Psychiatria Danubina, 2025 Vol. 37, No. 2, pp 180-193 https://doi.org/10.24869/psyd.2025.180 *Research article*

Sensory ratings and sensitivity to perceptual variables: Novel approach to evaluating semantic memory in mild cognitive impairment

Dušica Filipović Đurđević[1,2], Martina Sekulić Sović[3], Vlasta Erdeljac[3], Ninoslav Mimica[4,5], Draženka Ostojić[4,6], Dubravka Kalinić[4,5], Jakša Vukojević[4] & Aleksandar Savić[4,5]

[1] *University of Belgrade, Faculty of Philosophy, Belgrade, Serbia*
[2] *University of Novi Sad, Faculty of Philosophy, Novi Sad, Serbia*
[3] *University of Zagreb, Faculty of Humanities and Social Sciences, Zagreb, Croatia*
[4] *University Psychiatric Hospital Vrapče, Zagreb, Croatia*
[5] *University of Zagreb, School of Medicine, Zagreb, Croatia*
[6] *University of Zagreb, Faculty of Law, Social Work Study Centre, Zagreb, Croatia*

received: 31. 3. 2023; revised: 1. 8. 2023; accepted: 31. 8. 2023

Summary

Background: *The lexical-semantic impairments at different levels of semantic processing are often observed in Mild cognitive impairment (MCI). To better understand the nature of the lexical-semantic impairment in MCI, this study included two experiments: a sensory rating task and a lexical decision task.*

Subjects and Methods: *Twenty individuals diagnosed with MCI were recruited as well as eighty healthy subjects to serve as a control group. For the first time, the sensory ratings of words were collected in the MCI population and compared with ratings of the same words collected from the control population.*

Results: *Furthermore, the MCI patients showed impaired performance related to executive functioning and preserved long-term memory-related performance. Unlike most studies that found semantic deficits, we were able to observe the highly preserved aspect of knowledge both in terms of semantic and episodic memory.*

Conclusion: *Also, we showed that this knowledge could be exploited in visual word recognition, proposing further use of visual lexical decision task to investigate not only sublexical but also semantic variables in the clinical population.*

Keywords: *Mild cognitive impairment, MCI, lexical impairment, semantic impairment, lexical decision task, cognitive dysfunction*

* * * * *

INTRODUCTION

Cognitive deterioration is thought to exist on a spectrum ranging from normal aging to confirmed dementia. While dementia implies the existence of cognitive deterioration severe enough to impair daily functioning, mild cognitive impairment (MCI) is considered a stage at which cognitive disturbances do not preclude patients from functioning independently and carrying out their usual daily activities (Aretouli & Brandt, 2010; Winblad et al., 2004). Although there are several guidelines for diagnosing MCI (Chen et al., 2021; Jack Jr et al., 2018; Kasper et al., 2020), there are no criteria for diagnosing MCI outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), but a condition that encompasses a more diverse group of entities called minor neurocognitive disorder (Sachs-Ericsson & Blazer, 2015). The diagnosis of MCI remains in the clinical criteria domain, as arbitrary neuropsychological testing cut-offs didn't have predictive value by themselves (Panza et al., 2005; Ritchie et al., 2001).

The most established criteria for MCI are the guidelines provided by the National Institute on Aging and Alzheimer's Association (NIA-AA), which state that MCI individuals have a cognitive performance below the expected range for that individual based on all available information and evidence (Albert et al., 2011; Jack Jr et al., 2018). Furthermore, MCI individuals perform daily life activities independently but may experience difficulty in the more complex daily life activities (Albert et al., 2011; Jack Jr et al., 2018).

Lexical semantic impairments in MCI are most often associated with memory loss and/or executive function impairments, but the exact mechanism of the impairments remains unclear. Quaranta et al. (2019) indicate that the performance in categorical fluency test in Alzheimer's type dementia and MCI has been variously attributed to an impairment of semantic memory or a reduced ability to access the verbal representation of otherwise intact conceptual representations (Foster et al., 2013; Salehi et al.; 2017; Tchakoute et al., 2017). Furthermore, Taler et al., pointed out that several studies have demonstrated that significant declines in semantic memory are consistent and common in MCI and early stages of Alzheimer's disease (AD) (Ahmed et al., 2008; Barbeau et al., 2012; Salmon 2012). In addition, Nakhla et al. (2022) findings suggest that a decline in semantic and episodic memory may lead to a decline in different and specific aspects of functional abilities in AD and MCI. Opposite to these findings, the study of Nevado et al. (2021) suggests that the semantic network is preserved in MCI but also that the existing associations are exploited less efficiently during long-term memory search, possibly because of deficits in executive functions. Executive functions affect language comprehension by allowing the speaker to bypass initial erroneous interpretations of linguistic input, thus preventing a failure in comprehension (Novick et al., 2005).

Typically, patients with MCI exhibit significantly worse performance in visual lexical decision tasks, both in accuracy and processing speed, as observed by multiple research (Bush et al., 2007; Manoulidou et al., 2015), typically associated with overall cognitive decline. In addition, research in visual word recognition in a control population has revealed numerous lexical-semantic variables related to the organization of memory (Bormann, 2011; Brysbaert et al., 2014; Filipović Đurđević, 2019; Filipović Đurđević & Kostić, 2021; Hino et al., 2002; McRae et al., 2005; Mišić & Filipović Đurđević, 2021; Muraki et al., 2020; Rodd et al., 2002, Schwanenflugel et al., 1988; Yap et al., 2011). Furthermore, it has been demonstrated that multiple semantic attributes are activated during word recognition.

In the past decades, there has been a noticeable increase in psycholinguistic studies that emphasize the importance of perceptual information in the structure and function of semantic knowledge (Barsalou, 1999; Meteyard et al., 2010). In the sensory rating task, the participants are presented with written words and asked to rate the extent of their sensory experience with an object denoted by the word. Based on the modality-specific sensory ratings, multiple estimates of perceptual richness can be estimated. According to the embodied approach to semantic knowledge, during word recognition, healthy speakers take advantage of the reactivation of the neural pathways that were active during the perceptual experience with an object denoted by the word. Psycholinguistic studies show the perceptual richness effect over and above the concreteness effect (Connell & Lynott, 2012; Filipović Đurđević et al., 2016; Lynott & Connell, 2009; Lynott et al., 2020; Miklashevsky, 2018; Speed & Brysbaert, 2021; Vergallito et al., 2020), faster processing in visual lexical decision task (Filipović Đurđević et al., 2016), better-cued recall in PAL (Popović Stijačić & Filipović Đurđević, 2015; 2022) and congruence of modalities effect (Connell & Lynott, 2014; Scerrati et al., 2017; Živanović & Filipović Đurđević, 2011).

Our aim is to investigate the status of conceptual knowledge in MCI population from a novel angle, by building upon the conclusions that semantic memory impairment represents an important part of the MCI profile, in addition to problems with episodic memory and executive functions (Joubert et al., 2010; Joubert et al., 2021; Manoulidou et al., 2014; Olichney et al., 2002), and taking advantage of the latest findings in the study of sensory norms and the role of perceptual variables in language processing (Connell & Lynott 2012; Filipović Đurđević et al., 2016; Lynott & Connell, 2009). In order to achieve this goal, we set several objectives. Our first objective will be to collect sensory norms for nouns from individuals with MCI to elicit their knowledge of objects denoted by those words. By doing so, we aim to evaluate the status of their semantic memory. Our second objective will be to conduct one visual lexical decision task (VLD) to investigate whether individuals with MCI reveal sensitivity to perceptual properties of the objects denoted by those words during word recognition. To the best of our knowledge, none of the two goals has been set in the previous studies.

SUBJECTS AND METHODS

Study 1: Sensory ratings

In the first study, we administered a group of nouns to individuals with MCI and the control group, asking them to rate the sensory experience with the objects denoted by those nouns and to do that separately for five sensory modalities. Therefore, they rated how much something can be seen, heard, touched, tasted, and smelled. The rating was performed separately for the knowledge of the possibility of experiencing, therefore tapping into the general knowledge of these objects, and the memory of the actual personal experience with the object, thus also tapping into episodic memory. By comparing the ratings of the MCI group to the ratings of the healthy controls, we will gain insight into the state of the semantic (and episodic) memory of individuals with MCI

Study 2: Visual Lexical decision task

In this study, we applied a visual lexical decision task to investigate the effects of a semantic variable, namely perceptual richness, on lexical decision time. Previous research used this task to investigate sublexical variables, such as orthographic features, whereas semantics was typically investigated using other tasks (Froeclich et al., 2016; Vita et al., 2014). Here, we aim to use a visual lexical decision task to asses semantic memory.

Method

Participants

The recruitment of subjects for the study and subsequent data collection was approved by the ethics committee of the University Psychiatric Hospital Vrapče, Zagreb, Croatia. Subjects were divided into mild cognitive impairment (MCI) and healthy controls (HC). The MCI group's inclusion criteria required them to meet the NIA-AA guidelines and were stratified according to the MMSE score and educational level regarding population-based norms (Crum et al., 1993, Jack Jr et al., 2018). MCI participants were, as per defined exclusion criteria, not diagnosed with any psychiatric or general medical condition that could explain their cognitive changes, including other psychiatric diagnoses, neurological diagnoses, and acute somatic disease. Subjects in the MCI group were recruited while being provided with standard care at the University Psychiatric Hospital Vrapče.

The final clinical sample included 20 individuals diagnosed with MCI, with a mean age of 74.9 (SD=10.1). All but one were right-handed, and 20% of the subjects were males. Based on years spent in education, on average, these participants were halfway through high school (M=10.15, SD = 3.51). The MCI group had a relatively low average Mini-Mental State Examination (MMSE) score (M=19.8, SD=4.4), which indicated more significant cognitive deterioration. Two participants from the MCI group failed to finish the test (therefore, the data from 18 participants was analyzed). The mean age of the final sample was 75.50 (SD = 9.53), all but one were right-handed, 22.22% were male, the average number of years spent in education was 9.72 (SD = 3.37), and the average score on MMSE was 19.85 (SD = 4.56). Healthy control subjects were recruited from the population of students at the University of Zagreb. The data were collected from 39 participants, aged 20 to 25 years. However, four participants failed to finish the test and were thus excluded.

For the second study, the participants from the MCI group were the same 20 participants as in Study 1. A novel group of 41 control participants was recruited from the same population of students at the University of Zagreb.

Materials and design

In the first study, we selected 30 familiar and concrete nouns which differed concerning the distribution of modality-specific sensory ratings. The selection criterion was to sample a small number of words that would span various types of distributions and which would differ to possible versus actual experience.

In the second study, participants were presented with 60 Croatian words and 60 pseudo-words. All stimuli were taken from the study by Živanović and FilipovićĐurđević (2011) and adapted to Croatian. Word stimuli consisted of 20 words denoting objects that could be experienced in the visual modality, 20 words denoting objects that could be experienced in the auditory modality, and 20 words denoting objects that could be experienced in a multitude of modalities. Pseudo-words were created by replacing the final letter of existing words and were consequently highly word-like. Word frequency measures were taken from the Croatian web corpus (Ljubešić & Klubička 2014; 2016).

Procedure

For the first study, the procedure was identical for the control and MCI groups. The experiment was organized into two blocks. In the first block, the task was to rate the possibility of experiencing the object denoted by the word in each of the five sensory modalities (visual, auditory, tactile, gustatory, olfactory). In the second block, the task was to perform the same rating for the actual experience with the objects. Within each block, the target word would appear at the top of the screen with five rating scales presented below. Each sensory modality was presented with a question and a five-point rating scale next to the question. Extreme rating scale points were marked by "Not at all" and "To a large extent." The participants had unlimited time to provide their ratings by checking the appropriate boxes, and by pressing the "Next" button, they proceeded to the next word. The sequence of words within the block was randomized across participants. Before beginning the task, the participants were given detailed instructions, followed by three examples and three practice stimuli.

The only difference between the procedures for the two groups of participants was that we used different software for presentation and data collection. For reasons unrelated to experimental design, the experiment for the controlled group was prepared in the Sosci platform for online data collection (Leiner, 2019), whereas the experiment for the MCI group was prepared in OpenSesame software (Mathôt et al., 2012). Also, control participants completed the task at home, whereas the participants with MCI were tested in controlled conditions in the hospital. The level of cognitive deterioration was assessed using the MMSE, a brief and widely used test for screening for dementia. MMSE is an 11-item, 30-point test that evaluates different functions, including orientation, recall, registration, memory, language, and the ability to follow simple orders and draw a complex polygon (Folstein, 1975).

For the second study, the experiment was prepared and ran in OpenSesame software (Mathôt et al., 2012). Control participants were performing the task from home, using an online presentation, whereas participants from the MCI group completed the task in a more controlled hospital environment. All participants were presented with a visual lexical decision task in which each trial would start by presenting a blank screen for 500ms and a fixation point for 1000ms, followed by either word or pseudo-word, which would remain on the screen until the response, or 5000ms timeout. The Stimuli presentation was randomized individually for each participant. Before the experiment, participants were provided with detailed instructions and 20 practice trials not included in the analyses.

Data analysis

For both studies, the data were analyzed using **R** statistical software (R Core Team 2022), applying packages **ggplot2** (Wickham 2016), **lme4** (Bates et al., 2015), **lmertest** (Kuznetsova et al., 2017), and **RePsychLing** (Bates et al., 2015; Matuschek et al., 2017). We applied correlation analysis, t-test, and conducted linear and generalized linear mixed-effects regression when appropriate. The models were built by considering the recommendations provided by Barr et al. (2013), thus including random slopes whenever justified by design. However, we also additionally checked whether their inclusion was justified by the data, as suggested by Bates et al. (2015) and Matuschek et al. (2017). The reaction time was transformed according to recommendations provided by Baayen and Milin (2010). Each model was refitted by excluding the residuals outside the -/+ 2.5 standard deviation units range. In doing so, between 3.2% and 4.5% of the data points were removed in various analyses. This process did not affect the structure of the effects, and refitted models were reported.

RESULTS

In the first study, the ratings collected from control and MCI participants are available as Supplementary material to this paper. As presented in the top right segment of Figure 1, participants with MCI provided ratings that were highly similar to the ratings provided by the control group: r=.944 (.93-.955; t(298) = 49.6, p < .0001). The correlations were almost identical across modalities.

As presented in the bottom row of Figure 1 in red, the control participants rated the words mostly as either very easy to experience or very unlikely to be experienced by the given sensory modality. The revealed bimodal distribution of ratings is expected, given the strategy, we applied in choosing the stimuli, and it revealed more about the stimuli than about the participants. Additionally, the two groups of participants (red and blue in Figure 1) provided highly similar bimodal patterns of results, as also visible from the high correlation between the ratings provided by the two groups (as depicted in Figure 1). However, we observed the discrepancy between the

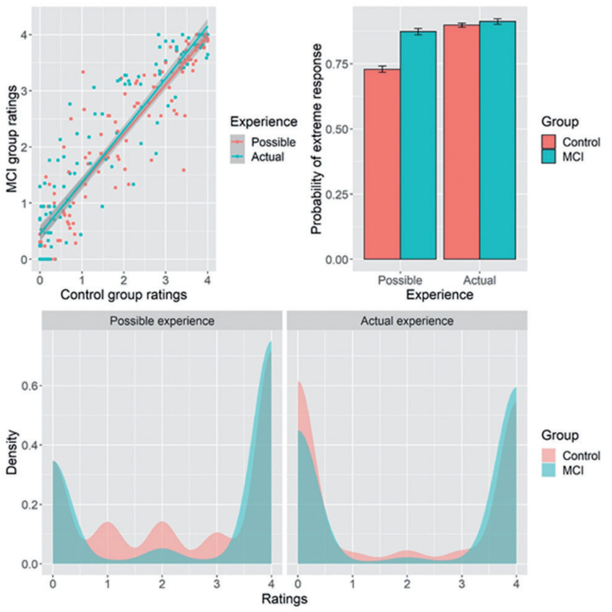

Figure 1. Ratings provided by the MCI group and the control group

Upper left figure: correlation between mean by-item modality-specific sensory ratings obtained from the control group (x-axis) and the group of participants with MCI (y-axis).
Upper right figure: probability of extreme responses for the possible and actual experience provided by the MCI and the control participants.
Bottom figure: distribution of average ratings for possible (left) and actual (right) experience, provided by the participants from the control (red) and MSI group (blue).

Table 1. The coefficients from the generalized linear mixed-effects regression of the participant and MCI group

A) Analysis conducted on all participants (control and MCI)

Random Effects:

	Variance	St. deviation
By-participant intercept adjustments	1.436	1.198
By-participant experience[possible] slope adjustments	2.599	1.612
By-participant experience[actual] slope adjustments	19.15	4.376
By-item intercept adjustments	.0001	.011
By-item group[control] slope adjustments	.826	.909
By-item group[MCI] slope adjustments	2.428	-.070
By-item experience[possible] slope adjustments	.068	.262
By-item experience[actual] slope adjustments	.094	.307

Fixed effects:

	Estimate	Std. Error	z value	-95% CI	+95% CI	Pr(>|z|)
Intercept [control participants, possible experience]	1.3461	.3641	3.697	.632	2.060	<.0001
Group[MCI]	4.4696	.7134	6.265	3.071	5.868	<.0001
Experience[actual]	3.7504	.5135	7.303	2.744	4.757	<.0001
Intercept [control participants, possible experience]	1.3461	.3641	3.697	.632	2.060	<.0001

B) Analysis conducted only the MCI group

Random Effects:

	Variance	St. deviation
By-participant intercept adjustments	3.454	1.858
By-item intercept adjustments	1.462	1.209
By-item slope adjustments for the effect of MMSE score of the participant	.0002	.015

Fixed effects:

	Estimate	Std. Error	z value	-95% CI	+95% CI	Pr(>|z|)
Intercept[Possible experience, Auditory modality]	5.671	0.965	5.878	3.78	7.562	<.001
MMSE score of the participant	-0.142	0.04	-3.569	-0.22	-0.064	<.001
Experience[actual]	0.464	0.115	4.026	0.238	0.69	<.001
Modality[gustatory]	0.739	0.177	4.18	0.392	1.085	<.001
Modality[olfactory]	-0.267	0.156	-1.714	-0.572	0.038	.087
Modality[tactile]	0.512	0.171	3.002	0.178	0.846	<.001
Modality[visual]	1.131	0.19	5.958	0.759	1.502	<.001

LEFT: The coefficients from the generalized linear mixed-effects regression of the participant group and experience to the probability of providing an extreme-type rating (1-extreme rating; 0-midrange rating).

RIGHT: The coefficients from the generalized linear mixed-effects regression of modality, experience, and MMSE score to the probability of providing an extreme-type rating (1-extreme rating; 0-midrange rating) conducted on the subset of MCI data.

two groups, as the control participants tended to produce more mid-range ratings as compared to participants with MCI, which seemed to be slightly more prone to providing extreme ratings (either 0 or 4) as compared to the control group.

To test whether the observed differences between the two groups were significant, we conducted generalized mixed-effect regression with the participant group (control, MCI) and experience type (possible, actual) as fixed effects. By dichotomizing the rating scale, we created a binomial variable, with level 1 indicating the presence of the extreme rating (either 0 or 4) and level 0 indicating the absence of the extreme rating, i.e., the presence of the mid-range rating (1, 2, or 3). In addition to by-participant and by-item intercept adjustments, the random effects in our model were also by-participant slope adjustments for experience type and by-item slope adjustments for the effects of experience type and participant group. As presented in Table 1A (lefthand side od the table, and illustrated in the top righthand segment of Figure 1), participants were more prone to giving extreme actual experience ratings than the ratings of possible experience. Crucially, as predicted, participants with MCI were more likely to give extreme ratings than control participants. Although this difference tended to be more pronounced in the case of possible experience, the interaction was insignificant (p=.06).

To test whether the observed tendency of the MCI group to provide extreme ratings was related to cognitive decline and not merely a consequence of the age difference between the MCI group and the control group, we conducted another analysis of the data from the MCI group. Here, we included the MMSE score as the main predictor and experience and modality as fixed effects. The final model (presented in Table 1B, right), in addition to the effects of experience and modality, also revealed the effect of the MMSE score. We observed that the participants with higher MMSE scores (less decline) were less likely to provide an extreme rating, i.e., were more likely to provide a mid-range rating. Therefore, the difference reported in Table 1A can not be attributed only to the age difference; it is also related to cognitive decline.

For the second study, we first analyzed the full data set to test the prediction regarding the performance of participants with MCI on pseudo-words compared to words. As depicted in Figure 2 (left), the overall accuracy of participants with MCI is lower than that of control participants, and the difference is particularly dramatic in the case of pseudo-words. This has been confirmed in generalized mixed effects regression which revealed a significant interaction between groups of participants and lexicality (Table 2A, left). This pattern of results is

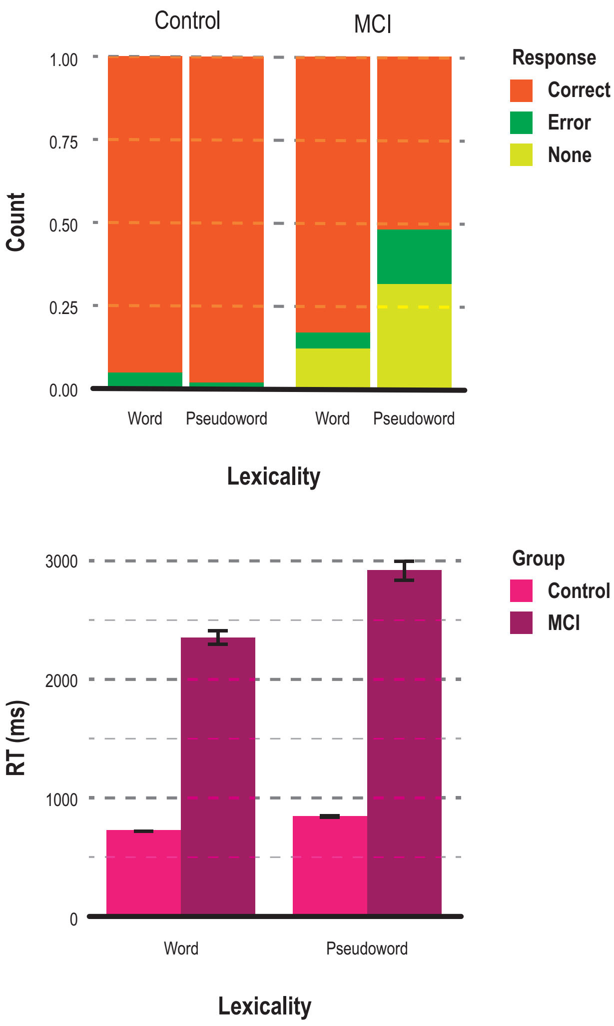

Figure 2. Accuracy and reaction time for the control group and MCI group, as observed in VLD task.

Lefthand figure: Proportion of the errors, correct responses, and missing responses to words and pseudowords, for the control group and MCI group.
Righthand figure: average reaction time of the participants from the control and MCI group to words and pseudowords in VLD task.

repeated on processing latencies, as depicted in Figure 2 (right) and Table 3A (left).

To further test our hypothesis that cognitive impairment should be seen as the cause of the high error rate in the VLD task, we conducted generalized linear mixed effects regression on the subset of data from participants with MCI in which we tested whether their score on MMSE test could predict the accuracy. As presented in Table 2B (right), individuals who scored higher were more likely to respond accurately to both words and pseudo-words (the interaction was tested but was insignificant). Therefore, the tendency to make more errors was

Table 2. The coefficients from the generalized linear mixed-effects regression

A) Analysis conducted on all participants (control and MCI)

Random Effects:

	Variance	St. deviation
By-participant intercept adjustments	.648	.805
By-participant slope adjustments for the effect of lexicality[Word]	.207	.454
By-participant slope adjustments for the effect of lexicality [Pseudo-word]	1.562	1.250
By-item intercept adjustments	.622	.789
By-item slope adjustments for the effect of group[control]	1.255	1.121
By-item slope adjustments for the effect of group[MCI]	.082	.286

Fixed effects:

	Estimate	Std. Error	z value	-95% CI	+95% CI	Pr (>|z|)
Intercept[control participants, words]	4.012	0.293	13.696	3.437	4.586	<.001
Lexicality[Pseudowords]	1.474	0.428	3.444	0.635	2.313	<.001
Group[MCI]	-1.815	0.356	-5.101	-2.512	-1.118	<.001
Lexicality[Pseudowords]:Group [MCI]	-3.549	0.507	-7.001	-4.543	-2.556	<.001

B) Analysis conducted only the MCI group

Random Effects:

	Variance	St. deviation
By-participant intercept adjustments	.869	.932
By-participant slope adjustments for the effect of lexicality [Pseudo-word]	2.661	1.631
By-participant slope adjustments for the effect of lexicality[Word]	.120	0.346
By-item intercept adjustments	<.001	<.001
By-item slope adjustments for the effect of MMSE score	.002	.050

Fixed effects:

	Estimate	Std. Error	z value	-95% CI	+95% CI	Pr(>|z|)
Intercept[Pseudoword, control participants]	-3.869	1.302	-2.972	-6.42	-1.317	.003
Lexicality[Word]	2.089	.462	4.522	1.184	2.994	<.001
MMSE score	.209	.061	3.410	.089	.330	<.001

LEFT: The coefficients from the generalized linear mixed-effects regression of the participant group and lexicality to the accuracy in VLD tasks.
RIGHT: The coefficients from the generalized linear mixed-effects regression of the MMSE score of MCI participants and lexicality to the accuracy observed in the VLD task.

Table 3. The coefficients from the generalized linear mixed-effects regression to the VLD latencies

A) Analysis conducted on all participants (control and MCI)			**B) Analysis conducted only the MCI group**		
Random Effects:					
	Variance	St. deviation		Variance	St. deviation
By-participant intercept adjustments	.023	.151	By-participant intercept adjustments	.108	.328
By-participant slope adjustments for the effect of lexicality[Word]	.016	.125	By-participant slope adjustments for the effect of word length	.001	.023
By-participant slope adjustments for the effect of lexicality [Pseudo-word]	.010	.098	By-participant slope adjustments for the effect of frequency	.001	.036
By-item intercept adjustments	<.001	<.001	By-participant slope adjustments for the effect of perceptual richness	<.001	<.001
By-item slope adjustments for the effect of group[control]	.018	.134	By-item intercept adjustments	.002	.044
By-item slope adjustments for the effect of group[MCI]	.004	.059	Residual	.072	.269
Residual	.072	.268			

Fixed effects:

	Estimate	Std. Error	z value	-95% CI	+95% CI	Pr (>|z|)		Estimate	Std. Error	z value	-95% CI	+95% CI	Pr(>|z|)
Intercept[control participants, words]	-1.49	.036	-41.814	-1.367	-1.236	<.001	Intercept	7.720	.074	104.166	7.574	7.864	<.001
Lexicality[Pseudowords]	.188	.034	5.607	-.254	-0.122	<.001	Word length in letters	.064	.013	4.952	.039	.089	<.001
Group[MCI]	.975	.056	17.463	.780	0.988	<.001	(log) Word frequency	-.038	.015	-2.549	-.067	-.009	.016
Lexicality[Pseudowords]:Group [MCI]	-.091	.046	-1.999	.002	0.18	.049	Perceptual richness	-.054	.012	-4.481	-.078	-.030	<.001

LEFT: The coefficients from the generalized linear mixed-effects regression of the participant group and lexicality to the accuracy in VLD tasks.
RIGHT: The coefficients from the linear mixed-effects regression of the lexical-semantic variables to the VLD latencies of the MCI group.

not only the consequence of the MCI group's age but was also related to the level of cognitive decline.

In the subsequent step, we also tested for the effects of participant group and item lexicality on correct response processing latencies. We observed a pattern that mirrored the results obtained in the analysis of accuracy data. Figure 3 and Table 3A (left) depict that the MCI group participants were dramatically slower than the control participants. Additionally, both groups of participants were slower to respond to pseudo-words than words. This difference seemed even more pronounced within the MCI group, as we also observed significant group-by-lexicality interaction. In the final step, we applied linear mixed-effects regression analysis to the processing latencies for the subset of words presented to the MCI participants in the VLD task. The model coefficients presented in Table 3B (right) revealed typical significant effects of all tested fixed effect predictors. As illustrated in Figure 3, the word length in letters was positively correlated with processing latencies, whereas (log) word frequency and perceptual richness were negatively correlated with processing latencies.

DISCUSSION

The results of the study present different levels of lexical-semantic processing in MCI. For the first time, the sensory ratings of words in the MCI population have been compared with ratings of the same words collected from the control population. The results show that participants with MCI provided ratings highly similar to those provided by the control group, thus indicating preserved semantic knowledge. This finding is in accordance with the studies that compared young adults to healthy older speakers (Froehlich et al., 2018, Froehlich & Jacobs 2016). However, our findings are not following the results of the studies that investigated the semantic knowledge of MCI individuals (Joubert et al., 2010; Joubert et al., 2021; Manoulidou et al., 2014; Olichney et al., 2002). We showed that there is a preserved aspect of the knowledge of the sensory modalities that can be used to investigate an object denoted by the word. In addition to observing the similarity in semantic knowledge of concepts being explorable in different sensory modalities, we also observed that MCI and the control group were equally similar in terms of ratings based on actual personal memories of experiences, indicating a preserved aspect of episodic memory. However, we also observed that the MCI group tended to give more extreme ratings, making the decision more binary. That "binarization" can conditionally be seen as a simplification of the task, as there is a reduction in information load and, consequently, the number of possible replies, reducing processing requirements.

Furthermore, their tendency to give more extreme answers is related to the degree of cognitive impairment. Higher MMSE scores made subjects less prone to giving extreme ratings, thus corroborating our interpretation of binarization as the off-loading strategy. This finding also follows frequent observations of executive function problems in the MCI population (e.g., Novick et al., 2005).

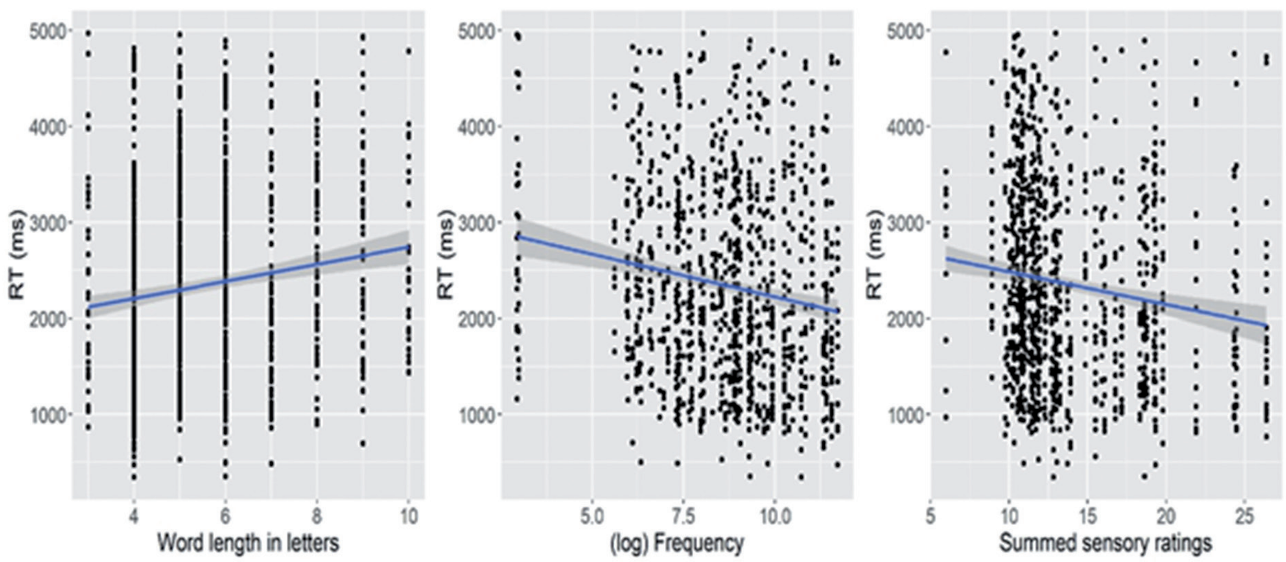

Figure 3. Processing latencies of two groups for words and pseudowords.

In the lexical decision task, the overall accuracy of participants with MCI is lower than that of control participants, and the difference is particularly dramatic in the case of pseudo-words. This pattern was also reflected in longer processing latencies. Crucially, individuals who scored higher on MMSE were more likely to provide accurate responses to both words and pseudo-words, indicating that the problems with accuracy were related to the level of cognitive decline. However, our main focus in the lexical decision task was on the effects of lexical-semantic variables. We observed typical effects of word length and (log) word frequency, as previously observed (Froechlich et al., 2016; Spaniol et al., 2006). Crucially, we documented the effect of summed sensory ratings (perceptual richness) on processing latencies for the first time. These effects indicated that long-term memory-related processes were well preserved within the population. The state of semantic knowledge has been tested in semantic decision tasks (Froeclich et al., 2016) and semantic fluency tasks (Vita et al., 2014). Here, we have applied a visual lexical decision task to test for semantic variables' effects. In sum, the MCI patients showed impaired performance that could be related to executive functioning and preserved long-term memory-related performance. These findings are from previous lexical semantics studies in MCI related to impairment in language processing caused by executive dysfunction (Novick et al., 2005; Manouilidou et al., 2015; Nikolaev et al., 2019).

To summarize, we observed some dramatic and some subtle differences between the MCI and the control group. Some of those were predictable (e.g., higher error rate and lower overall processing speed), whereas some were recorded for the first time (e.g., the profile of sensory ratings, the increased tendency towards binarization of the ratings, the effect of perceptual variables on the lexical decision). Before generalizing, we should be aware of the nature of our control group, which consisted of young, healthy, and well-educated adults. In other words, our control group was not properly matched with the MCI group. However, we believe that this issue is partly resolved by our finding that, within the MCI group, the tendency towards binarization and the lexical decision performance was related to the MMSE score. The next potential confounding risk is related to the fact that the MCI group was tested in the lab (hospital), whereas control participants performed the tasks online using their computers. However, rich research that compared the data collected in the lab and in the wild converged in a solid conclusion that there were no differences that could be related either to hardware or the online vs. offline testing conditions (Bridges et al., 2020; de Leeuw & Motz, 2016; Filipović Đurđević, 2020; Filipović Đurđević & Đurđević, 2021; Hilbig, 2016; Kim et al., 2019). While MMSE scores in the present study tend to be lower than expected in the MCI population, we must be aware of different factors that influence MMSE scores. The primary reason a more detailed evaluation of those scores in an MCI population, and factors influencing them, was not attempted was that we used clinical criteria to define MCI, and MMSE scores were used solely as a way to achieve intersubject comparison, allowing us to see if identified lexical-semantic processing effects scaled with the cognitive deterioration or not. In addition to this limitation, several issues should be addressed in future studies: including more subjects to make clearer conclusions, an increase of statistical power, as the MCI group is more likely to be a heterogeneous group of individuals, and constructing future longitudinal studies to follow changes in the MCI population over time.

CONCLUSION

In conclusion, the study brought a novel approach to investigating the status of semantic memory in the MCI population. For the first time, the sensory norms are collected from the MCI speakers, and a visual lexical decision task is used to investigate the effects of the semantic variable of perceptual richness on the processing latencies of MCI individuals. The collected norms highly resembled those of the healthy controls, suggesting preserved semantic and episodic knowledge of sensory properties of objects denoted by the presented words. The MCI speakers were also sensitive to the perceptual richness of objects denoted by the words in the visual lexical decision task, further corroborating this conclusion. We believe that in the future, the observed profile of results in these tasks could help differentiate the MCI from some other conditions.

Acknowledgments: The research is funded by Faculty of Philosophy, University of Zagreb grant Deficits of sensorimotor features in lexical-semantic processing in psychosis and dementia and The Ministry of Education, Science, and Technological Development of the Republic of Serbia grant awarded to Faculty of Philosophy, University of Belgrade (info:eu-repo/grantAgreement/MESTD/inst-2020/200163/RS//).

Ethical Considerations: Does this study include human subjects? YES

Authors confirmed the compliance with all relevant ethical regulations.

Funding sources: University of Zagreb funded research: Deficits of sensorimotor features in lexical-semantic processing in psychosis and dementia The Ministry of Education, Science, and Technological Development of the Republic of Serbia (info:eu-repo/grantAgreement/MESTD/inst-2020/200163/RS//)

Conflict of Interest: All authors have no conflict of interest to report. Hereby all authors disclose that they do not have any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

Authors Contributions: DFĐ, MSS, VE, and NM have made substantial contributions to the conception and design of the work; DK, DO, and JV have done the clinical testing and acquired the data; DFĐ did the analysis of the data; JV and AS have conducted literature research; DFĐ and AS drafted the first version of the paper; VE, MSS, and NM revised it critically for important intellectual content; all authors have approved the final version and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

Abutalebi, J., Guidi, L., Borsa, V., Canini, M., Della Rosa, P. A., Parris, B. A., & Weekes, B. S. (2015). Bilingualism provides a neural reserve for aging populations. *Neuropsychologia, 69*, 201–210. https://doi.org/10.1016/j.neuropsychologia.2015.01.040

Ahmed, S., Arnold, R., Thompson, S. A., Graham, K. S., & Hodges, J. R. (2007). Naming of objects, faces and buildings in mild cognitive impairment. *Cortex, 44*(6), 746–752. https://doi.org/10.1016/j.cortex.2007.02.002

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, B., Feldman, H. H., Fox, N. C., Gamst, A., Holtzman, D. M., Jagust, W. J., Petersen, R. C., Snyder, P. J., Carrillo, M. C., Thies, B., & Phelps, C. H. (2011). The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer S & Dementia, 7*(3), 270–279. https://doi.org/10.1016/j.jalz.2011.03.008

Aretouli, E., & Brandt, J. (2009). Everyday functioning in mild cognitive impairment and its relationship with executive cognition. *International Journal of Geriatric Psychiatry*, *25*(3), 224–233. https://doi.org/10.1002/gps.2325

Baayen, R. H., & Milin, P. (2010). Analyzing reaction times. *International Journal of Psychological Research*, *3*(2), 12–28. https://doi.org/10.21500/20112084.807

Barbeau, E. J., Didic, M., Joubert, S., Guedj, E., Koric, L., Felician, O., Ranjeva, J., Cozzone, P., & Ceccaldi, M. (2012). Extent and neural basis of semantic memory impairment in mild cognitive impairment. *Journal of Alzheimer S Disease*, *28*(4), 823–837. https://doi.org/10.3233/jad-2011-110989

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Barsalou, L. W. (1999a). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*(4), 577–660. https://doi.org/10.1017/s0140525x99002149

Barsalou, L. W. (1999b). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*(4), 577–660. https://doi.org/10.1017/s0140525x99002149

Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.1506.04967

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting Linear Mixed-Effects Models using lme4. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.1406.5823

Bormann, T. (2011). The role of Lexical-Semantic Neighborhood in Object Naming: Implications for Models of Lexical access. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00127

Bridges, D., Pitiot, A., MacAskill, M. R., & Peirce, J. W. (2020). The timing mega-study: comparing a range of experiment generators, both lab-based and online. *PeerJ*, *8*, e9414. https://doi.org/10.7717/peerj.9414

Brysbaert, M., Mandera, P., & Keuleers, E. (2017). The Word Frequency Effect in Word Processing: An updated review. *Current Directions in Psychological Science*, *27*(1), 45–50. https://doi.org/10.1177/0963721417727521

Bush, A. L. H., Allen, P. A., Kaut, K. P., & Ogrocki, P. K. (2006). Influence of mild cognitive impairment on visual word recognition. *Aging Neuropsychology and Cognition*, *14*(4), 329–352. https://doi.org/10.1080/13825580600630278

Chen, Y., Liang, N., Li, X., Yang, S., Wang, Y., & Shi, N. (2021). Diagnosis and treatment for Mild cognitive impairment: A systematic review of clinical practice guidelines and consensus statements. *Frontiers in Neurology*, *12*. https://doi.org/10.3389/fneur.2021.719849

Chumbley, J. I., & Balota, D. A. (1984). A word's meaning affects the decision in lexical decision. *Memory & Cognition*, *12*(6), 590–606. https://doi.org/10.3758/bf03213348

Clark, L. R., Stricker, N. H., Libon, D. J., Delano-Wood, L., Salmon, D. P., Delis, D. C., & Bondi, M. W. (2012). Yes/No Versus Forced-Choice Recognition Memory in Mild Cognitive Impairment and Alzheimer's Disease: Patterns of Impairment and Associations with Dementia Severity. *The Clinical Neuropsychologist*, *26*(7), 1201–1216. https://doi.org/10.1080/13854046.2012.728626

Connell, L., & Lynott, D. (2012). Strength of perceptual experience predicts word processing performance better than concreteness or imageability. *Cognition*, *125*(3), 452–465. https://doi.org/10.1016/j.cognition.2012.07.010

Connell, L., & Lynott, D. (2013). I see/hear what you mean: Semantic activation in visual word recognition depends on perceptual attention. *Journal of Experimental Psychology General*, *143*(2), 527–533. https://doi.org/10.1037/a0034626

Crum, R. M. (1993). Population-Based Norms for the Mini-Mental State Examination by age and Educational level. *JAMA*, *269*(18), 2386. https://doi.org/10.1001/jama.1993.03500180078038

Cummings, L. (2020). *Language in dementia*. https://doi.org/10.1017/9781108587921

De Leeuw, J. R., & Motz, B. A. (2015). Psychophysics in a Web browser? Comparing response times collected with JavaScript and Psychophysics Toolbox in a visual search task. *Behavior Research Methods*, *48*(1), 1–12. https://doi.org/10.3758/s13428-015-0567-2

Duong, A., Whitehead, V., Hanratty, K., & Chertkow, H. (2006). The nature of lexico-semantic processing deficits in mild cognitive impairment. *Neuropsychologia*, *44*(10), 1928–1935. https://doi.org/10.1016/j.neuropsychologia.2006.01.034

Filipović Đurđević, D. (2021). Slobodni i otvoreni softver u laboratorijskim i mrežnim istraživanjima u eksperimentalnoj psihologiji. *Zbornik treće nacionalne konferencije sa međunarodnim učešćem pod nazivom Primena slobodnog softvera i otvorenog hardvera PSSOH 2020, 24. oktobar 2020, Elektrotehnički fakultet u Beogradu, Beograd*, 79-83. http://doi.org/10.5281/zenodo.4064303

Filipović Đurđević, D., & Đurđević, Đ. (2021). Ultralab — slobodan softver za izvođenje psiholoških eksperimenata. *Primenjena psihologija, 14*(1), 9-32. https://doi.org/10.19090/pp.2021.2.9-32

Filipović Đurđević, D., & Milin, P. (2019). Information and Learning in Processing Adjective Inflection. *Cortex, 116*, 209-227. https://doi.org/10.1016/j.cortex.2018.07.020

Filipović Đurđević, D., & Kostić, A. (2017). Number, Relative Frequency, Entropy, Redundancy, Familiarity, and Concreteness of Word Senses: Ratings for 150 Serbian Polysemous Nouns. In S. Halupka-Rešetar and S. Martínez-Ferreiro (Eds.) *Studies in Language and Mind 2* (pp.13-77). RS, Novi Sad: Filozofski fakultet u Novom Sadu. http://digitalna.ff.uns.ac.rs/sadrzaj/2017/978-86-6065-446-7

Filipović Đurđević, D., & Kostić, A. (2023). We probably sense sense probabilities. *Language, Cognition and Neuroscience, 38*(4), 471-498. https://doi.org/10.1080/23273798.2021.1909083

Filipović Đurđević, D., Popović Stijačić, M., & Karapandžić, J. (2016). A quest for sources of perceptual richness: Several candidates. In S. Halupka-Rešetar and S. Martínez-Ferreiro (Eds.) *Studies in Language and Mind* (pp. 187-238). RS, Novi Sad: Filozofski fakultet u Novom Sadu. http://digitalna.ff.uns.ac.rs/sadrzaj/2016/978-86-6065-359-0

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state." *Journal of Psychiatric Research*, *12*(3), 189–198. https://doi.org/10.1016/0022-3956(75)90026-6

Foster, P. S., Drago, V., Yung, R. C., Pearson, J., Stringer, K., Giovannetti, T., Libon, D., & Heilman, K. M. (2013). Differential lexical and semantic spreading activation in Alzheimer's disease. *American Journal of Alzheimer S Disease & Other Dementias®*, *28*(5), 501–507. https://doi.org/10.1177/1533317513494445

Froehlich, E., Liebig, J., Morawetz, C., Ziegler, J. C., Braun, M., Heekeren, H. R., & Jacobs, A. M. (2017). Same same but different: processing words in the aging brain. *Neuroscience*, *371*, 75–95. https://doi.org/10.1016/j.neuroscience.2017.11.042

Froehlich, E., Liebig, J., Ziegler, J. C., Braun, M., Lindenberger, U., Heekeren, H. R., & Jacobs, A. M. (2016). Drifting through Basic Subprocesses of Reading: A Hierarchical Diffusion Model Analysis of Age Effects on Visual Word Recognition. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01863

Hilbig, B. E. (2015). Reaction time effects in lab- versus Web-based research: Experimental evidence. *Behavior Research Methods*, *48*(4), 1718–1724. https://doi.org/10.3758/s13428-015-0678-9

Hino, Y., Lupker, S. J., & Pexman, P. M. (2002). Ambiguity and synonymy effects in lexical decision, naming, and semantic categorization tasks: Interactions between orthography, phonology, and semantics. *Journal of Experimental Psychology Learning Memory and Cognition*, *28*(4), 686–713. https://doi.org/10.1037/0278-7393.28.4.686

Jack, C. R., Bennett, D. A., Blennow, K., Carrillo, M. C., Dunn, B., Haeberlein, S. B., Holtzman, D. M., Jagust, W., Jessen, F., Karlawish, J., Liu, E., Molinuevo, J. L., Montine, T., Phelps, C., Rankin, K. P., Rowe, C. C., Scheltens, P., Siemers, E., Snyder, H. M., . . . Silverberg, N. (2018). NIA-AA Research Framework: Toward a biological definition of Alzheimer's disease. *Alzheimer S & Dementia*, *14*(4), 535–562. https://doi.org/10.1016/j.jalz.2018.02.018

Joubert, S., Brambati, S. M., Ansado, J., Barbeau, E. J., Felician, O., Didic, M., Lacombe, J., Goldstein, R., Chayer, C., & Kergoat, M. (2009). The cognitive and neural expression of semantic memory impairment in mild cognitive impairment and early Alzheimer's disease. *Neuropsychologia*, *48*(4), 978–988. https://doi.org/10.1016/j.neuropsychologia.2009.11.019

Joubert, S., Gardy, L., Didic, M., Rouleau, I., & Barbeau, E. J. (2020). A Meta-Analysis of semantic memory in mild Cognitive Impairment. *Neuropsychology Review*, *31*(2), 221–232. https://doi.org/10.1007/s11065-020-09453-5

Kasper, S., Bancher, C., Eckert, A., Förstl, H., Frölich, L., Hort, J., Korczyn, A. D., Kressig, R. W., Levin, O., & Palomo, M. S. M. (2020). Management of mild cognitive impairment (MCI): The need for national and international guidelines. *The World Journal of Biological Psychiatry*, *21*(8), 579–594. https://doi.org/10.1080/15622975.2019.1696473

Kelley, B. J., & Petersen, R. C. (2007). Alzheimer's disease and mild cognitive impairment. *Neurologic Clinics*, *25*(3), 577–609. https://doi.org/10.1016/j.ncl.2007.03.008

Kim, J., Gabriel, U., & Gygax, P. (2019). Testing the effectiveness of the Internet-based instrument PsyToolkit: A comparison between web-based (PsyToolkit) and lab-based (E-Prime 3.0) measurements of response choice and response time in a complex psycholinguistic task. *PLoS ONE*, *14*(9), e0221802. https://doi.org/10.1371/journal.pone.0221802

Kucian, K., Kohn, J., Hannula-Sormunen, M., Richtmann, V., Grond, U., Käser, T., Esser, G., & Von Aster, M. (2012). Kinder mit Dyskalkulie fokussieren spontan weniger auf Anzahligkeit. *Lernen Und Lernstörungen*, *1*(4), 241–253. https://doi.org/10.1024/2235-0977/a000024

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). LMERTest Package: Tests in Linear Mixed Effects models. *Journal of Statistical Software*, *82*(13). https://doi.org/10.18637/jss.v082.i13

Mueller, K. D., Hermann, B., Mecollari, J., & Turkstra, L. S. (2018). Connected speech and language in mild cognitive impairment and Alzheimer's disease: A review of picture description tasks. *Journal of Clinical and Experimental Neuropsychology*, *40*(9), 917–939. https://doi.org/10.1080/13803395.2018.1446513

Leiner, D. J. (2019). SoSci Survey (Version 3.1.06) [Computer software]. Available at https://www.soscisurvey.de

Ljubešić, N., Klubička, F. (2014). {bs, hr, sr} wac-web corpora of Bosnian, Croatian and Serbian. In *Proceedings of the 9th web as corpus workshop (WaC-9)*, 29-35.

Ljubešić, N., and Klubička, F. (2016). *Croatian web corpus hrWaC 2.1*. Slovenian language resource repository CLARIN. SI, ISSN 2820-4042, http://hdl.handle.net/11356/1064.

Lynott, D., & Connell, L. (2009). Modality exclusivity norms for 423 object properties. *Behavior Research Methods*, *41*(2), 558–564. https://doi.org/10.3758/brm.41.2.558

Manouilidou, C., Dolenc, B., Marvin, T., & Pirtošek, Z. (2015). Processing complex pseudo-words in mild cognitive impairment: The interaction of preserved morphological rule knowledge with compromised cognitive ability. *Clinical Linguistics & Phonetics*, *30*(1), 49–67. https://doi.org/10.3109/02699206.2015.1102970

Lee, M. D., & Wagenmakers, E. (2014). *Bayesian Cognitive Modeling*. https://doi.org/10.1017/cbo9781139087759

Matuschek, H., Kliegl, R., Vasishth, S., Baayen, H., & Bates, D. (2017). Balancing Type I error and power in linear mixed models. *Journal of Memory and Language*, *94*, 305–315. https://doi.org/10.1016/j.jml.2017.01.001

McRae, K., Cree, G. S., Seidenberg, M. S., & Mcnorgan, C. (2005). Semantic feature production norms for a large set of living and nonliving things. *Behavior Research Methods*, *37*(4), 547–559. https://doi.org/10.3758/bf03192726

Meteyard, L., Cuadrado, S. R., Bahrami, B., & Vigliocco, G. (2010). Coming of age: A review of embodiment and the neuroscience of semantics. *Cortex*, *48*(7), 788–804. https://doi.org/10.1016/j.cortex.2010.11.002

Miklashevsky, A. (2017). Perceptual experience norms for 506 Russian nouns: modality rating, spatial localization, manipulability, imageability and other variables. *Journal of Psycholinguistic Research*, *47*(3), 641–661. https://doi.org/10.1007/s10936-017-9548-1

Mišić, K., & Đurđević, D. F. (2021). Redesigning the exploration of semantic dynamics: SSD account in light of regression design. *Quarterly Journal of Experimental Psychology*, *75*(6), 1155–1170. https://doi.org/10.1177/17470218211048386

Muraki, E. J., Sidhu, D. M., & Pexman, P. M. (2019). Mapping semantic space: property norms and semantic richness. *Cognitive Processing*, *21*(4), 637–649. https://doi.org/10.1007/s10339-019-00933-y

Nakhla, M. Z., Banuelos, D., Pagán, C., Olvera, A. G., & Razani, J. (2021). Differences between episodic and semantic memory in predicting observation-based activities of daily living in mild cognitive impairment and Alzheimer's disease. *Applied Neuropsychology Adult*, *29*(6), 1499–1510. https://doi.org/10.1080/23279095.2021.1893172

Nikolaev, A., Ashaie, S., Hallikainen, M., Hänninen, T., Higby, E., Hyun, J., Lehtonen, M., & Soininen, H. (2018). Effects of morphological family on word recognition in normal aging, mild cognitive impairment, and Alzheimer's disease. *Cortex*, *116*, 91–103. https://doi.org/10.1016/j.cortex.2018.10.028

Novick, J. M., Trueswell, J. C., & Thompson-Schill, S. L. (2005). Cognitive control and parsing: Reexamining the role of Broca's area in sentence comprehension. *Cognitive Affective & Behavioral Neuroscience*, *5*(3), 263–281. https://doi.org/10.3758/cabn.5.3.263

Popović Stijačić, M., & Filipović Đurđević, D. (2015). Uspešnost reprodukcije u zavisnosti od broja čula kojima je moguće iskusiti pojam. *Primenjena psihologija, 8*(3), 335-352. https://doi.org/10.19090/pp.2015.3.335-352

Popović Stijačić, M., & Filipović Đurđević, D. (2022). Perceptual richness and its role in free and cued recall. *Primenjena Psihologija, 15,* 255-381. https://doi.org/10.19090/pp.v15i3.2400

Olichney, J. M., Morris, S. K., Ochoa, C., Salmon, D. P., Thal, L. J., Kutas, M., & Iragui, V. J. (2002). Abnormal verbal event related potentials in mild cognitive impairment and incipient Alzheimer's disease. *Journal of Neurology Neurosurgery & Psychiatry*, *73*(4), 377–384. https://doi.org/10.1136/jnnp.73.4.377

Panza, F. (2005). Current epidemiology of mild cognitive impairment and other predementia syndromes. *American Journal of Geriatric Psychiatry*, *13*(8), 633–644. https://doi.org/10.1176/appi.ajgp.13.8.633

Quaranta, D., Piccininni, C., Caprara, A., Malandrino, A., Gainotti, G., & Marra, C. (2019). Semantic Relations in a Categorical Verbal Fluency Test: an exploratory investigation in Mild Cognitive Impairment. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02797

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ritchie, K., Artero, S., & Touchon, J. (2001). Classification criteria for mild cognitive impairment. *Neurology*, *56*(1), 37–42. https://doi.org/10.1212/wnl.56.1.37

Rodd, J., Gaskell, G., & Marslen-Wilson, W. (2002). Making sense of semantic ambiguity: Semantic competition in Lexical access. *Journal of Memory and Language*, *46*(2), 245–266. https://doi.org/10.1006/jmla.2001.2810

Sachs-Ericsson, N., & Blazer, D. G. (2014). The new DSM-5 diagnosis of mild neurocognitive disorder and its relation to research in mild cognitive impairment. *Aging & Mental Health*, *19*(1), 2–12. https://doi.org/10.1080/13607863.2014.920303

Salehi, M., Reisi, M., & Ghasisin, L. (2017). Lexical Retrieval or Semantic Knowledge Which One Causes Naming Errors in Patients with Mild and Moderate Alzheimer's Disease. *Dementia and Geriatric Cognitive Disorders Extra*, *7*(3), 419–429. https://doi.org/10.1159/000484137

Salmon, D. P. (2012). Loss of semantic knowledge in mild cognitive impairment. *American Journal of Psychiatry*, *169*(12), 1226–1229. https://doi.org/10.1176/appi.ajp.2012.12101262

Scerrati, E., Lugli, L., Nicoletti, R., & Borghi, A. M. (2016). The multilevel Modality-Switch effect: What happens when we see the bees buzzing and hear the diamonds glistening. *Psychonomic Bulletin & Review*, *24*(3), 798–803. https://doi.org/10.3758/s13423-016-1150-2

Schwanenflugel, P. J., Harnishfeger, K. K., & Stowe, R. W. (1988). Context availability and lexical decisions for abstract and concrete words. *Journal of Memory and Language*, *27*(5), 499–520. https://doi.org/10.1016/0749-596x(88)90022-8

Spaniol, J., Madden, D. J., & Voss, A. (2006). A diffusion model analysis of adult age differences in episodic and semantic long-term memory retrieval. *Journal of Experimental Psychology Learning Memory and Cognition*, *32*(1), 101–117. https://doi.org/10.1037/0278-7393.32.1.101

Speed, L. J., & Brybaert, M. (2021). Dutch sensory modality norms. *Behavior Research Methods*, *54*(3), 1306–1318. https://doi.org/10.3758/s13428-021-01656-9

Sun, T., Xie, T., Wang, J., Zhang, L., Tian, Y., Wang, K., Yu, X., & Wang, H. (2020). Decision-Making under ambiguity or risk in individuals with Alzheimer's disease and mild cognitive impairment. *Frontiers in Psychiatry*, *11*. https://doi.org/10.3389/fpsyt.2020.00218

Taler, V., & Phillips, N. A. (2008). Language performance in Alzheimer's disease and mild cognitive impairment: A comparative review. *Journal of Clinical and Experimental Neuropsychology*, *30*(5), 501–556. https://doi.org/10.1080/13803390701550128

Taler, V., Monetta, L., Sheppard, C., & Ohman, A. (2020). Semantic function in mild cognitive impairment. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.03041

Tchakoute, C. T., Sainani, K. L., & Henderson, V. W. (2017). Semantic memory in the clinical progression of Alzheimer disease. *Cognitive and Behavioral Neurology*, *30*(3), 81–89. https://doi.org/10.1097/wnn.0000000000000131

Vergallito, A., Petilli, M. A., & Marelli, M. (2020). Perceptual modality norms for 1,121 Italian words: A comparison with concreteness and imageability scores and an analysis of their impact in word processing tasks. *Behavior Research Methods*, *52*(4), 1599–1616. https://doi.org/10.3758/s13428-019-01337-8

Vita, M. G., Marra, C., Spinelli, P., Caprara, A., Scaricamazza, E., Castelli, D., Canulli, S., Gainotti, G., & Quaranta, D. (2014). Typicality of words produced on a semantic fluency task in amnesic Mild cognitive impairment: linguistic analysis and risk of conversion to dementia. *Journal of Alzheimer S Disease*, *42*(4), 1171–1178. https://doi.org/10.3233/jad-140570

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York. https://doi.org/10.1007/978-3-319-24277-4_9

Winblad, B., Palmer, K., Kivipelto, M., Jelic, V., Fratiglioni, L., Wahlund, L., Nordberg, A., Bäckman, L., Albert, M., Almkvist, O., Arai, H., Basun, H., Blennow, K., De Leon, M., DeCarli, C., Erkinjuntti, T., Giacobini, E., Graff, C., Hardy, J., . . . Petersen, R. (2004). Mild cognitive impairment – beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. *Journal of Internal Medicine*, *256*(3), 240–246. https://doi.org/10.1111/j.1365-2796.2004.01380.x

Yap, M. J., Tan, S. E., Pexman, P. M., & Hargreaves, I. S. (2011). Is more always better? Effects of semantic richness on lexical decision, speeded pronunciation, and semantic classification. *Psychonomic Bulletin & Review*, *18*(4), 742–750. https://doi.org/10.3758/s13423-011-0092-y

Živanović, J., & Filipovic-Đurđević, D. (2011). On advantage of seeing text and hearing speech. *Psihologija*, *44*(1), 61–70. https://doi.org/10.2298/psi1101061z

Correspondence:
Dušica Filipović Đurđević
University of Belgrade, Faculty of Philosophy,
Department of Psychology
Čika Ljubina 18-20, 11000 Belgrade, Serbia
dusica.djurdjevic@f.bg.ac.rs / +381 11 2630 542