Psicothema

Psicothema 2014, Vol. 26, No. 4, 449-456
doi: 10.7334/psicothema2014.31

ISSN 0214 - 9915 CODEN PSOTEG

www.psicothema.com

Independent effects of imageability and grammatical class in synonym judgement in aphasia

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Abstract

Background: The grammatical class effect in aphasia, i.e. dissociated processing of words according to their respective grammatical class, has been attributed to either grammatical, lexical or semantic (i.e., imageability) deficits. This study explores the hypotheses of impaired semantic treatment as the source of the grammatical class effect in aphasia. **Method:** A synonym judgement task that includes nouns and verbs of high and low imageability has been administered to 30 Spanish-speaking patients suffering from receptive or productive aphasia and 30 controls. **Results:** Normal controls performed significantly better than aphasic patients. Although globally the productive aphasics performed significantly better than the receptive aphasics, grammatical class (nouns better than verbs) and imageability (high imageability better than low imageability) affected performance in both subgroups. No significant interaction emerged between these two factors. **Conclusion:** The results suggest that the grammatical class effect may emerge from semantic impairment and that it is –at least partially- independent of the imageability of words.

Keywords: aphasia, grammatical class effect, imageability, nouns, verbs.

Resumen

Efectos independientes de la imaginabilidad y la clase gramatical en juicios de sinonimia en pacientes afásicos. **Antecedentes:** el "efecto de clase gramatical" en la afasia, es decir, la disociación en el procesamiento de palabras según su clase gramatical, ha sido explicado por dificultades en el procesamiento a nivel gramatical, lexical o semántico (v.g., imaginabilidad). El presente trabajo explora las hipótesis de la alteración semántica como posible origen del efecto de clase gramatical en la afasia. **Método:** se administró una tarea de juicios de sinonimia con sustantivos y verbos de alta y baja imaginabilidad a 30 pacientes afásicos (productivos o receptivos) hispano-parlantes y 30 controles. **Resultados:** los controles obtuvieron puntuaciones significativamente mejores que los afásicos. Los afásicos de producción obtuvieron puntuaciones significativamente mejores que los receptivos. Los efectos de clase gramatical (sustantivos mejor que verbos) y de imaginabilidad (alta mejor que baja) afectaron ambos grupos de pacientes. La interacción entre imaginabilidad y clase gramatical no fue significativa. **Conclusiones:** los resultados sugieren que el efecto de clase gramatical puede surgir de una alteración semántica y que este efecto es independiente de la imaginabilidad.

Palabras clave: afasia, efecto de clase gramatical, imaginabilidad, sustantivos, verbos.

In the last decades, several studies of aphasia have reported the cases of patients presenting with a grammatical class (GC) effect, in which the processing of words appears to be selectively disrupted according to their GC, notably, nouns and verbs (Berndt, Haendiges, Burton, & Mitchum, 2002). While a majority of aphasic patients presenting with such dissociation show a better performance for nouns than for verbs, others show the opposite pattern, either in single word tasks such as picture naming (Berndt et al., 2002; Luzzatti et al., 2002; Mätzig, Druks, Masterson, & Vigliocco, 2009; Miceli, Silveri, Villa, & Caramazza, 1984), naming to definition (Zingeser & Berndt, 1990), or in tasks at the sentence level, such as sentence production (Rapp & Caramazza, 2002).

Received: February 7, 2014 • Accepted: August 6, 2014
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Different hypotheses have been put forward to account for the observed dissociation in the treatment of nouns and verbs, namely the grammatical, the lexical and the semantic-conceptual hypotheses (Shapiro & Caramazza, 2001). The former contends that the observed specific deficit for verbs stems from difficulties in processing the argumental structure of sentences (e.g., in agrammatic Broca's aphasia) (Saffran, 1980, 1982). However, as noted by Crepaldi et al. (2006), this grammatical interpretation does not provide an explanation for the relative preservation of verbs in the presence of noun treatment difficulties, nor does it explain the cases in which fluent patients, whose speech shows no syntactic problems, may suffer from selective verb processing impairment in single word tasks.

A second group of explanations turns to the lexical representation of words, which is thought to include traits that specify their GC. According to this view, grammatical information associated with nouns or verbs can be selectively impaired following brain damage, as it is stored in different cortical areas (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Miceli & Caramazza, 1988; Miceli et al., 1984). Because

the associated cognitive model proposes separate lexicons for the different modalities of language (input/output, oral/written), this explanation suits very well the cases of patients with dissociations for verbs versus nouns treatment that are manifested in one modality exclusively. For instance, some aphasic patients show no GC effect in oral picture naming, while being specifically impaired at one category in written naming (Caramazza & Hillis, 1991) or others show good receptive treatment of both categories but are impaired in the expression of one of the categories (Hillis & Caramazza, 1995).

The third group of explanations is related to a semantic-conceptual account and suggests that rather than a deficit affecting the GC per se, it is the conceptual information represented by one category that is affected (Bird, Howard, & Franklin, 2000; Vinson & Vigliocco, 2002). As in picture naming nouns are generally evoked from drawings of concrete objects and verbs from drawings of actions, an observed deficit for nouns, for instance, may originate from the impaired semantic representation of the concrete properties of objects, rather than from impairment of the features specifying the GC of nouns.

Bird and colleagues (2000) have explored this hypothesis and proposed another version of the semantically-based GC effect. According to the authors, the specific deficit for verbs, as often observed in picture-naming tasks with aphasic patients, would basically be an artefact of the *imageability* effect. Imageability, this semantic variable, has been defined as the ease with which a mental image is evoked from a particular word, as estimated by normal subjects (Crepaldi et al., 2006; Desrochers & Thompson, 2009). Imageability values are classically assessed by asking normal participants to rate different words on a 7-point scale, in which values closer to 1 are given to the less picturable words and closer to 7 if the words evoke a mental image more easily. As reported by Crepaldi et al. (2006), verbs normally have lower imageability than nouns. Thus, in tasks that use pictures, as picture naming tasks, it is not possible to properly match nouns and verbs for imageability without reducing the validity of this task. Indeed, it appears that to obtain pictures of nouns that are equated with those of verbs on imageability, the likelihood of evoking the right target from their respective pictures is greatly diminished in picture naming of nouns.

In order to clarify the potential confounding role of imageability in the GC effect, Berndt et al. (2002) analysed the data obtained from seven aphasic patients on a sentence completion task involving nouns and verbs equated for imageability. They compared these results to those of the same patients on picture naming and oral reading of nouns and verbs of low and high imageability. The authors found that the patients presenting with a noun/verb dissociation in picture naming continued to show better processing of nouns as compared to verbs in sentence completion, even if the stimuli were matched for imageability. Only two patients did not show a significant GC effect after the imageability had been equated across the two GC groups. Altogether, these results suggest that while for some patients the GC effect may depend upon semantic factors (namely, imageability in this case), for others the two effects can manifest independently.

Similar results emerge from a study by Luzzatti et al. (2002) in which a confrontation naming task was administered to 58 aphasic patients. After controlling for lexical and semantic confounds, Luzzatti et al. reported a persisting GC effect for only 20% of the patients. The results obtained by Crepaldi et al. (2006) point in the same direction. These authors have compared the performance of aphasic patients on a task of noun/verb retrieval in sentence context, for which the imageability of the words had been equated across GC, to the results of the same patients on a standard picture naming task. Fourteen of the 16 patients with a selective verb deficit in the picture naming task did not show a significant GC effect in the retrieval task, once imageability was controlled across GC conditions. The authors concluded that at least some patients do present a GC effect that is imageability-independent.

Although stating, unlike Bird et al. (2000), that the better processing for nouns cannot be completely explained by the imageability-confounding effect, these studies do not clearly identify the impaired language processing component(s) responsible for the GC dissociation. First, because the tasks mostly used in these studies (i.e., sentence completion and nouns and verbs retrieval in sentence context) imply an oral output, the interpretation is complicated for patients with expressive deficits. Even in the presence of a demonstrated independence of GC and imageability, the deficit could originate either from the semantic system, from the phonological output lexicon or from the path between these two processing components (see Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001 for detailed description of the dual route model). Similarly, because the stimuli in most of these studies have only been administered orally, it is not possible, when confronted to a selective deficit for verbs or nouns, to rule out the possibility of language processing impairment previous to the answer (e.g., acoustic analysis, phonological input lexicon or semantics). This is especially true for aphasics presenting with receptive difficulties.

Moreover, the distinction between these two profiles of aphasia – receptive vs expressive – has not been considered in establishing the role of imageability in the GC effect in most of the above mentioned studies. This issue is of particular interest if we consider the fact that some explanations tend to ascribe the GC effect to multiple loci of impairment that, in turn, could give rise to the apparent similar GC effect observed in different patients (Berndt et al., 2002; Bird et al., 2000; Crepaldi et al., 2006; Shapiro & Caramazza, 2001).

A recent review that explores the underlying mechanisms of the noun/verb dissociation (Vigliocco, Vinson, Druks, Barber, & Cappa, 2011) seems to corroborate the hypothesis of the confounding role of semantics in the GC effect. After reviewing the behavioural, electrophysiological, neuropsychological and neuroimaging studies that have focussed on whether or not different GC are represented in different neural networks, these authors have come to the conclusion that although objects and action words do have segregated representations in the brain, this partition relies more on the differential nature or organisation of their semantic features than on the GC of their lexical labels. More precisely, Vigliocco et al. (2011) observed that when semantic differences are removed from analyses, the GC effect only subsists when integration processes are highly implicated (for instance in tasks that impose an inflected form of the word, as implied by the retrieval of a verb in a sentence).

Hence, controversy still remains as to the locus or loci of the GC effect. That is why the aim of this study is to clarify the potential semantic deficit implication in the GC effect in aphasia and to re-examine the claim made by Bird et al. (2000) that the specific impairment for verbs is due to their lower degree of imageability. To disentangle the possible effects of imageability and GC in both

receptive and expressive aphasia, a synonym judgement task (SJT) has been developed. This kind of picture-independent task enables the manipulation of imageability and targets semantic treatment, the component of language processing that has been alleged to lie at the core of the GC effect.

If GC and imageability effects are independent, then both should affect performance in the SJT (Berndt et al., 2002; Crepaldi, 2006). Additionally, since the task targets semantic processing, productive aphasics, known to present with milder semantics impairment than receptive aphasics, are predicted to perform better in the SJT.

Method

Participants

Thirty Spanish-speaking aphasic patients and 30 matched control subjects from Argentina participated in the study. All aphasic patients had a diagnosis of aphasia after brain damage confirmed by two neurologists and had undergone CAT or MRI scans confirming the presence of a brain lesion (ischemic, haemorrhagic or brain trauma). Patients were at least six months post-stroke at the moment of assessment and their language impairment was mild to moderate. None of the patients was receiving speech-language therapy at the moment of assessment.

Normal controls were included in the study if they fulfilled the inclusion criteria of absence of brain injury, no history of neurological or psychiatric disorders, no learning or literacy acquisition difficulties and no pharmacological treatment at the time of assessment.

Following the broadly used dichotomic classification (Weisenburg & McBride, 1935) of productive or expressive aphasia (Hébert, Racette, Gagnon, & Peretz, 2003), and receptive or comprehension aphasia (Francis, Clark, & Humphreys, 2003), the group of aphasic patients was divided into two groups, those showing production problems (productive aphasia group) and those with comprehension problems (receptive aphasia group). Patients with productive aphasia have been generally described as non-fluent, with relatively spared language comprehension but impaired oral production, at least at the level of single word processing (Benson, 1976). Their production presents phonemic and phonetic paraphasias. Receptive aphasia patients have been described as fluent, with moderate to severe anomia and language comprehension difficulties.

This classification in two groups was conducted on the base of the results of the language assessment carried out before the experimental testing. To that end we chose tasks that followed the classic syndromic approach of aphasia assessment: (a) language production (word reading and repetition), (b) language comprehension (auditory word-picture matching task), and (c) presence of anomia (two tasks of picture naming) and type of compensatory error (e.g., phonemic and phonetic vs semantic paraphasias). All the tasks —except for one of the naming tasks, the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983)—were taken from the BEA battery, a battery of language processing assessment in Spanish-speaking individuals (Wilson, 2009; Wilson, Jaichenco, & Ferreres, 2005). The performance of each patient was then compared to the cutoff scores of the BEA battery. A patient was considered as belonging to the productive or the receptive groups if his/her performance was below the cutoff score of production or comprehension tasks. To further support this classification, a qualitative analysis of errors was performed on the picture naming tasks. The sample of productive aphasia was composed of 17 patients, whereas the group of receptive aphasia was formed by 13 aphasic patients. Only one patient in the production group and two in the receptive group were aphasics secondary to brain trauma. This represents 10% of the total sample. The other 90% had language difficulties secondary to single CVA.

Each aphasic patient was matched with a normal control by age, gender, years of education and hand dominance. Table 1 shows the characteristics of the group of aphasic patients (production and receptive) and the control group. No significant differences were found between the group of productive aphasia and its controls or the group of receptive aphasia and its controls for age or education (all *p*s >.1).

Instruments

The items of the synonym judgement task were factorially manipulated by imageability (high and low imageability words) and GC (nouns and verbs). In order to determine whether two words were synonyms or not, Spanish synonym dictionaries were consulted. If the two words appeared as synonyms, they were chosen as a pair. A total of 13 nouns of high imageability, 13 nouns of low imageability, 7 verbs of high- and 7 of low-imageability pairs of items, as well as an equal number of non-synonym pairs, were presented to ten healthy controls of a varied level of education (from 5 to 18 years). The items for which at least 50% of the controls failed to identify as synonyms were removed from the final list. In this way, 20 pairs of noun-noun words and 10 pairs of verb-verb synonyms were selected as final items for the task. Half of the pairs were of low imageability, while the other half was of high imageability. All sets were matched for

Table 1
Mean and standard deviation (SD) for age and education (in years) as a function of the type of patient (productive and receptive) and control groups

	Production aphasia			
	Patients		**Controls**	
Variable	**Mean**	**SD**	**Mean**	**SD**
Age	57	12.89	53.88	7.68
Education	11.65	4.44	12	3.71
Sex	**Male**	**Female**	**Male**	**Female**
	10	7	10	7
	Receptive aphasia			
	Patients		**Controls**	
Variable	**Mean**	**SD**	**Mean**	**SD**
Age	57.08	16.51	55	16.94
Education	12.38	4.74	12.38	4.13
Sex	**Male**	**Female**	**Male**	**Female**
	8	5	8	5

length (in syllables) and word frequency (both *p*s at least > .07). Table 2 shows the characteristics of the items used in the task and examples of synonym pairs of low and high imageability (see Table 3 for the full list of stimuli and their psycholinguistic properties). Adult word frequency data were obtained from the LEXESP database (Sebastián, Martí, Carreiras, & Cuetos, 2000). Length in syllables values were taken from the B-Pal programme (Davis & Perea, 2005). Imageability was measured on a 7-point scale. In our set of stimuli, imageability ratings were missing for certain words, e.g. "boda" (marriage), "clemencia" (merci), "colegio" (school), "vestido" (outfit) and "perfeccionar" (to perfect). Following the same procedure used for collecting age-of-acquisition ratings in Spanish by Davies, Barbón and Cuetos (2013), we collected new imageability ratings. To that end, 20 Argentinean participants (mean age: 34.7 years old, *SD* = 6.69 years; 11 female) were given standard instructions for imageability (Desrochers & Thompson, 2009) and were asked to rate the imageability of the 60 words of our task from which 55 already had imageability norms and five words (above mentioned) did not have imageability values. The new 55 imageability values highly correlated with those already existing for Spanish, and obtained from the B-Pal programme, $r(55) = .92$, $p < .001$. Thus, the new values for the 60 items were used because they better represented the Argentine population of aphasic patients tested in the present study. An equal number ($n = 30$) of non-synonym pairs was created by mixing two words (either two nouns or two verbs, e.g., cuero (leather) - nave (vessel)/andar (to wander) – construir (to build) and by respecting the group of imageability, i.e., both words in the non-synonym pair were either low or high imageability items.

Table 2
Means, standard deviations (SD), minimum (min) and maximum (max) values of the items used in the synonym judgement task, as a function of grammatical class (nouns and verbs) and imageability (high and low)

		Grammatical class			
		Nouns		Verbs	
Variable	Descriptive	High imag	Low imag	High imag	Low imag
Imageability	Mean	6.49	3.07	5.57	2.78
	SD	0.29	0.66	0.31	4.58
	Min	5.30	2.05	4.55	1.70
	Max	6.80	4.45	6.45	4.10
Word frequency	Mean	41.45	29.24	24.31	19.15
	SD	25.75	22.57	13.41	18.25
	Min	2.68	3.75	3.04	2.86
	Max	101.25	106.25	60.54	84.11
Length in syllables	Mean	2.65	2.95	2.60	3.20
	SD	0.47	0.50	0.22	0.27
	Min	2	1	2	3
	Max	5	4	4	4
Examples (and their English equivalent) of the Spanish synonym pairs		cabello (hair) pelo (fur)	proyecto (project) plan (plan)	construir (to build) edificar (to construct)	acontecer (to occur) suceder (to happen)

Note: High Imag: High Imageability; Low Imag: Low Imageability; Word frequency: frequency is on 1 million tokens and was taken from the LEXESP database (Sebastián et al., 2000); Imageability: imageability is given as 7-point subjective ratings

Table 3
Spanish items (and their English translation/equivalent) used in the synonym judgement task

Nouns

High Imageability

Synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	Imageability	Frequency	Stimulus	Imageability	Frequency
1	cabello (hair)	6.6	25.54	pelo (fur)	6.85	100.71
2	barco (ship)	6.7	47.68	buque (vessel)	6.85	16.25
3	agujero (orifice)	6.35	21.25	hueco (hole)	5.3	23.93
4	semilla (seed)	6.6	6.07	grano (grain)	6	8.93
5	techo (ceiling)	6.75	40.18	tejado (roof)	6.65	11.07
6	roca (rock)	6.65	20.89	piedra (stone)	6.55	64.46
7	ropa (clothes)	6.2	72.32	vestido (outfit)	6.7	57.14
8	periódico (newspaper)	6.05	101.25	diario (newspaper)	6.5	72.14
9	casamiento (wedding)	6.55	2.68	boda (marriage)	6.65	22.86
10	escuela (school)	6.8	56.79	colegio (school)	6.5	56.79
	Mean	6.53	39.47		6.46	43.43
	SD	0.25	30.92		0.47	31.08

Nouns

High Imageability

Non-synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	Imageability	Frequency	Stimulus	Imageability	Frequency
1	tejado (roof)	6.65	11.07	escuela (school)	6.8	56.79
2	colegio (school)	6.5	56.79	techo (ceiling)	6.75	40.18
3	vestido (outfit)	6.7	57.14	semilla (seed)	6.6	6.07
4	ropa (clothes)	6.2	72.32	piedra (stone)	6.55	64.46
5	roca (rock)	6.65	20.89	barco (ship)	6.7	47.68
6	grano (grain)	6	8.93	periódico (newspaper)	6.05	101.25
7	boda (marriage)	6.65	22.86	buque (vessel)	6.85	16.25
8	diario (newspaper)	6.5	72.14	cabello (hair)	6.6	25.54
9	agujero (orifice)	6.35	21.25	casamiento (wedding)	6.55	2.68
10	pelo (fur)	6.85	100.71	hueco (hole)	5.3	23.93
	Mean	6.51	44.41		6.48	38.48
	SD	0.26	31.55		0.47	30.26

Table 3
Spanish items (and their English translation/equivalent) used in the synonym judgement task (continued)

Nouns

Low Imageability

Synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	**Imageability**	**Frequency**	**Stimulus**	**Imageability**	**Frequency**
1	dueño (owner)	4.45	40.36	propietario (proprietor)	4.15	17.5
2	consejo (advice)	3.2	34.64	sugerencia (suggestion)	2.35	6.25
3	sufrimiento (suffering)	3.85	26.61	tormento (torment)	3.35	6.79
4	compasión (compassion)	3.25	10.71	lástima (sympathy)	3.05	19.46
5	costumbre (custom)	3	42.5	hábito (habit)	2.75	24.82
6	mentira (lie)	2.45	38.57	falsedad (falseness)	2.2	6.07
7	perdón (forgiveness)	3.7	25.89	clemencia (mercy)	3.3	3.75
8	término (term)	2.05	65.18	plazo (period)	2.05	29.29
9	proyecto (project)	3.85	106.25	plan (plan)	3	63.75
10	humildad (humilty)	3.05	8.75	modestia (modesty)	2.35	7.68
	Mean	3.29	39.95		2.86	18.54
	SD	0.71	28.43		0.65	18.20

Nouns

Low Imageability

Non-synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	**Imageability**	**Frequency**	**Stimulus**	**Imageability**	**Frequency**
1	falsedad (falseness)	2.2	6.07	proyecto (project)	3.85	106.25
2	tormento (torment)	3.35	6.79	compasión (compassion)	3.25	10.71
3	lástima (sympathy)	3.05	19.46	término (term)	2.05	65.18
4	plan (plan)	3	63.75	sufrimiento (suffering)	3.85	26.61
5	modestia (modesty)	2.35	7.68	hábito (habit)	2.75	24.82
6	sugerencia (suggestion)	2.35	6.25	dueño (owner)	4.45	40.36
7	clemencia (mercy)	3.3	3.75	consejo (advice)	3.2	34.64
8	plazo (period)	2.05	29.29	humildad (humilty)	3.05	8.75
9	costumbre (custom)	3	42.5	mentira (lie)	2.45	38.57
10	propietario (proprietor)	4.15	17.5	perdón (forgiveness)	3.7	25.89
	Mean	2.88	20.30		3.26	38.18
	SD	0.65	19.68		0.73	28.80

Table 3
Spanish items (and their English translation/equivalent) used in the synonym judgement task (continued)

Verbs

High Imageability

Synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	**Imageability**	**Frequency**	**Stimulus**	**Imageability**	**Frequency**
1	construir (to build)	5.7	38.04	edificar (to construct)	5.35	3.04
2	trazar (to sketch)	4.55	5.71	dibujar (to draw)	6.2	4.82
3	dormir (to sleep)	6.45	60.54	descansar (to rest)	5.5	19.29
4	caminar (to walk)	6.25	24.82	andar (to wander)	5.25	43.04
5	subir (to climb)	5.55	36.96	ascender (to scale)	4.85	6.79
	Mean	5.70	33.21		5.43	15.40
	SD	0.74	20.07		0.49	16.72

Non-synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	**Imageability**	**Frequency**	**Stimulus**	**Imageability**	**Frequency**
1	dibujar (to draw)	6.2	4.82	descansar (to rest)	5.5	19.29
2	edificar (to construct)	5.35	3.04	subir (to climb)	5.55	36.96
3	andar (to wander)	5.25	43.04	construir (to build)	5.7	38.04
4	dormir (to sleep)	6.45	60.54	caminar (to walk)	6.25	24.82
5	ascender (to scale)	4.85	6.79	trazar (to sketch)	4.55	5.71
	Mean	5.62	23.65		5.51	24.96
	SD	0.68	26.46		0.61	13.40

Verbs

Low Imageability

Synonym pairs

	First word in the pair			Second word in the pair		
	Stimulus	**Imageability**	**Frequency**	**Stimulus**	**Imageability**	**Frequency**
1	suceder (to happen)	2.1	15.71	acontecer (to occur)	1.9	3.57
2	aludir (to cite)	1.7	2.86	mencionar (to mention)	2.75	10.89
3	resistir (to resist)	4	12.14	aguantar (to endure)	3	16.25
4	perfeccionar (to perfect)	3	3.04	mejorar (to improve)	2.8	24.29
5	mantener (to keep)	2.45	84.11	conservar (to maintain)	4.1	18.57
	Mean	2.65	23.57		2.91	14.71
	SD	0.89	34.31		0.79	7.87

Table 3
Spanish items (and their English translation/equivalent) used in the synonym judgement task (continued)

	Non-synonym pairs					
	First word in the pair			Second word in the pair		
	Stimulus	Imageability	Frequency	Stimulus	Imageability	Frequency
1	mencionar (to mention)	2.75	10.89	resistir (to resist)	4	12.14
2	conservar (to maintain)	4.1	18.57	acontecer (to occur)	1.9	3.57
3	mejorar (to improve)	2.8	24.29	aludir (to cite)	1.7	2.86
4	suceder (to happen)	2.1	15.71	mantener (to keep)	2.45	84.11
5	aguantar (to endure)	3	16.25	perfeccionar (to perfect)	3	3.04
	Mean	2.95	17.14		2.61	21.14
	SD	0.73	4.88		0.93	35.41

Note: Word frequency is on 1 million tokens and was taken from the LEXESP database (Sebastián et al., 2000). Imageability is given as 7-point subjective ratings. Both variables are reported as absolute values

Procedure

Participants were first presented with three practice items (two nouns, one verb) to familiarise them with the task. Each pair of words was presented visually and the examiner read them aloud. The reading of each item could be repeated once if the participant asked for a repetition. Participants then had to say orally whether the pair of words had a shared meaning or not by giving a "yes/no" answer. Verbs and nouns were presented in an interleaved fashion. Only accuracy was measured in this task, no time limits were imposed to participants, and no feedback was given on the accuracy of the response.

Data analysis

Analyses of variance (ANOVA) were carried out with GC (nouns vs verbs) and imageability (high and low) as repeated measures and group of participants as between-subject factor by participants (F_1). In the by items analyses (F_2), GC and imageability were entered as between-subject factors and the group of participants was considered as repeated measures. In both analyses, score was entered as the dependent variable. For the computation of the score both the acceptance of the correct pairs of synonyms and the refusal of the pairs of non-synonyms inside each category were considered as correct answers (score).

Results

Figure 1 shows the mean score and standard deviation of the performance of the groups of patients (productive vs. receptive) and normal controls in the task of synonym judgement, as a function of GC and imageability. In a first analysis, group (normals vs. aphasic patients, collapsed by their type of aphasia) was entered as between-subjects factor. The ANOVAs showed a main effect of GC, $F_1(1, 58) = 10.89$, $p < .01$, $\eta^2 = .16$; $F_2(1, 56) = 6.38$, $p<.05$, $\eta^2 = .10$, and imageability, $F_1(1, 58) = 15.43$, $p<.001$, $\eta^2 = .21$; $F_2(1, 56) = 10.01$, $p<.01$, $\eta^2 = .15$, both by participants and items. The effect of group was also significant, by participants and items, $F_1(1, 58) = 30.57$, $p<.001$, $\eta^2 = .35$; $F_2(1, 56) = 72.93$, $p<.001$, $\eta^2 = .57$, with normal controls performing significantly better than aphasic patients. Also, the interaction GC × group, $F_1(1, 58) = 9.86$, $p<.01$, $\eta^2 = .15$; $F_2(1, 56) = 7.41$, $p<.01$, $\eta^2 = .12$, and imageability × group, $F_1(1, 58) = 5.13$, $p<.05$, $\eta^2 = .08$; $F_2(1, 56) = 4.33$, $p<.05$, $\eta^2 = .07$, reached significance both by participants and items. All the other interactions were not significant, that is, GC × Imageability and GC × Imageability × Group (all Fs < 1).

To analyze the main effect of group and the interactions, the same analyses were conducted by group (normals and aphasics) separately. For normal controls, only the main effect of imageability reached significance, marginally by participants and significant by items, $F_1(1, 29) = 3.71$, $p = .064$, $\eta^2 = .11$; $F_2(1, 56) = 4.64$, $p<.05$, $\eta^2 = .08$. The main effect of GC or the interaction GC × imageability did not reach significance (both Fs < 1). In the group of aphasic participants, GC, $F_1(1, 29) = 11.32$, $p<.01$, $\eta^2 = .28$; $F_2(1, 56) = 7.65$, $p<.01$, $\eta^2 = .12$, and imageability, $F_1(1, 29) = 11.78$, $p<.01$, $\eta^2 = .29$; $F_2(1, 56) = 7.88$, $p<.01$, $\eta^2 = .12$, were significant by participants and items. The interaction GC × imageability did not reach significance (both Fs < 1).

To further study the influence of GC and imageability in the aphasic population, the group of aphasic patient (productive vs receptive) was added as between-subjects factor. For the aphasic participants both the main effects of GC, $F_1(1, 28) = 12.80$, $p<.01$, $\eta^2 = .31$; $F_2(1, 56) = 7.84$, $p<.01$, $\eta^2 = .12$, and imageability, $F_1(1, 28) = 12.76$, $p<.01$, $\eta^2 = .31$; $F_2(1, 56) = 7.78$, $p<.01$, $\eta^2 = .12$, were significant by participants and items. The scores for nouns were better than those for verbs, and highly imageable word pairs better than low imageable ones. Also, the effect of group reached significance, both by participants and items, $F_1(1, 28) = 11.47$,

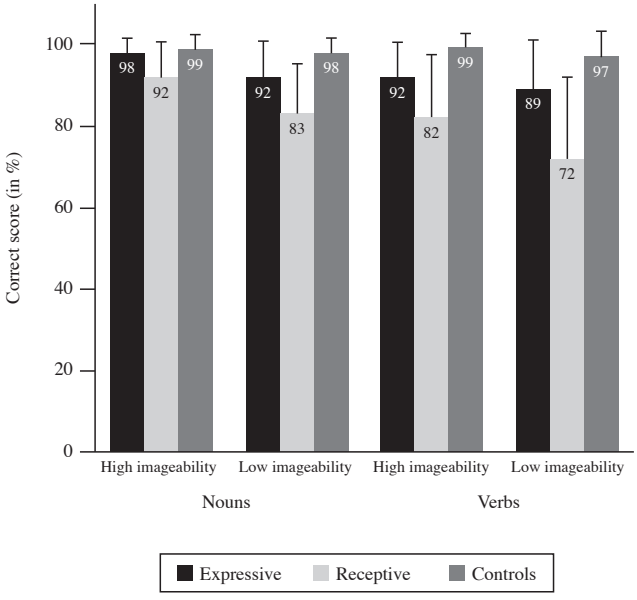

Figure 1. *Mean score (in %) and standard deviation (error bars) in the synonym judgment task as a function of grammatical class (nouns and verbs), imageability (high and low) and group of participants (expressive and receptive aphasia, and controls)*

$p<.01$, $\eta^2 = .29$; $F_2(1, 56) = 49.90$, $p<.001$, $\eta^2 = .47$. Patients with productive aphasia performed better than patients with receptive aphasia. Again, interactions were not significant, that is, GC × Imageability and GC × Imageability × Subgroup did not reach significance (all Fs < 1).

To control for the possible effect of the type of lesion, new analyses were carried out removing the three brain trauma patients. The results remained unchanged, thus, these participants remained in the main analyses.

Discussion

This study aimed to examine (a) the possibility that the apparent dissociation in verbs and nouns processing reported in aphasic patients could be, at least partially, explained by semantic-conceptual impairments and, (b) the claim made by Bird et al. (2000) that the semantic deficit affecting specifically verbs is due to the lower degree of imageability associated with this GC. The independent effects of GC and imageability found here provide evidence against the idea that the GC effect is, indeed, an effect of imageability in disguise (Berndt et al., 2002; Crepaldi et al., 2006). Alternatively, these results support the hypothesis that the GC effect can emerge from a semantic locus.

The fact that on the overall SJT, the aphasic group performed significantly worse than the controls demonstrates that these patients have impaired semantic processing. Congruent with what has been predicted, the comparative global results of the aphasic subgroups manifests greater severity of this deficit in the receptive aphasia group, known to have greater semantics impairments (Turgeon & Macoir, 2008).

The main GC effect obtained for the two subgroups of aphasics indicates that despite the more serious semantic deficit of the receptive aphasia subgroup, both receptive and expressive patients in this study display a significant noun/verb dissociation, which emerges in a task engaging mainly semantic knowledge. Additionally, the absence of an interaction between the subgroups of patients and the GC effect in the present study is in line with the results obtained by Luzzatti et al. (2002), who found no significant interaction between the relative impairment of verbs vs nouns for the receptive (fluent) compared to the expressive (non-fluent) groups of aphasics.

Altogether, these results appear to be consistent with the conclusion expressed by Vigliocco et al. (2011) that the differences in the treatment of nouns and verbs could rely, in good part, on semantic basis. Then the apparent GC effect could be the expression of impaired semantic features related to the underlying concepts (actions vs objects), rather than specific grammatical impairments. However, Bird et al. (2000) and Luzzatti et al. (2002) found that once semantic confounding factors were taken into account, most- if not all- of the GC effect vanished, which was not the case in the present study. Both GC and imageability affected performance in the SJT in the aphasic groups.

Nonetheless, although the results of the present study demonstrate that the GC effect may indeed be the manifestation of impaired semantic treatment, no interaction emerged between the imageability parameter and the respective performance for nouns and verbs. Though congruent with anterior results (Berndt et al., 2002; Crepaldi et al., 2006), this result may appear somewhat intriguing, in so far as imageability is usually associated to the nature of concepts' semantic features. This apparent contradiction also appeared in a neuroimaging study conducted by Bedny and Thompson-Schill (2006), who used a semantic similarity judgment task to compare the neural activations associated with the semantic treatment of verbs and nouns of varying degrees of imageability. Congruent with the results of the present study, Bedny and Thompson-Schill found anatomically separable main effects for GC and imageability, in addition to the interaction between imageability and GC. These results showed that the brain network sustaining normal GC processing differed from that of imageability treatment, even though both effects partially correlated. Namely, Bedny and Thompson-Shill found activation associated with imageability increase independently of the GC in the left superior parietal lobule and the left fusiform, greater activation for verbs than nouns of equal imageability in the left superior temporal gyrus and activation in both the left middle temporal gyrus and the left inferior frontal lobe associated to a decrease in imageability, but only for nouns, not for verbs.

In sum, the results of the present study show that imageability and GC independently affect performance in aphasia. Also, that the GC effect seems to stem—at least partially —from a semantic locus, rather than exclusively on syntactic or lexical loci. Still, further research is needed to better clarify the respective contributions of semantic and grammatical treatment and their role in the noun-verb dissociation observed in aphasia. In particular, one thing that has not been included in the present study that would permit to extend this comprehension is to measure latencies (reaction times) during processing. By doing so, subtler differences in performance would become apparent and allow the emergence of an even clearer pattern.

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