvornih pravil ne kršijo (d):

(a) Psevdobesede z udeleženskimi kršitvami (tovrstna izpeljanka je izpeljana samo iz glagolov, pri katerih je osebek vršilec dejanja (Marvin, 2002); osebka glagolov *umirati* in *viseti* nista vršilca): *umiralec, *viselec.

(b) Psevdobesede z besednovrstnimi kršitvami (tovrstna izpeljanka je lahko izpeljana samo iz glagolske podstave; *črka* in *telefon* sta samostalniški podstavi): *črkilec, *telefonilec.

(c) Psevdobesede z vidskim kršitvami (tovrstna izpeljanka je lahko izpeljana samo iz nedovršnih glagolov (Marvin, 2002); npr. *plavalec*, *morilec*): *preplavalec, *umorilec.

(d) Psevdobesede brez kršitve, ki v slovenskem jeziku kljub temu ne obstajajo, saj imamo namesto njih že leksikalizirane in v uporabi druge besede, ki označujejo ta pomen: *risalec (bi lahko bila beseda za nekoga, ki riše, a imamo namesto nje že v rabi besedo *risar*), *kuhalec (bi lahko bila beseda za nekoga, ki kuha, a imamo namesto nje že v rabi besedo *kuhar*).

3 Procesiranje besed in psevdobesed

3.1 Procesiranje besed

Rumelhart and McClelland (Rumelhart & McClelland, 1982) sta predlagala model vizualnega procesiranja besed, ki sta ga poimenovala interaktivni aktivacijski model (*the interactive activation model*). Glede na ta model poteka procesiranje besed na treh nivojih: (1) »nivo oblike« (*the feature level*), (2) »nivo črke« (*the letter level*) in (3) »nivo besede« (*the word level*). Vsak izmed treh nivojev sestoji iz različnih enot – vsaka izmed njih predstavlja en možen element na določenem nivoju (na primer: nivo črke sestoji iz različnih enot, vsaka izmed njih predstavlja posamezno črko na posameznem položaju znotraj besede). Vsaka izmed teh enot je z ostalimi povezana s trenutno aktivacijo, stopnja aktivacije pa je odvisna od moči domneve, ali predstavljena enota vsebuje določeno enoto. Bolj kot je ena enota aktivna in manj kot so aktivne preostale enote, bolj verjetno je, da bo sistem zaznal, da vizualni stimulus vsebuje element, ki ga aktivna enota predstavlja. Ko je aktivacijski prag take enote presežen, se enota aktivira in hkrati aktivira vse ostale, s katerimi je konsistentna (na primer začetna črka *n* je konsistentna z besedo *noga*), poleg tega pa hkrati inhibira tudi vse ostale enote, s katerimi ni konsistentna.

3.2 Procesiranje psevdobesed

Libben (Libben, 1994) predlaga štiristopenjski model procesiranja psevdobesed: na prvi stopnji procesiranja se zgodi pregled niza, med katerim se razkrijejo vsi leksikalni podnizi. Manouilidou dodaja, da govorci na tej fazi zavrnejo vse nebesede (Manouilidou, 2007). Na drugi stopnji se zgodi morfološko procesiranje. Iz leksikalnih podnizov se ustvarijo strukture, ki se jih da interpretirati: zgodi se prepoznavanje predstavljenih kombinacij podnizov. Manouilidou dodaja, da se na tej stopnji zavrnejo psevdobesede z besednovrstnimi kršitvami. Poleg tega dodaja še, da je na tem mestu (pred tretjo stopnjo po Libbenu), še ena stopnja, v kateri se zgodi udeležensko procesiranje predstavljene besede. Na tretji stopnji po Libbenu sledi interpretacija posamezne reprezentacije, na četrti stopnji pa govorec izbere med različnimi interpretacijami (Libben, 1994).

Kar nekaj je torej že znanega o tem, kako pri zdravih govorcih poteka procesiranje psevdobesed, manj pa je znano, kako to procesiranje poteka pri bolnikih z demenco. Prav zato smo se v tej nalogi osredotočili na to področje ter na tak način skušali združiti dognanja nevroznanosti z dognanji jezikoslovja.

4. Demenca

Demenca je vse bolj pogosta diagnoza naše starajoče se populacije in zaradi staranja prebivalstva lahko v prihodnosti pričakujemo, da se bo število obolelih le še povečevalo (Grossman et al., 2006). Ključna lastnost te bolezni, kot jo definira diagnostični kriterij DSM-IV-TR (APA, 2000), je: "razvoj več kognitivnih okvar, ki vključujejo spominske motnje in vsaj še eno izmed sledečih kognitivnih motenj: afazijo, apraksijo, agnozijo ali motnje izvršilnih funkcij.« (APA, 2006: 148)

4.1 Alzheimerjeva demenca

Alzheimerjeva demenca je najpogostejša oblika demence (Henderson, 1996; Altmann & McClung, 2008), ki prizadene bolnikove kognitivne funkcije in se konča s smrtjo (Cummings & Cole, 2002, Fox et al., 1998).

Bolniki s to obliko demence imajo težave z različnimi kognitivnimi domenami (Taler & Philips, 2007), najbolj opazne med njimi pa so motnje epizodičnega spomina (Altmann & McClung, 2008; Taler & Philips, 2007; Fox et al., 1998), izvršilnih funkcij (Albert, et al., 2001; Daly et al., 2000), hitrosti zaznavanja (Albert, et al., 2001; Fox et al., 1998), vidno-prostorske orientacije (Albert, et al., 2001; Fowler et al., 2002) in pozornosti (Rubin et al., 1998; Tierney et al., 1996, both in Taler & Philips, 2007).

Poleg tega pa je pri vseh bolnikih z AD moč opaziti tudi jezikovne motnje (Henderson, 1996). Pri bolnikih je tako med drugim moč opaziti težave v verbalni fluentnosti (Grossman et al., 1996; Taler & Philips, 2007), razumevanju posameznih besed (Grossman et al., 1999; Martin & Fedio, 1983) in ponavljanju (Grossman et al., 1996). Bolniki poleg tega relativno pogosto uporabljajo semantične parafraze (Kempner, 1987 in Altmann & McClung, 2008), prav tako pa imajo težave tudi pri poimenovanju (Taler & Philips, 2007; Henderson, 1996; Grossman et al., 1996), še posebej bioloških stvari, pri katerih igra pomembno vlogo semantični spomin (Martin & Fedio, 1983), medtem ko imajo pri poimenovanju umetno izdelanih stvari, kot na primer orodij, precej manjše težave (Garrard, 2005; Martin & Fedio, 1983).

V nalogi smo se posvetili eni izmed zgoraj naštetih jezikovnih težav – izgubi leksikalnih reprezentacij. V ta namen smo se posvetili procesiranju besed, pri čemer smo uporabili tako besede kot tudi psevdobesede. Izhajali smo iz Libbenovega predloga, da procesiranje psevdobesed poteka v štirih stopnjah (Libben, 1994), ki ga je kasneje nadgradila še Manouilidou (Manouilidou, 2007).

5 Eksperiment

V raziskavi smo se osredotočili na leksikalne reprezentacije pri bolnikih z demenco, saj nas je zanimalo, kako z razvojem bolezni napreduje izguba besed pri takih bolnikih. Našo raziskavo sta vodili sledeči raziskovalni vprašanji. Zanimalo nas je, ali (1) bo bolnica jasno ločevala med besedami, ki kršijo slovenska besedotvorna pravila in ali (2) bodo imela vsa besedotvorna pravila za bolnico enak pomen ter če bo pri njej že moč opaziti znake izgube besedotvornih pravil in posledično tudi besedišča.

Glede na ti raziskovalni vprašanji smo osnovali dve hipotezi. Glede procesiranja psevdobesed pri zdravih govornikih smo osnovali prvo hipotezo:

1. Hipoteza: Pričakujemo, da bo kontrolna skupina pokazala kontinuiteto sprejemanja/zavračanja psevdobesed. Psevdobesede z besednovrstnimi kršitvami bo vztrajno zavračala, medtem ko bo pri sprejemanju psevdobesed z udeleženskimi in vidskimi kršitvami bolj fleksibilna (t.j. več bo pozitivnih odgovorov, da bi psevdobeseda lahko pripadala slovenskemu besedišču).

Za bolnika pa smo pričakovali drugačen vzorec sprejemanja/zavračanja psevdobesed: **Hipoteza 2:** Pri bolnici z demenco pričakujemo drugačen vzorec. Pričakujemo, da bo več psevdobesed sprejela kot možnih, da bo torej napravila več napak, saj bodo njene leksikalne reprezentacije že v upadu.

Za preverjanje zgoraj navedenih hipotez in za iskanje odgovorov na zastavljena raziskovalna vprašanja smo se odločili uporabiti nalogo sprejemanja besed, v kateri smo udeležencem predstavili stimule, ki so pripadali šestim različnim kategorijam. Raziskavo smo razdelili v dve fazi. V prvi, normativni študiji, smo nalogo predstavili skupini mladih udeležencev, v drugi fazi, študiji primera, pa bolnici z demenco in kontrolni skupini.

5.1 Faza 1: normativna študija

5.1.1 Naloga sprejemanja besed

V magistrski nalogi smo uporabili nalogo sprejemanja besed, v kateri se osredotočimo na vzorce zavračanja/sprejemanja psevdobesed, pri čemer upoštevamo za kateri tip kršitev gre. Udeležencem smo pokazali seznam psevdobesed in jih vprašali, naj povedo, ali gre za slovensko besedo ali ne.

5.1.2 Stimuli

Med stimule smo vključili tri zgoraj opisane kategorije psevdobesed, ki kršijo slovenska besedotvorna pravila, psevdobesede, ki teh pravil ne kršijo, nebesede in običajne slovenske besede za moške vršilce dejanja. Primeri stimulov so navedeni v Tabeli 1:

Tip stimula	Značilnosti	Primer
Psevdobesede z udeleženskimi kršitvami	kršena so osnovna razmerja glede udeleženskih vlog	*umiralec *viselec
Psevdobesede z besednovrstnimi kršitvami	lekiskalna kategorija podstave je neprimerna	*črkilec * telefonilec
Psevdobesede z vidskimi kršitvami	kršene so specifične besedotvorne zahteve glede glagolskega vida	*preplavalec *umorilec
Psevdobesede brez besedotvornih kršitev	Besede v slovenskem jeziku ne obstajajo, ker imamo namesto njih v rabi že drugo besedo	*kuhalec *risalec
Besede za vršilce dejanja moškega spola	besede, ki so del slovenskega besedišča	igralec občudovalec
Nebesede	niso del slovenskega besedišča	*dovina *lastje

Tabela 1: Primeri stimulov, ki smo jih uporabili v nalogi

5.1.2 Udeleženci

Izbrane stimule smo v tej fazi študije testirali na skupini zdravih udeležencev, rojenih govorcih slovenščine, da smo potrdili, če so izbrane besede govorcem slovenščine res poznane oz. da zdravi govorce prepoznajo, da te besede niso del slovenskega besedišča. V študijo smo vključili 20 udeležencev (M starost: 27,3; spol:11 moških, 9 žensk; M leta izobrazbe: 16,3).

5.1.3 Rezultati

Pri mladih udeležencih so odstotki sprejemanja razkrili, da so sprejemali zgolj prave besede za moške vršilce dejanja (npr. *storilec*) ter zavračali vse psevdobesede. Edina izjema so bile psevdobesede, ki besedotvornih pravil ne kršijo (npr. *risalec*) – ta kategorija je imela nekoliko višji odstotek sprejemanja in pri njej se je razkrila tudi statistično pomembna razlika.

5.1.4 Zaključek

Na podlagi rezultatov normativne študije smo lahko v nalogo sprejemanja besed uvedli določene spremembe. Preden smo nalogo predstavili bolniku in kontrolni skupini, smo namreč izključili stimule, ki so se izkazali za problematične že pri mladih udeležencih.

5.2 Druga faza: bolnica z Alzheimerjevo demenco (študija primera)

5.2.1 Naloga sprejemanja besed

Naloga je bila v splošnem enaka kot v prvi fazi naše raziskave, vendar pa smo uvedli določene spremembe glede na rezultate normativne študije, izvedene v prvi fazi. Te spremembe so bile uvedene glede stimulov, ki so vključeni v nalogo, in so zato podrobneje opisane v naslednji sekciji.

5.2.2 Stimuli

Pri stimulih, ki smo jih vključili v nalogo, smo uvedli določene spremembe. Sedem besed za moške vršilce dejanja smo zamenjali za druge besede z večjo frekvenco uporabe, prav tako pa smo število stimulov v vseh kategorijah zmanjšali na 20, z izjemo besed za moške vršilce dejanja, kjer smo pustili isto število kot pri normativni študiji (t.j. 30). Novo izbrane stimule smo nato predstavili bolnici z demenco in kontrolni skupini dveh udeleženk.

5.2.3 Udeleženci

Nalogo smo predstavili dvema skupinama udeležencev: bolnici z Alzheimerjevo demenco in kontrolni skupini dveh udeleženk za to bolnico, ki so se po starosti, spolu in nivoju izobrazbe ujemale z bolnico.

5.2.4 Analiza in rezultati

Rezultate bolnice z demenco smo posebej primerjali z rezultati vsakega kontrolnega udeleženca. Izvedli smo Fisherjev test eksaktne verjetnosti, s katerim smo najprej medsebojno primerjali rezultate obeh kontrolnih udeleženk, med katerima se ni razkrila nobena statistično pomembna razlika, nato pa smo z vsako kontrolno udeleženko ločeno primerjali še rezultate bolnice z demenco. Rezultati v primerjavi z obema kontrolnima udeleženkama so razkrili statistično pomembno razliko v kategoriji psevdobesed z vidskimi kršitvami ($p_1 < 0,005$, $p_2 < 0,002$), v ostalih kategorijah pa se statistično pomembna razlika v sprejemanju/zavračanju stimulov ni razkrila.

5.2.5 Diskusija

Cilj naše raziskave je bil odkriti, kako izguba leksikalnih reprezenacij poteka pri bolnikih z demenco. Analiza pridobljenih rezultatov je razkrila, da tako kontrolni udeleženki kot tudi bolnica z demenco razlikujejo med različnimi tipi besednotvornih kršitev, na podlagi česar lahko domnevamo, da predstavljena besednotvorna pravila za udeležence niso vsa enako pomembna (kar potrjuje hipotezo 1). Ta razlika je opazna že zgolj iz predstavljenih odstotkov sprejemanja besed in psevdobesed. Če pa primerjamo rezultate bolnice z demenco in kontrolne skupine, lahko pri bolnici opazimo različno občutljivost na predstavljena besednotvorna pravila. Bolnica namreč sploh ni občutljiva na vidске kršitve, saj je psevdobesede s tem tipom kršitve obravnavala kot prave slovenske besede, kar nakazuje na to, da je to pravilo popolnoma izgubila. Ti rezultati delno potrjujejo hipotezo 2, ki pravi, da bo bolnica z demenco sprejemala več psevdobesed in tako napravila več napak kot kontrolna skupina, saj je bolnica statistično pomembno sprejemala več psevdobesed le iz ene kategorije (t.j. z vidskimi kršitvami), ne pa tudi iz ostalih. Poleg tega se je pri bolnici razkrila večja občutljivost na udeleženske kršitve, največja občutljivost pa na besednovrstne kršitve, kar nakazuje, da ta pravila pri bolnici še niso prizadeta.

Dejstvo, da je bolnica še vedno občutljiva na dve besdnovrstni pravili, medtem ko sploh ni občutljiva na vidske kršitve, morda nakazuje, da se je izguba njenih reprezentacij v začetni fazi, ki se je pričela z izgubo pravila o vidskih kršitvah, medtem ko sta drugi dve pravili na tej stopnji še nedotaknjeni. Ti rezultati pa poleg tega nudijo tudi razlago, zakaj je imela bolnica relativno visok rezultat na jezikovnem delu testa KPSS (7/8), čeprav je njen mentalni leksikon glede na rezultate naše raziskave že v propadu. Te okvare namreč ni moč izslediti s pomočjo testa, kot je KPSS, saj ta vključuje zgolj besede, ki ne kršijo nobenih besedotvornih pravil, torej vključuje zgolj stimule, pri kateri se propad leksikalnih reprezentacij na tej stopnji razvoja bolezni še ne odraža.

6 Zaključek

Na podlagi preteklih raziskav smo osnovali specifična raziskovalna vprašanja in dve hipotezi. Te smo preverili s pomočjo naloge sprejemanja, ki smo jo predstavili trem različnim skupinam udeležencev. Rezultati raziskave so razkrili nekatere značilnosti o procesiranju psevdobesed pri bolnikih z demenco, saj na podlagi testa, ki smo ga razvili v tej magistrski nalogi, lahko sklepamo, da se pri testirani bolnici kaže popolna izguba občutljivosti na eno izmed treh testiranih slovenskih besedotvornih kršitev, kar kaže na to, da so pri bolnici leksikalne reprezentacije že v upadu. A tega upada ni moč zaznati s standardnim testom KPSS, saj ta vključuje zgolj stimule, pri katerih je delovanje bolnice še nedotaknjeno. Velja pa poudariti, da so naši zaključki osnovani na podlagi študije primera, zato menimo, da moramo biti previdni pri oblikovanju zaključkov o procesiranju besed, psevdobesed in izgubi leksikalnih reprezentacij pri bolnikih z demenco na splošno. Kljub temu pa glede na pridobljene rezultate menimo, da je ta raziskava pomemben prispevek, saj je prvi poskus uporabe slovenskega jezika kot diagnostičnega orodja za demenco pri slovensko govoreči populaciji in tako predstavlja pomembno izhodišče za nadaljnje raziskave.

9.2. Appendix 2: List of Words and Pseudo-Words

List of words and pseudo-words, which were presented to the patient with Alzheimer's disease and to the control group of two participants.

Pseudo-words with thematic violations
rumenelec
bolelec
stalec
sovražilec
ljubilec
krvavelec
počivalec
živelec
zelenelec
trpelec
cvetelec
viselec
ležalec
venelec
oskrbelec
sedelec
jokalec
zorelec
umiralec
gostovalec
Pseudo-words with categorial violations
jadrilec
črkilec
tortilec
mizilec
ptičilec
dlakilec
iglilec
nogavilec

antenilec
vazilec
orehilec
odejilec
srajčilec
nohtilec
trakilec
ravnilec
medaljilec
škatlilec
buldožerilec
balonilec
Pseudo-words with aspectual violations
presnemalec
ulovilec
preplavalec
pogasilec
zlomilec
pozdravilec
umorilec
prekršilec
posadilec
nahranilec
preplezalec
prejadralec
preposlušalec
prepotovalec
pokadilec
preskakalec
počistilec
prebralec
ustrelec
Words with blocking
zabavljalec

garalec
balinalec
godrnjalec
čuvalec
bahalec
zvonilec
tiskalec
računalec
klicalec
kuhalec
pleskalec
krmilec
pisalec
sankalec
čvekalec
klepalec
tekalec
pekalec
risalec

Words for masculine agents

morilec
storilec
gasilec
ponarejevalec
poznavalec
oblikovalec
plesalec
opazovalec
reševalec
tožilec
napovedovalec
oglaševalec
iskalec
skakalec
jadralec
zbiralec

plezalec
bralec
tekmovalec
drsalec
metalec
snemalec
branilec
plavalec
spremljevalec
kadilec
dajalec
ustvarjalec
darovalec
Non- Words
lemsikon
nagramenec
minčnik
dosenček
stomica
hokavica
bostelja
sohraštvo
kapuščina
emastika
fekulteta
molezen
buldomer
kamira
dovina
unimerza
gogovje
intervet
pemenka
nastovač