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Interindividual Variability in Vocabulary, Sentence Comprehension and Working Memory in the Elderly: Effects of Cognitive Deterioration

Ramón López-Higes S., Susana Rubio Valdehita, Mª Teresa Martín Aragoneses, and David Del Río
Universidad Complutense (Spain)

Interindividual variability in vocabulary, sentence comprehension and working memory is studied in older people with mild cognitive impairment, very low cognitive impairment and normal state, according to the Mini Examen Cognoscitivo (MEC). In the study participated 71 seniors, aged between 62 to 90 years of age, with low instructional level (from one to five years of regular education). Variability measures were calculated in a test of lexical knowledge, another of working memory, and also in one of sentence comprehension.
The results obtained using a polynomial regression analysis of the absolute residual scores on the MEC, showed that: (a) variability increases in a linear fashion as the MEC score decreases in the case of nouns, and sentences with one proposition that do not follow the canonical order of constituents in Spanish; (b) Performance on the simpler sentences (one proposition and canonical order) and in the most complex ones (two propositions and non-canonical order) variability showed a change in its trend from MEC scores that indicate cognitive deterioration; (c) In relation to performance on the verbs, variability's change of trend is not linked to cognitive deterioration. We discuss the results in terms of the utility of these measures as potential indicators of cognitive impairment.
Keywords: interindividual variability, sentence comprehension, elderly, cognitive impairment.

Se estudia la variabilidad interindividual en el vocabulario, la comprensión de oraciones y la memoria operativa en personas mayores con deterioro cognitivo leve, deterioro cognitivo muy leve y normales, de acuerdo con el Mini-Examen Cognoscitivo (MEC). Participaron 71 personas mayores, de edades comprendidas entre los 62 y los 90 años de edad, con un nivel de estudios bajo (de uno a cinco años de escolaridad). Se calcularon las medidas de variabilidad interindividual en una prueba de conocimiento del léxico, otra de memoria operativa, y en una de comprensión de oraciones.
Los resultados obtenidos empleando un análisis de regresión polinómica de los residuos absolutos sobre las puntuaciones del MEC, muestran: (a) que la variabilidad aumenta de forma lineal a medida que disminuye la puntuación del MEC en el caso de los sustantivos y de las oraciones de una proposición que no siguen el orden sintáctico canónico; (b) que en las oraciones más fáciles (una proposición y orden canónico) y en las más difíciles (dos proposiciones y orden no-canónico) la variabilidad muestra un cambio de tendencia a partir de puntuaciones del MEC que indican deterioro cognitivo; (c) en relación con el rendimiento ante los verbos, el cambio de tendencia que se observa en la variabilidad no está vinculado a la constatación de deterioro cognitivo. Se discuten los resultados en relación con la utilidad de estas medidas como posibles indicadores del deterioro cognitivo.
Palabras clave: variabilidad interindividual, comprensión de oraciones, envejecimiento, deterioro cognitivo.

Correspondence concerning this article should be addressed to Ramón López, Departamento de Psicología Básica II (Procesos cognitivos). Facultad de Psicología. Campus de Somosaguas. 28223 Madrid. (Spain). Phone: +34-913943077. Fax: +34-913943189. E-mail: rlopezsa@psi.ucm.es

Traditionally, the study of age-related differences has been based on the assumption that behaviors of interest are stable over time, or alternatively, the assumption that the pattern of change will be similar for everyone.

Although a general idea exists to establish that cognitive performance tends to diminish during normal aging, all cognitive functions certainly do not diminish equally. In the case of language, there is evidence to confirm that passive vocabulary increases, or is maintained during old age (Verhaeghen, 2003). Meanwhile, difficulties occur in lexical access (Juncos-Rabadán, Facal, Álvarez & Rodríguez, 2006), and in comprehension and immediate recall of syntactically complex sentences (Kemper, 1987; Kemper & Kemtes, 1999; Wingfield, Peelle & Grossman, 2003; Veliz, 2004).

Just as the consequences of the passage of time are not the same for all cognitive functions, they are not the same for all people either. Variability and discontinuity are characteristics that are inherent to the processes of development that take place across the life span. For that reason, there is growing interest in the study of variability in its different aspects: interindividual variability (*diversity*) in a task, variability between the measures of a single subject on multiple tasks, or *dispersion*, and variability in a subject's execution of the same task on multiple occasions, or *inconsistency*.

The evidence that aging is related to an increase in interindividual differences (*diversity*) is more abundant than evidence in support of the other two types of variability mentioned above (Hultsch, MacDonald & Dixon, 2002). One potential explanation for diversity is the regressive nature of systemic and neurodegenerative diseases, since people suffering from such diseases are often included in samples for studies of the characteristics of aging. There have been scarcely any studies of interindividual variability in linguistic abilities of the elderly. However, some recent studies, such as one by Hultsch, MacDonald and Dixon (2002), have found that interindividual variability in reaction time on lexical decision tasks increase as a function of age.

In Spain, a study by Pereiro, Juncos-Rabadán, Facal and Álvarez (2006) used subjects ranging from 19 to 82 years old and demonstrated a significant increase in interindividual variability during aging in TOT (lexical access difficulty; "having it on the tip of the tongue") reaction times and in Peabody scores. However, this did not occur for the frequency of TOTs or for scores on the vocabulary subtest of the WAIS. These results are in agreement with those of prior studies (Christensen, Mackinnon, Jorm, Henderson, Scout & Korten, 1994) in showing that interindividual variability during aging are greater in cognitive aspects related to memory and fluid intelligence (*"on-line"* processing abilities) than when it comes to crystallized intelligence (*"off-line"* processing abilities).

Another study analyzed interindividual variability in sentence comprehension as a function of age (López-Higes, Rubio, Martín & Del Río, 2008) and found that this variability increases linearly for every sentence category employed, except for the most difficult (two propositions, non-canonical word order). For the most difficult sentence type, variability increased until approximately the age of 65, and then decreased, fitting a quadratic function with a negative slope.

Increased variability is sometimes interpreted as an indicator of transition or change between phases or stages of life (Pereiro et al., 2006). However, this assertion must be qualified, since what is important are the changing patterns observed as a function of relevant factors such as age or general cognitive deterioration, as in the present study.

If the pattern of interindividual variability observed does not change as a function of cognitive deterioration, the conclusions have little informational value. In this case, the observed pattern for normal subjects would simply be confirmed in subjects with various levels of deterioration. On the other hand, the results would have far greater relevance if pattern changes coincide with the early signs of cognitive deterioration.

The main aim of this study is to identify patterns and possible changes related to interindividual variability (a) in sentence comprehension, (b) working memory span, (c) and vocabulary as a function of the level of general cognitive deterioration that elderly people show on a Spanish language version of the Mini Mental State Exam (MEC; Lobo, Saza, Marcos, Día, De la Cámara, Ventura, et al., 1999).

A measure of working memory span has also been included because several authors explain the decline in linguistic abilities associated with aging as a consequence of decreased resources available from the verbal component of working memory (Burke, 1997; Salthouse, 1991; Kemper, 1992). A related question of great interest, although it does go far beyond the proposed objectives of this study, is that of the specificity of resources: while some authors believe there is a general system of resources dedicated to processing verbal material (Just & Carpenter, 1992), others posit that there is a dispersal, or fragmentation of working memory resources that interferes with language comprehension based on what are called *interpretive* and *post-interpretive processes* (Caplan & Waters, 1999). According to the second perspective, classical measures of verbal working memory span would be related to post-interpretive processes (cognitive activities of a general purpose), but not with interpretive processes (processes that assign meaning to a sentence).

It was expected that in the present study, as working memory span decreases as a function of cognitive deterioration, interindividual variability, too, will decrease

as a function of cognitive deterioration given that the range of possible variation between subjects will be less as cognitive deterioration increases.

It is also typical in this type of study to include measures of vocabulary comprehension (e.g. Fallon, Peelle & Wingfield, 2006; Facal, González, Buiza, Laskibar, Urdaneta & Yanguas, 2009). To understand a sentence necessitates access to the meaning of the words that comprise that sentence, and determining the thematic roles played by each word according to the sentence's syntactical structure (consider that syntax regulates the assigning of meaning). Normally, one's problem understanding a sentence originates from difficulty using relevant structural cues to interpret it. However, it could also be due to a specific difficulty recognizing words and accessing their meanings.

The vocabulary test employed in this study includes elements of moderate to high frequency of use, and does not include any time limit. On this test, an increase in interindividual variability is expected to occur as a function of cognitive deterioration, as occurs as a function of age (Pereiro et al., 2006).

To evaluate sentence comprehension, four categories of items were created by combining two relevant factors to defining sentence complexity (Hagiwara & Caplan, 1990; Waters, Rochon & Caplan, 1998; Ferreira, 2003): the items' fit to the subject-verb-object (SVO) canonical word order in Spanish (canonical vs. non-canonical) and the number of propositions (one vs. two).

Note that this study is exploratory in nature, and that previous studies of interindividual variability in sentence comprehension as a function of one's level of general, cognitive deterioration are lacking. That being said, it is expected that interindividual variability (*diversity*) will decrease as subjects' performance decreases on comprehension of the most complex sentences (sentences with two propositions that do not follow the canonical word order) such that interindividual variability and performance will parallel one another. Additionally, we predict that on the hardest sentence type, the pattern of diversity will change meaningfully for normal subjects and subjects with very slight cognitive deterioration, versus those with obvious cognitive deterioration. We base these tentative predictions on the results of an earlier study (López-Higes et al., 2008) in which age was considered the predictor variable. In that study, for more complex sentences, diversity decreased after the age of 65.

On the other hand, for sentences of little complexity (one proposition and following the SVO canonical word order) and moderate complexity, a relatively stable pattern, or a slight increase in interindividual variability, is expected as scores on the MEC decrease. In the study described above, the diversity of performance for subjects older than 65 years old on complex sentence comprehension followed a lineal trend with a soft, positive slope.

Methods

Participants

71 subjects were selected to participate in the study, including 7 men and 64 women ranging in age from 62 to 90 years old. They all had a low level of education (between one and five years). Participants were distributed into three groups according to their level of general cognitive deterioration:

- Normal subjects, with MEC scores between 29 and 35;
- Subjects with very slight cognitive deterioration (VSCD), MEC scores between 25 and 28 and,
- Subjects with cognitive deterioration (CD), MEC less than or equal to 24.

Table 1 displays the number of subjects assigned to each group and the data corresponding to their age and MEC scores. All subjects in the sample were native Spanish speakers, lived in Madrid, and participated voluntarily in this research study. None of the participants experienced sensory alterations that could have affected their execution of the experimental task.

Materials and Instruments

To measure the subjects' level of general cognitive deterioration, a Spanish language version of the Mini Mental State Exam (MEC) was used, which consists of 35 items (Lobo, Saza, Marcos, Día, De la Cámara, Ventura, et al., 1999). The ECCO battery was also administered (*Exploración Cognitiva de la Comprensión de Oraciones*;

Table 1
Number of subjects in each group, mean and standard deviation (in parentheses) of scores on the Spanish version of the Mini Mental State Exam (MEC) and subjects' age

Groups	N	MEC	AGE
Normal	30	31.83 (2.02)	73.20 (7.25)
Very Slight Cognitive Deterioration	25	26.28 (1.17)	81.52 (5.38)
Cognitive Deterioration	16	22.25 (1.84)	79.81 (5.71)

English translation: *Cognitive Exploration of Sentence Comprehension*; López-Higes, Del Río & Fernández, 2005) to all subjects in the sample. To administer the battery fully to each subject took approximately an hour and ten minutes.

The Sentence Comprehension subtest of the ECCO battery is a simple test that evaluates the process of assigning thematic roles (Mitchum & Berndt, 2001) and it uses pairs of sentences and pictures. For the purposes of this study, 72 items were selected from the 102 that comprise the full test. The 72 items were grouped into four categories of 18 items each that combine two factors: *propositional density* (one vs. two propositions) and sentences' fit to the *syntactic canonical order* (canonical [SVO] vs. non canonical). In each category, three types of sentences were included (see Appendix) of which six of each were randomly distributed throughout the test:

1. Two in which the sentence and the picture are *congruent*,
2. Two *lexical distractors* in which the action/predicate or one of the picture's arguments is altered,
3. Two *syntactic distractors,* where the thematic roles in the sentence are reversed in the picture.

Furthermore, the ECCO battery includes a vocabulary test (a matching task of words and pictures), which consists of 15 nouns, eight noun-adjective combinations (e.g. small horse) and 16 verbs, all of moderate to high frequency of use according to the frequency dictionary by Alameda and Cuetos (1995).

Next, individual working memory span was evaluated by a test similar to the "*Reading Span Test"* (RST) (Daneman & Carpenter, 1981), which is also part of the ECCO battery. It includes ascending and descending series of sentences. The length of the sentences employed varies from 13 to 16 words. The words that appear at the end of each sentence are matched in frequency of use and in length (in syllables).

Procedure

The data collection procedure was performed in two sessions. In the first, the subjects filled out a form with their personal information and they took the MEC.

In the second session, the ECCO battery was administered on the computer. The three tests that comprise the battery were administered to subjects, alternating the order in which they were presented to control for the possible effects of fatigue.

In the Sentence Comprehension test, each sentence-picture pair appeared on the computer screen until the subject responded either True or False. Upon responding with the mouse, a new item would appear on the screen. This process was repeated until the test was complete.

The total number of items on the Sentence Comprehension test was divided into sets of 51, which allowed the subjects a break in the middle. The subjects were not provided with feedback at any time during the experiment so that no learning effect could be produced.

Then, the Vocabulary test was given. The subjects' task for each essay was to select the picture corresponding to the noun, or the noun+adjective combination, from three alternatives (A, B, C). In the final set of items (infinitive verbs), two pictures were presented and the subjects' task was to select the one that represented the action denoted by the verb. As before, the subject's answer cued the computer to present the next item on the screen. Before beginning this test, a series of sample essays were given.

On the two aforementioned tests, the experimenter would control the presentation of stimuli if a subject seemed unable to handle the mouse.

Next came the test of working memory in which a computer program would present series of sentences, one sentence at a time. When a subject finished reading a sentence aloud, the experimentor would press a key and it would vanish from the screen; the next would then be presented. This procedure was repeated until the entire series was complete. At that time, a question would appear on the screen asking the subject to say the words he or she recalled. The experimenter recorded the words the subject remembered and pressed a key to begin a new series. This was repeated until all the ascending and descending series of the test had been completed.

The subjects were given specific instructions to try and remember the last word of each sentence presented, and at the end of each series, they were asked to say those words, in any order. Before beginning the test, subjects completed a set of sample questions with series of two and three sentences.

Variables

The computerized application of the battery automatically calculated the dependent measures that were later used in analysis:

1. The number of correct responses for the different types of sentences on the comprehension test, which also allowed one to calculate the number of correct responses for each category (P1OCSI: one proposition and canonical word order; P1OCNO: one proposition and non-canonical word order; P2OCSI: two propositionss and canonical word order; P2OCNO: two propositions and non-canonical word order).
2. The total number of correct responses for each category of items on the Vocabulary test (nouns, nouns+adjetives and verbs).
3. The average number of elements the subjects remembered on the ascending and descending series of the verbal working memory test.

Of all the variables, the one that determined selection, or grouping, was the level of general cognitive deterioration, and it was determined by scores on the MEC. This established three groups of subjects: normal (MEC between 29 and 35), very slight cognitive deterioration (VSCD; MEC between 25 and 28) and cognitive deterioration (CD; MEC less than or equal to 24).

Results

First, the descriptive statistics for the dependent measures mentioned above were calculated for each group of subjects, as depicted in Table 2.

Table two conveys that as the level of sentence complexity increases on the comprehension test, the number of correct responses decreases. It appears that P1OCSI are the easiest, followed by P1OCNO, the P2OCSI and finally, the P2OCNO (which were the most difficult).

Study of Variability

First of all, the Levene Test for Equality of Variance between groups was performed for each variable under consideration. The results of this test appear in Table 3. The only statistically significant results were found for sentences with two propositions that did not follow the canonical word order in Spanish, for nouns and for verbs.

To analyze the variability more thoroughly than could be done by interpreting standard deviations, we followed the procedure proposed by Christensen et al. (1994), which was later used in studies by Hultsch et al. (2002), Pereiro et al. (2006) and López-Higes et al. (2008). The objective of this procedure is to analyze the effects of cognitive decline (measured by the MEC) on measures of variability reflected by regression analysis residuals. To perform this analysis, the following steps were taken:

1. First, the linear or quadratic function to best fit the direct scores was analyzed. In doing so,

Table 2
Descriptive statistics –mean and standard deviation- for the number of correct answers in each sentence category, types of elements on the vocabulary test and working memory span for each group and for the total sample. VSCD: Very Slight Cognitive Deterioration; CD: Cognitive Deterioration

	Normal		VSCD		CD		Total	
	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.
P1OCSI	14.87	1.99	12.68	1.81	11.94	2.59	13.43	2.41
P1OCNO	13.50	1.87	12.16	2.56	11.94	2.40	12.67	2.33
P2OCSI	12.53	2.77	10.24	2.35	10.44	3.20	11.25	2.91
P2OCNO	10.73	2.71	8.72	2.33	10.00	3.52	9.85	2.89
NOUNS	14.70	.59	14.52	.87	13.94	1.18	14.46	.89
NOUN + ADJ	7.33	.80	7.04	1.05	7.19	1.10	7.19	.96
VERBS	14.70	1.05	13.72	1.59	13.81	1.47	14.15	1.42
WORKING MEMORY	2.52	.88	1.76	.59	1.72	.72	2.07	.83

Table 3
Results of the Levene Test of Equality of Variance

	Levene Statistic	1*df*	2*df*	Sig.
P1OCSI	2.175	2	68	.121
P1OCNO	2.249	2	68	.113
P2OCSI	1.325	2	68	.273
P2OCNO	3.780	2	68	**.028**
NOUNS	10.292	2	68	**.000**
NOUNS + ADJECTIVES	.708	2	68	.496
VERBS	3.653	2	68	**.031**
WORKING MEMORY	1.612	2	68	.207

Table 4
Results of the polynomial contrasts of group on each dependent variable

Dependent Variable	Polynomial Contrast MEC	Estimation of the contrast	Standard Error	Significance	95 % confidence interval	
					Upper limit	Lower limit
P1OCSI	Linear	-2.710	.457	**.000**	-2.982	-1.160
	Quadratic	.590	.431	.176	-.270	1.449
P1OCNO	Linear	-1.105	.494	**.028**	-2.090	-.120
	Quadratic	.456	.466	.331	-.473	1.385
P2OCSI	Linear	-1.482	.599	**.016**	-2.678	-.286
	Quadratic	1.017	.565	.077	-.112	2.145
P2OCNO	Linear	-.519	.612	.400	-1.739	.702
	Quadratic	1.344	.577	**.023**	.193	2.496
NOUNS	Linear	-.539	.187	**.005**	-.912	-.167
	Quadratic	-.164	.176	.354	-.516	.187
NOUNS + ADJECTIVES	Linear	-.103	.212	.629	-.527	.321
	Quadratic	.180	.200	.372	-.220	.580
VERBS	Linear	-.628	.298	**.039**	-1.222	-.033
	Quadratic	.438	.281	.124	-.123	.998
WORKING MEMORY	Linear	-.564	.165	**.001**	-.894	-.234
	Quadratic	.292	.156	.065	-.019	.603

polynomial contrasts were taken to determine the effect of group on, first, correct responses on each sentence type, second, correct answers for each item category on the Vocabulary test, and finally, on verbal working memory span. Since there were three groups of subjects – determined by the results of the MEC – the statistical significance of all possible polynomial contrasts was analyzed up to the second order. The results of said analysis appear in Table 4.

As for the comprehension test, the linear contrasts turned out to be statistically significant across the board, except for sentences with two propositions that do not follow the canonical word order. For those, the quadratic contrast was significant. Regarding the test of vocabulary, the linear trend was only statistically significant for nouns and verbs. The linear contrast was also statistically significant for working memory span.

2. With the objective in mind of analyzing whether or not previous results were confirmed, and considering cognitive decline as a continuous variable, a curvilinear regression analysis was employed (linear and quadratic) for the effect of number of correct answers on each sentence type, each type of item on the Vocabulary test, and the average number of words recalled on the working memory test, on scores on the Spanish version of the Mini Mental State Exam (MEC). The results of this analysis appear in Table 5.

As Table 5 shows, positive values were obtained for all ß coefficients. This indicates that as cognitive decline increases, the number of correct answers decreases and so does verbal working memory span. In addition, in light of the R-squared values obtained, we may conclude that the explanatory value of one's level of cognitive deterioration was acceptable, generally speaking. In the present study, the greatest percentage of explained variance in MEC scores was obtained for the easiest sentences (P1OCSI).

3. Next, from the polynomial trends that were shown to be statistically significant, standardized residuals were calculated, in absolute value, for each of the variables. These absolute standardized residuals represent a measure of variability for each subject (difference between direct and predicted values).
4. Last, the effects of cognitive decline on absolute standardized residuals were analyzed. To do this, regression functions were found (linear and quadratic) for the effect of absolute value of the

Table 5

Summary of linear and quadratic regression analyses of the effect of the variables on subjects' scores on the MEC

	ß	R	Δ R^2	Sig
P1OCSI				
Linear effect of the MEC	.516	.516	.266	**.0000**
Quadratic effect of the MEC	2.330	.549	.035	.0678
P1OCNO				
Linear effect of the MEC	.398	.398	.158	**.0006**
Quadratic effect of the MEC	1.810	.424	.021	.1878
P2OCSI				
Linear effect of the MEC	.405	.405	.164	**.0005**
Quadratic effect of the MEC	1.217	.417	.010	.3760
P2OCNO				
Linear effect of the MEC	.204	.204	.042	.0876
Quadratic effect of the MEC	3.082	.322	.062	**.0338**
NOUNS				
Linear effect of the MEC	.351	.351	.123	**.0027**
Quadratic effect of the MEC	-.698	.356	.003	.6208
NOUNS + ADJECTIVES				
Linear effect of the MEC	.109	.109	.012	.3665
Quadratic effect of the MEC	3.608	.311	.085	**.0139**
VERBS				
Linear effect of the MEC	.342	.342	.117	**.0035**
Quadratic effect of the MEC	1.159	.354	.009	.4122
WORKING MEMORY				
Linear effect of the MEC	.405	.405	.164	**.0005**
Quadratic effect of the MEC	.005	.405	.000	.9972

standardized residuals on cognitive decline for each of the study's variables (see Table 6).

Figures 1 through 5 graphically depict the trends found to be statistically significant in this analysis.

The results obtained show:

a. That the variability increases linearly as MEC scores (negative slope) decrease in the case of nouns and sentences with one proposition that do not follow the canonical word order (P1OCNO), although nouns do have the greater slope (see Figures 2 and 4).

b. That for the easiest sentences (one proposition and SVO canonical word order; P1OCSI) and the most difficult ones (two propositions and non-canonical word order; P2OCNO), variability decreases until reaching the scores between 28 and 30 on the MEC. From then on, it increases until reaching its maximum at the scores indicating greatest cognitive deterioration (a quadratic trend with positive slope; see Figures 1 and 3).

Two univariate ANOVAs were performed, considering Group as a between-subjects factor and standardized residuals in absolute value as the dependent measures for the two sentence types mentioned above (P1OCSI and P2OCNO). The results convey the existence of significant between-groups differences [$F(2.68) = 5.31$, $p = .007$, for P1OCSI, and $F(2.68) = 3.78$, $p = .028$, for P2OCNO]. Performing Scheffe's post-hoc multiple comparison procedure revealed that significant differences were only produced between the group of subjects with very slight cognitive deterioration (VSCD) and the group of subjects with cognitive deterioration (CD). For the easiest sentences (P1OCSI), the value of the Scheffe's comparison between means equaled .4804 ($p = .008$). For the most difficult sentences (P2OCNO), the difference between means equaled .4370 ($p = .030$). For both, there appears to be a point of inflection after which variability increases significantly along with MEC scores to clearly indicate the presence of cognitive deterioration.

c. With respect to verbs, a quadratic function of negative slope was observed to fit the data, with a point of inflection at the MEC scores between 26 and 28 (see Figure 5). As before, an ANOVA was performed, considering Group to be the between-subjects factor and standardized residuals in absolute value corresponding to verbs as the dependent measure. The effect of Group was shown to be statistically significant [$F(2,68) = 3.37$, $p = .04$). Performing Scheffe's post-hoc multiple comparison procedure this time revealed that statistically significant differences only occurred between the normal group of subjects and the group of subjects with very slight cognitive deterioration (difference equal to .4027; $p = .042$). Thus, the greatest variability occurred for the group of normal subjects, while the group of subjects with very slight cognitive deterioration (VSCD) was more stable.

d. No effects of the MEC were found when the variability was analyzed for P2OCSI sentences, noun+adjective combinations, and individual verbal working memory span.

Upon comparing the results of the Levene test (Table 3) with those already described in the context of standardized residuals in absolute value (Table 6), it becomes clear that the procedure employed here allowed for the discovery of a significant effect of MEC score on two sentence categories (P1OCSI and P1OCNO), which did not appear in the preliminary analysis.

Discussion and Conclusions

Considering the present study's objectives, the results of greatest interest are those related to interindividual variability based on the analysis of standardized residuals.

The study of the effects of one's level of cognitive decline on new measures of variability (standardized residuals in absolute value for each variable) shows a linear increase in diversity as a function of level of cognitive decline on P1OCNO sentences (having one proposition and not following the Spanish SVO canonical word order) and on nouns. The negative slopes of both indicate a tendency toward greater variability as MEC scores decrease.

The result obtained for nouns on the Vocabulary test is consistent with previous studies that found the same linear trend for vocabulary tests, but as a function of age (Pereiro et al., 2006). On another note, the preliminary hypothesis has been confirmed about the general trend expected for the indicators of vocabulary comprehension, since the slope was greater for nouns than for P1OCNO sentences, which are considered to be of moderate difficulty (see Figures 2 and 4). Also, the percentage of variance explained by MEC scores when it comes to interindividual variability and nouns was found to be the highest in the study (see Table 6; it reaches almost 29%).

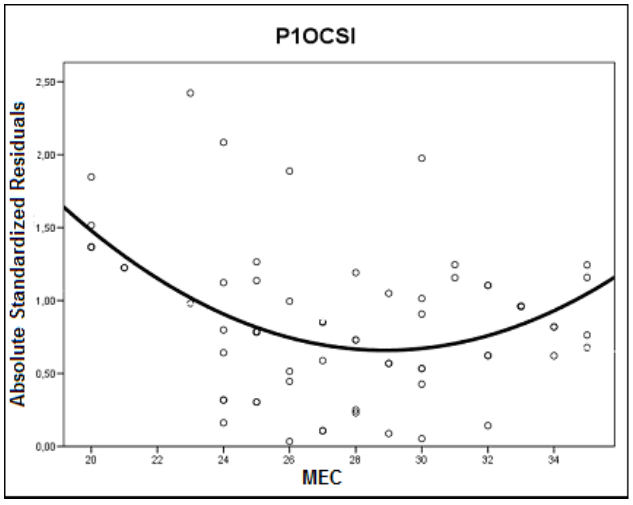

Figure 1. Diagram of the dispersion and line of regression for the absolute standardized residuals of sentences with one proposition that follow the canonical word order in Spanish, as a function of cognitive decline.

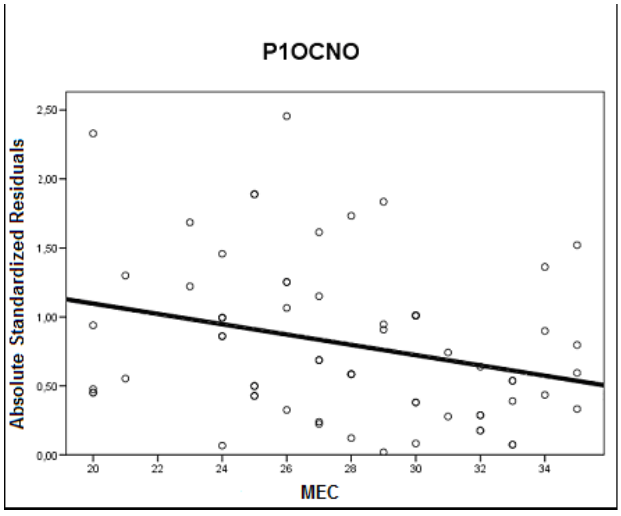

Figure 2. Diagram of the dispersion and line of regression for the absolute standardized residuals of sentences with one proposition that do not follow the syntactic canonical order in Spanish, as a function of cognitive decline.

The analysis of standardized residuals also revealed the existence of a significant quadratic effect of positive slope on the easiest (P1OCSI) and most difficult (P2OCNO) sentence types. The shape of the function would indicate that variability decreases until MEC scores reach between 28 and 30 and from then on, it increases until reaching its maximum. However, an analysis of between-groups differences revealed that an increase in interindividual variability on these two sentence categories occurred when

Table 6
Summary of linear and quadratic regression analyses of the effect of absolute, standardized residuals for each variable on subjects' scores on the MEC

	ß	R	Δ R^2	Sig
P1OCSI				
Linear effect of the MEC	-.214	.214	.046	.0727
Quadratic effect of the MEC	4.907	.450	.157	**.0005**
P1OCNO				
Linear effect of the MEC	-.276	.276	.076	**.0196**
Quadratic effect of the MEC	-.272	.277	.000	.8511
P2OCSI				
Linear effect of the MEC	-.077	.077	.006	.5210
Quadratic effect of the MEC	-1.375	.135	.012	.3588
P2OCNO				
Linear effect of the MEC	-.145	.145	.021	.2278
Quadratic effect of the MEC	2.971	.280	.058	**.0432**
NOUNS				
Linear effect of the MEC	-.537	.537	.288	**.0000**
Quadratic effect of the MEC	-1.492	.550	.014	.2383
NOUNS + ADJECTIVES				
Linear effect of the MEC	-.126	.126	.016	.2936
Quadratic effect of the MEC	-1.260	.162	.010	.3982
VERBS				
Linear effect of the MEC	-.211	.211	.044	.0772
Quadratic effect of the MEC	-3.836	.375	.096	**.0075**
WORKING MEMORY				
Linear effect of the MEC	.161	.161	.026	.1803
Quadratic effect of the MEC	2.438	.254	.039	.0979

MEC scores clearly indicated cognitive deterioration (see Figures 1 and 3). On the other hand, a significant trend shift was observed in both cases when MEC scores were equal to or less than 24, yet no significant differences between normal subjects and subjects with very slight cognitive deterioration surfaced.

Comparing these results with the hypotheses proposed earlier in this paper reveals a discrepancy related to the sentences considered to be least complex, or easiest (P1OCSI). In these sentences, a relatively stable pattern, or a very slight increase in interindividual variability was expected to occur as MEC scores decreased.

The results show that there are no statistically significant differences between normal subjects and subjects with very slight cognitive deterioration where diversity in the P1OCSI sentence type is concerned. Thus, it may be deemed relatively stable. Nevertheless, a very significant increase in interindividual variability was observed where MEC scores indicated cognitive deterioration. The slope (β) that corresponds to this sentence category is the greatest in all the regression analyses performed (see Table 6). The percentage of variance explained by MEC scores for this sentence category was the second greatest found in the study, reaching 20% (see the fourth column of Table 6; keep in mind that in this case, the significance gained by using the quadratic effect instead of the linear one, is then added to the linear effect).

With respect to the most complex sentences (P2OCNO), the results contradict the tentative hypothesis posed at the beginning of this paper. In this case, a decrease was expected in interindividual variability as MEC scores lowered. However, the results show that although diversity decreased between normal MEC scores and scores indicating very slight cognitive deterioration, this trend was not of statistical significance. Furthermore, considering subjects with cognitive deterioration

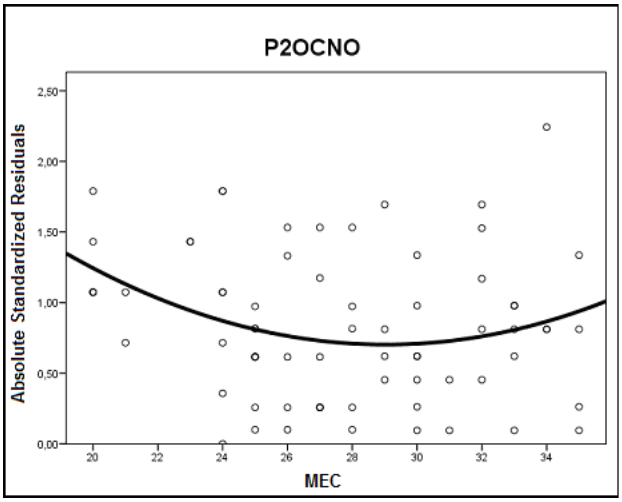

Figure 3. Diagram of the dispersion and line of regression for the absolute standardized residuals of sentences with two propositions that do not follow the canonical word order in Spanish, as a function of cognitive decline.

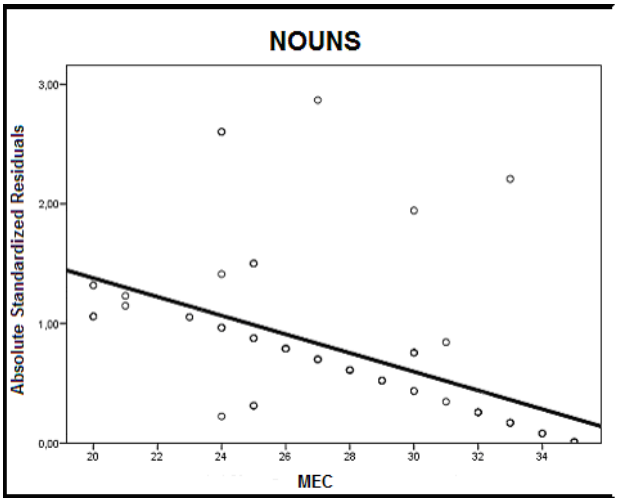

Figure 4. Diagram of the dispersion and line of regression for the absolute standardized residuals of sentences with one proposition that follow the canonical word order in Spanish, as a function of cognitive decline.

according to MEC scores suggested a possible trend shift (see Figure 3). Similarly, while interindividual variability decreased slightly or remain stable for these complex sentences in normal subjects and in subjects with very slight cognitive deterioration (MEC between 25 and 35), they increased significantly in subjects presenting with cognitive deterioration (MEC less than or equal to 24). The percentage of variance explained by MEC scores for this measure of diversity was eight percent (see Table 6).

On the subject of verbs, interindividual variability in subjects' mastery of verbs fit a quadratic function with negative slope (inverted U shape). The post-hoc mean contrasts demonstrated that statistically significant differences were only produced between normal subjects and subjects with very slight cognitive deterioration, according to MEC scores. In contrast to what occurred in the nouns, where a linear increase in diversity was found to occur as a function of general cognitive deterioration, consistent with our prediction, for verbs, an increase in variability was observed only for normal subjects (MEC between 29 and 35). Meanwhile, variability was stable or slightly decreased for MEC scores less than or equal to 28 (see Figure 5). In this case, the variance explained by the MEC reached 14%, as shown in Table 6.

On the other hand, no definitive profile for the progression of variability was found for P2OCSI-type sentences, established ahead of time to be of moderate complexity. This result is compatible with the predictions discussed in the Introduction. No definitive profile was found for noun+adjective combinations either, contrary to what was expected.

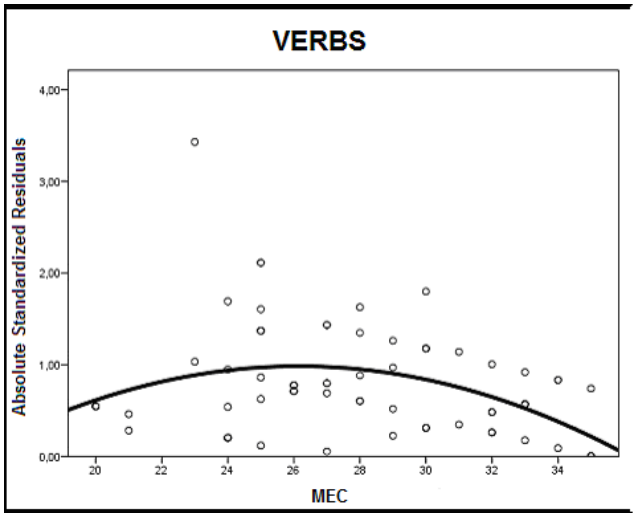

Figure 5. Diagram of the dispersion and line of regression for absolute, standardized residuals of verbs on the test of Vocabulary, as a function of cognitive decline

Also, it is important to highlight that in this study, no significant effects of level of general cognitive deterioration on diversity were found for subjects' performance on the working memory test. These results indicate that variability on this test decreases as MEC scores decrease, as discussed among our hypotheses. However, this pattern was not of statistical significance. The test employed in this study measures the short-term, verbal working memory component, but no processing component. With this in mind, in future research studies, it would be convenient

to use other tasks equipped to evaluate both components (e.g. combining the recall task with a verification test, or alternately, including a digit ordering task as MacDonald, Almor, Henderson, Kempler & Andersen suggested in their 2001 study).

Consider these findings for a moment from the point of view of trying to characterize risk factors and create a clinical profile for people suffering from mild cognitive impairment (MCI). In light of the progression toward a state of dementia, there is a wide body of support for the assertion that the erosion of memory and executive functioning, and anomia (difficulty naming objects), seem to be the best, most precocious predictors of the onset of Alzheimer's among subjects with MCI. In addition, other data clearly supports that deficits in language, attention and executive functioning are more probable in more advanced stages of cognitive deterioration (Iñiguez, 2006).

To identify predictors of cognitive deterioration, it would be very informative to study interindividual variability on different indicators of linguistic ability. In the present study, some such predictors were considered, such as sentence comprehension, vocabulary and verbal working memory span.

The results of this study allow one to reach a series of conclusions that might be relevant to identifying indices that could differentiate between the cognitive deterioration associated with age, and deterioration that reaches the point of pathology:

1. If we take the percentage of variance explained by the MEC as our criterion, the most consistent trends seem to occur in nouns, and in the simplest sentences (P1OCSI), in that order.
2. Considering the profiles of the progression of variability for different sentence types, the results obtained would demonstrate that independently of syntactical and/or semantic complexity, when there is cognitive deterioration, there is an increase in diversity. This trend is especially significant for the simplest sentences, such that those may be considered good indicators of cognitive deterioration.
3. As for the indices of vocabulary, it is especially useful to note the pattern of variability for nouns, but not verbs or noun+adjective combinations.
4. No significant effects of one's level of cognitive deterioration on diversity were found for the measure of working memory. However, this result could be due to the specificity of format, having only evaluated the short-term component of memory.

Finally, it would be interesting to compare this study's results with those of other research studies that have used broader samples of elderly subjects grouped by age and educational level, since those factors condition the results of tests like the MEC.

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APPENDIX

Sentence categories used in the present study according to propositional density (number of propositions), fit to canonical word order in Spanish, and types of variants within each category (spanish sentences and english translations).

SENTENCES WITH ONE PROPOSITION AND CANONICAL WORD ORDER (P1OCSI)
SPECIAL PASSIVE V-PP-NP: *Es despertado por el hombre el niño (Awoken by the man the boy is).*

ACTIVE – SVO: *El caballo mordió al hombre (The horse bit the man).*

FOCUSED-SUBJECT SENTENCES: *Es el perro el que mordió al gato (It is the dog that bit the cat).*

SENTENCES WITH ONE PROPOSITION AND NON-CANONICAL WORD ORDER (P1OCNO)
VERBAL PASSIVE (VP)**:** *El hombre es adelantado por el caballo (The man is passed by the horse).*

SPECIAL PASSIVE V-NP-PP: *Es atacado el gato por el niño (Attacked is the cat by the boy).*

OBJECT-FOCUSED SENTENCE: *Fue al gato al que encerró el niño (It was the cat that was locked in by the boy).*

SENTENCES WITH TWO PROPOSITIONS AND CANONICAL WORD ORDER (P2OCSI)

RELATIVE SENTENCE – MADE PASSIVE – TRACE ON SUBJECT'S POSITION: *El perro que está arrastrando al gato es pequeño (The dog that is dragging the cat is small).*

SENTENCE WITH NESTED AND RELATIVE CLAUSES (trace on the subject): *El perro que mordió al caballo es grande (The dog that bit the horse is big).*

RELATIVE OBJECT-SUBJECT SENTENCE: *El niño besó a la mujer que arrastra al perro (The boy kissed the woman who drags the dog).*

SENTENCES WITH TWO PROPOSITIONS AND NON-CANONICAL WORD ORDER (P2OCNO)

RELATIVE SENTENCE – MADE PASSIVE – TRACE ON THE OBJECT'S POSITION: *El gato que el caballo está persiguiendo es blanco (The cat that the horse is chasing is white).*

SENTENCE WITH NESTED AND RELATIVE CLAUSES (trace on the object): *La niña a quien el perro mordió es alta (The girl who the dog bit is tall).*

RELATIVE SUBJECT-OBJECT SENTENCE: *El perro al que el gato mordió, empuja al niño (The dog that the cat bit pushed the boy).*