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Imageability and subjective frequency of the 500 rated nouns in the Croatian Lexical Database

Properties such as word class, length, phonological and morphological complexity, concreteness, frequency, age of acquisition, and imageability have to be controlled in research and clinical practice, since they strongly affect the speed and accuracy of language processing by monolinguals and bilinguals as well as by speakers with language disorders. The purpose of this paper is to present the online Croatian Lexical Database (Cro. *Hrvatska leksička baza* [HLB], http://polin–hlb.erf.hr/) that contains different (psycho)linguistic word properties, and to use the HLB to provide the first analyses about (1) the relationship between frequency and imageability for the rated 500 nouns, and (2) the influence of raters' age, gender and education on their judgement. The results indicate a significant positive correlation between noun frequency and imageability, but no significant influence of the three non–linguistic rater factors on judgements about (psycho)linguistic property.

Introduction

Word recognition is a cognitive process of linking acoustic or printed forms of words with their meaning (Stanovich, 1991; Auer, 2009; Jackendoff, 2012). Besides form and meaning, word processing must take into account several other specific, inherent (psycho)linguistic properties of words in order for them to be accurately and effortlessly recognised. These properties refer to features that are conceptual (e.g. imageability and concreteness), linguistic (e.g. word class, phonological and morphological complexity, orthographic similarity) and usage–related (e.g. frequency of use, age of acquisition, familiarity) (Lind et al., 2015; Soares et al., 2017). Some of these properties are measured objectively, others subjectively, and still others (e.g. frequency) in both ways. Objective measures, such as word class and word length (number of graphemes or syllables) are defined by the grammatical principles of the language and can be accessed through grammar (e. g. the word *cvijet (Eng. flower)* is a monosyllabic noun as well as word *pas (Eng. dog)*). In contrast, subjective measures such as

concreteness, imageability, frequency (usage frequency) and age of acquisition are based on ratings by native speakers. Typically these ratings take the form of 5– or 7–point Likert–type scales, where 1 is assigned to words perceived as being *rare* (for subjective frequency) or *completely unimageable* (for imageability), and the maximum score is assigned to words perceived as *highly frequent* or *completely imageable.*

All these features of words have a significant impact on language acquisition and language processing. It is well known that concrete, frequent, more imageable and earlier–acquired words are retrieved and processed faster (Paivio, 1966; Ghyselinck, De Moor & Brysbaert, 2000; Łuniewska et al., 2016). If these features of words strongly define word processing, then they should be controlled in research and clinical settings. In the last few decades researchers have turned their attention to controlling these variables in various types of studies, such as those involving tasks of lexical retrieval or sentence comprehension; for example, Łuniewska et al., (2016) have reviewed studies examining age of acquisition, and Desrochers and Thompson (2009) have reviewed studies examining imageability and frequency. In clinical settings, these variables are especially important during construction of assessment tools or planning of therapy. For example, patients with stroke–induced aphasia retrieve faster more imageable concrete words (see Bastiaanse, Wieling & Wolthuis, 2016). In studies of children aged 3–5 years, imageability is a robust predictor of object naming, while frequency is the most important predictor of verb naming (Masterson, Druks & Gallienne, 2008).

Since word properties are language–specific, information and norms for each language should be gathered separately and systematically. A lexical database is an organised resource capturing the range of inherent (psycho) linguistic properties of words in a certain language. Lexical databases have been established in some languages, most often English, for which databases exist on imageability, frequency, concreteness, familiarity, meaningfulness and age of acquisition (Paivio, Yuille & Madigan, 1968; Coltheart, 1981; Altarriba, Bauer and Benvenuto, 1999; Balota, Pilotti & Cortese 2001; Bird, Franklin & Howard 2001; Cortese & Khanna, 2008; Brysbaert, Warriner & Kuperman, 2014). Similar lexical data are also available for several other languages, such as Swedish (Blomberg & Öberg, 2015), Norwegian (Lind et al., 2013), Portuguese (Marques et al., 2007), Italian (Rofes, de Aguiar & Miceli, 2015), Dutch (Ghyselinck, De Moor & Brysbaert, 2000), and French (Flieller & Tournois, 1994). Some of these database are available online (e.g., Italian, Norwegian, Swedish) and some on paper (Dutch, English).

The motivation for developing a Croatian lexical database (Cro. *Hrvatska leksička baza* [HLB]) is the lack of normative data for all (psycho)linguistic properties of words in Croatian generally and, specifically, the need to provide a basis for adapting and developing clinical diagnostic tools in that language. For example, constructing the Croatian version of the Comprehensive Aphasia Test (CAT; Swinburne, Porter & Howard, 2005) required taking into account

a range of (psycho)linguistic properties of words that were controlled in the original CAT (see more in Fyndanis et al., 2017).

HLB was launched in 2016 as an open–access, online database at http://polin–hlb.erf.hr/. Currently HLB contains 1,211 words, all of which were taken from the following standardised diagnostic tools in order to ensure clinical relevance:

1. Comprehensive Aphasia Test (CAT–HR) – Kuvač Kraljević, Lice, Matić, (in press), Jastrebarsko: Naklada Slap;
2. Communicative Development Inventories (KORALJE) – Kovačević, Jelaska, Kuvač Kraljević, Cepanec (2007), Jastrebarsko: Naklada Slap; and
3. Peabody Picture Vocabulary Test (PPVT–III–HR) – Dunn, Dunn, Kovačević, Padovan, Hržica, Kuvač Kraljević, Mustapić, Dobravac, Palmović (2010), Jastrebarsko: Naklada Slap.

HLB includes not only open–class words but also function words. This contrasts with some databases in other languages that focus on open–class words. For example, the Norwegian Words Database (Lind et al., 2015) includes only nouns, verbs and adjectives. HLB contains data on three objective word properties: word length (N of graphemes), syllabic length (N of syllables) and word class. It also contains data on two subjective properties: frequency and imageability.

Subjective frequency and imageability

Subjective word frequency is an estimation of the number of times a word is encountered by an individual, be it in spoken or written form (Balota, Pilotti & Cortese, 2001; Desrochers & Thompson, 2009; Soares et al., 2017). The term *frequency effect* claims that subjects respond more rapidly and more accurately to higher–frequency words than to lower–frequency words in tasks of lexical decision (Whaley, 1978; Grainger, 1990), and that speed naming by healthy adults and adults with aphasia is higher for higher–frequency words than for lower–frequency words (Forster & Chambers, 1973; Kay & Ellis, 1987; Grainger, 1990; Kittredge et al., 2008). Objective measurement of this (psycho)linguistic property is based on calculation of word frequency per 1 million words extracted from large corpora (Leech, Rayson & Wilson, 2001). Word frequency in linguistic studies is calculated more often using this objective method than using the subjective method. Nevertheless, the objective method has two limitations: (1) in many languages corpora are not available and (2) when they are available, they contain mostly extensive collections of written samples of professional writers, so the objective frequency is based only on written samples and may not reflect the frequency of words spoken by typical speakers. In this way, the subjective frequency rating may more reliably reflect exposure to the word (Balota, Pilotti & Cortese, 2001), even though it also contains judgement error.

Unlike frequency, imageability can be measured only in a subjective way, based on an evaluator's ratings. Paivio, Yuille and Madigan (1968) defined imageability as the capacity of the word to arouse a sensory experience, i. e. mental images of things or events. Depending on that capacity, some words arouse a mental picture very quickly and easily, e.g. *žaba* (Eng. *frog*), while others arouse images only with difficulty or not at all, e. g. *gravitacija* (Eng. *gravity*). The term *imageability effect* refers to the fact that highly imageable words are processed faster and more accurately than poorly imageable ones (see Rofes at al., 2017). Previous studies have shown that word imageability predicts word reading, word association and picture naming performance by healthy subjects (Barry, Morrison & Ellis, 1997; Strain, Patterson and Seidenberg, 1995), as well as written and auditory comprehension and word production by patients with aphasia (Allport & Funnell, 1981; Franklin, Howard & Patterson, 1995; Hanley & Kay, 1997). More imageable words and higher–frequency words trigger faster and more accurate responses in tasks that require word processing (e.g. Balota et al., 2004; Norris, 2006; Zevin & Balota, 2000).

The relationship between frequency and imageability is multi–directional. Some words reflect the reciprocal relationship of these two properties, such as *house* and *swim,* which are highly imageable and highly frequent, or *scorn* and *moor,* which are poorly imageable and infrequent. Some words reflect an inverse reciprocal relationship, such as *should,* which is highly frequent but poorly imageable, or *amphora,* which is clearly imageable but infrequent.

Desrochers and Thompsons (2009) found a significant correlation between frequency and imageability ($r=0.26$, $p<0.001$) but also showed that these two properties are relatively independent from each other, especially for words used with intermediate to high frequency. Low–frequency words are typically perceived as having low imageability, even when their referents are concrete. Those authors conclude that „human judges can differentiate degrees of imageability only when a word is known to them, and the probability of knowing a word varies as a function of its frequency of use in the language (Desrochers & Thompsons, 2009; p. 547–548). At the same time, other studies have observed an inverse negative relationship between these (psycho)linguistic properties, with imageability decreasing with increasing subjective frequency (e.g. Ferrand et al., 2008).

Besides inherent (psycho)linguistic properties of words, non–linguistic factors can affect the rater's language processing and, consequently, judgement about those (psycho)linguistic properties. These non–linguistic factors include age, gender and education. Studies in some languages have shown a gender effect in imageability, with women tending to rate words as more imageable than men do (Benjafield & Muckenheim, 1989 for English; Imbir, 2016 for Polish). Kavé, Samuel–Enoch and Adiv (2009) found an age effect in word production: older speakers appear to produce more infrequent nouns, most likely because they have a larger vocabulary from which to choose. One Norwegian study (Simonsen et al., 2013) found an age effect in imageability, with subjects aged 30 and older tending to rate words as more imageable. On the other hand, the same Norwegian study found no evidence of either gender or education effects on imageability. It

is difficult to draw general conclusions from this somewhat discordant literature, in large part because so few studies have focused on the relationship between non–linguistic factors and judgements about imageability and frequency.

Therefore the present study aims to explore this relationship as well as the relationship between the two subjective measures of frequency and imageability in the nouns included in the HLB database. This paper answers two main questions:

1. Is there a relationship between ratings of frequency and imageability for 500 nouns in the HLB?
2. Are differences between frequency and imageability ratings of nouns associated with raters' gender, age and education?

Method

Selection of words from the HLB

All of 500 rated nouns were selected from the HLB. They were selected to capture variations in length, number of graphemes and syllabic structure (Figures 1 and 2). The most common syllabic structures among the analysed words were two– and three–syllable structures (Figure 2). The most frequent words in this sample were disyllabic words and words with five or six graphemes. The other word classes were not included in the analysis as they were added later in the database and in the time of preparing this study they were rated by only a few raters.

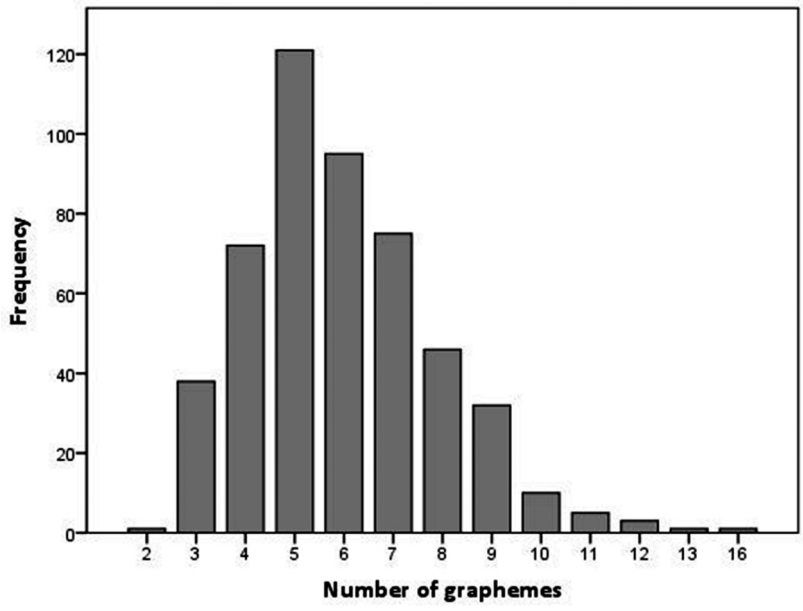


Figure 1: Lengths of nouns selected from the HLB (n=500), measured as the number of graphemes

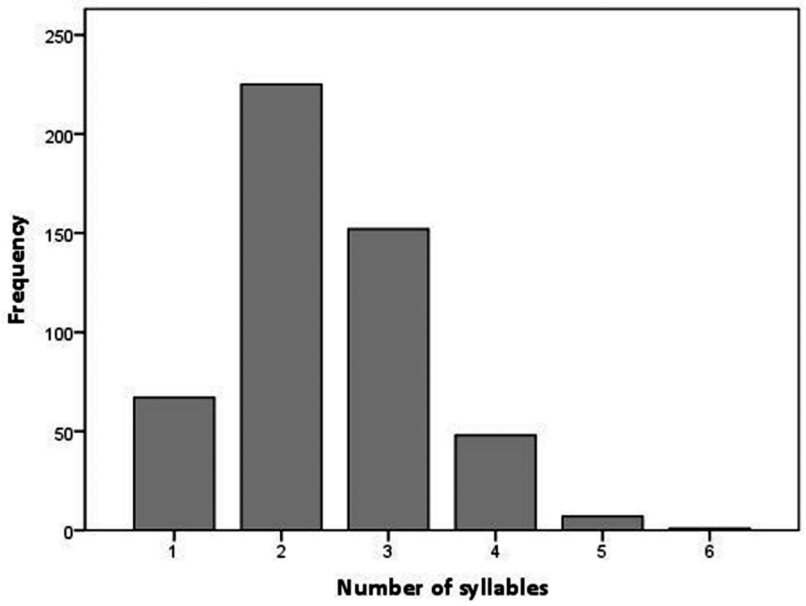


Figure 2: Syllabic structure of nouns selected from the HLB (n=500)

Participants

All nouns in the HLB were rated on frequency and imageability by approximately 33 raters (range, 27–44). The total pool of 197 raters comprised 46 men and 151 women ranging in age from 21 to 85 (M=42.12; SD=16.30). All raters are native speakers of Croatian. Raters differed according to education level: 41% completed high school only, while 58% completed higher education, which in some cases included master's degrees. Participants were recruited via academic communication (student and faculty staff) and private communication (mostly family settings).

Procedure

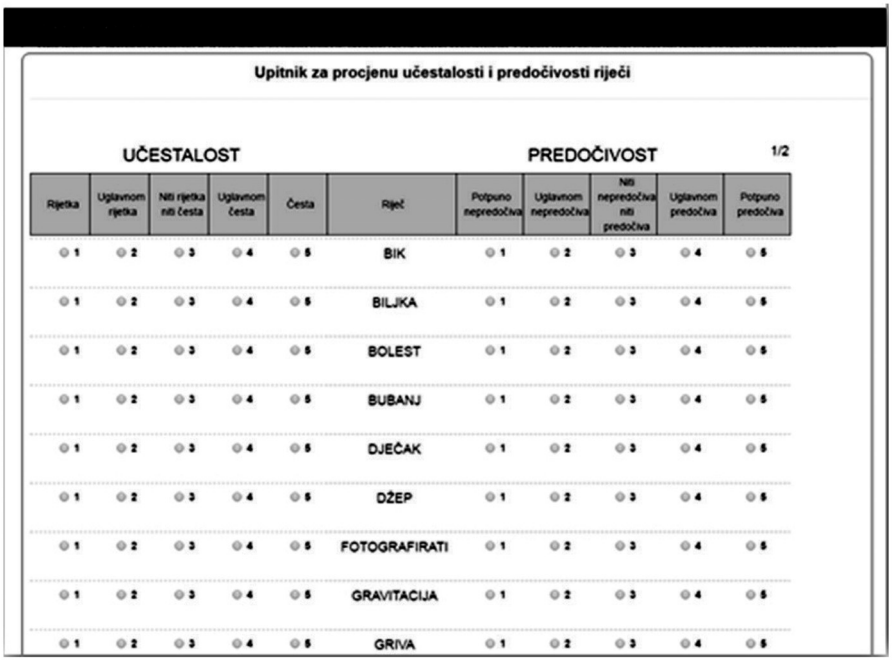
Raters logged into the HLB website and provided basic information about gender, age and education level. Then the website displayed the following instructions:

> *Your task is to rate each word on frequency and imageability on a 5–point scale, i.e. from 1 to 5. Frequency refers to the frequency with which you use a word, i.e. how often you use or hear it. (For example, the word "plate" is used or heard daily, so most participants will rate it as highly frequent, giving it a rating of 5; whereas the word "salute" is not so common, so most participants will rate it as extremely infrequent, giving it a rating of 1.) The imageability of a word refers to how easy or hard it is to imagine. (For example, the word "umbrella" is quite easy to imagine,*

so most participants will give it a rating of 5, while the word "awe" is difficult to imagine, so most participants will give it a rating of 1 or 2.)

Other lexical databases ask participants to rate words on a 5– or 7–point Likert–type scale, and it is unclear from available evidence which scale is better (e.g. Cummins & Gullone, 2000; Leung, 2011). A 5–point scale was chosen for the HLB for several reasons. One is that it appears less time–consuming to the participant. Another is that it may result in less effort and therefore less fatigue when participants are choosing each item (Leung, 2011), particularly when many words appear on the questionnaire as in the present case. A third reason is that participants may better understand the gradations of the scale when only five levels are present. In the questionnaire, the five levels for rating frequency were interpreted as follows: 1 – rare, 2 – relatively infrequent, 3 – neither rare nor frequent, 4 – frequent and 5 – highly frequent. Similarly, the five levels for rating imageability were interpreted as follows: 1 – completely unimageable, 2 – relatively unimageable, 3 – neither unimageable nor imageable, 4 – imageable and 5 – completely imageable.

Each participant had to rate 100 words on frequency and imageability in order to avoid placing excessive demands on participants (Hansen et al., 2011). The words were randomly selected from the preselected list of 500 (Figure 3). Frequency and imageability ratings for a given word were then averaged across all participants who rated that word.



Upitnik za procjenu učestalosti i predočivosti riječi

UČESTALOST PREDOČIVOST 1/2

Rijetka	Uglavnom rijetka	Niti rijetka niti česta	Uglavnom česta	Česta	Riječ	Potpuno nepredočiva	Uglavnom nepredočiva	Niti nepredočiva niti predočiva	Uglavnom predočiva	Potpuno predočiva
1	2	3	4	5	BIK	1	2	3	4	5
1	2	3	4	5	BILJKA	1	2	3	4	5
1	2	3	4	5	BOLEST	1	2	3	4	5
1	2	3	4	5	BUBANJ	1	2	3	4	5
1	2	3	4	5	DJEČAK	1	2	3	4	5
1	2	3	4	5	DŽEP	1	2	3	4	5
1	2	3	4	5	FOTOGRAFIRATI	1	2	3	4	5
1	2	3	4	5	GRAVITACIJA	1	2	3	4	5
1	2	3	4	5	GRIVA	1	2	3	4	5

Figure 3. Screen image showing an example of the on–line questionnaire to rate word frequency and imageability for the HLB

Results and discussion

The aim of this study was to investigate the relationship between frequency and imageability for the 500 nouns in the HLB, and to analyse the impact of non–linguistic rater factors on their judgement. Table 1 shows descriptive statistics for the imageability and frequency of 500 Croatian nouns. The Kolmogorov–Smirnov Z test indicates that the results for both variables show a non–normal distribution, whereas skewness and kurtosis analyses indicate a normal distribution for both variables. Imageability ratings show a slightly negative skew: higher scores are more frequent, with ratings starting around 2 and clustering around 4. Subjective frequency ratings do not show skew, although they do tend to be slightly platykurtic: each score from 1 to 5 is approximately equally represented, with no clear peak. On average, words are rated as *imageable* to *completely imageable,* while their frequency is rated as *neither rare nor frequent* to *frequent*. The clustering of results can be seen on the boxplot in Figure 4.

	Imageability	Frequency
N	500	500
Minimum	1.85	1.03
Maximum	5.00	5.00
Mean	4.24	3.40
Std. Deviation	0.84	0.96
Median	4.67	3.42
Range	3.15	3.97
Skewness (Stand. Error)	–0.99 (0.11)	–0.19 (0.11)
Kurtosis (Stand. Error)	–0.34 (0.22)	–0.83 (0.22)
Kolmogorov–Smirnov Z	4.70 ($p<0.01$)	1.55 ($p<0.05$)

Table 1. Descriptive statistics about imageability and frequency of 500 Croatian nouns in the HLB

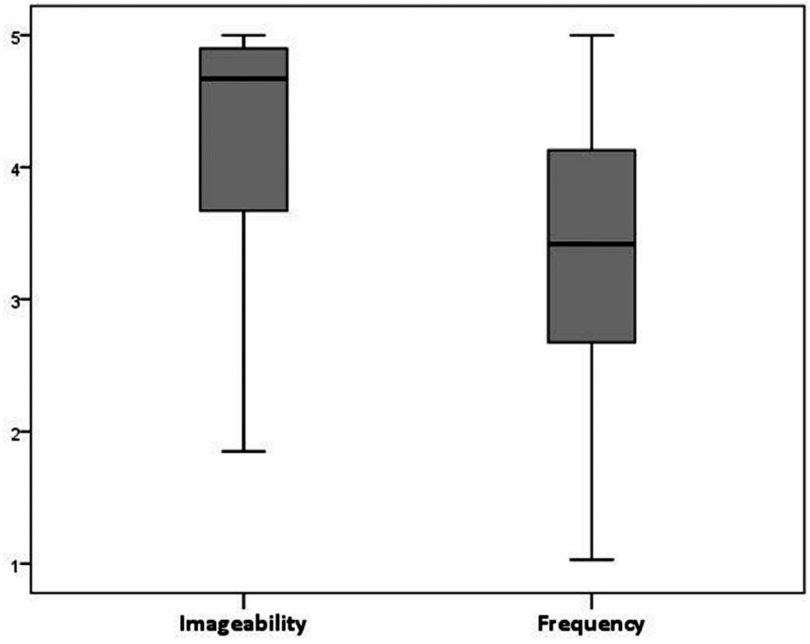


Figure 4. Box plot showing median, quartiles and range in the imageability and frequency ratings of 500 Croatian nouns in the HLB

Relationship between imageability and frequency

Our first research question concerns the relationship between the two (psycho)linguistic word properties imageability and subjective frequency. Figure 5 shows the Loess regression line within the scatter diagram, depicting the trend line of imageability along the frequency scale. Although the scatter plot shows strong dispersal, the regression line and correlation coefficient indicate a low but significant positive relationship between the two properties (non–parametric Spearman's rho=0.33; $p<0.001$).

Although the overall trend is that imageability increases with frequency, the relationship is curvilinear rather than linear. The relationship is linear between scores of 1 and 3 and between 4 and 5. Between 3 and 4, imageability appears to vary inversely to some extent with subjective frequency. The relationship may be even more complex given the apparent clustering of data into two groups (Figure 5). When words are highly imageable (scores around 5), little or no correlation is evident between imageability and subjective frequency; when words are less imageable (scores of 2–3.5), positive correlation is clearly visible.

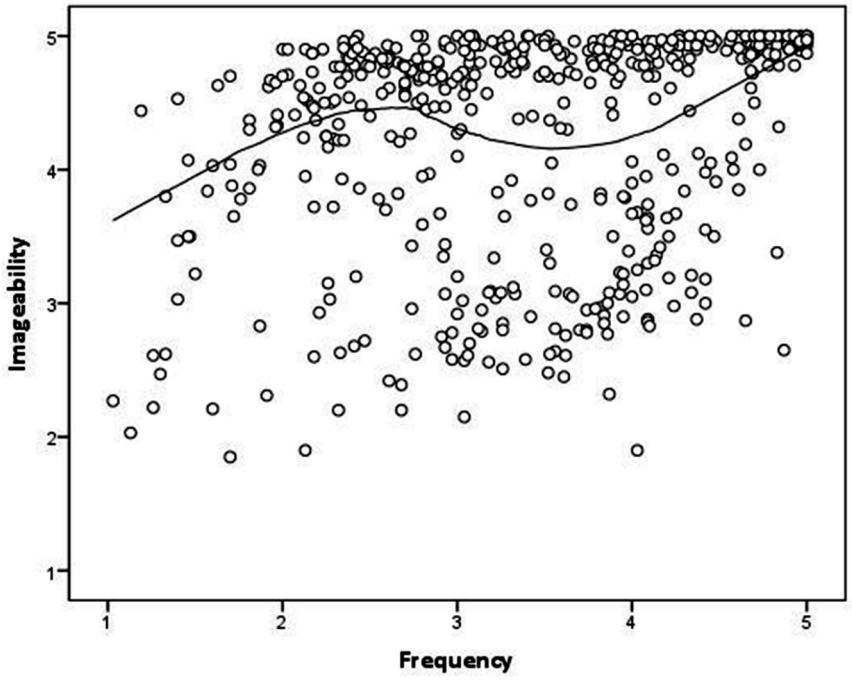


Figure 5: Scatter plot of the relationship between imageability and subjective frequency of 500 Croatian nouns in the HLB. The Loess regression line is shown.

Our results are consistent with some previous studies of imageability and subjective frequency. Desrochers and Thompson (2009) analysed subjective frequency and imageability ratings for 3,600 French nouns and, like our study in Croatian, they found a low but significant positive correlation ($r=0.26$; $p<0.001$). In a study of 1,760 monosyllabic French words, Gonthier et al. (2009) showed a stronger positive correlation between imageability and subjective frequency ($r=0.64$; $p<0.001$). Using linear regression, Gonthier et al. (2009) showed that subjective frequency was a significant predictor of imageability only for less frequent words.

On the other hand, our results differ from the results in other studies. In the study on 1,493 monosyllabic French words, Ferrand et al. (2008) found a significant inverse relationship between imageability and subjective frequency ($r=–0.28$; $p<0.01$). In a study of 998 lexical words randomly drawn from a French dictionary, Flieller and Tournois (1994) did not find any correlation ($r=–0.01$; $p>0.05$).

These discrepancies suggest that we still do not understand in detail the relationship between imageability and frequency, much less their potential mutual interaction (see more in Bastiaanse, Wieling & Wolthuis, 2016). Part of the problem may lie in the fact that our study focused only on nouns, whereas most of the French studies cited above did not control for word class.

Relationship of imageability and frequency to rater gender, age and education level

Our second question focuses on possible effects of non–linguistic and external characteristics of raters (gender, age and education level) on imageability and subjective frequency ratings. Before analysis, similar to the research by Simonsen et al. (2013), the age factor was categorised into six bands: 20–29, 30–39, 40–49, 50–59, 60–69, and 70+. The same age bands were chosen in order to test the age effect that was previously found. The factor of education level was dichotomised from the initial 5–level scale to two levels of "higher" and "lower" education. Differences in gender, age and education levels within imageability and subjective frequency ratings were tested using multivariate ANOVA. Results showed no significant effects of age, gender or education level on imageability or frequency ratings (Table 2).

Table 2. Multivariate ANOVA of between–subject effects

Source	Dependent Variable	df	F	Sig.	Partial η^2
Gender (M/F)	imageability	1	0.17	0.684	0.00
	frequency	1	0.41	0.521	0.00
Education (low/high)	imageability	1	0.50	0.482	0.00
	frequency	1	0.21	0.651	0.00
Age (decades)	imageability	5	1.32	0.258	0.04
	frequency	5	0.08	0.995	0.00
Gender * Education	imageability	1	0.45	0.502	0.00
	frequency	1	1.61	0.206	0.01
Gender * Age	imageability	5	1.74	0.128	0.05
	frequency	5	0.51	0.769	0.02
Education * Age	imageability	5	1.50	0.193	0.04
	frequency	5	0.94	0.459	0.03
Gender * Education* Age	imageability	4	1.28	0.280	0.03
	frequency	4	0.62	0.654	0.01
Error	imageability	172			
	frequency	172			
Total	imageability	195			
	frequency	195			

Our results are consistent with previous research that failed to find gender bias in imageability ratings, including one study of 1,599 Norwegian words (56% nouns, 30% verbs and 14% adjectives) (Simonsen et al., 2013), a study involving 244 Spanish words (Campos, 1990), and a study involving 1,080 English words (Friendly et al., 1982). On the other hand, our results contrast with two studies demonstrating that women rate imageability significantly higher than men do; one of those studies involved 1,046 words randomly chosen from the Oxford English Dictionary (Benjafield & Muckenheim, 1989), and the other study involved 4,905 Polish words (Imbir, 2016).

Our failure to detect an association between rater age and imageability only adds uncertainty to an already discordant literature. Simonsen et al. (2013) found that imageability increased significantly with age, with the largest jump occurring between 40 and 50 years. Those authors concluded that greater life experience may help raters image words, which would be consistent with the fact that older speakers use infrequent nouns more often than younger speakers, implying a larger vocabulary (Kave, Samuel–Enoch & Adiv, 2009). On the other hand, Grunwald et al. (1999) found that older participants perceived lexical stimuli with significantly lower accuracy than younger participants. In addition, those authors found that women processed lexical stimuli more accurately than men.

To help resolve apparent discrepancies in the literature, further research is needed into the effects of rater gender and age on imageability and subjective frequency. In the case of age, it is difficult to predict the likely relationship. Many cognitive abilities decline with age, including episodic memory, attention, executive functions, spatial orientation, visual perception, processing speed, information access, and verbal memory (Glisky, 2007; Glisky & Kong, 2008; Park et al., 2002; Schaie, 1994; Souchay, Isingrini & Espagnet, 2000; West, 1996). Similarly, some linguistic abilities decline with age, such as auditory comprehension (Obler et al., 1991), reading comprehension (De Beni, Borella & Carretti, 2007), and word retrieval (Wierenga et al., 2008). However, other linguistic abilities remain stable across the lifespan, including visual naming, spelling, articulation, and praxic features of writing (Schum & Sivan, 1997). Based on our results, we hypothesise that frequency and imageability for noun processing remain stable in adulthood. One of the explanations could be the fact that both of these (psycho)linguistic features are mostly lexical–semantic variables that correspond to a core aspect of the language system.

Our finding that education level was not associated with ratings of imageability or subjective frequency is consistent with the work of Simonsen et al. (2013), who reported a similar finding for imageability. We are unaware of other studies examining effects of education on imageability. Based on the available evidence, we hypothesise that education level is not a discriminatory variable for noun processing.

Conclusion

This study found a low positive relationship between imageability and subjective frequency. Gender, age and education level did not significantly affect ratings of subjective frequency or imageability. These results agree with some previous results obtained in studies that also included imageability ratings by nouns only. However, in studies that controlled word length that correlation is even higher.

The currently obtained results should be interpreted with caution given that the word sample is relatively small and came entirely from clinical diagnostic tests. Future work on the HLB will aim to increase the number of included words, expand the number of word classes beyond nouns, and integrate other (psycho)linguistic word properties, such as syllabic structure, age of acquisition and familiarity.

Acknowledgements

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The Croatian Lexical Database is public and open–access. All data stored in it can be shared by the wider community and used in professional and scientific work. In all cases, the data source should be properly cited as the present study.

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Predočivost i subjektivna učestalost 500 procijenjenih riječi u Hrvatskoj leksičkoj bazi

Pojedina obilježja riječi, kao što su vrsta, duljina, fonološka i morfološka složenost, konkretnost, učestalost, dob usvajanja, predočivost itd., potrebno je kontrolirati u istraživanjima kao i u kliničkoj primjeni. Naime, prethodna istraživanja govore kako navedena obilježja riječi imaju značajan utjecaj na brzinu i točnost jezične obrade kod osoba s različitom jezičnom pozadinom – kod jednojezičnih i dvojezičnih govornika, govornika urednoga jezičnog razvoja, govornika s jezičnim poremećajima. Svrha je ovoga rada predstaviti *Hrvatsku leksičku bazu* – HLB (engl. Croatian Lexical Database) – dostupnu na internetskoj poveznici http://polin–hlb.erf.hr/, a koja sadržava (psiho)lingvistička obilježja riječi. Takoder, cilj je i dati prve podatke 1) o odnosu učestalosti i predočivosti na 500 procijenjenih riječi te 2) o utjecaju nelingvističkih čimbenika kao što su dob, spol i razina obrazovanja ispitanika na njihovu procjenu. Rezultati upućuju na značajnu pozitivnu korelaciju između učestalosti i predočivosti imenica, ali ne i na značajan utjecaj triju ispitanih nelingvističkih čimbenika ispitanika na procjenu tih obilježja.

Keywords: Croatian Lexical Database (HLB), imageability, subjective frequency, psycholinguistics, Croatian

Ključne riječi: Hrvatska leksička baza (HLB), predočivost riječi, subjektivna učestalost riječi, psiholingvistika, hrvatski jezik