

Research Report

Alexia and agraphia in Spanish

Rafael Gonzalez†, Macarena Rojas† and Alfredo Ardila‡§ 

†Departamento de Neurología y Neurocirugía, Hospital Clínico de la Universidad de Chile, Santiago, Chile

‡Institute of Linguistics and Intercultural Communication, Sechenov University, Moscow, Russia

§Psychology Doctoral Program, Albizu University, Miami, FL, USA

(Received March 2020; accepted July 2020)

Abstract

Background: Every language has certain specific idiosyncrasies in its writing system. Cross-linguistic analyses of alexias and agraphias are fundamental to understand commonalities and differences in the brain organization of written language. Few reports of alexias and agraphias in the Spanish language are currently available.

Aims: To analyse the clinical manifestations of alexias and agraphias in Spanish, and the effect of demographic variables.

Methods & Procedures: Spanish versions of the Western Aphasia Battery (WAB) and Boston Diagnostic Aphasia Examination (BDAE) were used for language assessment. Lesion localization was obtained by using computed axial tomography and magnetic resonance imaging. The final sample included 200 patients: 195 (97.5%) right-handed and five (2.5%) left-handed; 119 men and 81 women with a mean age of 57.37 years (SD = 15.56), education of 13.52 years (SD = 4.08), and mean time post-onset of 6.58 months (SD = 12.94). Using the WAB, four quotients were calculated: aphasia quotient (AQ), reading–writing quotient (RWQ), language quotient (LQ) and cortical quotient (CQ).

Outcomes & Results: The types of aphasia were: global = 11 patients (5.5%), Broca = 31 (15.5%), Wernicke = 30 (15.0%), conduction = 22 (11.0%), transcortical sensory = 17 (8.5%), transcortical motor = 3 (1.5%), amnesic or anomic = 54 (27.0%) and mixed non-fluent = 32 (16.0%). The degree of oral and written language impairment differed across the various aphasia types. Most severe reading and writing difficulties were found in global, mixed non-fluent and transcortical motor aphasia; fewer difficulties were observed in amnesic, Broca and conduction aphasia. The severity of the written language impairments paralleled the severity of the oral language disturbances. Age negatively, while schooling positively, correlated with the scores in reading and writing tests. No effect of sex and time since onset was found.

Conclusions & Implications: In Spanish-speaking aphasia patients, difficulties in reading and writing are similar to oral language difficulties. This similarity of performance is mostly based on severity rather than the participants' patterns of errors.

Keywords: Alexia, Agraphia, Spanish language, Western Aphasia Battery.

What this paper adds

What is already known on the subject

- There is limited information about alexia and agraphia in Spanish.

What this paper adds to existing knowledge

- An extensive study with a large sample of patients.

What are the potential or actual clinical implications of this work?

- The study contributes to the clinical management of patients with reading and writing disturbances.

Address correspondence to: Alfredo Ardila, 12230 NW 8th Street, Miami, FL 33182, USA; email: ardilaalfredo@gmail.com

Introduction

Information about alexia and agraphia in Spanish-speaking adult is limited. The Spanish writing system, as with any other language, has certain idiosyncrasies that can affect the characteristics of alexias and agraphias. Understanding alexias and agraphias in diverse languages is fundamental to understand the commonalities and differences in brain organization and acquired disturbances of written language. Regardless that alexias and agraphias were described over a century ago (Dejerine 1891, 1892) and have been reported in a diversity of languages, few studies have compared reading and writing disturbances across different languages. Two notable exceptions are Karanth's *Cross-Linguistic Study of Acquired Reading Disorders* (2003) and a special issue of the *Journal Behavioural Neurology* titled 'Acquired Dyslexia and Dysgraphia across Scripts' (Weekes 2012). In both publications, Spanish was included. However, both were basically analysing the applicability of the cognitive models of acquired alexias and agraphias to a diversity of languages. Interestingly, the first concludes that those models are not applicable cross-linguistically, whereas the second concludes that they are applicable across different languages.

Only a few studies have analysed the characteristics of alexias and agraphias in Spanish, despite the fact that Spanish, as a first language, is the second most spoken language in the world, with close to 500 million speakers (Ethnologue 2020). Most reports are single case studies (e.g., Cuetos *et al.* 1996, Davies and Cuetos 2005, Ferreres *et al.* 2005, 2012, Iribarren *et al.* 2001, Ruiz *et al.* 1994). These case studies attempted to analyse the applicability of current psycholinguistics models of alexias to Spanish. Two studies have presented a case series (Ardila *et al.* 1989, 1996). The first was mostly devoted to finding the clinical/anatomical correlations of different written language disturbances, while the second was restricted to reviewing agraphias. In this second study, data from three groups of patients were analysed: (1) patients with Broca aphasia, (2) patients presenting Wernicke aphasia and (3) right hemisphere-damaged patients. Two normal population groups—children and adults—were included. Two types of errors were identified: 'homophone' (or 'orthographic') errors and 'non-homophone' (or 'writing') errors. Homophone errors were found in brain-damaged and also neurotypical participants. However, significantly more of these errors were found in right hemisphere-damaged patients and those with Wernicke's aphasia. In contrast, non-homophone errors were observed in the brain-damaged population, but not in age-matched neurotypical adults. Two additional papers using series of patients were devoted specifically to spatial alexia and spatial agraphia in Spanish (Ardila and Rosselli 1993, 1994).

To address the characteristics of alexias and agraphias in Spanish, it is fundamental to consider the specific idiosyncrasies of the Spanish writing system.

Frequently, reading systems are divided between into 'transparent' (languages in which each grapheme corresponds to a phoneme) and 'opaque' (languages in which each grapheme can correspond to more than one phoneme) systems (Kwok *et al.* 2017, Vaessen *et al.* 2010). Spanish has a transparent reading system, except (1) when reading certain words taken from other languages (e.g., *souvenir*, *jeep*); (2) some incongruences in the transcription of words taken from Amerindian languages—these incongruences are particularly evident in Mexico where, for example, the city name Oaxaca is read/guaxaka/; and (3) certain archaisms in writing. As an example of the latter, *México* in Spanish should be written *Méjico*. The name of this country was written as *México* until the early 19th century when, at this point, it was decided that all the words written with X and pronounced/x/should be written with a J. However, the name of this country is frequently written in Spanish using the archaic orthography.

Reading in Spanish is completely transparent (except for the mentioned irregularities). However, in writing some decision must be taken, considering that many words can be written in different ways (e.g., the spoken word/muxer/meaning 'woman' could be written MUJER or MUGER, and in both cases the reading is/muxer/. However, only the first spelling is considered as correct according to the contemporary writing rules (Real Academia Española 2014).

In writing two different types of errors are possible: homophones and non-homophones. In a homophone error—orthographic error—reading is equivalent, but it does not correspond to the accepted orthography. For example, MUJER is written MUGER. Homophone errors are found in those words in which alternate forms of writing are possible. Different writing decisions have to be taken. For example, two different letters can be used to represent the phoneme/b/(voiced bilabial); the phoneme/R/(alveolar trill) sometimes is written R and sometimes RR, etc. (Ardila 1998). In cases of cerebral pathology, orthographic errors in Spanish are not just associated with aphasia, while in the case of right hemispheric pathologies, it is common to find an increase in these homophone errors (Ardila and Ostrosky-Solis 1984).

The other type of error is called a non-homophone error or 'writing error'. For example, the word MUJER is written NUJER. Homophone errors are frequent, particularly in people with limited levels of schooling; nonetheless, they are also found even in people with university levels of education (Ardila *et al.* 1996). Non-homophone errors are found only in cases of brain pathology and in children when learning to write.

Alexia and agraphia depends on the type of aphasia (e.g., Ardila 2014, Benson 1979, Benson and Ardila 1996, Hecaen and Albert 1978). Alexia is usually found associated with Wernicke's, transcortical sensory and anomic aphasia. In contrast, errors in agraphia are to parallelize similar to the spoken errors in aphasia. That means in Broca's aphasia agrammatism in writing is also found in spoken language; literal and semantic paraphasias mirror the phonological and semantic paraphasias found in Wernicke's aphasia, etc. The association of alexia and agraphia with demographic variables, excepting the level of education, remains unclear.

The purpose of this study was to analyse the characteristics of alexias and agraphias in Spanish using a large sample of patients with brain pathologies. This is a descriptive study, and hence no specific hypotheses were proposed.

Methods

Participants

In this study, participants attended the Cognitive Communicative Speech Language Pathology Unit of the Clinical Hospital, University of Chile in Santiago of Chile (Unidad de Patología del Habla y Lenguaje Cognitiva Comunicativa del Departamento de Neurología y Neurocirugía del Hospital Clínico de la Universidad de Chile) and were patients with speech and language disorders associated with brain pathology. We recorded aphasia cases for over a 12-year period (2008–20), with prior approval obtained from the institutional ethics committee.

The database included 1404 entries. The following procedure was used to select the patients for the current study. Initially, we entered all the patients that who had been assessed using the Spanish revised version of the Western Aphasia Battery (SWAB-R) (González *et al.* 2015; translated and adapted to Spanish by González 2008), and the Boston Diagnostic Aphasia Examination—Spanish version (SBDAE) (Goodglass 2005). We found that 915 patients (65.17%) fulfilled this condition. In a second stage, only those patients having the initial evaluation including both the SWAB-R Parts 1 and 2 were retained (504 patients). Later, from those 504 patients, only those with a single cerebrovascular accident were selected, reducing the sample to 231 cases (45.83%). Finally, the following inclusion criteria were used: (1) adult (≥ 18 years) literate participants with aphasia due to first-ever left hemisphere stroke; (2) conscious (according to the World Health Organization definition) at the time of language assessment; and (3) native Spanish speaker. We also used the following exclusion criteria: (1) aphasia caused by intracranial haemorrhage—we did so because intracranial haemor-

rhages produce an extended effect (Flowers *et al.* 2016); (2) pre-morbid psychiatric pathologies; (3) pre-morbid significant cognitive disturbances, congruent with a dementia process; and (4) significant non-linguistic cognitive disturbances at the assessment, such as confusion and attentional deficits, impairing the language evaluation. From this 231-patient sample, 31 were removed from the study because they did not fulfil these criteria. Consequently, the final sample for the current study included 200 vascular aphasia patients.

Handedness was determined based on the direct clinical observation and/or a brief questionnaire answered by a close family member or by the patient him/herself, when possible. We received 195 (97.5%) right-handed and five (2.5%) left-handed participants. In our aphasia sample, there were 119 men and 81 women, with a mean age of 57.37 years ($SD = 15.56$).

A total of 69 patients presented right hemiparesis, but only 39 of them had to use their left hand for writing. It is noteworthy that studies have found in neurotypical adults that writing with the non-preferred hand affects the calligraphy, but does not significantly affect the ability to select the letters or the letters sequence in a word.

The participants had a mean level of education of 13.52 years ($SD = 4.08$) corresponding to approximately high school, according to the Chilean education system. The mean time post-onset that they evaluated was in on average 6.57 months ($SD = 12.94$); time post-onset was the following: acute: ≤ 1 month ($n = 63$); subacute: 2–4 months ($n = 73$); and chronic: ≥ 5 months ($n = 64$). All the patients had localized strokes according to computed axial tomography and magnetic resonance imaging scans.

Language examination

Two different aphasia test batteries were administered: the SWAB-R and SBDAE. The maximum interval between the two tests was 1 week, initially administering the SBDAE and later the SWAB. The SWAB-R includes two sections:

(1a) SWAB-R Part 1 is used to determine the aphasia severity. We only administered four subtests: spontaneous speech, auditory verbal comprehension, repetition and naming. An aphasia quotient (AQ) was calculated based on these four scores. It was calculated using the following formula:

$$\begin{aligned} \text{AQ} = & (\text{Spontaneous speech } 20 \\ & + \text{comprehension } 200/20 + \text{repetition } 100/10 \\ & + \text{naming } 100/10) \times 2 \end{aligned}$$

According to the AQ, aphasia severity is interpreted as follows: 0–25 = very severe, 26–50 = severe, 51–75 = moderate and ≥ 76 = mild. In our sample, the mean AQ was 59.26 (SD = 30.03).

(1b) SWAB-R Part 2 is a supplementary instrument, including the following subtests: reading, writing, praxis, drawing, block design, calculation and Raven's coloured progressive matrixes.

Three different quotients were calculated: reading–writing quotient (RWQ), language quotient (LQ) and cortical quotient (CQ). The RWQ has a maximum score of 100 points and is calculated using the formula:

$$(\text{Reading } 100 + \text{Writing } 100)/2$$

LQ includes oral and written language (Shewan 1986); the following formula is used:

$$\begin{aligned} &(\text{Spontaneous speech } 20) \\ &+ (\text{auditory comprehension } 200/10) \\ &+ (\text{repetition } 100/10) + (\text{naming } 100/10) \\ &+ (\text{Reading } 100/5) + (\text{Writing } 100/5), \end{aligned}$$

with a maximum score of 100.

Finally, the CQ includes all the battery subtests; to calculate it, the following formula is used:

$$\begin{aligned} &(\text{Spontaneous speech } 20) \\ &+ (\text{auditory comprehension } 200/10) \\ &+ (\text{repetition } 100/10) \\ &+ (\text{naming } 100/10) \\ &+ (\text{Reading } 100/10) + (\text{Writing } 100/10) \\ &+ (\text{praxis } 60/6) + (\text{drawing } 30) \\ &+ \text{block design } 9 + \text{calculation } 24 \\ &+ \text{Raven's coloured progressive matrixes } 37/10 \end{aligned}$$

Its maximum score is 100.

(2) The SBDAE was used to determine the type of aphasia. We preferred to use the SBDAE in determining the aphasia subgroups because it uses not only quantitative but also qualitative classification criteria. In the current study, the distribution of the aphasia types was as follows: global = 11 patients (5.5%), Broca = 31 (15.5%), Wernicke = 30 (15.0%), conduction = 22 (11.0%), transcortical sensory = 17 (8.5%), transcortical motor = 3 (1.5%), amnesic or anomic = 54 (27.0%), and mixed non-fluent = 32 (16.0%). Mixed non-fluent aphasia refers to those patients with a significantly impaired expressive language and auditory comprehension deficits (< 50%). Patients with Broca's aphasia score > 50% in auditory

comprehension, while in global aphasia auditory comprehension falls to < 25%. The number of patients in each aphasia subtype is unequal; this is an implicit limitation not only in this study but also in similar clinical studies (Lahiri *et al.* 2020, Pedersen *et al.* 2004).

The software IBM SPSS STATISTICS 25 was used to analyse the data in two ways. First the clinical characteristics of the different types of aphasia were examined, with a particular emphasis on reading and writing disturbance. This analysis is presented in tables 2–4. Second, the impact of the demographic variable on reading and writing was evaluated. This analysis is presented in tables 5–8. The assumption of normality was met for the data.

Results

Table 1 presents the demographic characteristics of the patients. The information corresponding to each aphasia type and the 200-patient sample is included.

Table 2 shows that aphasia severity was greater in people with global, mixed non-fluent, and transcortical motor aphasia and that their LQ, RWQ and CQ was lower than the other types of aphasia. Patients with global, mixed non-fluent and transcortical motor aphasia had more severe language, cognitive, and reading and writing deficits than patients with amnesic, conduction, Broca's and transcortical sensory aphasia. The differences between the aphasia types were statistically significant across all quotients.

Reading subtest scores in the SWAB-R Part 2 according to the aphasia type are presented in table 3. Reading was most impaired in global but also and transcortical motor aphasia. However, depending upon the specific reading subtest, difficulties varied according to the type of aphasia. Reading comprehension of sentences was severely impaired not only in global but also in transcortical motor aphasia. The 'commands' subtest was specially affected in global and mixed non-fluent aphasia. For the rest of the reading subtest, greater difficulties were found in patients with global and also transcortical motor aphasia.

Table 4 presents the scores in the writing subtests of the SWAB-R Part 2 according to aphasia type. Writing was affected in all the aphasia groups, but primarily in global and transcortical motor aphasia. Writing to dictation was particularly difficult for patients with Wernicke aphasia.

To analyse the impact of different demographic variables on reading, correlations between the scores in the reading subtest and demographic variables were also analysed (table 5). Age negatively correlated with the scores in all the subtests, except in commands, spoken word–written word and letter discrimination. The

Table 1. Demographic characteristics of all participants according to aphasia type

Demographic variables	Broca (<i>n</i> = 31)	Wernicke (<i>n</i> = 30)	Conduction (<i>n</i> = 22)	Transcortical		Amnesic (<i>n</i> = 54)	Global (<i>n</i> = 11)	Mixed non-fluent (<i>n</i> = 32)	All aphasias (<i>n</i> = 200)
				sensory (<i>n</i> = 17)	motor (<i>n</i> = 3)				
Age	55.77	61.57	52.59	64.18	54.00	57.37	57.45	54.94	57.37
Mean (SD)	(16.88)	(15.55)	(17.39)	(15.87)	(14.00)	(13.80)	(13.99)	(15.72)	(15.56)
Schooling	13.74	12.17	13.64	14.06	12.00	13.61	12.82	14.41	13.52
Mean (SD)	(3.49)	(4.54)	(3.72)	(4.98)	(2.00)	(3.99)	(4.58)	(4.00)	(4.08)
Time post-onset (months)	8.76	6.80	6.67	4.62	3.16	5.18	4.51	8.65	6.58
Mean (SD)	(22.16)	(13.07)	(10.18)	(4.70)	(2.01)	(12.16)	(2.58)	(9.26)	(12.94)
Gender, males (%)	48.40%	63.33%	72.72%	58.82%	66.66%	57.40%	54.54%	62.50%	59.50%

Note: Differences in age were not statistically significant.

Table 2. Scores in the different quotient SWAB-R Parts 1 and 2 according to aphasia type. Analyses of variance (ANOVAs) and Tukey's test for multiple comparisons were used

Variables	Broca (<i>n</i> = 31)	Wernicke (<i>n</i> = 30)	Conduction (<i>n</i> = 22)	Transcortical		Amnesic (<i>n</i> = 54)	Global (<i>n</i> = 11)	Mixed non-fluent (<i>n</i> = 32)	<i>F</i>	<i>p</i>
				sensory (<i>n</i> = 17)	motor (<i>n</i> = 3)					
Aphasia quotient (AQ) (/100) (SD)	67.01 (24.14)	47.83 (18.40)	71.03 (13.68)	67.07 (19.39)	33.40 (33.45)	87.67 (9.37)	4.23 (2.72)	23.61 (13.75)	70.90	0.0001
Reading-writing quotient (RWQ) (/100) (SD)	71.32 (20.18)	40.53 (24.02)	68.48 (13.50)	55.26 (20.81)	18.58 (25.07)	80.18 (16.72)	7.64 (8.25)	30.30 (15.57)	43.06	0.0001
Language quotient (LQ) (/100) (SD)	70.86 (19.16)	46.53 (19.04)	71.50 (11.64)	62.78 (18.68)	27.63 (30.88)	85.18 (10.30)	6.64 (5.18)	29.56 (12.96)	70.52	0.0001
Cortical quotient (CQ) (/100) (SD)	71.76 (17.14)	50.14 (18.07)	73.52 (10.17)	65.30 (17.46)	33.84 (28.09)	85.29 (9.15)	10.20 (7.07)	33.73 (11.92)	72.78	0.0001

Table 3. Scores in reading subtests SWAB-R Part 2 according to the aphasia type. Analyses of variance (ANOVAs) and Tukey's test for multiple comparisons were used

Variables	Broca (n = 31)	Wernicke (n = 30)	Conduction (n = 22)	Transcortical			Mixed non-fluent (n = 32)		F	p
				sensory (n = 17)	motor (n = 3)	Amnesic (n = 54)	Global (n = 11)			
Reading (/100) (SD)	77.85 (17.76)	46.55 (26.09)	76.02 (12.02)	59.59 (21.73)	23.17 (40.13)	83.15 (18.30)	11.27 (13.30)	37.16 (19.06)	35.72	0.0001
Comprehension of sentences (/40) (SD)	31.16 (9.59)	14.93 (12.77)	28.55 (7.79)	19.06 (10.89)	8.00 (13.86)	30.15 (10.95)	5.27 (9.09)	14.13 (11.93)	17.38	0.0001
Commands (/20) (SD)	14.56 (5.04)	6.72 (6.82)	15.16 (4.26)	11.24 (6.47)	4.83 (8.37)	17.43 (4.64)	0.00 (0.00)	2.56 (3.16)	42.01	0.0001
Written word-object (/6) (SD)	5.87 (0.72)	5.07 (1.84)	6.00 (0.00)	5.82 (0.53)	2.00 (3.46)	6.00 (0.00)	1.45 (2.02)	5.03 (1.49)	27.33	0.0001
Written word-pictures (/6) (SD)	5.87 (0.43)	5.20 (1.79)	6.00 (0.00)	5.47 (1.07)	2.00 (3.46)	5.69 (0.89)	1.36 (1.86)	4.72 (1.59)	22.49	0.0001
Picture-written word (/6) (SD)	5.74 (0.93)	4.90 (1.99)	5.91 (0.29)	5.24 (1.52)	2.00 (3.46)	5.67 (0.82)	1.45 (2.11)	4.44 (1.83)	16.60	0.0001
Spoken word-written word (/4) (SD)	3.61 (0.76)	2.57 (1.36)	3.50 (0.96)	3.24 (0.97)	1.33 (2.31)	3.85 (0.53)	0.64 (0.92)	2.47 (1.32)	19.86	0.0001
Letter discrimination (/6) (SD)	5.61 (0.88)	4.57 (2.03)	5.68 (0.78)	4.88 (1.58)	2.00 (3.46)	5.81 (0.75)	1.09 (2.02)	3.53 (2.23)	19.83	0.0001
Spelled word recognition (/6) (SD)	2.84 (1.93)	1.13 (1.55)	2.23 (1.90)	2.41 (2.18)	0.33 (0.58)	4.09 (1.80)	0.00 (0.00)	0.25 (0.57)	22.63	0.0001
Spelling (/6) (SD)	2.58 (2.46)	1.47 (2.15)	3.00 (1.77)	2.24 (2.11)	0.67 (1.15)	4.46 (1.77)	0.00 (0.00)	0.03 (0.18)	22.83	0.0001

Table 4. Scores in writing subtests SWAB-R Part 2 according to the aphasia type. Analyses of variance (ANOVAs) and Tukey's test for multiple comparisons were used

Variables	Broca (n = 31)	Wernicke (n = 30)	Conduction (n = 22)	Transcortical			Mixed non-fluent (n = 32)		F	p
				sensory (n = 17)	motor (n = 3)	Amnesic (n = 54)	Global (n = 11)			
Writing (/100) (SD)	64.78 (24.59)	34.52 (23.79)	60.93 (17.68)	50.94 (21.11)	14.00 (11.82)	77.20 (18.18)	4.00 (4.93)	23.45 (15.44)	39.45	0.0001
Writing upon request (/6) (SD)	4.45 (1.63)	3.13 (2.14)	5.23 (0.95)	3.62 (1.96)	1.67 (1.44)	5.56 (0.89)	0.27 (0.47)	1.83 (1.81)	31.89	0.0001
Writing output (/34) (SD)	14.58 (11.90)	5.53 (7.50)	12.84 (9.15)	10.24 (7.95)	0.50 (0.87)	20.49 (9.54)	0.00 (0.00)	1.17 (2.60)	22.04	0.0001
Writing to dictation sentence (/10) (SD)	4.81 (3.80)	0.70 (1.81)	2.95 (2.82)	3.09 (3.17)	0.33 (0.58)	6.64 (3.16)	0.00 (0.00)	0.06 (0.25)	26.88	0.0001
Writing dictated words (/10) (SD)	7.18 (3.28)	2.77 (3.21)	5.98 (3.62)	5.59 (3.55)	0.67 (1.15)	8.79 (2.21)	0.00 (0.00)	1.20 (1.96)	34.86	0.0001
Alphabet and numbers (/22.5) (SD)	18.36 (4.70)	11.68 (7.37)	18.43 (3.52)	15.06 (6.26)	5.33 (5.86)	19.63 (3.48)	1.86 (2.39)	10.00 (6.92)	25.90	0.0001
Dictated letter and numbers (/7.5) (SD)	6.90 (1.14)	3.40 (2.57)	6.23 (1.72)	5.62 (2.53)	1.17 (1.61)	7.16 (0.86)	0.14 (0.32)	2.89 (2.38)	40.99	0.0001
Rewriting sentences (/10) (SD)	8.50 (2.06)	7.30 (3.75)	9.27 (1.13)	7.74 (2.50)	4.33 (5.13)	8.94 (2.05)	1.73 (2.40)	6.30 (3.94)	12.10	0.0001

Table 5. Correlations of Pearson between SWAB-R Parts 2 (reading total + reading subtests) and demographic variables

Variables (<i>n</i> = 200)	Reading	Sentence comprehension	Commands	Written word-object	Written word-picture	Picture-written word	Spoken word-written word	Letter discrimination	Spelled word recognition	Spelling
Age	-0.228**	-0.278**	-0.110	-0.148*	-0.156*	-0.21**	-0.087	-0.110	-0.216**	-0.145*
Sex	-0.045	-0.023	-0.073	-0.057	-0.031	-0.037	-0.026	-0.024	-0.042	-0.021
Schooling	0.208**	0.246**	0.075	0.137	0.124	0.128	0.192**	0.112	0.238**	0.220**
Time since onset	-0.025	-0.034	-0.025	0.007	0.036	0.034	0.016	0.016	-0.044	-0.060

Note: **p* < 0.05; ***p* < 0.001.

highest correlation was with the comprehension of sentences. Schooling correlated with the scores in all the subtests, excepting commands, written word-object, written word-picture, picture-written word and letter discrimination. No significant correlation was found with sex and time since onset.

The same analysis was performed with regard to writing. Table 6 presents the correlations between SWAB-R Part 2 (total writing+ subtests writing) and the demographic variables. Age negatively correlated with total writing, writing upon request, writing output, writing dictated word, alphabet and numbers, and sentences copy. While schooling positively correlated with total writing, writing upon request, writing output, writing dictated sentences, alphabet and numbers, and sentences copy. Sex and time post-onset were not significantly associated with the scores in any of the writing subtests.

The correlations between the four quotients and the demographic variables were calculated (table 7). Only age and schooling were correlated with these quotients, age with RWQ, LQ and CQ, while schooling with RWQ.

Finally, correlations between SWAB-R Part 2 scores and demographic variables were calculated (table 8). Again, age negatively correlated with both reading and writing scores, whereas schooling positively correlated with both reading and writing scores. Sex and time since onset did not correlate with reading and writing scores.

Discussion

The main finding in this study is the degree of difference in oral and written language impairment across the different types of aphasia, regardless of the use of a non-selected sample of vascular aphasia patients. Although it is not surprising that the greatest level of impairment was found in global and mixed non-fluent aphasia, and the least in amnesic aphasia, yet the degree of reading and writing impairment in the other aphasia groups was unexpected. Major findings in this study include:

- Overall, the severity of the written language disturbances paralleled the severity of the oral language disturbances across all types of aphasia.
- Using the CQ as an indicator of general cognitive ability, the pattern of impairment observed in both oral and written language was similar to the general cognitive impairment. A lower level of cognitive ability was found in global aphasia and at a higher level in amnesic aphasia.
- In the three participants with transcortical motor aphasia, the severity of the oral and written language impairments was particularly high. Their oral language disturbances were less severe

Table 6. Correlations of Pearson between SWAB-R Parts 2 (writing total + writing subtests) and demographic variables

Variables ($n = 200$)	Writing	Writing upon request	Writing output	Writing dictated sentences	Writing dictated words	Alphabet and numbers	Dictated letter and numbers	Sentence copying
Age	-0.231**	-0.189**	-0.202**	-0.137	-0.152*	-0.274**	-0.086	-0.280**
Sex	-0.048	-0.044	-0.077	-0.047	-0.065	-0.026	-0.005	0.046
Schooling	0.229**	0.166**	0.208**	0.235**	0.138	0.244**	0.125	0.196**
Time since onset	-0.004	-0.005	-0.043	-0.044	0.004	0.031	-0.007	0.091

Note: * $p < 0.05$; ** $p < 0.001$.

Table 7. Correlations of Pearson between the different quotients and demographic variables

Variables ($n = 200$)	Aphasia quotient (AQ)	Reading-writing quotient (RWQ)	Language quotient (LQ)	Cortical quotient (CQ)
Age	-0.061	-0.237**	-0.139*	-0.155*
Sex	-0.089	-0.048	-0.074	-0.063
Schooling	-0.008	0.225**	0.090	0.092
Time since onset	-0.014	-0.015	-0.014	-0.013

Note: * $p < 0.05$; ** $p < 0.001$.

Table 8. Correlations of Pearson between the SWAB-R Part 2 subtests and demographic variables

Variables	Reading	Writing
Age	-0.228**	-0.231**
Sex	-0.045	-0.048
Schooling	0.208**	0.229**
Time since onset	-0.025	-0.004

Note: * $p < 0.05$; ** $p < 0.001$.

than their written language disturbances. Although this pattern of performance is interesting, the size of the group means that caution needs to be taken when interpreting these findings.

- The impediment of both oral and written language was twice as severe in Wernicke's than in Broca's aphasia.
- The severity of both oral and written language disturbance in conduction aphasia was similar to the severity observed in Broca's aphasia.
- Although it seemed obvious to anticipate that reading would be most impaired in posterior aphasias and writing in anterior aphasias, we did not find this pattern. Both reading and writing were impaired in a similar way in all the aphasia types. For instance, reading was severely impaired in transcortical motor aphasia, an anterior type of aphasia, whereas writing was significantly abnormal in transcortical sensory aphasia, a posterior type of aphasia.

Although the results show that acquired difficulties in both reading and writing are significantly correlated with age and schooling, but not with sex or time post-

onset, the proportion of the score variance that can be explained by these two variables is small. Noteworthy, r^2 indicates the percentage of the score variance accounted for by a variable. In general, correlations were low, and hence these two variables—age and schooling—account for only a small percentage of the variance. The negative effect of age on alexia/agraphia severity seems understandable, and can be interpreted as follows: while with advancing age the brain becomes more sensitive to the consequences of an abnormal condition and clinical manifestations are likely to be more severe. The attenuating effect of education, however, could be interpreted in two different ways: (1) people with a higher education have an increased cognitive reserve ameliorating the effect of the brain pathology; this association between education and cognitive reserve has frequently been suggested (e.g., Mungas *et al.* 2018, Wilson *et al.* 2019); and (2) people with lower education, with or without brain pathology, obtain lower scores in reading and writing tests. Probably both explanations may be correct, as they are not contradictory.

It is difficult to compare the results with those obtained in other languages because studies using similar procedures in other languages are not readily available. However, we can speculate that the general conclusions presented above may be applicable to other languages, at least to those closer to Spanish.

The study has several important limitations related to the specific population selected, including but not limited to age range, educational level, aphasia aetiology and the specific location where the sample was taken. Moreover, there is a second, probably even more important, limitation related to the particular testing procedure used. We administered very specific tests, and a very particular scoring procedure, which did not

include the whole assessment of all the potential abilities involved in reading and writing. Further research will contribute to clarify the similarity and differences in alexias and agraphias among languages, and the variables affecting their clinical manifestations.

Acknowledgement

The authors are very grateful to Adriana Ardila for editorial support. **Declaration of interest:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

- ARDILA, A., 1998, Semantic paralexias in the Spanish language. *Aphasiology*, **10**, 885–900.
- ARDILA, A., 2014, *Aphasia Handbook*. (Miami, FL: Florida International University).
- ARDILA, A. and OSTROSKY-SOLIS, F., 1984, Right hemisphere participation in language. In: Ardila, A. and Ostrosky-Solis, F. (Eds.), *The Right Hemisphere: Neurology and Neuropsychology* (London: Gordon & Breach), pp. 99–107.
- ARDILA, A. and ROSSELLI, M., 1993, Spatial agraphia. *Brain and Cognition*, **22**(2), 137–147.
- ARDILA, A. and ROSSELLI, M., 1994, Spatial alexia. *International Journal of Neuroscience*, **76**(1–2), 49–59.
- ARDILA, A., ROSSELLI, M. and PINZON, O., 1989, Alexia and agraphia in Spanish speakers. In *Brain Organization of Language and Cognitive Processes* (Boston, MA: Springer), pp. 147–175.
- ARDILA, A., ROSSELLI, M. and OSTROSKY-SOLIS, F., 1996, Agraphia in Spanish language. *Aphasiology*, **10**, 723–739.
- BENSON, D. F., 1979, *Aphasia, Alexia, and Agraphia* (Vol. 1) (London: Churchill Livingstone).
- BENSON, D. F. and ARDILA, A., 1996, *Aphasia: A Clinical Perspective*. (Oxford: Oxford University Press).
- CUETOS, F., VALLE-ARROYO, F. and SUAREZ, M. P., 1996, A case of phonological dyslexia in Spanish. *Cognitive Neuropsychology*, **13**, 1–24.
- DEJERINE, J., 1891, Sur un cas de cécité verbale avec agraphie suivi d'autopsie [On a case of verbal blindness with agraphia followed by autopsy]. *Comptes Rendus, Societe de Biologie*, **3**, 197–201.
- DEJERINE, J., 1892, Contribution a l'étude anatomo-pathologique et clinique des différents variétés de cécité verbale [Contribution to the anatomo-pathological and clinical study of the different varieties of verbal blindness]. *Comptes Rendus, Societe de Biologie*, **4**, 61–90.
- DAVIES, R. and CUETOS, F., 2005, Acquired dyslexia in Spanish: a review and some observations on a new case of deep dyslexia. *Behavioural Neurology*, **16**(2–3), 85–101.
- Ethnologue.com/language/spa (accessed 3 January 2020).
- FERRERES, A. R., CUITINO, M. M. and OLMEDO, A., 2005, Acquired surface alexia in Spanish: a case report. *Behavioural Neurology*, **16**(2–3), 71–84.
- FERRERES, A., LÓPEZ, C. and FABRIZIO, S., 2012, Alexia de superficie en español sin déficit semántico. *Neuropsicología Latinoamericana*, **4**(1), 86–103.
- FLOWERS, H. L., SKORETZ, S. A., SILVER, F. L., ROCHON, E., FANG, J., FLAMAND-ROZE, C. and MARTINO, R., 2016, Poststroke aphasia frequency, recovery, and outcomes: a systematic review and meta-analysis. *Archives of Physical Medicine and Rehabilitation*, **97**(12), 2188–2201.
- GONZÁLEZ, R., 2008, *Batería de Afasias Western Revisada. Versión traducida y adaptada al español chileno* [Western Aphasia Battery Revised Translated and Adapted to the Chilean Spanish]. (San Antonio: PsychCorp).
- GONZÁLEZ, R., HORNAUER-HUGHES, A., LEYTON, C., NEUMANN, S. and VERA, R., 2015, Clinical characterization of primary progressive aphasia cases using Western Aphasia Battery (WAB-R). *Journal of Neurological Sciences*, **357**, e432–e456.
- GOODGLASS, H., 2005, *Evaluación de la afasia y de trastornos relacionados* [Assessment of aphasia and related disorders]. With the contribution of E. Kaplan and B. Barresi. 3a Edición. (Buenos Aires; Madrid: Editorial Médica Panamericana).
- HECAEN, H. and ALBERT, M.L., 1978, *Human Neuropsychology*. (New York: Wiley).
- IRIBARREN, I. C., JAREMA, G. and LECOURS, A. R., 2001, Two different dysgraphic syndromes in a regular orthography, Spanish. *Brain and Language*, **77**(2), 166–175.
- KARANTH, P., 2003, *Cross-Linguistic Study of Acquired Reading Disorders: Implications for Reading Models, Disorders, Acquisition, and Teaching*. (Berlin: Springer Science & Business Media).
- KWOK, R. K. W., CUETOS, F., AVDYLI, R. and ELLIS, A. W., 2017, Reading and lexicalization in opaque and transparent orthographies: Word naming and word learning in English and Spanish. *The Quarterly Journal of Experimental Psychology*, **70**(10), 2105–2129.
- LAHIRI, D., DUBEY, S., ARDILA, A., SAWALE, V. M., ROY, B. K., SEN, S. and GANGOPADHYAY, G., 2020, Incidence and types of aphasia after first-ever acute stroke in Bengali speakers: age, gender, and educational effect on the type of aphasia. *Aphasiology*, **34**(6), 688–701.
- MUNGAS, D., GAVETT, B., FLETCHER, E., FARIAS, S. T., DECARLI, C. and REED, B., 2018, Education amplifies brain atrophy effect on cognitive decline: implications for cognitive reserve. *Neurobiology of Aging*, **68**, 142–150.
- PEDERSEN, P. M., VINTER, K. and OLSEN, T. S., 2004, Aphasia after stroke: type, severity and prognosis. *Cerebrovascular Diseases*, **17**(1), 35–43.
- REAL ACADEMIA ESPAÑOLA, 2014, *Diccionario de la lengua española [Dictionary of Spanish language]* (23rd ed.), (Madrid: Espasa).
- RUIZ, A., ANSALDO, A. I. and LECOURS, A. R., 1994, Two cases of deep dyslexia in unilingual hispanophone aphasics. *Brain and Language*, **46**(2), 245–256.
- SHEWAN, C. M., 1986, The language quotient (LQ): a new measure for the Western Aphasia Battery. *Journal of Communication Disorders*, **19**, 427–439.
- VAESSEN, A., BERTRAND, D., TÓTH, D., CSÉPE, V., FAÍSCA, L., REIS, A. and BLOMERT, L., 2010, Cognitive development of fluent word reading does not qualitatively differ between transparent and opaque orthographies. *Journal of Educational Psychology*, **102**(4), 827.
- WEEKES, B. S., 2012, Acquired dyslexia and dysgraphia across scripts. *Behavioural Neurology*, **25**(3), 159–163.
- WILSON, R. S., YU, L., LAMAR, M., SCHNEIDER, J. A., BOYLE, P. A. and BENNETT, D. A., 2019, Education and cognitive reserve in old age. *Neurology*, **92**(10), e1041–e1050.