When Negative Turns out to Be Positive: Exploring Changes in Word Associations in the Aftermath of the COVID-19 Pandemic

Mai Raet
Tallinn University, Estonia
mairaet@tlu.ee

Abstract

The COVID-19 pandemic has had a significant impact on various aspects of society, including language and cognitive processes. This research investigates how the pandemic has influenced associations related to health-related words among 1,454 Estonian native speakers. Data collected between January and March 2023 were compared with a pre-pandemic dataset, the Dictionary of Estonian Word Associations (DEWA), compiled from 2016 to 2018. The study focuses on fifteen health-related cue words. The results revealed that five terms experienced significant changes in their association sequences concerning the COVID-19 crisis. Notably, among these 15 words, three stand out as the most significant cases where a change occurred in their primary responses: these typically exhibit the most robust and enduring associative links, making them less susceptible to change. This unveils shifts in the mental lexicon's representations and the evolving perceptions of specific words and concepts amidst the pandemic backdrop. These findings illustrate how unforeseen external disruptions, such as the COVID-19 crisis, can reconfigure the salience of certain concepts within language and cognition. This research contributes to our comprehension of the linguistic repercussions and potential language adaptations triggered by a health crisis. It also enriches the relatively understudied field of word association research, particularly in languages beyond the dominion of English.

Keywords: word associations, mental lexicon, COVID-19, corona language, language processing, Estonian.

Streszczenie

Kiedy negatywność okazuje się pozytywnością: badanie zmian w skojarzeniach słów w następstwie pandemii Covid-19

Pandemia Covid-19 wywarła znaczący wpływ na różne aspekty życia społecznego, w tym na język i procesy poznawcze. W badaniu tym zbadano, jak pandemia wpłynęła na skojarzenia związane ze słowami związanymi ze zdrowiem wśród 1454 rodzimych użytkowników języka estońskiego. Dane zebrane między styczniem a marcem 2023 r. porównano ze zbiorem danych sprzed pandemii, słownikiem pt. „Dictionary of Estonian Word Associations" (DEWA),

opracowanym w latach 2016–2018. W badaniu skupiono się na piętnastu słowach związanych ze zdrowiem. Wyniki wykazały, że, w związku z kryzysem związanym z Covid-19, pięć z tych słów doznało znaczących zmian w swoich ścieżkach skojarzeń. Warto zauważyć, że spośród badanych 15 słów trzy wyróżniają się jako najbardziej znaczące przypadki, gdzie nastąpiła zmiana w podstawowych reakcjach na nie; te zazwyczaj wykazują najsilniejsze i najtrwalsze powiązania skojarzeniowe, co czyni je mniej podatnymi na zmiany. Ten proces ujawnia zmiany w reprezentacjach leksykonu mentalnego oraz ewoluujące postrzeganie określonych słów i pojęć w kontekście pandemii. Wyniki te ilustrują, jak nieprzewidziane zakłócenia zewnętrzne, takie jak kryzys związany z Covid-19, mogą zmienić konfigurację znaczeń niektórych pojęć w obrębie języka i poznania. Niniejsze badanie przyczynia się do zrozumienia skutków językowych i procesów adaptacji języka wywołanych kryzysem zdrowotnym. Wzbogaca także stosunkowo słabo zbadaną dziedzinę badań nad skojarzeniami słów, szczególnie w językach spoza obszaru anglojęzycznego.

Słowa kluczowe: skojarzenia słowne, leksykon mentalny, COVID-19, koronamowa, przetwarzanie języka, język estoński.

1. Introduction

The COVID-19-inflicted health crisis was among the most significant precedents in recent healthcare history. Although horrific, one positive co-occurring aspect was the increased public interest in the work of lexicographers (Klosa-Kückelhaus 2022). That attention is perhaps not surprising since new vocabulary emerged to support effective communication, especially in critical times of crisis. Some of the vocabularies did not exist before and were specifically tailored for the crisis (lexical neologisms), COVID-19 itself being the most prominent example, a term originally coined by the World Health Organization in a report published on 11 February 2020.

Other changes also occurred: words that had previously no strong associational links, like mask and mall, became semantically related, and meanings of the pre-existing words shifted, acquiring new implications (semantic neologisms). For example, during the height of the pandemic, the adjective 'negative' carried a positive connotation—a negative covid-test was a positive instance.

In the COVID-19 heyday, one of the most frequent topics discussed in the media revolved around health, i.e., people were recurrently exposed to COVID-related health concerns and symptoms. However, the acute crisis has passed (at least, for the time being), and the focus of media attention has moved to new emergencies (energy crisis, security crisis, etc.). That raises the question if the "coronaspeak" (Thorne 2020) has left a lasting impression on people's language use. Corona-language is commonly characterized by the appearance of novel words and meanings; for instance, speakers come up with their own terms when describing the new

reality and experiencing it. Another aspect of the corona-language was the greater importance of scientific and medical vocabulary and the prevalence of phrases that describe both individual and governmental measures taken to control the transmission of the virus and reduce its impact on society and the economy (Thorne 2020; Salazar and Wild 2022: 25).

Previous research indicates that sudden and unexpected changes in linguistic exposure can, indeed, cause lasting changes in language processing (Kleinman *et al*. 2022). In a more specific context, Planchuelo *et al*. (2022) provided evidence of how the social environment shaped by the COVID-19 pandemic has influenced the emotional appraisal of words. Their findings indicate a consistent elevation in arousal levels when individuals encounter COVID-19-related terms, implying that the lexicon associated with COVID-19 elicits heightened levels of cognitive and physiological activation compared to the lexicon unrelated to the pandemic. On the other hand, language specialists note that most COVID neologisms will likely not endure, and highly professional words revert to their initial domains (Crystal 2020; Trap-Jensen and Lorentzen 2022: 830).

Based on these somewhat opposing statements, this paper seeks to discern if and how the COVID-19 crisis has changed the mental representations of specific, primarily health-related words in the general public's mental lexicon. To explore this matter, data from native Estonian speakers via an online word association test was collected from January to March 2023. The results were compared to the corresponding dataset, the *Dictionary of Estonian Word Associations* (DEWA) (Vainik 2019a, 2019b), assembled before the pandemic, during 2016–2018.

Studying the imprint that the pandemic has left on the collective subconsciousness lends itself to understanding the extent of the impact that a crisis like COVID-19 has on language and its role in potential language change.

Investigating the associations linked to health-related terms is a valuable approach to this endeavour, as it can provide insights into the underlying cognitive structures and semantic networks that individuals utilize to navigate health-related information. Moreover, it can also be seen as a tool to reveal the values and hierarchies that are present within a given culture, or as Daniel Everett (2016) metaphorically put it, a "dark matter". Additionally, exploring potential changes in these associations brought about by the pandemic could shed light on how the crisis has influenced public health literacy and awareness. Awareness of these nuances contributes to more informed linguistic choices that lead to more efficient communication. This information could prove beneficial in designing effective public health campaigns and interventions aimed at promoting healthy behaviours and preventing the spread of disease.

2. Theoretical background

2.1. Mental lexicon and word associations

Within the field of linguistics, the term "word association" (WA) refers to the mental connection between two or more words that are perceived to have semantic relatedness. The ability to form such associations is crucial in language acquisition (Elman *et al*. 1996; Rogers and McClelland 2004). Word associations serve as a direct means of understanding an individual's semantic knowledge (Nelson *et al*. 2004; Mollin 2009) and hold significance in comprehending human thought processes more broadly (Deese 1965). Furthermore, word associations have been proposed as a way to identify shared experiences and commonalities among individuals within a social group (Nelson *et al*. 2000). Consequently, exploring the dynamics of perceptual changes in individuals' associations with specific words offers a fertile ground for scholarly inquiry, especially considering the increased interest in association studies within applied linguistics and psycholinguistics over the past two decades (Fitzpatrick and Thwaites 2020: 238).

In the field of linguistics, studies on word associations rely on the theoretical concept of the mental lexicon (Oldfield 1966; Schmid and Köpke 2009; Aitchison 2012). The mental lexicon, also known as the internal lexicon, is believed to represent the network-like arrangement of lexical information in long-term memory, including information about words' form, sound, meaning, grammatical properties, and associations (Deese 1962; Quillian 1968; Collins and Loftus 1975; Hickok and Poeppel 2007; Gow 2012). In response to external stimuli, this "language of thought" (De Deyne and Storms 2015) has the capacity to self-organize and undergo changes over time (Libben and Jarema 2002). This means that some connections weaken while others are reinforced. Consequently, the corona crisis, as a significant external event, is expected to be reflected in participants' associative behaviour as they attempt to access their mental lexicon via associations.

In the study of word associations, the word association test (WAT) has been one of the most commonly employed methods. Originating from the works of British polymath Francis Galton (1879) and Swiss psychiatrist Carl Gustav Jung (1910), the WAT has been used to investigate the substance and structure of words and ideas in the human mind (for a more detailed historical overview, see Deese 1965; Fitzpatrick and Thwaites 2020). As a research method, a classical word association task involves presenting individuals with a stimulus word (cue word) and asking them to produce one or more words that come to mind in response,

either in writing or verbally. The responses to stimuli can be constrained, such as participants being asked to name a specific word type or members of a particular word category with a specific type of category, or uncontrolled, referred to as free associations (De Deyne and Storms 2015: 465; see also Nelson *et al*. 2000). The patterns of responses generated by this method are believed to provide insights into the organization and structure of the mental lexicon, the properties of lexical networks, and the interconnections among words (Deese 1962, 1966; De Deyne and Storms 2015).

2.2. Methodological considerations

It is essential to consider the context and the manner in which cue words are presented. For instance, there are differences in lexico-grammatical patterns between spoken and written registers (Biber *et al*. 2000; Rapp *et al*. 2015), which can impact the responses.

Another important aspect is deciding whether participants should provide only one or multiple responses. The multiple-response experiment format has faced criticism because it often exhibits an effect of "chaining", where subsequent responses are influenced by previous ones rather than the cue word (Milton and Fitzpatrick 2017: 99; Nelson *et al*. 2000). On the other hand, single-response word association tests have been criticized for their limitations in capturing the complexity and richness of the mental lexicon (e.g. Schmitt 1998; De Deyne and Storms 2008; De Deyne *et al*. 2012).

Adding to the complexity of the Word Association Test (WAT) is the absence of a consistent, universally accepted criterion for the selection of stimulus words and the classification of association responses. As noted by Meara (2009) and Kang (2018), due to the various methodological options available, it can be challenging to determine what should be considered reliable word association data and how to analyse it appropriately. Different researchers employ various approaches concerning the choice of stimuli, participants, data collection formats, and subsequent data treatment. In particular, the latter can lead to difficulties interpreting and comparing research findings. Therefore, it is unsurprising that there is a "frustrating lack of reliably consistent findings in word association research" (Fitzpatrick and Thwaites 2020: 241).

In the analysis of word associations, the role of the "primary" association has been emphasized. To facilitate comparisons between associations obtained from different respondents, association strength is a useful metric. Association strength indicates the degree of association between a specific cue word and the response provided by participants in a word

association task. It is typically calculated by dividing the frequency of a particular response by the total number of responses to that cue, resulting in a proportion of participants who produced the same word in response. The resulting number can be interpreted as the strength (or weight) of the association between the cue word and the response. Therefore, the more frequently a word occurs, the more connections it has to other words in the mental lexicon (de Groot 1989; Steyvers and Tenenbaum 2005). Frequency can be argued to be one of the most important factors influencing the organization of the mental lexicon (Forster 1976), along with the individual's subjective familiarity with the presented lexical item (Harley 2014; Hallin and Van Lancker-Sidtis 2017).

Selecting appropriate stimulus words is a crucial methodological concern, and the absence of a homogeneous systematic approach to stimulus word selection has been widely acknowledged as a challenge (Fitzpatrick and Izura 2011; Wolter 2001). Therefore, determining whether a cue word is associated with COVID-19 or not presents an even more demanding challenge due to the widespread nature of the pandemic crisis (Trap-Jensen and Lorentzen 2022: 826). Nevertheless, criteria were established in the current study for the selection of the 15 health-related stimuli (see section 3.2.1.)

3. Studying the change in word associations

The subsequent section examines associations primarily related to health in two distinct studies. The original study was conducted prior to the pandemic by Ene Vainik (2018), while the second study took place in 2023, immediately after the pandemic.

3.1. The original study

The initial study was carried out by Ene Vainik, a senior researcher at the Institute of the Estonian Language, during autumn-winter 2016-2017, with supplementary data collection conducted in January 2018. The results of her work were published as an online Estonian *Dictionary of Word Associations* (see Vainik 2019a). The *Dictionary of Associations* comprises 1296 keywords, which have been selected to encompass the most significant aspects of daily life and several lexemes instrumental in comprehending Estonian culture and mentality.

The distinguishing feature of the glossary resides in its methodology, as the associations listed have been collected through testing ordinary language users. The test was designed to elicit spontaneous responses to a series of verbal stimuli, and an average of 308 responses were

gathered for each keyword (stimulus). The glossary exclusively presents commonly repeated associations, meaning that the same stimulus-response pair was elicited from at least two respondents. Unique responses (approximately 50 per stimulus, on average) have been excluded from the glossary.

3.2. Follow-up study 2023

3.2.1 Criteria for word choice and data collection

The free word association test (WAT) was used as a data collection instrument to investigate possible changes in the word associations among regular native Estonian speakers related to health after the COVID-19 pandemic.

The data collection involved using 50 unique keywords (stimuli) divided into two sets of 25 words to maximize participant response rate, as questionnaire length has been shown to have a significant impact on response rate (Edwards *et al*. 2009). The specific selection of 50 stimulus words was aimed at harmonizing with the overarching discourse surrounding the coronavirus. Among these, 15 words were directly related to health, diseases, or symptoms (see Table 1) and were distributed across two tests (for the complete list of words used in the test, see Appendix). Non-health-related words were used as filler words to distract participants from the critical items and were not of interest to the specific aims of this study.

The choice of health-related keywords had to satisfy two conditions: Firstly, the stimulus had to be a keyword represented in the previous work of Vainik (2019a) to facilitate comparison with the prior results and identify any discrepancies between the two datasets. Secondly, the selected stimuli had to have some connection to COVID-19. For instance, words such as KÖHA 'cough,' NOHU 'runny nose,' and PALAVIK 'fever' were listed as symptoms of COVID-19 on the Estonian Health Board's (2022) and World Health Organization's (WHO 2023) websites and are frequently used in (social) media when referring to the condition (Cinelli *et al*. 2020; Hiiemäe *et al*. 2020; Alshaabi *et al*. 2021).

The study was administered using the professional survey software LimeSurvey (LimeSurvey GmbH: 2019) and was disseminated via various social media channels and email. Participation in the study was voluntary, and participants received no remuneration for their contribution. The data collection period spanned from January 21st, 2023, to March 6th, 2023.

Table 1. Health-related stimuli (cue words) in Estonian along with their corresponding English equivalents examined in the present study.

haige *(sick)*	positiivne *(positive)*
keha *(body)*	ravi *(treatment)*
kriis *(crisis)*	surm *(death)*
köha *(cough)*	süst *(injection)*
negatiivne *(negative)*	valus *(pain)*
nohu *(runny nose)*	viirus *(virus)*
nõrk *(weak)*	väsimus *(fatigue)*
palavik *(fever)*	

During the online WA task, each participant was presented with a survey containing 25 stimulus words, displayed on the screen of the subject's personal computer, one at a time, in a randomized sequence to mitigate the potential priming effect. In the context of a WAT, the priming effect refers to the phenomenon where exposure to a stimulus (prime) influences or biases a person's response to a subsequent stimulus. In the case of a WAT, the cue word presented to a participant can act as a prime, and it can influence the participant's response to that cue word. To minimize the priming effect, the randomizing of the presentation of cue words is used to reduce the predictability of responses and ensure that responses are more reflective of genuine word associations rather than mere priming from the previous cues.

Participants were instructed to provide their first associative answer to the stimuli, with the option to provide up to three different responses or to skip a stimulus word if a response was not at hand. Participants were also allowed to end the survey anytime during the test. On average, the test took approximately 10 minutes to complete.

To interpret the strength of the effect between the datasets of 2018 and 2023, frequency counts, as well as the chi-square test residuals, were employed. The latter test is deemed appropriate for analysing nominal and ordinal data characterized by frequency counts. In the current study, it was used to evaluate whether the observed frequencies from 2023 are significantly different from what we would expect given the 2018 frequencies. Therefore, the null hypothesis is that there is no difference between the 2018 and 2023 frequencies.

3.2.2 Participants

The study did not impose strict eligibility criteria on the participants, except for the mandatory requirement for native-level proficiency in the Estonian language. In order to ensure that the respondents identified Estonian as their native language, the questionnaire specifically included

a question to determine the participants' first language. Based on that criteria, 17 subjects were excluded (not included in the total number of participants). Altogether, the study involved 1454 participants with ages ranging from 14 (b. 2009) to 85 (b. 1938) with an average age of 46.1 (SD=12.86).

The distribution of respondents within the context of gender went as follows: among the total sample size, 25 participants did not specify their gender; 570 respondents self-identified as males and 859 as females. Regarding education, most participants (78.5%) had a bachelor's degree or higher education. These findings suggest a noticeable bias towards female participants (59.1%) and those with higher education levels. These statistics on participants' educational background, age, and gender align with the results reported by Ene Vainik (2018). In light of the observation mentioned above, it can be inferred that comparing datasets concerning participants is compatible.

In analysing the results, it is important to highlight that the original investigation conducted by Vainik (2018) did not examine the impact of sociodemographic factors in the final phase, thus limiting the consideration of their impact in the present study. However, these factors were considered in the initial phase of her study. The findings of Vainik indicated that neither age nor gender was a statistically significant factor in relation to the observed outcomes. However, some effect of education was noted in the results: as the subjects' level of education increased, their responses became more stereotypical. As a result, the current findings may be more biased toward a greater degree of stereotyping, which may not accurately represent the general population's attitudes (Vainik 2018: 239).

4. Results

Among the 15 health-related words investigated, a significant proportion displayed a consistent primary association, indicating that the most frequent associative response remained unchanged. Specifically, this pattern was observed in 10 of the 15 keywords examined. Notably, the cue word 'fever' exhibited the most consistent response order, with the sequence of the first five responses remaining unchanged.

Regarding the set of 15 words, the stimulus KÖHA 'cough' elicited the highest degree of unanimous response (33.8%), with NOHU 'runny nose' being the primary association. Conversely, the stimulus KRIIS 'crisis' yielded the lowest level of unanimity (7.9%) regarding the responses obtained. When comparing these findings to Vainik's data, it is noteworthy that KÖHA 'cough' exhibited a similarly high level of unanimity, while the stimulus KEHA 'body'

showed the least consensus in her dataset, which aligns with the present study where it ranked as the second least unanimous response.

In her recent study, Vainik (2021) conducted a comparative analysis between her 2018 study and the data collected by Toim (1980) during the 1970s. The findings revealed a decline in the percentage of agreement with the leading response words over time. Similar results were observed in the present 2023 study, i.e., the levels of agreement were lower in the primary responses than in the dataset of Vainik. It is worthy of attention that the time difference between the two studies in question was less substantial when compared to Vainik's examination of responses to Toim's study, as a greater temporal difference is associated with a lower degree of overlap in primary associations (Jenkins and Russell 1960; Jenkins and Palermo 1965). In addition, compared to the original study, the current one utilized a larger sample size which is thought to lead to more accurate results (Cohen 1962; Cohen 1992).

4.1. Changes in word associations: primary associations

Out of a total of 15 primarily health-related keywords, one-third, i.e., five words (33.3%), displayed a notable change in the response sequence and COVID-19-relatedness. These words were SÜST 'injection', KRIIS, 'crisis', NEGATIIVNE 'negative', POSITIIVNE 'positive', and VIIRUS 'virus'. Similarly to Vainik's (2021) result, the changes do not occur significantly in the primary responses but in positions 2.–5. The results generally confirmed that primary, stronger associations remain more stable over time (Jenkins and Russell 1960; Jenkins and Palermo 1965). From 15 studied words, the primary association had changed in three cases. The new primary association for the cue-word SÜST 'injection' (Table 2) in 2023 was "vaktsiin" *vaccine* with a weight (here fore-after as w) of 0.127. That replaced the former primary response "nõel" *needle*; in 2018, w=0.174.

Table 2. Change of the primary association for the keyword SÜST 'injection' in 2018 (n=351) compared to 2023 (n=723).

Rank 2018			f	w	Rank 2023		f	w
1	NÕEL, ARST	*needle, doctor*	61	0.174	VAKTSIIN	*vaccine*	92	0.127
2	SÜSTAL	*syringe*	39	0.111	SÜSTAL	*syringe*	89	0.123
3	VALUS	*painful*	36	0.103	ARST	*doctor*	67	0.093
4	VALU	*pain*	21	0.06	NÕEL	*needle*	60	0.083
5	VAKTSIIN	*vaccine*	14	0.04	VALUS	*painful*	44	0.061
6	HAIGUS	*illness*	11	0.031	TORGE	*jab*	30	0.041

The second cue word that demonstrated a change in primary response was cue word KRIIS 'crisis' (Table 3), with the new primary response "sõda" *war* (w=0.079) replacing the former "majandus" *economy* (in 2018, w=0.097).

Table 3. Change of the primary association for the keyword KRIIS 'crisis' in 2018 (n=351) compared to 2023 (n=717).

Rank	2018		f	w	2023		f	w
1	MAJANSUS	*economy*	34	0.097	SÕDA	*war*	57	0.079
2	SÕDA	*war*	19	0.054	KOROONA	*corona*	53	0.074
3	LAHENDUS	*solution*	15	0.043	MAJANDUS	*economy*	51	0.071

Lastly, when in 2018, the primary response to the cue word KEHA *'body'* (Table 4) was "pea" *head* (in 2018, w=0.083), then in 2023 "inimene" *human* was the response in the first position (w=0.104).

Table 4. Change of the primary association for the keyword KEHA 'body' in 2018 (n=314) compared to 2023 (n=608).

Rank	2018		f	w	2023		f	w
1	PEA	*head*	26	0.083	INIMENE	*human*	63	0.104
2	INIMENE	*human*	23	0.073	PEA	*head*	34	0.056
3	VAIM	*mind*	18	0.057	VAIM	*mind*	28	0.046

4.2.   Changes in word associations: response sequence and COVID-19 relatedness

4.2.1 Süst (injection)

In 2018, the top three responses, with their respective weights, were *needle/doctor* (w=0.174), *syringe* (w=0.111), and *painful* (w=0.103). However, five years later, after the coronavirus pandemic, a subsequent study found that the sequence of responses had undergone a significant shift (see Table 2). Notably, the response "vaktsiin" *vaccine*, which had initially occupied the sixth position (w=0.04), had become the primary association with a weight of w=0.127. This was followed closely by the "süstal" *syringe* (w=0.123), which occupied the original study's second position with a weight of w=0.111 and strengthened its position in the subsequent study.

The other notable difference was the weakening of the associative link between the cue word SÜST 'injection', and its response "arst" *doctor*. Back in 2018 it shared the first position (w=0.174) with the response answer "nõel" *needle*; five years later, the link weakened, and it moved to a third position (w=0.093). The weakening of the response needle (w=0.174) was even more drastic, which fell to the fourth position (w=0.083). Interestingly, in primary responses,

there was no mention of the word "rohi" *medicine* (previously w=0.02). An argument can be posited that the hypernymous term "rohi" *medicine* has assumed a more specific and characterized manifestation as a vaccine, functioning as a hyponym. This notion is supported by the information provided by ConceptNet, an online knowledge graph tool, which indicates that the designated location for a vaccine is a "medicine chest" (Speer *et al*. 2017).

The "vaktsiin" *vaccine* emerged as the most frequently mentioned term, which is corroborated by the results of the chi-square residual analysis. Figure 1 illustrates that the term "vaktsiin" *vaccine* exhibits significantly higher residual values, aligning with expectations. Similarly, the terms "torge" *jab* and, to a lesser extent, "süstal" *syringe* display higher-than-expected residual values. Conversely, the terms "nõel" *needle*, "arst" *doctor*, and "valus" *painful* indicate fewer responses than anticipated, considering the values obtained from the 2018 study.
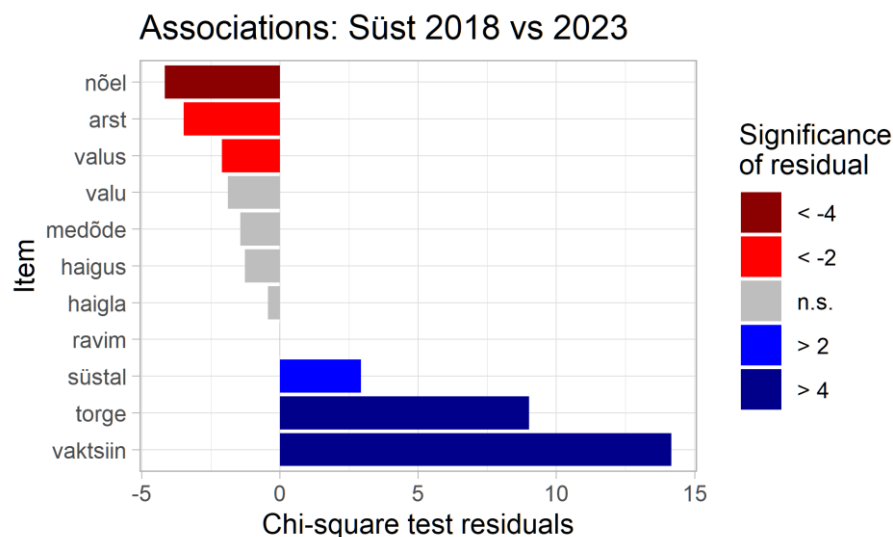

Figure 1. Chi-square test residuals for the cue word SÜST 'injection' in 2023 based on the data of 2018.

In this context, a noteworthy transition along the positive-negative spectrum is discernible. In the year 2018, the cue word SÜST 'injection' exhibited two prominent negative experiential associative responses, specifically, "valus" *painful* ranking fourth and "valu" *pain* ranking fifth in terms of association strength (see Table 2). However, by 2023, the response "valu" *pain* has been replaced with "torge" *jab*, a term devoid of explicit negative experiential connotations. This transition suggests a shift towards a state of neutrality on the conceptual positive-negative spectrum.

4.2.2 Kriis (crisis)

In 2018, the word most frequently associated with the term KRIIS 'crisis' (see Table 5) was "majandus" *economy* with a weight of 0.097, followed by "sõda" *war* with a weight of 0.054 and "lahendus" *solution* (w=0.043).

Table 5. Response ranking for the keyword KRIIS 'crisis' by the year 2018; 2018 n=351; 2023 n=717.

Rank 2018			f	w	Rank 2023	f	w
1	majandus	*economy*	34	0.097	3	51	0.071
2	sõda	*war*	19	0.054	1	57	0.079
3	lahendus	*solution*	15	0.043	12	10	0.014
4	kolle	*outbreak/danger zone*	13	0.037	30	4	0.006
5	abi	*help*	12	0.034	10	11	0.015

However, in 2023 (see Table 6), the ranking of associated words has shifted, with "sõda" *war* taking the lead (w=0.079), followed closely by "koroona" *corona* (w=0.074), and *majandus* economy (w=0.071). These weight distributions suggest the presence of multiple concurrent issues within the given context, as the values are relatively equal. Notably, personal life issues such as mid-life and marriage, which were much more prominent in the 2018 dataset, were not so salient in 2023 (see Figure 5).

Table 6. Response ranking for the keyword KRIIS 'crisis' by 2023; 2018 n=351; 2023 n=717.

Rank 2018			f	w	Rank 2023	f	w
2	sõda	*war*	19	0.054	1	57	0.079
NA	koroona	*corona*	NA	NA	2	53	0.074
1	majandus	*economy*	34	0.097	3	51	0.071
8	häda	*trouble*	11	0.031	4	22	0.031
10	valitsus	*government*	10	0.028	5	16	0.022

"Koroona" *corona* was not present in the 2018 dataset, but in 2023, it took the second most frequent response (w=0.074); its synonym COVID was also prevalent (w=0.021). Curiously enough, "lahendus" *solution*, which can be considered a positive outcome, has weakened its associative link dropping from the third position in 2018 (w=0.043) to the tenth position (w=0.014) in 2023. A similar tendency was notable regarding the response to the response word "kolle" *outbreak/danger zone*, which dropped from the fourth position in 2018 (w=0.037) to a

weighted value of w=0.006. The chi-square test also reflected the statistically significant decline for "lahendus" *solution* and "kolle" *outbreak/danger zone* (see Figure 2).
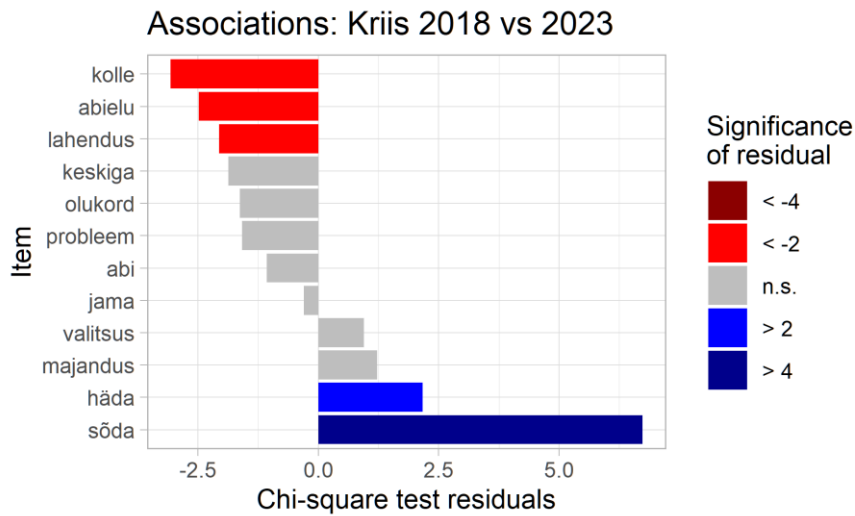
Figure 2. Chi-square test residuals for the cue word KRIIS 'crisis' in 2023 based on the values of 2018.

4.2.3 Viirus (virus)

In 2018 (see Table 7), the top three responses, with their respective weights, were "haigus" *illness* (w=0.361), "nohu" *runny nose* (w=0.079), and "gripp" *flu* (w=0.070). The results of the current study clearly reflect the impact of the pandemic on the associations with the virus. However, the primary response to VIIRUS is still "haigus" *illness* as in the previous study (w=0.361), its associative strengths has weakened (w=0.239).

Table 7. Response ranking for the keyword VIIRUS 'virus' 2018 n=330; 2023 n=716. On the second
rank in 2023, which is missing in the table, is "koroona" (corona), see Table 6.

Rank 2018			f	w	Rank 2023	f	w
1	haigus	*illness*	119	0.361	1	171	0.0239
2	nohu	*runny nose*	26	0.079	8	16	0.022
3	gripp	*flu*	23	0.07	4	35	0.049
4	haige	*ill/sick*	22	0.067	9	11	0.015
5	nakkus	*infection*	12	0.039	5	22	0.031
6	arvuti	*computer*	11	0.033	7	18	0.025
7	bakter	*bacterium*	9	0.027	6	19	0.027
8	palavik	*fever*	8	0.024	12	7	0.01

The most dramatic change appears in the second and third positions (see Table 8), words that were not present in the Vainik's study. Response "koroona" *corona* is in the second position

(w= 0.124) followed by COVID-19 (w=0.091) which are synonyms but counted as separate entities in the current study.

Table 8. Response ranking for the keyword VIIRUS 'virus' in 2018 (n=330) and 2023 (n=716). The graph shows responses containing the terms "corona" and "covid", indicating a strong association with the stimulus.

Rank	2018		f	w	2023		f	w
1	HAIGUS	*illness*	119	0.361	HAIGUS	*illness*	171	0.239
2	NOHU	*runny nose*	26	0.079	KOROONA	*corona*	89	0.124
3	GRIPP	*flu*	23	0.07	COVID	*COVID*	65	0.091
4	HAIGE	*ill/sick*	22	0.067	GRIPP	*flu*	35	0.049
5	NAKKUS	*infection*	13	0.039	NAKKUS	*infection*	22	0.031

Furthermore, besides the decline in agreement with leading response words over time, there were other notable changes in the response order. For instance, the response word "nohu" *runny nose* held the second position (w=0.361) in 2018, but it dropped to the eighth position (w=0.022) in 2023. Interestingly, if the cue word is switched to NOHU and used as a response word instead, the associative link is almost non-existent (w=0.005). This outcome illustrates the unidirectional relationship (which, of course, is not always the case) between the stimulus and response word, wherein the stimulus word elicits a response word. In contrast, the reverse causality, i.e., the response word triggering the original stimulus word, does not hold universally.

The second significant change is undergone with the word "haige" *ill*, which held a 4th position in 2018 (w=0.067) but dropped significantly five years later (w=0.015). The chi-square residual analysis (see Figure 2) confirms the under-representation of "nohu" *runny nose* and "haige" *ill* in the dataset of 2023. Interestingly, the response word "bakter" *bacterium* appears more often than expected.
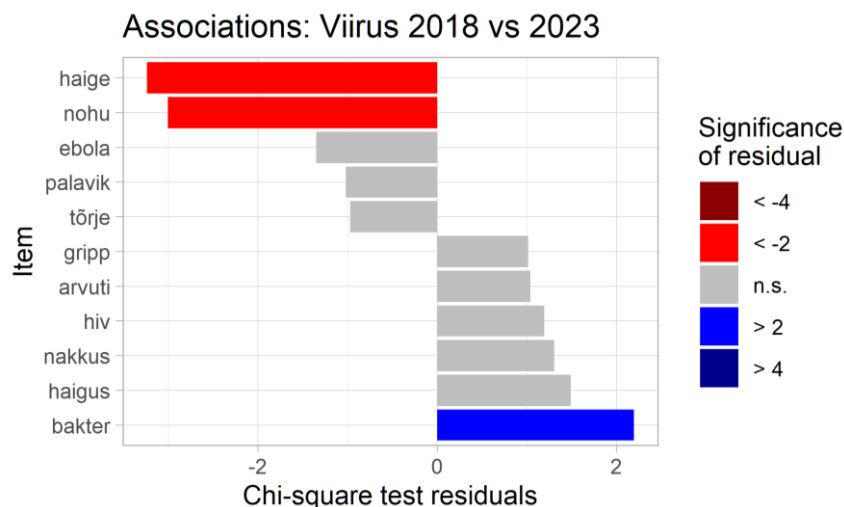

Figure 3. Chi-square test residuals for the cue word VIIRUS 'virus' in 2023 based on the values of 2018.

4.2.4 Positiivne (positive) and negatiivne (negative)

The cue words "positive" and "negative" consistently exhibit their highest frequency responses in the first and second positions, as depicted in Table 9 and Table 10. This finding aligns with the results reported in the previous investigation conducted by Vainik (2019a). It is worth noting that *positive* and *negative* are adjectives. The grammatical class of a cue word impacts the responses: nouns tend to yield more paradigmatic responses (words that share a similar semantic category and can be substituted) than adjectives and verbs (Nissen and Henriksen 2006). The grammatical class also has an impact on the structure of associative links. Deese (1964, 1966) found that adjective pairs with strong mutual associations typically exhibited contrasting or opposite meanings, e.g., positive ↔ negative.

Table 9. Response ranking for the keyword NEGATIIVNE 'negative' by the year 2023;
2018 n=290; 2023 n=721

Rank 2018			f	w	Rank 2023	f	w
1	positiivne	*positive*	118	0.407	1	230	0.319
2	halb	*bad*	28	0.097	2	100	0.139
3	miinus	*minus*	17	0.059	4	38	0.053
4	paha	*unpleasant*	6	0.021	7	10	0.014
5	iive	*population growth*	5	0.017	9	9	0.012

Table 10. Response ranking for the keyword POSITIIVNE 'positive' by the year 2018;
2018 n=305; 2023 n=614.

Rank 2018			f	w	Rank 2023	f	w
1	negatiivne	*negative*	76	0.249	1	139	0.226
2	hea	*good*	46	0.151	2	90	0.147
3	rõõmus	*cheerful*	24	0.079	3	53	0.086
4	pluss	*plus*	13	0.043	6	18	0.029

However, a significant difference was identified with the response word "test". In the original study, the results were relatively insignificant for both stimuli, "positive" (w=0.01) and "negative" (w=0.013). In the new study of 2023 (see Table 11 and Table 12), "test" had strengthened its associative link and occupies the third position (w=0.074) for cue word NEGATIIVNE 'negative' and for cue word POSITIIVNE 'positive', "test" occupies the fourth position (w=0.06). Furthermore, the stimulus POSITIIVNE 'positive', introduced a new word in its sequence, namely "corona." Interestingly, POSITIIVNE 'positive', was strongly associated

with "corona" (w=0.033), while the corresponding value for the cue word NEGATIIVNE 'negative' was only 0.007.

Table 11. Response ranking for the keyword NEGATIIVNE 'negative' by the year 2023; 2018 n=290; 2023 n=721.

Rank 2018			f	w	Rank 2023	f	w
1	positiivne	*positive*	118	0.407	1	230	0.319
2	halb	*bad*	28	0.097	2	100	0.139
8	test	*test*	3	0.01	3	53	0.074
3	miinus	*minus*	17	0.059	4	38	0.053

Table 12. Response ranking for the keyword POSITIIVNE 'positive' by the year 2023; 2018 n=305; 2023 n=614.

Rank 2018			f	w	Rank 2023	f	w
1	negatiivne	*negative*	76	0.249	1	139	0.226
2	hea	*good*	46	0.151	2	90	0.147
3	rõõmus	*cheerful*	24	0.079	3	53	0.086
9	test	*test*	4	0.013	4	37	0.06
NA	koroona	*corona*	NA	NA	5	20	0.033
4	pluss	*plus*	13	0.043	6	18	0.029

The chi-square residual analysis, as depicted in Figure 4 and Figure 5, further substantiates the statistical significance associated with the response word "test" in relation to both keywords. Notably, in the case of the stimulus NEGATIIVNE 'negative' the observed mentions of "positiivne" *positive* and "vale" *wrong* were found to be lower than anticipated. For the stimulus POSITIIVNE 'positive' the corresponding responses were "inimene" *person* and "suhtumine" *attitude* which displayed decreased associative strength.
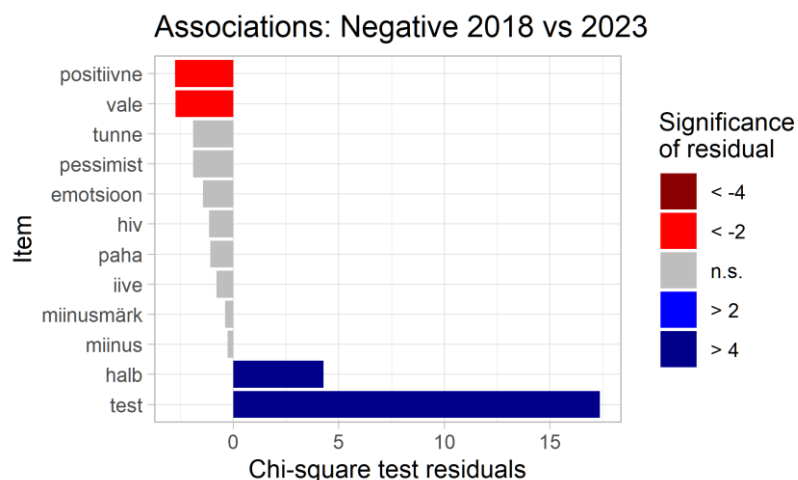

Figure 4. Chi-square test residuals for the cue word NEGATIIVNE 'negative' in 2023 based on the values of 2018.
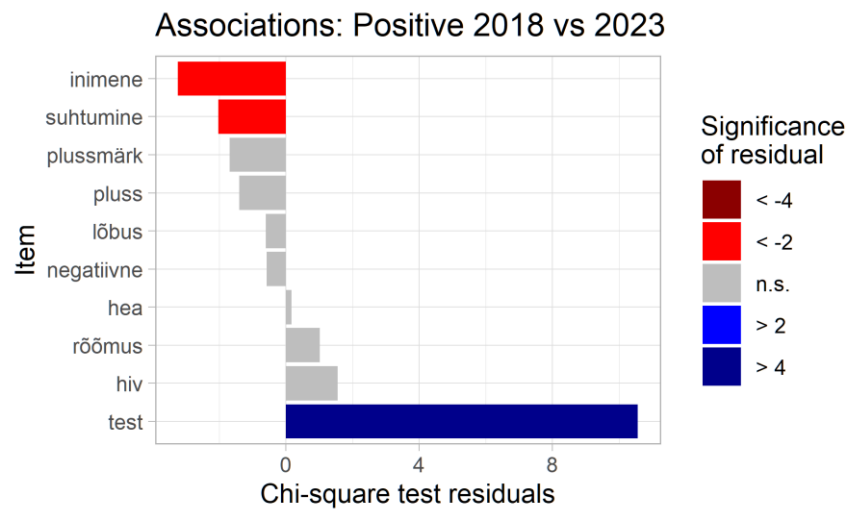
Figure 5. Chi-square test residuals for the cue word POSITIIVNE 'positive' in 2023
based on the values of 2018.

5. Discussion

Out of 15 words predominately connected to health and diseases, five demonstrated remarkable change and pointed to the possible consequences of the corona pandemic: notably, SÜST 'injection', KRIIS 'crisis', NEGATIIVNE 'negative', POSITIIVNE 'positive', and VIIRUS 'virus'. It is worthy of notice that all five words except the SÜST 'injection' are cognates with corresponding international terms. Cognates are pairs of words in two or more languages with similar meanings (i.e., translation equivalents) and similar forms (i.e., phonological or orthographic similarities). If there exists a relationship between cognates and their susceptibility to associative changes, it warrants further investigation. Previous research on cognates has indicated that they are processed differently from non-cognate items (van Hell and Dijkstra 2002; Lemhöfer and Dijkstra 2004).

Why precisely these five words? One possible interpretation would be that these five words were more frequently connected with the pandemic, as repetition is a crucial aspect of learning. When a specific group of words frequently appear together in a sequence of messages, it prepares the audience to perceive those ideas as interconnected. It forms the associative framework for the interpretation of a situation or topic. For instance, Aimei Yang and Charles Self (2015) demonstrated how the frequent occurrence of the word "mosque" along with terms

such as "attack," "terrorist," and "war" created an association between these concepts and how this interpretation then spread to the mainstream media and the general public.

The observed changes in word associations described in the previous sections are meaningful examples of the impact of the pandemic on the public's collective consciousness, i.e., how perceptions and attitudes towards certain words and concepts can shift in response to external events. As the study results indicate, some significant shifts have taken place. The cue words SÜST 'injection', KRIIS 'crisis', KEHA 'body' stand out as the most significant cases where there was a change in their primary response, which usually possess the strongest associative link and are therefore more resilient to change. For example, in 2023, the primary association for the SÜST 'injection' was "vaktsiin" *vaccine*, which could indicate that people's attention has been refocused on the role of injections in preventing illness rather than on the more negative aspects of the experience like syringe, needle, pain etc. Moreover, the cue words SÜST 'injection', KRIIS 'crisis', KEHA 'body' display a reduced presence of strong stereotypical responses, making them more prone to changes in word associations. This susceptibility stems from the fact that these words evoke a broader range of responses among individuals, influenced by personal experiences, individual perspectives, and unique encounters. Unlike words with more universally shared or culturally ingrained associations, the associations formed with these cue words exhibit more significant variability, reflecting the role of subjective factors in shaping cognitive connections to linguistic stimuli.

The associations that individuals form with the cue word KRIIS 'crisis' offer valuable insights into the complex and interconnected nature of human memory and cognition, as well as provide a window into how people perceive and respond to difficult situations within a social, political, or economic context. Specifically, in the present case, the outbreak of the COVID-19 pandemic emerged as a highly salient factor in the perception of crisis, competing strongly with the primary responsibility of "soda" *war*. The timing of the study can explain the strong association between war and crisis: the survey coincided with the one-year anniversary of the start of the conflict in Ukraine, a topic that had dominated public discourse since its inception on the 24th of February 2022. Analysis of the distribution of the most salient responses to the keyword KRIIS 'crisis' reveals that in the given context, there are several issues (war, corona, economy) that individuals associate with the notion of crisis, with roughly equal prominence. This contrasts with the results of 2018, where the economy emerged as the most strongly linked factor to the concept of crisis. These findings indicate that political and security-based themes have become more critical than individual struggles. Furthermore, the associative link between crisis and solution has weakened, which can be interpreted as an unfortunate tendency – even

more so when considering that the associative link with the response word "häda" *trouble* has increased.

The current study also demonstrated that the words "corona" and "COVID" are often associated with the word "virus". That is altogether not surprising as the official name for the root cause of the pandemic was formally named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). As a rather complicated medical term, consequently, people often use the terms "corona" and "COVID" interchangeably with "virus" when referring to the disease. In addition, "corona" and "COVID" are frequently used as a modifier linked with words like "test", "crisis", "cases" etc.

The general public does significantly more frequently associate the word "test" with adjectives like *positive* and *negative*, *negative* being the strongest of the two, i.e, it's more likely that people associate the test as negative, which in this specific case is actually positive. The current results indicate a significant bias towards associating the adjective "positive" with "corona". Overall, while both adjectives are commonly used in reference to COVID-19 testing, the use of the word "positive" may be more noticeable and have a stronger impact due to the severity and impact of the pandemic. It could be argued that "positive" indicates a confirmed case of the virus, which can have severe consequences for the individual and those around them. As a result, using the word "positive" in this context can elicit fear and anxiety. That is not surprising because there is a well-established association between strong negative emotions and memory. This is because negative experiences are often perceived as more salient and important, and the brain wants to ensure that we can remember and learn from them in the future (more on this see Lazarus 1991).

It is noteworthy, however, that some respondents associated the cue word "positive" with the word "haige" *ill*. Although this association was not prevalent (eight out of the total of 614 respondents (w=0.013), it may be of interest due to the contextual significance of the COVID-19 pandemic, where the terms "positive" and "ill" may have gained added meaning and importance. The arbitrary nature of the association between the words "positive" and "ill" without this contextual background underscores the complex and nuanced nature of word associations and their underlying psychological mechanisms.

6.   Concluding remarks

The primary objective of this study was to explore whether there have been alterations in the associative patterns exhibited by native Estonian speakers concerning predominantly health-

related words. By doing so, it attempted to explore more closely the potential of word associations as an avenue through which the organization of the mind can be better understood, yielding insights into the contents of the mental lexicon, its retrieval processes, as well as the values and hierarchies that are present within a given culture.

While interpreting word association data can be intricate due to its multifaceted nature, noticeable changes were, indeed, observed in the current study. The sequences of response order, as well as COVID-19 relatedness for certain specific words, were the most remarkable regarding the cue words SÜST 'injection', KRIIS 'crisis', NEGATIIVNE 'negative', POSITIIVNE 'positive', and VIIRUS 'virus'. In addition, three cue words out of 15 had changed their primary association (SÜST 'injection', KRIIS 'crisis', and KEHA 'body').

These five words mentioned above emerged as central and contentious subjects of discourse within the public sphere and on social media platforms. Conversely, the remaining ten words within the set of fifteen primarily represent symptoms universally encountered at the individual level, lacking prominence as socially relevant discussion topics. Secondly, these instances can be characterized as moments that necessitate individuals to reassess their existing perceptions, acquire new knowledge, prioritize the health crisis, and temporarily set aside personal and psychological concerns.

In conclusion, this study aimed to conduct a nuanced investigation into the intricate relationship among external events, language dynamics, and cognitive processes. Through the examination of changes in word associations in response to external factors like the COVID-19 pandemic, it illuminates the profound influence of major societal events, not only on the collective consciousness but also on the broader landscape of language evolution. This exploration underscores that semantic shifts, among other factors, have the potential to catalyse language change.

Appendix

CUE WORD IN ENGLISH	CUE WORD IN ESTONIAN
bandage	side
blast	puhang
body	keha
bounty	and
cargo	last

chair	tool
climate	kliima
cloak	keep
cough	köha
crisis	kriis
cure	ravi
death	surm
disinfection station	desojaam
distribution	levik
duck	part
energy	energia
fatigue	väsimus
fever	palavik
grill	rest
horse bow	look
hybrid work	hübriidtöö
ill	haige
injection	süst
leprosorium	seek
long	pikk
negative	negatiivne
outbreak/danger zone	kolle
painful	valus
pass	pass
positive	positiivne
prentice	sell
proof	tõend
recovery plan	taastekava
restriction	piirang
runny nose	nohu
rupture	song
sample	proov
shutdown	laussulgemine
sick leave for self-isolation	karantiinileht
situation	olukord

spike protein	ogavalk
stem	tüvi
talc	talk
test	test
vaccine	vaktsiin
vein	soon
virus	viirus
warrant	order
wave	laine
weak	nõrk

References

Aitchison, Jean (2012) *Words in the Mind: An Introduction to the Mental Lexicon*. 4th ed. Chichester: Wiley-Blackwell.

Alshaabi Thayer, Michael V. Arnold, Joshua R. Minot, Jane Lydia Adams, David Rushing Dewhurst, Andrew J. Reagan, Roby Muhamad, Christopher M. Danforth, Peter Sheridan Dodds (2021) "How the World's Collective Attention is Being Paid to a Pandemic: COVID-19 Related N-Gram Time Series for 24 Languages on Twitter." *PLoS One*, 16(1). https://doi.org/10.1371/journal.pone.0244476.

Biber, Douglas, Stig Johansson, Geoffrey Leech, Susan Conrad, Edward Finegan (2000) *Longman Grammar of Spoken and Written English*. Harlow: Longman.

Cinelli, Matteo, Walter Quattrociocchi, Alessandro Galeazzi, Carlo Michele Valensise, Emanuele Brugnoli, Ana Lucia Schmidt, Paola Zola, Fabiana Zollo, Antonio Scala (2020) "The COVID-19 Social Media Infodemic." *Scientific reports*, 10(1); 1–10. https://doi.org/10.1038/s41598-020-73510-5.

Cohen, Jacob (1962) "The Statistical Power of Abnormal-Social Psychological Research: A Review." *Journal of Abnormal Social Psychology*, 65; 145–153.

Cohen, Jacob (1992) "A Power Primer." *Psychological Bulletin*, 112; 155–159.

Collins, Allan M., Elizabeth F. Loftus (1975) "A Spreading-Activation Theory of Semantic Processing." *Psychological Review*. 82(6); 407–428.

Crystal, Davis (2020) "Cambridge Reflections-COVID-19: Vocabulary." *Cambridgeblog*. URL: http://www.cambridgeblog.org/2020/05/covocabulary/. Accessed: 17.05.2023.

Deese, James (1962) "On the Structure of Associative Meaning." *Psychological Review*, 69(3); 161–175.

Deese, James (1964) "The Associative Structure of Some Common English Adjectives." *Journal of Verbal Learning and Verbal Behavior*, 3(5); 347–357.

Deese, James (1965) *The Structure of Associations in Thought and Language*. Baltimore: Johns Hopkins University Press.

Deese, James (1966) *The Structure of Associations in Language and Thought*. Baltimore: Johns Hopkins University Press.

De Deyne, Simon, Gert Storms (2008) "Word Associations: Network and Semantic Properties." *Behavior Research Methods*, 40(1); 213–231.

De Deyne, Simon, Gert Storms (2015) "Word Associations." [In:] In John R. Taylor (ed.), *The Oxford Handbook of the Word*. Oxford: Oxford University Press; 465–480.

De Deyne, Simon, Daniel J. Navarro, Gert Storms (2012) "Better Explanations of Lexical and Semantic Cognition Using Networks Derived from Continued rather than Single-Word Associations." *Behavior Research Methods*, 45; 480–498.

de Groot, Annette M. (1989) "Representational Aspects of Word Imageability and Word Frequency as Assessed through Word Association." *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15(5); 824–845.

Edwards, Philip James, Ian Roberts, Mike J. Clarke, Carolyn DiGuiseppi, Reinhard Wentz, Irene Kwan, Rachel Cooper, Lambert M. Felix, Sarah Pratap (2009) "Methods to Increase Response to Postal and Electronic Questionnaires." *Cochrane Database of Systematic Reviews* 3; 1–38. https://doi.org/10.1002/14651858.MR000008.pub4.

Elman, Jeffrey L., Elizabeth A. Bates, Mark H. Johnson (1996) *Rethinking Innateness: A Connectionist Perspective on Development*. Cambridge, MA: MIT Press.

Estonian Health Board (2023) What is COVID-19? URL: https://www.terviseamet.ee/en/what-covid-19. Accessed: 23.05.2023.

Everett, Daniel L. (2016) *Dark Matter of the Mind: The Culturally Articulated Unconscious*. Chicago; London: University of Chicago Press.

Fitzpatrick, Tess, Cristina Izura (2011) "Word Association in L1 and L2: An Exploratory Study of Response Types, Response Times, and Interlingual Mediation." *Studies in Second Language Acquisition*, 33(3); 373–398.

Fitzpatrick, Tess, Peter Thwaites (2020) "Word Association Research and the L2 Lexicon." *Language Teaching*, 53(3); 237–274. https://doi.org/10.1017/S0261444820000105.

Forster, Kenneth I. (1976) "Accessing the Mental Lexicon." [In:] Edward Walker, Roger J. Wales (eds.), *New Approaches to Language Mechanisms*; Amsterdam; New York: North-Holland Publishing Company; 257–287.

Galton, Francis (1879) "Psychometric Experiments." *Brain*, 2(2); 149–162.

Gow, David W. (2012) "The Cortical Organization of Lexical Knowledge: A Dual Lexicon Model of Spoken Language Processing." *Brain and Language*, 121(3); 273–288.

Hallin, Anna Eva, Diana Van Lancker-Sidtis (2017) "A Closer Look at Formulaic Language: Prosodic Characteristics of Swedish Proverbs." *Applied Linguistics*, 38(1); 68–89. https://doi.org/10.1093/applin/amu078.

Harley, Trevor A. (2014) *The Psychology of Language: From Data to Theory*. London; New York: Psychology Press.

Hickok, Gregory, David Poeppel (2007) "The Cortical Organization of Speech Processing." *Nature Reviews Neuroscience*, 8(5); 393–402.

Hiiemäe, Reet, Mare Kalda, Mare Koiva, Piret Voolaid (2020) "Koroonakriisi rahvapärased väljendused Eestis Folkloori taaskasutus kui toimetulekuviis." *Keel ja Kirjandus*, 12; 1011–1032. https://doi.org/10.54013/kk757a1.

Jenkins, James J., David S. Palermo (1965) "Further Data on Changes in Word-Association Norms." *Journal of Personality and Social Psychology*, 1(4); 303–309. https://doi.org/10.1037/h0021914.

Jenkins, James J., Wallace A. Russell (1960) "Systematic Changes in Word Association Norms: 1910–1952." *Journal of Abnormal and Social Psychology*, 60(3); 293–304. https://doi.org/10.1037/h0042234.

Jung, Carl G. (1910) "The Association Method." *The American Journal of Psychology*, 21(2); 219–269.

Kang, Beom-mo (2018) "Collocation and Word Association: Comparing Collocation Measuring Methods." *International Journal of Corpus Linguistics*, 23(1); 85–113.

Kleinman, Daniel, Adam M. Morgan, Rachel Ostrand, Eva Wittenberg (2022) "Lasting Effects of the COVID-19 Pandemic on Language Processing." *Plos One*, 17(6): e0268121. https://doi.org/10.1371/journal.pone.0269242.

Klosa-Kückelhaus, Annette (2022) "Lexicography for Society and with Society-COVID-19 and Dictionaries." [In:] Annette Klosa-Kückelhaus, Stefan Engelberg, Christine Möhrs, and Petra Storjohann (eds.), *Dictionaries and Society. Proceedings of the XX EURALEX International Congress, 12-16 July 2022, Mannheim, Germany.* Mannheim: IDS-Verlag; 113–128.

Lazarus, Richard S. (1991) *Emotion and Adaptation*. New York: Oxford University Press.

Lemhöfer, Kristin, Ton Dijkstra (2004) "Recognizing Cognates and Interlingual Homographs: Effects of Code Similarity in Language-Specific and Generalized Lexical Decision." *Memory & Cognition*, 32; 533–550.

Libben, Gary, Gonia Jarema (2002) "Mental Lexicon Research in the New Millennium." *Brain and Language*, 81(1-3); 2–11.

LimeSurvey GmbH (2019) LimeSurvey (Version 3.24.0+201013) [Computer software]. Retrieved from https://www.limesurvey.org.

Meara, Paul (2009) *Connected Words: Word Associations and Second Language Vocabulary Acquisition*. Amsterdam: John Benjamins.

Milton, James, Tess Fitzpatrick (2017) *Dimensions of Vocabulary Knowledge*. London: Bloomsbury Publishing.

Mollin, Sandra (2009) "Combining Corpus Linguistic and Psychological Data on Word Co-Occurrences: Corpus Collocates versus Word Associations". *Corpus Linguistics and Linguistic Theory*, 5(2); 175–200. https://doi.org/10.1515/CLLT.2009.008.

Nelson, Douglas L., Cathy L. McEvoy, Simon Dennis (2000) "What is free association and what does it measure?" *Memory & Cognition.* 28(6); 887–899.

Nelson, Douglas L., Cathy L. McEvoy, Thomas A. Schreiber (2004) "The University of South Florida Free Association, Rhyme, and Word Fragment Norms." *Behavior Research Methods, Instruments, & Computers*, 36(3); 402–407.

Nissen, Henriette Bagger, Birgit Henriksen (2006) "Word Class Influence on Word Association Test Results 1." *International Journal of Applied Linguistics*, 16 (3); 389–408.

Oldfield, Richard Charles (1966) "Things, Words and the Brain." *Quarterly Journal of Experimental Psychology*, 18(4); 340–353.

Planchuelo, Clara, Ana Baciero, José Antonio Hinojosa, Manuel Perea, and Jon Andoni Dunabeitia (2022) "Social Context Effects on Emotional Language: The Influence of the COVID-19 Pandemic on the Emotional Evaluation of Words." *Acta Psychologica* 229: 103686.

Quillian, M. Ross (1968) "Semantic Memory." [In:] Marvin Minsky (ed.), *Semantic Information Processing*. Cambridge, MA: MIT Press; 216–270.

Rapp, Brenda, Simon Fischer-Baum, Michele Miozzo (2015) "Modality and Morphology: What We Write May Not Be What We Say." *Psychological Science*, 26(6); 892–902.

Rogers, Timothy, James L. McClelland (2004) *Semantic Cognition: A Parallel Distributed Processing Approach*. Cambridge, MA: MIT Press.

Salazar, Danica, Kate Wild (2022) "The Oxford English Dictionary and the Language of Covid-19." [In:] Annette Klosa-Kückelhaus, Ilan Kernerman (eds.), *Lexicography of Coronavirus-Related Neologisms*. Berlin; Boston: de Gruyter, 11–26. https://doi.org/10.1515/9783110798081-002.

Schmid, Monika S., Barbara Köpke (2009) "L1 Attrition and the Mental Lexicon." Anetta Pavlenko (ed.), *Lexicon: Interdisciplinary Approaches*. Bristol, UK–Buffalo, NY: Multilingual Matters; 209–238. https://doi.org/10.21832/9781847691262.

Schmitt, Norbert (1998) "Quantifying Word Association Responses: What is Native-Like?" *System*, 26(3); 389–401.

Speer, Robyn, Joshua Chin, Catherine Havasi (2017) "ConceptNet 5.5: An Open Multilingual Graph of General Knowledge." *Proceedings of AAAI Conference on Artificial Intelligence*, 31. Palo Alto; 4444–4451. http://aaai.org/ocs/index.php/AAAI/AAAI17/paper/view/14972

Steyvers, Mark, Joshua B. Tenenbaum (2005) "The Large-Scale Structure of Semantic Networks: Statistical Analyses and A Model of Semantic Growth." *Cognitive Science*. 29(1); 41–78.

Thorne, Tony (2020) "Spotlight on COVID: Pandemic Language and the Role of Linguists." [In:] Annette Klosa-Kückelhaus, Ilan Kernerman (eds.), *Lexicography of Coronavirus-Related Neologisms*. Berlin/Boston: de Gruyter, 11–26. https://doi.org/10.1515/9783110798081.

Toim, Kalju (1980) "Estonian Word Association Norms for the Kent-Rosanoff Test." *Problems of Cognitive Psychology*. Tartu Riikliku Ülikooli Toimetised 522. Tartu; 60–76.

Trap-Jensen, Lars, Henrik Lorentzen (2022) "Recent Neologisms Provoked by COVID-19–in the Danish Language and in the Danish dictionary". [In:] Annette Klosa-Kückelhaus, Stefan Engelberg, Christine Möhrs, and Petra Storjohann (eds.), *Dictionaries and Society. Proceedings of the XX EURALEX International Congress, 12-16 July 2022, Mannheim, Germany*. Mannheim: IDS-Verlag; 825–832.

Vainik, Ene (2018) "Compiling the Dictionary of Word Associations in Estonian: From Scratch to the Database." *Estonian Papers in Applied Linguistics*. 14; 229–245. https://doi.org/10.5128/ERYa14.14.

Vainik, Ene (2019a) *Eesti keele assotsiatsioonisõnastik*. https://doi.org/10.15155/3-00-0000-0000-0000-07DF6L. Accessed: 17.05. 2023.

Vainik, Ene (2019b) *Eesti keele sõna-assotsiatsioonide andmebaas*. https://doi.org/10.15155/3000000000000007DF4L. Accessed: 17.05.2023.

Vainik, Ene (2021) "Muutuv meel. Aastatel 1973–1974 ja 2016–2018 kogutud sõna-assotsiatsioonide võrdlus." *Keel ja Kirjandus*, 64(12); 1058–1077.

van Hell, Janet G., Ton Dijkstra (2002) "Foreign Language Knowledge Can Influence Native Language Performance in Exclusively Native Contexts." *Psychonomic Bulletin & Review*, 9(4); 780–789. https://doi.org/10.3758/BF03196335.

World Health Organization (2023) "Advice for the Public: Coronavirus Disease (COVID-19)." WHO. URL: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public. Accessed:13.04.2023.

Wolter, Brent (2001) "Comparing the L1 and L2 Mental Lexicon: A Depth of Individual Word Knowledge Model." *Studies in Second Language Acquisition*, 23 (1); 41-69.

Yang, Aimei, Charles Self (2015) "Anti-Muslim Prejudice in the Virtual Space: A Case Study of Blog Network Structure and Message Features of the 'Ground Zero Mosque Controversy." *Media, War & Conflict*, 8(1); 46–69. https://doi.org/10.1177/1750635214541030.