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RESEARCH ARTICLE

Oral and Written Naming in Alzheimer's Disease: A Longitudinal Study

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Abstract: ***Background***: The expressive difficulties in patients with Alzheimer's dementia have been extensively studied, mainly in oral language. However, the deterioration of their writing processes has received much less attention.

Objective: The present study aims to examine the decline of the performance of patients with Alzheimer's disease in both oral and written picture-naming tasks.

Method: Sixty-four participants (half with Alzheimer's disease and half healthy elderly) were compared in the oral and written versions of a picture-naming task. Follow-up lasted two and a half years and patients were evaluated every six months.

Results: Cross-sectional data indicate that the controls performed better than the patients, and both groups showed a different pattern of errors. In terms of longitudinal data, the results show a similar pattern of deterioration in both tasks. In terms of errors, lexical-semantics were the most numerous at the beginning and their number remained constant throughout all evaluations. In the case of non-responses, there was a significant increase in the last session, both in oral and written naming.

Conclusion: These results replicate those found in previous studies and highlight the utility of the naming task to detect minimal changes in the evolution of patients with Alzheimer's disease.

Keywords: Alzheimer's disease, picture-naming, anomia, writing disorders, cognitive decline, longitudinal study.

1. INTRODUCTION

The language disorders associated to the Alzheimer's disease (AD) have been widely studied in recent decades, as they are among the earliest and most prominent symptoms of this dementia [1, 2]. These changes, highlight the difficulties in expressive language, since Alzheimer's patients show a marked anomia that can be observed in daily life or through formal tests [3]. As such expressive problems have an early onset and progress throughout the disease, the picture-naming task has become one of the most sensitive instruments we have to monitor the patient's cognitive deterioration [4], and the analysis of the type of errors committed by patients provides plenty of information about the pattern of cognitive decline in Alzheimer's disease. Thus Barbarotto, Capitani, Jori, Laiacona and Molinari [5] conducted a study that monitored the evolution of a group of 7 patients with AD for 3 years. Every 6 months, participants were administered the same oral naming task consisting of 60 drawings of various categories of animate and inanimate objects and examined the influence on the performance of a series of psycholinguistic variables such as frequency, prototypicality, familiarity, name agreement or visual complexity. The results showed a majority of lexical-semantic errors, however, their proportion decreases over time in relation to the total of errors, and the proportion of non-responses and non-related errors rises with increasing severity.

Similar results were found in the study conducted by Cuetos, González-Nosti and Martínez [6]. These authors evaluated a group of 10 patients with probable AD using a picture-naming task composed of 100 drawings of animate and inanimate objects belonging to different categories. Values of familiarity, imageability, name agreement, lexical frequency, age of acquisition (AoA) and length measured in phonemes and syllables were available for each stimulus. Two years later, a second evaluation was performed using the same task with the aim of comparing the evolution of patients. The results show a considerable reduction of the correct answers from the first session to the second, with a yield drop of more than 22%. Regarding the errors, the most frequent in the first session were semantic, followed by non-responses; in the second, however, semantic errors decreased slightly and non-responses increased considerably. As in the study of Barbarotto *et al.* [5], the amount of visual errors was minimal and hardly changed from one to another session, which rules out the presence of agnosia at this stage of the disease, at least in most patients. Similarly scarce phonological errors were found, which could indicate a preservation of phonological processes in the early stages of AD. As to psycholinguistic variables, the best predictor of the performance of subjects in both the first and second evaluation was the AoA, so that the names of objects acquired at an early age were more resistant to deterioration. This variable

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was also the most accurate predictor of the response changes from the first to the second session (correct- semantic error, semantic error-non response...). The importance of the AoA as a predictor of language impairment in Alzheimer's patients has been highlighted in other studies [6, 7]. However, other variables may also influence the performance of patients with AD. Thus, Cuetos, Rosci, Laiacona and Capitani [8] conducted a longitudinal research of two patients with AD using an oral picture-naming task. Their results show that AoA was the best predictor of task performance in one of the patients, and in addition this effect increased as the disease progressed. However, in the other patient, familiarity was found to be the variable that best predicted errors. These findings underscore the need to analyze the psycholinguistic variables as well as the quality of the errors, since their effects may be unlike in different patients, which would indicate that their difficulties in naming could be produced by different mechanisms.

These difficulties have been studied mainly in oral language, whereas the process of writing in these patients has received comparatively much less attention. One of the scarce studies on this subject was carried out by Hughes, Graham, Patterson and Hodges [9], who evaluated 31 patients (11 with minimal AD and 20 with mild AD) and 10 healthy elderly in a written and oral dictation task of 72 monosyllabic words. Frequency and predictability of stimuli were manipulated, considering as predictable those words with no ambiguity in their spelling, unpredictable those with more than a "reasonable" spelling and irregular the words which contained atypical sound-to-spelling correspondences. Patients' performance on both spelling tasks was below that of controls. The lexical frequency was significant, with better performance in high than in low-frequency words. However, these results should be taken with caution, since other variables such as AoA or familiarity were not included in this study, and could be more determinant of the performance, as already seen in the naming studies mentioned above [5, 6, 8]. Regarding the predictability of words, all three groups (minimal AD, mild AD and controls) performed worse when spelling irregular words. However, patients with more severe AD also had difficulty writing unpredictable words, unlike the other two groups. The qualitative examination of patients' individual errors revealed, on the other hand, a great heterogeneity. Thus, some patients did not present difficulties in any of the tasks, in others, the spelling errors predominated (what the authors consider surface dysgraphia), others had mostly errors affecting grapheme handwriting (indicative of peripheral dysgraphia), and the last group showed both deficits.

Despite the heterogeneity that patients appear to show in writing impairments Platel *et al.* [10], in a longitudinal study carried out with 22 patients with mild to severe AD, found that the changes followed the same logical progression. These authors point out three stages in the evolution of agraphia of patients with AD: Phonologically plausible errors predominate in a first phase. In the second, phonologically implausible errors appear and dominate, with special difficulties in the writing of irregular words and pseudowords. In the third and last stage, the alterations are more severe and affect all kinds of stimuli, appearing also errors due to the deterioration of graphomotor skills. Other studies, however, have failed to find a common pattern. Thus both Pestell, Shanks, Warrington and Venneri [11] and Forbes, Shanks and Venneri [12], found an increase in the number of errors as the disease progressed. However, the qualitative analysis did not allow differentiating patients with mild AD from those with moderate AD, since both groups showed both phonologically plausible and implausible errors.

In another longitudinal study [13] carried out with a group of 31 patients with minimal to moderate AD, the participants were instructed to describe in writing two scenes (one simpler and one more complex). As in the previous research, follow-up was performed at 6 and 12 months. Despite the heterogeneity in the results of the patients, the authors reported a general decrease in grammatical complexity, phrase length and number of ideas in this group compared to controls. In addition, they observed more sentences empty of content and more semantic and phonological paraphasias in patients. All this points to damage at the semantic level since the early stages of the disease. However, longitudinal data show no changes in any of these indices, except for the number of errors, which increased as the disease progressed.

Although the studies carried out using the spontaneous writing task provide much information, they do not allow to manipulate the psycholinguistic variables and to establish which of them are determinant in the prediction of the performance. The writing to dictation, on the contrary, does allow it, but since the patient is presented with stimuli already selected, it is not possible to observe semantic and lexical selection aspects. The written naming task combines the advantages of the previous ones, since it lends itself to the manipulation of the variables by the selection of the pictures, while it is sensitive to the lexical-semantic deterioration. In addition, this task allows comparing the patients' performance in oral and written language, which is important because this disease is characterized by profoundly affecting some cognitive aspects leaving relatively intact others. One of the few comparative studies between oral and written language to date is that of Groves-Wright, Neils-Strunjas, Burnett and O'Neill [14]. For this research, a battery of 4 tasks (spelling to dictation, word fluency, picture description and confrontational naming) was elaborated, each oral and written, and administered to a group of patients with mild AD, another group with moderate AD and a control group. Although performance generally tended to worsen as the disease progressed, in the naming task differences between the two versions were found only in the moderate AD group. The qualitative analysis of the errors indicates that the number of paragraphias and neologisms exceeded in this group the number of paraphasias. According to the authors, these written errors suggest that erosion of orthographic prints occurs in the moderate stage of AD and is evident prior to the erosion of verbal labels for the same words.

There is also no longitudinal study to date, as far as we know, carried out with the written naming task, much less any longitudinal studies comparing whether the deterioration produced by AD is similar in oral and written language. The aim of this study, therefore, is to check the evolution of a group of patients with AD over 2.5 years in an oral naming and a written naming task. To do this, we will analyze both the decline in the correct responses and the error pattern throughout the evaluation sessions.

According to previous results, in the last sessions, we expect to observe a decrease in correct answers and an increase in semantic errors and non-responses similar in both oral and written tasks. Also, we predict an increase in spelling errors in written naming. Regarding the variables of the participants, we consider that the degree of deterioration will be the most determinant variable in the performance in the oral task, while in the written, the educational level will also influence.

2. METHOD

2.1. Participants

A total of 64 participants took part in this study. Half were healthy elderly with an average age of 75.44 years (SD = 5.12) and a mean MMSE score of 29 (SD = 0.9). The other half were patients diagnosed with Alzheimer's disease (AD) according to NINCDS / ADRDA criteria [15]. The average age in this group was 75.16 years (SD = 5.43) and initial MMSE score ranged from 13 to 24, with an average of 18.56 points (SD = 3.18). Both groups were matched in terms of gender (12 men and 20 women in each), age ($t_{(1,62)}$=0.213, p=.832) and level of schooling ($t_{(1,62)}$=0.555, p=.581; being the averages 7.97 years (SD = 2.57) for controls and 7.60 (SD = 2.83) for patients). All of them were native Spanish speakers and had no history of alcohol abuse or psychiatric or neurological disorders, other than AD. All participants (and their families) were informed of the purpose of the study and signed written consent.

2.2. Stimuli

Fifty drawings, half living beings and half inanimate objects, were taken from the Snodgrass and Vanderwart battery [16] to develop the oral naming task. They had a name agreement above 85%, according to Sanfeliú and Fernández [17], and the age of acquisition (AoA), frequency, length and familiarity of the items were controlled. The values of frequency and familiarity were taken from the LEXESP database [18], while AoA data were obtained from subjective questionnaires answered by a group of 25 psychology students who did not participate in the experimental task. These questionnaires consisted of a 7- point Likert scale in which each number indicated the period of time in which the word had been acquired, thus, 1 corresponded to ages between 0 and 2 years old, 2 to ages between 2 and 4, and so on up to 7, which corresponded to ages over 12 years old.

Of these drawings, 15 were selected (9 living beings and 6 inanimate objects) for the written naming task, as writing the 50 items would have been too demanding for the patients. The 15 stimuli selected had in common that their names had some orthographic irregularity (ie: cannot be written correctly using the rules of phoneme-grapheme conversion), so subjects had to know the word or spelling rule appropriate to write the words correctly (eg: "ardilla" (squirrel), which could be written as "ardiya", "jirafa" (giraffe), which could be written as "girafa" or "oveja" (sheep), which could be written as "obeja"). AoA, frequency, and the length of the words and familiarity are also available in this case (see Table **1**).

The order of presentation of the stimuli in each task was established randomly and was the same for all participants.

2.3. Procedure

AD patients were recruited between January 2006 and April 2007 in the Cabueñes Hospital in Gijón, Asturias. Each participant completed a battery of neuropsychological tasks, which included the naming tasks described above. The assessment was conducted always by the same experimenter in a soundproof room at the hospital. The control group was evaluated in a single session of 17 to 65 minutes; all of them performed the oral naming task at the beginning of the session and the written naming at the end. Patients required two sessions conducted a week apart, since they took between 27 and 110 minutes to complete all tasks. In this case, the first half of the oral naming task and the last 7 drawings of the written naming task were presented in the first session and the remaining items in the second, so that the same stimulus was not repeated in the same session. No feedback or clues were given to participants throughout the evaluation session.

Patients were evaluated with the same battery every six months for a period of 2.5 years in order to observe the performance deterioration as a result of AD progression. However, only 21 of the 32 completed all sessions.

3. RESULTS

Data processing was performed using the SPSS 19.0 program. Firstly, the errors were classified into several categories: semantic, when the meanings of the error and the target are related (eg: "gato" (cat) for "ardilla" (squirrel));

Table 1. Summary of stimuli characteristics.

		AoA	Freq.	NA	Leng.	Fam.
Oral naming (N=50)	Average (SD)	2.7 (0.5)	14.73 (20.89)	96.4 (3.8)	5.98 (1.5)	5.77 (0.77)
	Range	1.85-3.85	0.4-120.8	86-100	4-11	3.07-6.85
Written naming (N=15)	Average (SD)	2.84 (0.45)	9.73 (10.36)	95.2 (3.7)	6.4 (1.84)	5.62 (0.92)
	Range	2.3-3.85	1-38.6	89-100	4-11	3.9-6.85

SD=Standard deviation; AoA=Age of acquisition; Freq.=Frequency per million; NA=Name agreement; Leng.=Length in letters; Fam.=Familiarity.

phonological, when the words for the target and the error are phonologically similar (eg: “ancar” (no meaning, pseudoword) for “ancla” (anchor)); circumlocution, when the participant explains the meaning of the word they cannot remember (eg: “para apuntar una cosa” (to point to something) for “flecha” (arrow)); visual, when the target and the error show a visual resemblance (eg: “bola” (ball) for “limón” (lemon)); perseverance, when the participant repeats a response that has previously appeared during the task; mixed, when the error could be classified into two different categories (eg: “perro” (dog) for “zorro” (fox) the error could be classified as semantic, phonological or visual); non-response and others. In the written naming task, a new category was added: the orthographic errors (also called spelling errors), which are those whose word is misspelled but the correct pronunciation is maintained (eg: “vandera” for “bandera” (flag)). After that, the transversal data of each task were analyzed independently, including the descriptive analysis of hits and errors and a comparative analysis of the items common to both using a cross-factor ANOVA.

Finally, a longitudinal analysis to observe the evolution of the performance of the 21 patients through 6 evaluation sessions was conducted. For this purpose, two repeated measures analyses were carried out (one for each task) in which the session was the within factor. Correlation and stepwise regression analyses were also carried out in order to verify which variables of the patients (age, years of schooling and MMSE and GDS scores in the first and last sessions) and of the stimuli (AoA, frequency, length of the words and familiarity) influenced the deterioration of performance in both tasks.

Of the 1600 responses registered in each group in the oral naming task, 441 were errors committed by patients and 92 by controls, representing respectively 27.56% and 5.75% of the total. Alzheimer patients named correctly an average of 36.22 drawings (SD = 8.89) and controls 47.13 (SD = 2.81). This difference was statistically significant ($t_{(1,37)}$=6.619, p=.000).

Regarding the errors, the most numerous were semantic in both groups, followed by non-responses and circumlocutions. There were no neologisms or morphological errors (see Fig. **1**). A qualitative analysis of the relative difficulty of the items was carried out using the overall success rate. The Alzheimer’s patients obtained a success rate of less than 50% in 7 stimuli (kangaroo, kite, helicopter, squirrel, anchor, fox, strawberry and pineapple). All of them (except strawberry) had in common the low familiarity. The easiest items for this group were 4 (ladder, wheel, iron and comb), all with a high degree of familiarity. The difficulty rate of the items in the control group generally coincides with that of the patients, although their performance was better, with a success rate above 75%. The 7 difficult stimuli were correctly named by less than 91% of the healthy elderly, while the 4 easiest ones got the 100%.

In the written naming task, 256 (53.33%) of the 480 responses registered in each group were errors made by patients and 102 (21.25%) by controls. Subjects with AD correctly wrote the name of the drawing in an average of 7.00 out of 15 (SD = 3.02), while healthy subjects did on 11.81 (SD = 2.49). This difference was statistically significant ($t_{(1,62)}$= 6.956, p = .000).

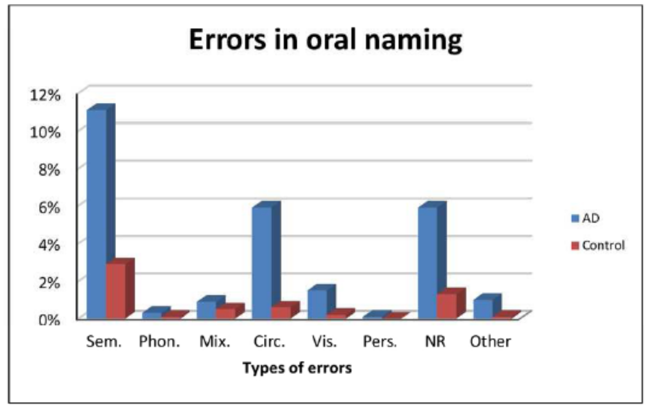

Fig. (1). Percentage of each type of error on the total answers. Sem.=semantic; Phon.=phonological; Mix.=mixed; Circ.=circumlocutions; Vis.=visual; Pers.=perseverance; NR=non responses.

In regards to the errors, the most frequent in the control group were the spelling errors, followed by phonological and semantic. In AD, the most numerous were the semantic and spelling errors, followed by phonological and non-responses (see Fig. **2**). The qualitative analysis of the difficulty of the items partially coincides with the oral naming task. Only three (helicopter, fox and squirrel) of the 7 difficult items were included in this task, but the worst performance of patients was in the first two. *Squirrel* was also among the most flawed items. As for the control group, the most difficult drawing was *helicopter* (22% success); *fox* had an average performance (84% success) and with *squirrel* no difficulties were observed. The 4 items considered easy in oral naming were not included in this task, as they were of regular spelling.

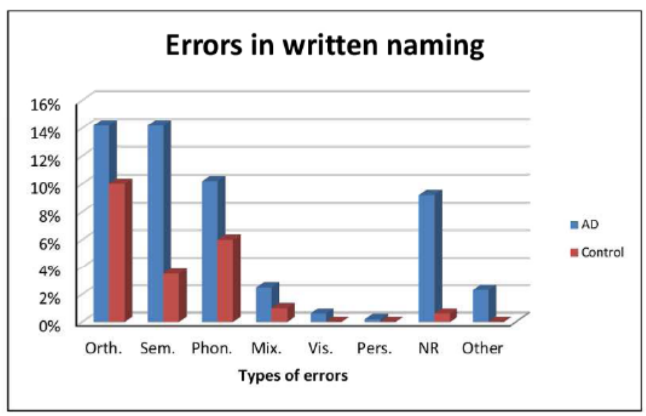

Fig. (2). Percentage of each type of error on the total answers. Orth.=orthographic; Sem.=semantic; Phon.=phonological; Mix.=mixed; Vis.=visual; Pers.=perseverance; NR=non responses.

As noted above, analyzes were conducted to compare the 15 items common to both tasks. However, spelling errors were not taken into account as they are specific to the written naming and therefore this task would be disadvantaged in comparison. A mixed repeated measures ANOVA was conducted in which the within factor was the type of task (oral vs. written) and the between factor was the group (control vs.

AD). The results show a main effect of both factors: task ($F_{(1,62)}$ =18.808, p = .000) and group ($F_{(1,62)}$ =52.631, p = .000), but the interaction between them was not significant (see Fig. **3**).

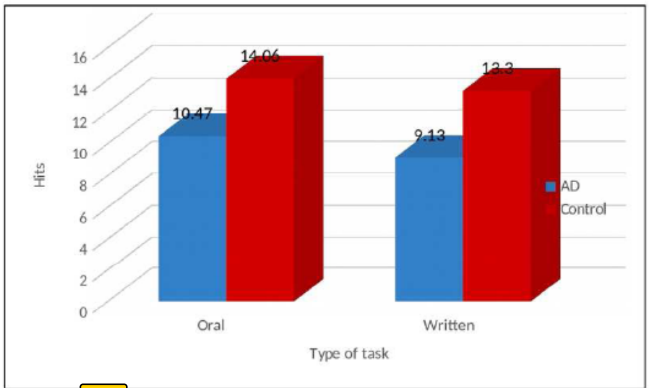

Fig. (3). Mean socres in oral and written naming in the two groups of participants.

Relating to the longitudinal data, the 21 patients who performed all evaluation sessions during the 2.5 years of the monitoring, answered correctly to 4283 of the 6300 total responses in the oral naming task (67.98%). AD patients worsened as time went on, as can be seen in Table **2**. According to the results of the ANOVA with repeated measures, the differences between the mean scores of the successive assessments were significant ($F_{(1,20)}$ = 180.744, p = .000).

Analyzes were performed to find out which variables predict performance decline in oral naming. The results show that the years of schooling (r_{xy}= .578, p= .006) and the scores on both the MMSE (r_{xy}= -.633, p= .002) and the GDS (r_{xy}= .522, p= .015) in the last visit correlated significantly with deterioration. In the stepwise regression analysis the ANOVA gives us a significant value (p= .000), so we conclude that linear dependence is statistically significant. The results show that MMSE score in the last session explained 36.9% of the variance (corrected R^2 = .369), years of schooling adds 26.7% of the explanatory value (corrected R^2 = .636) and the initial MMSE score another 6% (corrected R^2 = .696), although, curiously, the correlation between this latter variable and the task was not significant. No stimulus variables correlated significantly with the task, so no stepwise regression analysis was performed.

Regarding errors, the most frequent were semantic, followed by non-responses and circumlocutions; the other errors collected during the 30 months of monitoring accounted for 15.7% of the total. The number of errors was gradually increasing as time passed, mainly due to non-responses. Other error types remained fairly stable (See Table **2**).

In the written naming task patients made a total of 844 errors, representing 44.66% of the 1890 registered responses. The ANOVA with repeated measures showed significant differences between the mean scores on the various evaluations ($F_{(1,20)}$= 114.457, p = .000). As expected, the performance of the patients was declining as time passed and presumably the disease progressed (see Table **2**).

Correlation analysis shows that education was the only variable of the subjects that significantly correlated with impaired performance on this task (r_{xy}= .706, p= .000). In the stepwise regression analysis the ANOVA gives us a significant value (p = .000), so we conclude that linear dependence is statistically significant. The variable years of schooling managed to explain 47.3% of the variance (corrected R^2= .473), while the GDS score in the last session adds a 10.6% explanatory value (corrected R^2 = .579), again a variable that did not correlate significantly with the task.

As to the characteristics of the stimuli, a significant correlation between the length of the word and performance deterioration was found in the task. According to the stepwise regression analysis, which was also significant

Table 2. Percentage of hits and errors of Alzheimer's patients in the six evaluation sessions.

	Session	1	2	3	4	5	6
Oral naming	Correct	75.2	70.5	69.2	67.7	64.8	60.5
	Semantic	10.8	12.1	12.9	12.9	12.7	13.6
	Circumlocution	4.9	4.8	4.7	5.1	5	6.6
	Non response	4.9	7.9	8.1	9.6	11.3	13.9
	Other	4.2	4.7	5.1	4.7	6.2	5.4
Written naming	Correct	51.7	46.1	47.3	45.7	41	36.2
	Semantic	14.3	13.3	16.2	13.3	17.5	16.2
	Orthographic	14.6	16.2	15.9	14.3	14.9	17.1
	Phonological	7.9	9.8	6.6	7	7.6	7.6
	Non response	7.9	11.4	10.8	15.6	15.2	19.4
	Other	3.6	3.2	3.2	4.1	3.8	3.5

(p=.045), the percentage of variance explained by this variable in the regression analysis was 21.9% (corrected R^2 = .219).

Regarding errors in the written naming task, the most frequent were spelling errors, followed by semantic and non-responses. As time went by, and presumably the disease progressed, an increase was observed in the total number of errors, mainly at the expense of non-responses (see Table **2**). Although almost all types of errors were homogeneously distributed among patients, this was not the case for visual errors, which were mainly concentrated in three patients in both oral (19, 20 and 27 visual errors respectively) and written naming (5, 1 and 3 respectively). The rest of the patients showed little or no visual errors.

4. DISCUSSION

The aim of this study was to characterize the deterioration in AD by observing and comparing the evolution of patients' performance over 2.5 years in two picture-naming tasks: one oral and one written. The written naming task was designed by selecting 15 of the 50 drawings of the oral version. The patients' performance was assessed every 6 months and both the number of correct answers and the pattern of errors were analyzed in order to understand the lexical- semantic changes that occur during the course of AD.

Cross-sectional data in oral naming show, as expected, poorer patient performance compared to controls. Although healthy subjects made far fewer errors than patients did, the oral naming performance pattern is similar in both groups, with semantic errors being the most numerous, followed by non-responses and circumlocutions. These results are consistent with those obtained in previous studies [5, 6, 14], where lexical-semantic errors were the first to appear and the most prevalent in the early stages of the disease. Similarly, in our study visual errors were very scarce and concentrated in a few patients, which discards the presence of visual agnosia as a characteristic of AD. Our detailed analysis of individual patients allows us to confirm that, as Barbarotto *et al.* [5] point out, visual errors appear more as an individual feature of some patients than as a generalized marker of the disease.

In written naming, the overall achievement of the AD was also worse than that of the healthy elderly. Besides, patients' performance pattern was slightly different from that of the controls. Thus, in the subjects with AD, the spelling and semantic errors were the most numerous, followed by phonological and non-responses, as found in previous research [12, 14]. The controls, on the other hand, committed many spelling and some phonological errors but, as in oral naming, there are hardly any semantic errors and non-responses in this group. This pattern of responses of the control group contrasts with that obtained by Groves-Wright *et al.* [14], since these authors found that semantic paragraphias were much more numerous than phonemic paragraphias. Without questioning their results, we consider that in healthy subjects, errors in the recognition of drawings or in lexical access can occur in a small percentage of cases. However, nothing justifies that they exceed the number of phonological errors, since the processes that these involve (selection and organization of graphemes, maintenance of information in the working memory...) are more susceptible to failure in neurologically healthy people. As regards spelling errors, we cannot establish comparisons between the two studies, since they considered answers correct when they were phonologically plausible.

When the performance was compared in oral and written naming tasks, Groves-Wright *et al.* [14] found an interaction between the group and the type of task, so that only moderate AD patients showed a worse performance in written naming. In the control group and in mild AD, however, performance on both tasks was similar. In our study, we did not differentiate between mild and moderate AD, but the difference between oral and written appears in both the patients and the control group, even despite the spelling errors removed from the analysis. Another notable difference between the two studies is that Groves-Wright *et al.* [14] found an opposite behavior in semantic and phonological errors in the two tasks. Thus, the semantic errors are the most numerous in oral naming, but decrease in the written version. On the contrary, phonological errors hardly appear in oral naming, but they are the most numerous when writing. Our results coincide with theirs in terms of phonological errors, but semantics are equally frequent in both versions of the task, which seems more logical, since semantic processes should be common and there is nothing to justify that lexical recovery must be more damaged in oral than in written expression.

Regarding the performance of the patients in the oral naming task throughout the evaluation sessions, we observed, as expected, a deterioration in performance. These results agree with those found by Barbarotto *et al.* [5]. However, in our case, having taken into account variables of both patients and stimuli, we can add that the educational level is the best predictor of the worsening, since it explains almost one-third of the variance. The patient's score in the last session on the MMSE test and the GDS scale also predicts a part of the variance. The characteristics of the stimuli, however, do not appear to be explanatory of the deterioration in performance. We observed a large increase in non-responses as the disease progressed, which could be explained as a loss of concepts in semantic memory, as argued by Chertkow and Bub [19]. These data agree with those found by Barbarotto *et al.* [5] and Cuetos *et al.* [6] in their longitudinal studies. However, these authors found a decrease in semantic paraphasias in the last sessions, whereas in our patients this amount has remained constant throughout all the sessions, with a slight increase in the latter. This may indicate that patients begin to lose partial semantic information from some concepts that were previously complete, and to confuse them with similar ones.

The deterioration pattern in the performance of patients in the written naming task is very similar to that found in the oral version. Again, the educational level of the patient is the variable that best predicts this decline, although in this case explains almost half of the variance. The length of the stimulus explains another percentage, although smaller. The decisive role of the participant's schooling in the task of writing is very logical, since the educational level determines whether the subject has correct (or partially correct) orthographic representations of the names of the objects. The same thing happens with the length of the word, since the longer it is, the greater the probability that the patient will make mistakes in the selection or the order of graphemes.

As in the oral version, the semantic errors were among the most numerous in the first sessions, although the orthographic errors equal them. Both types of errors slightly increase in the last sessions, which again contradicts Barbarotto *et al.* [5] and Cuetos *et al.* [6] The low number of phonological errors in the first sessions, which is maintained throughout the follow-up, indicates a relative preservation of phonological processing, at least in mild and moderate stages. In the case of nonresponses, the amount starts being low, but their number rapidly increases as the subject worsens, even exceeding the number of semantic and orthographic errors, which is compatible with the hypothesis of the loss of semantic information.

CONCLUSION

In summary, the results of this study show that the naming task is especially useful to monitor the deterioration of patients with AD, since it is sensitive enough to capture minimal changes in the language production system, both oral and written. We have also replicated the results of previous studies that show that lexical-semantic errors are the first to appear in oral naming, although, as the disease progresses, dramatically increases the number of non-responses. We have found that this same pattern also occurs in writing. It also highlights the need for longitudinal studies to observe the pattern of evolution of subjects and to determine which variables predict more accurately changes due to deterioration.

LIST OF ABBREVIATION

AD = Alzheimer's disease
AoA = Age of acquisition
Fam. = Familirity
Freq. = Frequency
GDS = Global Deterioration Scale
Leng. = Length of the word
MMSE = Mini Mental State Examination
NINCDS-ADRDA = National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association
SD = Standard Deviation

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are basis of this research.

CONSENT FOR PUBLICATION

The authors agree that if this manuscript is accepted for publication in Current Alzheimer Research, all copyrights of the paper will be transferred to the journals.

CONFLICTS OF INTEREST:

The authors declare no conflict of interest, financial or otherwise.

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APPENDIX

Table 1. Summary of stimuli characteristics. The words in italics are the commons stimuli for the two tasks.

Picture	Translation	AoA	Freq.	N.A.	Leng.	Cat.	Fam.
Ancla	Anchor	3.85	3.8	97	5	NL	5.35
Araña	Spider	2.37	7.8	94	5	L	5.53
Ardilla	Squirrel	2.85	9	98	7	L	5.75
Bandera	Flag	2.85	38.6	90	7	NL	4.74
Bota	Boot	2.78	5.8	95	4	NL	6.35
Cadena	Chain	3.30	65.4	95	6	NL	6.55
Calcetín	Sock	1.85	1.6	100	8	NL	6.55
Campana	Bell	2.85	11.8	98	7	NL	6.18
Canguro	Kangaroo	2.89	0.4	97	7	L	5.48
Caracol	Snail	2.26	6	98	7	L	4.98
Cebolla	Onion	3.33	10.6	95	7	L	6.77
Cenicero	Ashtray	3.67	7.2	98	8	NL	6.14

(Appendix Table 1) contd….

Picture	Translation	AoA	Freq.	N.A.	Leng.	Cat.	Fam.
Cepillo	Brush	2.63	5.8	89	7	NL	6.85
Cereza	Cherry	2.63	1	90	6	L	5.76
Cesta	Basket	2.78	7.6	97	5	NL	5.76
Cometa	Kite	3.07	8.4	100	6	NL	4.67
Conejo	Rabbit	2.30	7.4	100	6	L	6.02
Corona	Crown	3.07	28.4	98	6	NL	3.07
Elefante	Elephant	2.07	8.2	100	8	L	5.81
Escalera	Ladder	2.67	42.8	95	8	NL	6.5
Falda	Skirt	2.33	24.6	97	5	NL	6.29
Flecha	Arrow	3.22	5	92	6	NL	5.71
Fresa	Strawberry	2.33	3.2	100	5	L	6.66
Gorra	Cap	2.59	8.6	90	5	NL	6.47
Hacha	Axe	3.85	7	98	5	NL	3.9
Helicóptero	Helicopter	3.52	6.4	98	11	NL	5.14
Hoja	Leaf	2.41	28.8	94	4	L	6.22
Iglesia	Church	2.59	120.8	100	7	NL	4.67
Jarrón	Vase	2.93	4.4	94	6	NL	5.42
Jirafa	Giraffe	2.74	1.2	100	6	L	4.39
Lámpara	Lamp	2.63	18.6	100	7	NL	6.15
León	Lion	2.00	33.6	100	4	L	4.85
Limón	Lemon	2.30	7.4	100	5	L	6.45
Martillo	Hammer	3.30	6	97	8	NL	5.55
Mono	Monkey	2.19	20.4	90	4	L	5.85
Nariz	Nose	2.00	59.2	100	5	L	6.5
Oveja	Sheep	2.33	7.4	90	5	L	5.88
Pato	Duck	1.89	5.4	98	4	L	5.46
Payaso	Clown	2.30	4.6	98	6	L	6.1
Peine	Comb	2.52	5.6	100	5	NL	6.55
Piña	Pineapple	3.07	2.8	100	4	L	5.9
Pipa	Pipe	3.26	16.2	98	4	NL	5.37
Plancha	Iron	3.26	5.8	100	7	NL	6.62
Plátano	Banana	2.41	2.8	100	7	L	6.36
Rana	Frog	2.04	7	86	4	L	5.78
Rueda	Wheel	2.70	25.6	92	5	NL	6.25
Tigre	Tiger	2.22	4.8	90	5	L	5.54
Tomate	Tomato	2.22	7.6	98	6	L	6.39
Zanahoria	Carrot	2.44	2.6	98	9	L	5.56
Zorro	Fox	3.11	5.4	97	5	L	5.68

AoA=Age of acquisition; Freq.=frequency per million; N.A.=Name agreement; Leng.=Length in letters; Cat.=Cathegory; L=Living; NL=Non living; Fam.=Familiarity.

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