izvorni znanstveni rad
UDK: 81'23
81'234.2:159.946.3

IMMAGEABILITY ASYMMETRY IN MENTAL LEXICON OF CROATIAN APHASICS AND HEALTHY SPEAKERS[1]

Anita Peti-Stantić
University of Zagreb, Croatia
Vlasta Erdeljac
University of Zagreb, Croatia
Jana Willer-Gold
University of Zagreb, Croatia
University College London, United Kingdom
Martina Sekulić
University of Zagreb, Croatia

Keywords: imageability, aphasics, PALPA test, grammatical complexity and task complexity

Abstract: Imageability has been argued to induce asymmetry in processing of nominal lexical units as this feature of the mental lexicon is sensitive to the organization of the conceptual system. Double modality of the representation of high imageable nouns in the mental lexicon, contrasted with single representation in low imageable nouns is argued to facilitate the processing of a concrete noun and slow down successful retrieval, access and any further processing of an abstract noun.
The aim of this study is to investigate whether there is a variation in the semantic processing of high and low imageable words in people with aphasia compared to the healthy control speakers when presented with a visual or auditive stimulus.
Conducted research was designed to examine the processing of the lexical feature of imageability and hence included four tests from PALPA battery of tests adapted for Croatian: Auditory Synonym Judgement, Written Synonym Judgement and Word Semantic Association. To reduce the effect of perceptive impairments, general semantic processing was verified by conducting two follow-up PALPA comprehension tests: Spoken Word-Picture Matching and Written Word-Picture Matching. The study included 30 aphasic participants and 30 paired healthy participants; all native speakers of Croatian.

[1] We were able to conduct research with aphasics during 2013 and 2014 thanks to the board and our colleagues in SUVAG polyclinic. We are deeply indebted for that.

In line with the predictions, there was a statistically significant difference between experimental and control group; the experimental group further confirmed the predictions by achieving significantly lower results with respect to low imageable words. Difficulties in recognition of low imageable words in aphasics confirm the existing variations in the organization of processing pathways. The main finding of the research demonstrates that the aphasics, especially Broca's aphasics, have problems when processing complex psycholinguistic tasks, as well as complex structures involved both in the grammatical and conceptual representations.

Ključne riječi: predočivost, osobe s afazijom, PALPA test, složenost gramatičkih struktura i složenost zadatka

Sažetak: U literaturi se smatra kako asimetrija u procesiranju visokopredočivih i niskopredočivih leksičkih jedinica proizlazi iz organizacije mentalnoga leksikona te je povezana s organizacijom pojmovnoga sustava. Neovisno o tipu reprezentacije (verbalnom ili neverbalnom), dvostruki reprezentacijski put konkretnih imenica u mentalnom leksikonu u opreci je prema jednostrukom putu verbalne reprezentacije apstraktnih imenica. Stoga se u literaturi smatra kako navedena dvostrukost olakšava i ubrzava procesiranje konkretnih riječi, dok postojanje samo jednog puta usporava usporava i otežava procesiranje apstraktnih riječi.
Cilj je ove rasprave istražiti postoji li statistički značajna razlika u semantičkom procesiranju visokopredočivih i niskopredočivih riječi u pacijenata s afazijom u usporedbi sa zdravim ispitanicima kojima su stimulusi prikazani u vizualnom i u auditivnom modalitetu.
Istraživanje je provedeno na temelju testova specifično projektiranih za ispitivanje procesiranja leksičkoga obilježja predočivosti. Riječ je o testovima iz baterije PALPA prilagođenima za hrvatski jezik (testovi procjene sinonima u auditivnom i u pisanom modalitetu te test semantičkih asocijacija riječi). Kako bi se smanjio efekt perceptivnog oštećenja, provedena su i dva dodatna istraživanja za ispitivanje razumijevanja, i to test spajanja riječi i slike, ponovo i u govorenom i u pisanom modalitetu. U istraživanje je uključeno 60 govornika hrvatskoga jezika, 30 osoba s afazijom i isto toliko zdravih ispitanika.
Tijekom istraživanja se pokazala statistički značajna razlika između eksperimentalne i kontrolne skupine. Rezultati osoba s afazijom u ispitivanju niskopredočivih riječi bili su znatno niži od rezultata kontrolne skupine. Razlike u raspoznavanju semantičkih odnosa između niskopredočivih riječi osoba s afazijom potvrđuju postojanje razlike u organizaciji puteva procesiranja niskopredočivih i visokopredočivih riječi. Dodatno se pokazalo kako osobe s afazijom, posebno Brokinom, imaju poteškoća s procesiranjem složenih psiholingvističkih zadataka i zadataka složene gramatičke i semantičke strukture.

1. INTRODUCTION

In aphasia, semantic processing is generally assumed to be affected by impairment specific to language. It has been widely accepted that Broca's aphasia primarily affects syntax (specifically processing of complex syntactic structures and functional words) while anomia, or nominal aphasia, affects the inability to select and use appropriate substantive words in verbal output and is therefore usually labeled word-finding deficit.[2] Accordingly, Broca's and anomic aphasics are taken to have different types of deficits, both with respect to the part of the language system that has been affected, but also in terms of its presupposed role in language processing.

Imageability[3] has been argued to induce asymmetry in processing of nominal lexical units as this feature of the mental lexicon is sensitive to the stimulus modality and to the conceptual system. High imageable words (HI) are assumed to hold richer semantic representations (Plaut and Shallice 1991; Nickels and Howard 1995) and to benefit from visual features in addition to semantic features in terms of their understanding and memorizing (Paivio 1991). Low imageable words (LI) on the other hand are assumed to have only semantic representation modulated by language and only one path to arrive at the understanding and memorizing. In other words, the first part of definition pertains to inner linguistic organization (semantic representation) while the second one relates to psycholinguistic reality (language processing). As imageability is shown to be highly correlated to concretness, this additionally underlines the role of the visual modality in types of tests performed.[4]

Moreover, imageability validation ratings studies have been used to develop normative measures for a specific languages and to develop online available datasets differing in length and to some extend also in methodology of data collection (for English see e.g., Bird, Franklin, & Howard, 2001; Coltheart, 1981; Cortese & Fugett, 2004; Schock, Cortese, & Khanna, 2012), for French (Desrochers & Thompson, 2009), for Italian (Della Rosa,

[2]Goodglass & Wingfield (1997) write about the variety of forms anomia can take. Libben (2008: 15) also writes how in some cases «the core problem seems to be semantic in nature, in other cases the difficulty seems not so much the ability to access the correct meaning, but difficulty in accessing and producing the correct form."

[3] See definition, for example, in Rofes et al (2017): "*Imageability* (also named *imagery*) is a psycholinguistic variable that is used to indicate how well a word gives rise to a mental image or sensory experience."

[4] Although many researchers, following Paivio, equate high imageability with concretness and low imageability with abstractness, there are also researchers showing that some of the specific groups of lexemes (i.e. emotional terms) do not fall into this equation (i.e. Altarriba et al. 1999, Bird et al. 2001, Dellantonio et al. 2014).

Catricalà, Vigliocco, & Cappa, 2010; Rofes, deAguiar, &Miceli, 2015) and for Norwegian (Lind, Simonsen, Hansen, Holm, & Mevik, 2015; Simonsen, Lind, Hansen, Holm, & Mevik, 2013)[5]. However, most findings confirm gradient, and not discrete distribution of imageability across population and across the semantic system.

Double modality of the representation of concrete nouns in the mental lexicon, verbal and non-verbal, contrasted with single, verbal, representation in abstract nouns (Paivio 1990, 2010) is argued to facilitate the processing of a concrete noun and slow down successful retrieval, access and any further processing of an abstract noun (Sabsevitz et al. 2005). However, research confirming double dissociation underlines the claim that in researching imageability, it is equally crucial to verify the processing capacity of the mental lexicon's interface with the conceptual system (Gvion & Friedmann 2013).

Previous research supports the idea that conceptual processes are modulated by word imageability. This is experimentally supported by shorter reaction times, as well as better recall and naming both in healthy subjects and patients, but also by the data which show that patients obtain better results on all tasks in which HI words are involed as compared to tasks with LI words. The developmental studies also confirm that the high imageable words are learned significantly earlier (Bird et al. 2001, Caramelli et al. 2004, Snedeker 2009).

2. DOUBLE CODING THEORY AND PALPA TEST

The theoretical starting point of our research is *Double coding theory* (Paivio, 1971, 1986, 1991, 2010), one of the most influential theories of cognition and memory in 20th century. The theory is building on the mnemonic effects of the imagery that have been uncovered in the time of its first proposal. The basic assumption of Dual coding theory is fairly simple and intuitive - human mind operates within two distinct classes of mental representations (or "codes"), mental images and verbal representations. As a consequence, memory consists of two functionally independent systems, verbal memory and image memory. These systems, although independent, interact with each other. The consequence for memory and especially language processing, that interests us most here, is that the formation of mental images aids learning (and memorizing). Imagery potentiates recall of verbal material that gains double strength by a double association (with a verbal and non-verbal representation). It is important to emphasize that both visual and verbal information can be used to represent information (either

[5] For an overwiew see Rofes et al (2017).

separately, simultaneously or successively). The key inference is that the ability of our mental system to code a stimulus in a twofold manner increases the chance to remember (retrieve, and use) the unit that was coded through both systems over the unit that was coded only through one system.

Speaking of these systems, Paivio (2010: 207) claims that "all cognition involves the activity of two functionally independent but interconnected multimodal systems, an internalized nonverbal system that directly represents the perceptual properties and affordances of nonverbal objects and events, and an internalized verbal system that deals with linguistic stimuli and responses." The claim about the internal nonverbal system directly representing the perceptual properties of nonverbal objects and events obviously has to do with the types of coding systems. Paivio (1971, 1986, 2010) assumes that the visual representation (mental image connected to the concept of imageability) is an analogue code in which the images we form in our mind highly resemble to the physical stimuli themselves. Problem with this assumption is that the code itself is at a certain level of abstraction (which is not specified) and that we have no evidence for the exact mechanisms of forming mental images and their similarity to the most often encountered stimulus, or to the stimulus that somehow represents the mean of all encountered stimuli (exemplar and prototype theories that are natural continuation of Dual coding theory in language processing). If we think of such a simple example as a *dog*, we might ask ourselves whether there is really a mental image of a dog that resembles the perceptual properties of a concrete animal that we have encountered, or the mental image has to be somehow different.

We chose Paivio's Double coding theory as a harbor of our investigation in order to supplement understanding of the long-standing discussion on the organization of mental lexicon within the subfield of semantic processing. In past few decades it has become clear that strictly modular approaches, similar to the ones in traditional generative syntax, do not offer the plausible solution to processing concerns. The difference between entirely modular models (Kay et al. 1992) and the ones that take modularity only as a starting point, but not as an endpoint, is that modular models predict that aphasia could result from impairment of a specific input or output module (phonological or orthographic input lexicon, visual object recognition system) and/or its interface with the semantic system module. The other types of models, such as the dual-coding theory (Paivio 1986, 2010), argues for verbal representations of low imageable words (LI), but for verbal and non-verbal representations of high imageabile words (HI), predicting that simultaneous activation of non-verbal representation further facilitates semantic processing only in high imageable lexical items (most

often tested nouns). Verbal representation is activated by verbal modality stimulus - spoken and written; and, non-verbal by non-verbal modality stimulus - picture. Two representations are connected by the referential connections. Hence our decision to test the predictions that can be extracted from the Double coding theory on Croatian aphasics.

In collaboration with rehabilitators from the SUVAG polyclinic,[6] we translated and adapted PALPA battery of tests to Croatian. As the authors set forth in their introduction of PALPA and as a separate piece in Clinical forum of Aphasiology (Kay et al. 1996), "PALPA (Psycholinguistic assessments of language processing in aphasia) is designed to be a resource for speech and language therapists and cognitive and clinical neuropsychologists who wish to assess language processing skills in people with aphasia." When this introduction, as well as the battery itself was published in 1996, the awareness of the importance of such instruments as tools for better understanding of language processing tasks was in its early stage.

Although PALPA was not originally designed for psycholinguists, rather primarily for clinicians, we decided to test whether it can be, alongside with using it as a basic assessment set of tests, used as well as a basic analytic tool for psycholinguistic research. Consequently, we used PALPA battery in testing aphasic patients alongside with healthy controls matched in age, gender, as well as educational background. To this end we firmly advocate the view that the results from controls provide indispensable psychometric normalization of PALPA for a certain language, in our case Croatian, to which it was adapted.[7]

Despite our disagreement with some of the basic theoretical assumption of PALPA, especially author's somewhat simplified view of language processing through modular approach, we chose to adapt this test to Croatian for its breadth (meaning the abundance of available materials) and gradual character (i.e. increasingly more and more complex testing

[6]SUVAG is a health institution specialized for consultative health protection of persons with problems of speech communication, both children and adults. In medical diagnostics and rehabilitation of the hearing and speech impaired, theoretic hypothesis, methodic procedures and electroacoustic equipment of the verbotonal method are applied. The name itself, SUVAG, is an acronym of the name: Guberina's Universal Verbotonal Auditory System (**S**ysteme **U**niversel **V**erbotonal d'**A**udition **G**uberina). Verbotonal method is used as a method in the rehabilitation of listening and speech at the SUVAG Polyclinic. See: http://www.suvag.hr/en/.

[7]The translation of the original PALPA battery of tests and the adaptation of multiple tests for the Croatian was performed at the University of Zagreb under the guidance of professors Vlasta Erdeljac and Anita Peti-Stantić during the academic years 2011-2013. The main collaborators on this project were research assistants Jana Willer-Gold and Martina Sekulić, alongside with a group of undergraduate linguistic students.

material). These two characteristics of PALPA enabled us to take notice of every patient's turning point, especially at the lexical and combinatorial levels that interest us most.[8]

PALPA battery consists of 60 individual assessment tests for recognition, comprehension and production of spoken and written words and sentences, designed to help in diagnosing language processing difficulties in individuals with acquired brain damage. The baseline theoretical assumption on which PALPA was build presupposes modular approach, which aims to provide the information about the integrity of putative modules. To be able to do this, the battery encompasses sets of tests that range from simple recognition of written words to sentence comprehension, systematically using standard word to word or picture to word and word to picture paradigms. In connection to the fact that each subtest corresponds to certain fragmentation of a real world language use which is more or less 'natural' and thereof accounts for particular departure from natural language processing, it has to be perceived that many researchers acknowledge that there exists a considerable gap between the assessment of language processing as a mental activity and actual language use in everyday life. This is assumed to be even more significant problem when testing patients than healthy language users.[9]

Although up to date psycholinguistic investigations of language processing (both concerning healthy subjects and patients) seem to maintain this gap, it is also true that when implementing sets of tests such as provided by PALPA, a language researcher can obtain highly valuable information on processing phonological, syntactic and semantic language properties of brain damaged individuals. Furthermore, if we use PALPA battery as a baseline for supplementary detailed examination complemented with targeted psycholinguistic tests, it can serve as a well-controlled material which can form a base for further analysis and theoretical modeling.[10]

---

[8]Author's prediction (Kay et al. 1996: 163) that really precise description of the language-processing system would pinpoint the exact procedure which enables exact representation to be found among the tens of thousands of other word-representations in a certain repository and would «depict it in a way that distinguishes between systems and representations and the procedures that are used to find entries in these systems», twenty years later, did not come to life yet.

[9] More on that see Kay et al. 1996; Gerber and Gurland, 1989; Lesser and Milroy, 1993; Goldstein and Beers, 2003; Noordzij et al., 2010. Also, Frattali, Thompson, Holland, Wohl, and Ferketic, 1995 provide tools to asses the use of language and other communicative skills in functional settings of everyday life.

[10] It should be taken into consideration that the authors admit that the data they collected at the time of publication of PALPA does not allow for a full standardization of the battery and that therefore no satisfactory psychometrical measures of validity and reliability were carried out (Kay et al. 1996: 160; more on that also Wertz 1996).

Assuming minimal information-processing system or step-by-step modularity, researchers gathered around PALPA created perplexed system of tests that does not allow for communication between modules in parallel. It also does not postulate synchronizing in phases that was proposed at the time of its first presentation, and further developed over the years (Jackendoff 1972, Bock & Levelt 1994).[11]

For all that, we used PALPA battery of tests to verify processing hypothesis extracted from the Dual coding theory. The issues raised during testing led to reconsideration of the existing approaches and instigated a new direction of inquiry, the one that requires an explanation of the difference between the complexity of semantic systems and the complexity of tasks.

3. MATERIALS AND METHODS

We tested 30 aphasic participants (among them specifically 11 Broca's and 11 anomic aphasics), all native speakers of Croatian. We collected behavioral classification, as well as clinical assessment and CT scan data for all patients.

Alongside aphasic patients, we also tested 30 paired neurologically healthy participants. They were paired with patients for the gender, age, level of education and right/left handedness. For present analysis we have selected a balanced set of 22 healthy subjects that were paired with 11 Broca's and 11 anomic aphasics.

3.1 MATERIALS

Patients were tested on the set of semantic tests of different complexity from the battery of tests Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) adapted for Croatian. Our target tests were PALPA 49 and 50: *Auditory and Written Synonym Judgment tests* specifically designed to examine processing of the lexical feature of imageability. Two follow-up comprehension tests of lesser and higher processing complexity were administered and analyzed to obtain more information on patients difficulties, namely PALPA 47 and 48, *Spoken and Written Word-Picture Matching* and PALPA 51, PALPA 47 and 48, and

[11] Among other things, the authors of PALPA assume that one can distinguish words from perfectly well-formed non-words of their language at the simplest level of processing, without any semantic knowledge, only based on the search and find procedure applied to the repository (orthographic input lexicon). Although acknowledging the existence of the semantic system, they postulate the orthographic input lexicon as a gateway to this system no further questions asked. Pseudo-words and non-words, however, remained to be one of the hard nuts of semantic investigations to this day.

Word Semantic Association (Kay et al. 1992, Erdeljac et al. 2014, Peti-Stantić et al. 2014).

3.2 METHODS

We conducted three sets of interconnected experiments. In experiment 1, we used PALPA 49, Auditory synonym judgment test and 50, Written synonym judgment test. Task consisted in judging whether two words are closely related in meaning. Two sets of words, HI and LI, claimed to be matched for frequency,[12] are presented in a verbal form in an auditory and written modality. The choice between target word and the stimulus in this test is only binary. Half of the words serve as distractors, matched in imageability (HI and LI) and not related in meaning to the target word. Question to be asked by an examiner was: "Do these two words mean aproximatly the same thing?"

In experiment 2, we used PALPA 47, Spoken word-picture matching and 48, Written word-picture matching, thought of as simpler tests than 49 and 50, presumably because there are no LI words in this tests. The aim of this test is to relate spoken and written words with pictures, so it is possible to test only HI concepts. This is a picture judgment task in which participants need to choose the picture (out of 5) that best represents the meaning of the word presented in auditive or written modality.[13] Instructions examiners gave to the participants read: "Please listen to/read this word. Do not say what it is. Just think carefully and point to the picture which matches it. Be sure that you look at all the pictures."

In experiment 3, we used PALPA 51, Word semantic associations task. Task consisted in judging whether two words are related in meaning by association. Two sets of words, HI and LI, again claimed to be matched for frequency, are presented in a verbal form (as words), in an auditory and written modality. The choice between target word and the stimulus consisted of one stimuls words and four words to choose from. Half of the words served as semantic distractors, matched in imageability (HI and LI). One distractor was semantically related, while the other two were not semantically related distractors. Question to be asked by an examiner was: "Look at this

[12] In an introduction to PALPA battery the authors claim that they matched all examples for frequency. However, already some random tests on native English speakers confirmed that several pairs of words are not well matched. Collins dictionary also record the decline in usage for many words from the set in the past 50 years.

[13] When designing the task, authors obviously did not consider that choosing from 5 pictures, a target and 4 distractors (close semantic distractor from the same superordinate category, a more distant semantic distractor, a visualy similar distractor and an unrelated distractor) should present significant problem for aphasics.

underlined word. Do not read it aloud. Here are four other words. Which one is the closest in meaning? Tick the one that is closest in meaning."

Out of three lexical tests performed, this one is the most complex for three reasons. Firstly, the experimental set consists of HI and LI imageable words which proved to generate processing load. Secondly, semantic association task is not a simple matching task (between words and pictures or words closely related in meaning), rather it is a task that involves establishing interconnections between diverse domains of the mental lexicon. Thirdly, this test is a multiple choice task with semantically related and unrelated distractors aiming at a higher level combinatoriality competence.

4. RESEARCH AIMS

Our research aims were threefold: 1. To investigate the difference in semantic processing of HI and LI words in aphasic patients compared to healthy controls when presented with visual or auditory stimuli; 2. To compare accuracy of HI and LI words for Broca's and anomic aphasics on semantic processing tasks of different complexity; 3. To investigate the correlation between the semantic processing of HI and LI words and the stimulus modality.

To that end, based on previous research, as well as on well established literature on aphasia, we formulated two hypotheses:

H1: Activation of lexical mental representation depends on the imageability. The accuracy is expected to be higher in the condition with higher imageability and lower in the condition with lower imageability.

H2: Broca's aphasics are expected to score higher than the anomic aphasics on semantic processing tasks of any complexity because of the established difference in manifestations of Broca's and anomic patients.

As already mentioned, it is widely accepted that anomia is taken to be impairment of the ability to retrieve words and/or the inability to select and use appropriate substantive words in verbal output. Anomia is defined as a deficit in patients with normal fluency, good auditory comprehension and repetition, minimal word-finding difficulties (Stemmer et al. 2008), with the impairment in the ability to retrieve words (Goodglass and Wingfield, 1997). Although there are various forms of anomia, as well as other aphasic deficits, anomia is usually labeled word-finding deficit. Broca's aphasia, on the other hand, is taken to be primarily agrammatic aphasia, or the inability to understand and process certain grammatical structures, especially complex syntactic structures and function words. This leads to a justified assumption that Broca's and anomic aphasics should perform differently on lexical tasks administered.

5. RESULTS

Results of T-test for the experiment 1 (PALPA 49 and 50) point to an expected statistically significant difference between the group of aphasic patients and group of healthy participants in recognizing synonyms, while even higher statistical difference was found between the two groups when judging non-synonyms.

TTest HEALTHY vs APHASICS		
	HI	LI
SYNONYMS	0.005245543	0.004842909
NON-SYNONYMS	9.19769E-08	1.54397E-05

Table 1: T-test for Palpa 49 and 50 results.

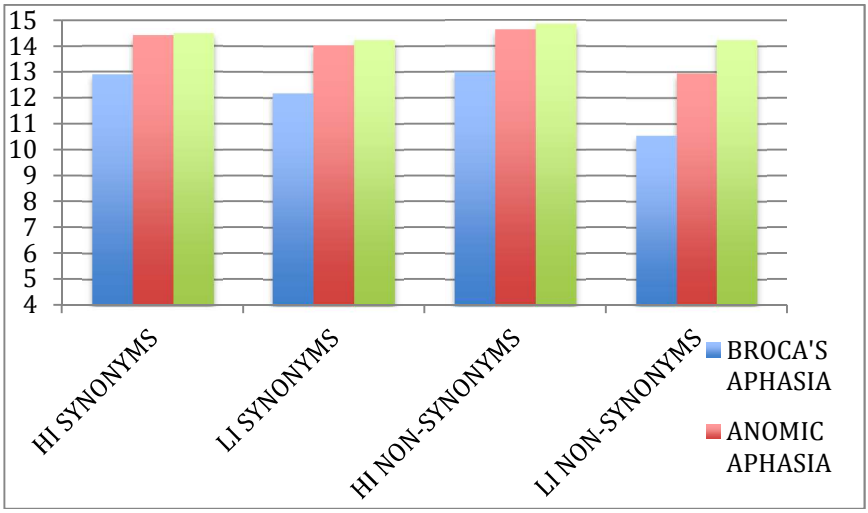
In addition, statistically significant difference was recorded between the group of Broca's and anomic patients. P-values for combined results from auditive and written modality for HI synonyms is 0.0013 and for LI synonyms is 0.0061. None of these tests showed statistically significant result when compared for the modality of presentation itself.

SYNONYMS HI (auditive+written)		
Broca's	Mean	13.0000
	SD	2.2039
Anomics	Mean	14.6250
	SD	0.7109
BROCA's vs ANOMICS	**TTest**	**0.0013**
SYNONYMS LI (auditive+written)		
Broca's	Mean	10.5455
	SD	*3.8013*
Anomics	Mean	13.0833
	SD	1.9542
BROCA's vs ANOMICS	**TTest**	**0.0061**

Table 2: T-test for HI and LI synonyms across groups of aphasic patients.

It is worth noting that we detected two interesting patterns already by comparing the results of Broca's and anomic patients on PALPA 49 and 50. These patterns as well get to be repeated in answers to other tests. Firstly, anomic patients scored very high on all tasks. As a group, they almost reached

the level of accuracy comparable to the group of healthy participants on all tests except for LI non-synonyms, where they scored significantly lower (see Graph 1). Broca's aphasics, on the other hand, scored significantly lower compared to the healthy group, but also compared to the group of anomics on all tasks. Secondly, SD in the group of Broca's aphasics is significantly higher than in the group of anomic patients on all tasks, pointing to the high variability within the group itself.

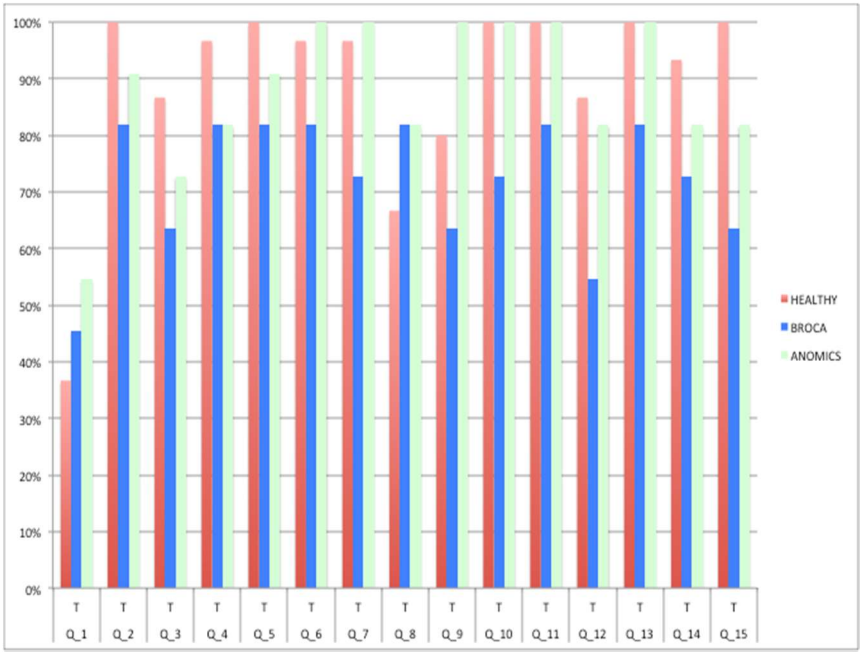


Graph 1: Results of Broca's and anomic patients compared to healthy participants (pictured in green) on results from PALPA 49 and 50.

There was no significant statistical difference between the auditory and visual modality in the experiment 2, although there was some difference in the accuracy of answers on individual sets of words between the auditive and visual modality (maximal difference between two modalities was 15%). Also, the difference in mean vaules between the group of Broca's and anomic aphasics did not show statistical significance (out of 40 questions, Broca's on average answered 35.72 correct compared to 37.33 correct in anomics in auditive modality, while Broca's answered 36.18 correct and anomics 38.17 in written modality). The proportion of SD difference between the groups of aphasic patients, however, remained the same as in PALPA 49 and 50 (1.77 for anomics compared to 3.37 for Broca's in the auditive and 1.64 for anomics compared to 3.09 for Broca's in the visual modality).

As we show in the graph 2, there are only few characteristic examples that presented problem for all groups, specifically 1, and to lesser

extent 8 and 9.[14] The low accuracy results on these questions are most likely due to the lack of necessary controls or the concepts that served as stimuli and targets. The detailed account of results on PALPA 51 HI words presented in Graph 2 again show the highest variability in answers in the group of Broca's patients, although on certain examples they scored equally high as anomics. Overall, when we excluded three "problematic" examples, the results show that the healthy participants were correct 90%, while anomic patients were correct 80% and Broca's patients were correct 70%. However, approximately 50% of Broca's patients in HI range is below the mean value.

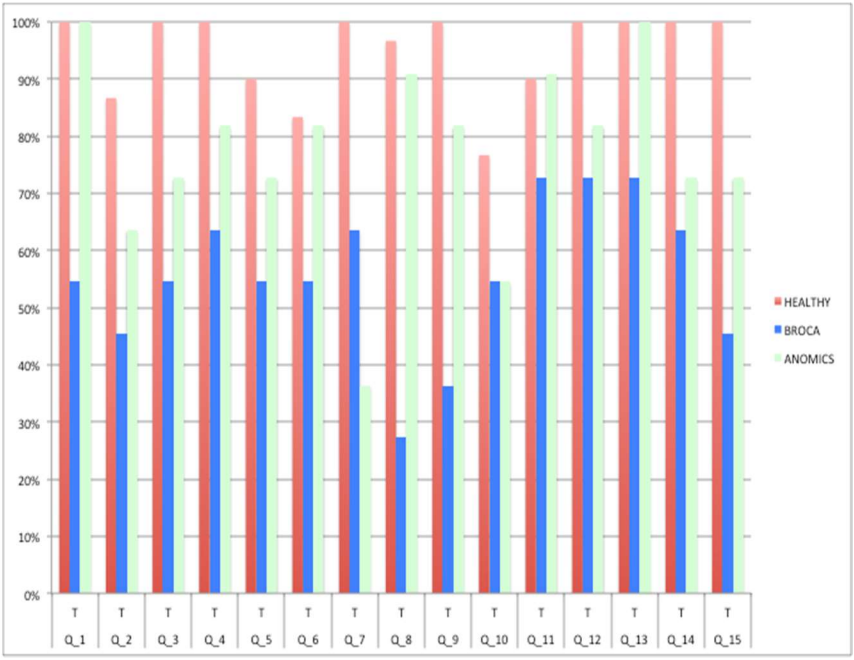


Graph 2: PALPA 51, HI words

The detailed account of results on PALPA 51 LI words presented in Graph 3 show the same pattern of high variability among the individual answers within the group of Broca's aphasics. The variability, as seen before, is significantly higher than in the other two groups. Within this group, the

[14] In our translation for example 1 magla – rosa, para, vijak, čavao (Engl. fog – dew – steam – screw
– nail).

results on only three questions are at the level of 73%, while all others are significantly lower. This might point to the fact that the copmlexity of the task itself is beyond the level that Broca's can compute. Overall results of accuracy within the group of healthy participants is at 95%, in the group of anomic patients 77%, while in the group of Broca's patients this measure shows only 56% correct answers.



Graph 3: PALPA 51, LI words

6. DISCUSSION AND CONCLUSION

Results confirm the first hypothesis. Aphasics as a group scored higher on accuracy of HI words in the task of lower complexity than in the task of higher complexity. Accordingly, aphasics as a group scored lower on the accuracy of LI than HI words in complex semantic processing tasks. Statistical analysis showed significant difference between aphasic patients as a group compared to healthy participants. Results also point to the difference between the subgroups of aphasics. Subsequently, the results suggest that imageability facilitates lexical unit's activation, even in complex semantic processing.

Results disconfirm the second hypothesis. Broca's aphasics scored lower than anomic aphasics on all tests. Their lower results on semantic processing at all levels of complexity, both identity relations (PALPA 47, 48, 49 and 50) and associative relation (PALPA 51), make it clear that for more accurate results on their impairment, Broca's aphasics should be tested both on syntactic and semantic tasks of different complexity.

In the end, it should be indicated that, while the overall performance of Broca's aphasics was lower in comparison to anomic aphasics, it was significantly lower in processing higly complex semantic tasks. This is the most interesting result for the linguistic theory because it concerns the fact that, although agrammatic Broca's aphasics are thought not to be primarily impaired in lexical processing, the number of their errors in semantic processing increased with the augmentation of task complexity. Alongside with the available data on their syntactic impairment, this does not suggests the impairment of a specific module, than, rather, the impairment of the capacity to solve complex linguistic tasks altogether.

This finding should govern the future research of aphasic patients in Croatian, but also in other languages, because the researchers should pay closer attention to the complexity of psycholinguistic tasks, as well as to the complexity of structures involved both in the grammatical and conceptual representations.

BIBLIOGRAPHY

1. Altarriba, Jeanette, Lisa M. Bauer and Claudia Benvenuto (1999). Concreteness, context availability, and imageability ratings and word associations for abstract, concrete, and emotion words. *Behavior Research Methods, Instruments, & Computers 31 (4),* 578-602.
2. Bird H., Franklin, S., & Howard, D. (2001). Age of acquisition and imageability ratings for a large set of words, including verbs and function words. *Behavior Research Methods, Instruments, & Computers*, 33, 73–79. doi:10.3758/BF03195349
3. Bock, K. & Levelt, W. (1994). Language production. Grammatical encoding. In: *Handbook of psycholinguistics*, ed. M. A. Gernsbacher. Academic Press.
4. Caramelli, Nicoletta, Annalisa Setti and Donatella D. Maurizzi (2004). Concretet and Abstract Concepts in School Age Children. *Psychology of Language and Communication* 2004, Vol. 8, No. 2, 19-34.
5. Coltheart, M. (1981). The MRC psycholinguistic database. Quarterly Journal of Experimental Psychology, 33, 497–505. doi:10.1080/ 14640748108400805
6. Cortese, M. J. & Fugett, A. (2004). Imageability ratings for 3,000 monosyllabic words. *Behavior Research Methods, Instruments, & Computers*, 36, 384–387. doi:10.3758/BF03195585

7. Dellantonio, Sara, Claudio Mulatti, Luigi Pastore and Remo Job (2014). Measuring inconsistencies can lead you forward: Imageability and the x-ception theory. *Frontiers in Psychology*, July 2014, Vol 5, Article 708, 1-9. doi: 10.3389/fpsyg.2014.00708.
8. Della Rosa, P. A., Catricalà, E., Vigliocco, G., & Cappa, S. F. (2010). Beyond the abstract–concrete dichotomy:Mode of acquisition, concreteness, imageability, familiarity, age of acquisition, context availability, and abstractness norms for a set of 417 Italian words. *Behavior Research Methods*, 42, 1042–1048. doi:10.3758/BRM. 42.4.1042
9. Desrochers, A. & Thompson, G. L. (2009). Subjective frequency and imageability ratings for 3,600 French nouns. *Behavior Research Methods*, 41, 546–557. doi:10.3758/BRM.41.2.546
10. Erdeljac, Vlasta, Sekulić Sović, Martina, Willer-Gold, Jana, Biočina, Zdravka, Čolović, Nina, Dragojević, Ema, Feldman, Eva, Jelovac, Tara, Masnikosa, Irina, Rosandić, Dorotea (2014). Leksičko obilježje predočivosti u mentalnom leksikonu osoba s afazijom, *Govor*: časopis za fonetiku, 31, 1; 29-47
11. Frattali, C. M., Thompson C. M., Holland A. L., Wohl C. B., Ferketic M. M. (1995). The FACS of life ASHA facs - a functional outcome measure for adults. ASHA 37(4): 40-46.
12. Gerber, S. and Gurland, G. B. (1989). Applied Pragmatics in the Assessment of Aphasia. *Seminars in Speech and Language*. Issue 4. doi: 10.1055/s-00000076.
13. Goldstein, Gerald and Beers, Sue R. (eds). (2003). *Comprehensive Handbook of Psychological Assessment, Intellectual and Neuropsychological Assessment*. Wiley
14. Goodglass, Harold & Wingfield, Arthur (1997). *Neuroanatomical and Cognitive Correlates.* A volume in Foundations of Neuropsychology. Elsevier.
15. Gvion, A. & N. Friedmann (2013). A selective deficit in imageable concepts: a window to the organization of the conceptual system; *Frontiers in human neuroscience*; 7; 1-13.
16. Jackendoff, Ray (1972). *Semantic Interpretation in Generative Grammar*. Cambridge, MA: MIT Press.
17. Kay, J. et al. (1992). *Psycholinguistic Assessment of Language Processing in Aphasia (PALPA)*. London: Lawrence Erlbaum Associates.
18. Kay et al. (1996). Psycholinguistic assessments of language processing in Aphasia (PALPA): An introduction. *Aphasiology* 10(2):159-180
19. Lesser, Rut and Milroy, Lesley (1993). *Linguistics and Aphasia: Psycholinguistic and Pragmatic Aspects of Intervention*. Routledge.
20. Libben, Gary (2008). Disorders of lexis. in: Stemmer, Brigitte and Harry A. Whitacker (eds.) *Handbook of the neuroscience of language*. 147-154.
21. Lind, M., H. G., Hansen, P., Holm, E.,&Mevik, B.-H. (2015). Norwegian words: A lexical database for clinicians and researchers. *Clinical Linguistics and Phonetics*, 29, 276–290.
22. Nickels, Lindsay and Howard, David (1995). Aphasic Naming - What Matters. *Neuropsychologia* 33(10):1281-1303.

23. Noordzij M., Tripepi G., Dekker, F. W., Zoccali, C., Tanck, M. W., Jager, K. J. (2010). Sample size calculations: basic principles and common pitfalls. *Nephrol Dial Transplant* 25(10):3461-2.
24. Paivio, A., Yuille, J. C.,& Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology*, 76 (1, Pt. 2), 1–25. doi:10.1037/h0025327
25. Paivio, Allan (1971). Imagery and Language, in: *Imagery: Current Cognitive Approaches*, ed. Sydney Joelson Segal, Academic Press. 9-35.
26. Paivio, Allan (1986, 1990, 1991). *Mental representations: A dual coding approach*. New York: Oxford University Press.
27. Paivio, Allan (2010). Dual coding theory and the mental lexicon, *The Mental Lexicon*; 5 (2); 205–230.
28. Peti-Stantić, Anita; Erdeljac, Vlasta; Willer-Gold, Jana (2014). Imagebility Asymetry in Mental Lexicon of Croatian Aphasics and Healthy Speakers, *The ninth international conference on the mental lexicon*, poster presentation at Brock University, MacMaster University.
29. Peti-Stantić, Anita, Erdeljac, Vlasta, Willer Gold, Jana (2015). Complexity matters: semantic availability of Croatian Broca's aphasics. *Psycho- and neurolinguistic approaches to the grammar- lexicon distinction*, Copenhagen, Danska (conference presentation) http://bib.irb.hr/datoteka/817375.PETI-STANTIC_et_al._COMPLEXITY_MATTERS_COPENHAGEN_2015.pdf
30. Plaut, D. C. and Shallice, T. (1991). Preservative and semantic influences on visual object naming errors in optic aphasia: A connectionist account. *Journal of Cognitive Neuroscience*, 5, 89–117.
31. Rofes, A., deAguiar V., & Miceli G. (2015). A minimal standardization setting for language mapping tests: An Italian example. *Neurological Sciences*, 36, 1113–1119.
32. Rofes, Adrià, Lilla Zakariás, Klaudia Ceder, Marianne Lind, Monica Blom Johansson, Vânia de Aguiar, Jovana Bjekić, Valantis Fyndanis, Anna Gavarró, Hanne Gram Simonsen, Carlos Hernández Sacristán, Maria Kambanaros, Jelena Kuvač Kraljević, Silvia Martínez-Ferreiro, İlknur Mavis, Carolina Méndez Orellana, Ingrid Sör, Ágnes Lukács, Müge Tunçer, Jasmina Vuksanović, Amaia Munarriz Ibarrola, Marie Pourquie, Spyridoula Varlokosta, David Howard (2017). Imageability ratings across languages, *Behavior Research Methods*, Springer Verlag, 1-11. doi: 10.3758/s13428-017-0936-0
33. Sabsevitz, D. S. et al. (2005). Modulation of semantic system by word imageability; *NeuroImage*; 27; 188–200.
34. Simonsen, H. G., Lind, M., Hansen, P., Holm, E.,& Mevik, B.-H. (2013). Imageability of Norwegian nouns, verbs and adjectives in a crosslinguistic perspective. *Clinical Linguistics & Phonetics*, 27, 435–446. doi:10.3109/02699206.2012.752527
35. Schock, J., Cortese, M. J., & Khanna, M. M. (2012). Imageability estimates for 3,000 disyllabic words. *Behavior Research Methods*, 44, 374–379. doi:10.3758/s13428-011-0162-0

36. Snedeker, Jesse (2009). Word Learning. in *Encyclopedia of Neuroscience.* ed. Larry R. Squire, Amsterdam: Elsevier, 503-508.
37. Stemmer, Brigitte and Harry A. Whitaker (eds.) (2008). *Handbook of the Neuroscience of Language*. Elsevier.
38. Wertz, Robert T. (1996). Aphasia in acute stroke: Incidence, determinants, and recovery, *Annals of Neurology*, 129-130. doi: 10.1002/ana.410400125