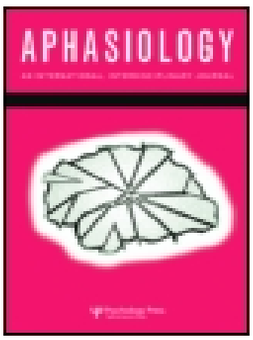

Aphasiology

ISSN: 0268-7038 (Print) 1464-5041 (Online) Journal homepage: http://www.tandfonline.com/loi/paph20

Recognition of thematic and taxonomic conceptual relations in patients with aphasia

Leticia Vivas, Ricardo García García, María Victoria Perea Bartolomé, Agostinho Leite D'almeida & Valentina Ladera Fernández

To cite this article: Leticia Vivas, Ricardo García García, María Victoria Perea Bartolomé, Agostinho Leite D'almeida & Valentina Ladera Fernández (2015): Recognition of thematic and taxonomic conceptual relations in patients with aphasia, Aphasiology, DOI: 10.1080/02687038.2015.1111996

To link to this article: http://dx.doi.org/10.1080/02687038.2015.1111996

Aphasiology, 2015
http://dx.doi.org/10.1080/02687038.2015.1111996

Recognition of thematic and taxonomic conceptual relations in patients with aphasia†

Leticia Vivas[a]*, Ricardo García García[b], María Victoria Perea Bartolomé[b], Agostinho Leite D'almeida[c] and Valentina Ladera Fernández[b]

[a]*CONICET; Centro de Procesos Básicos, Metodología y Educación, Facultad de Psicología, Universidad Nacional de Mar del Plata, Mar del Plata, Argentina;* [b]*Departamento de Psicología Básica, Psicobiología y Metodología de las Ciencias del Comportamiento, Facultad de Psicología, Universidad de Salamanca, Salamanca, Spain;* [c]*Departamento de Ciências Sociais e do Comportamento, Instituto Universitário da Maia (ISMAI), Porto, Portugal*

(Received 4 June 2015; Accepted 20 October 2015)

Background: There is mounting evidence that there exist conceptual non-verbal deficits in patients with aphasia. In the current paper, taxonomic and thematic conceptual relations are the focus of interest. There is a debate surrounding this topic regarding whether they are part of the same semantic system or there are independent systems dedicated to each kind of relations.
Aims: Our aim was to study and look for possible dissociations in a group of fluent and non-fluent aphasic patients on their ability to recognise conceptual relations (taxonomic and thematic).
Methods & Procedures: Previous studies have usually proposed forced-choice tasks, which give the patients closed response options and do not allow the researcher to assess the criteria for the choice the participants have made. In the following study we assigned different types of conceptual tasks (forced choice and free choice) to a group of 25 stroke patients (7 fluent and 18 non-fluent aphasic patients), as well as 30 healthy control participants. We assessed the hit rates and the response criteria followed by the patients.
Outcomes & Results: The results showed that although all aphasic patients experienced difficulties in establishing both types of conceptual relations in verbal tasks, dissociations were observed particularly in non-verbal tasks showing poor performance in thematic relations. This was especially noticeable in non-fluent aphasic patients. Meanwhile, fluent aphasic patients showed more difficulty in establishing taxonomic relations in the pictorial free-choice task and a tendency to use thematic criteria.
Conclusion: These results support the claim that there exist separate systems for both kinds of conceptual relations. Implications for the assessment of semantic deficits in aphasic patients were discussed.

Keywords: aphasia; conceptual deficit; thematic relation; taxonomic relation; stroke

Introduction

It has been shown, from early research in aphasia, that these patients often have conceptual non-verbal deficits which could be solved without the use of language (for a review, see Gainotti, 2014). There is a debate about the exact relation between the verbal communication disorder and this non-verbal difficulty. Some authors propose that non-

*Corresponding Author: lvivas@mdp.edu.ar
†This research was conducted at the National University of Mar del Plata (Argentina).

verbal disorders are due to a preverbal conceptual disorder consisting of a defect in controlled retrieval (Bay, 1964; Duffy & Watkins, 1984; Gainotti, D'Erme, Villa, & Caltagirone, 1986). Others consider that language disorders have a negative influence on non-verbal cognitive abilities (Lhermitte & Beauvois, 1973) or specifically in categorisation (Lupyan & Mirman, 2013). More recent research has shown that conceptual non-verbal disorders can be explained as a defect in executive processes that help direct and control semantic activation in a task appropriate fashion (Corbett, Jefferies, & Ralph, 2011; Gardner et al., 2012; Jefferies, Baker, Doran, & Lambon Ralph, 2007) or even a domain-specific semantic control (Hoffman, Jefferies, Haffey, Littlejohns, & Lambon Ralph, 2013).

Within the research in non-verbal cognitive deficits in patients with aphasia, there is a line of research that has focused particularly on the study of defects in establishing or detecting conceptual relations in patients with different types of aphasia (Bisiacchi, Denes, & Semenza, 1976; Gardner & Zurif, 1976; Semenza, Denes, Lucchese, & Bisiacchi, 1980) as was outlined above. Conceptual relationships are links that interconnect concepts and link them together. Two such relations—thematic and taxonomic—play a fundamental role. Taxonomic relations (also called categorical) are those that link concepts of the same semantic category (Lin & Murphy, 2001). Since the components of these relations have common features, linkages are established primarily through similarity detection mechanisms, i.e., comparing the properties of both concepts and on that basis deciding how similar they are (Wisniewski & Bassok, 1999). Taxonomic relations allow for anticipating, by deduction and inference processes, many of the properties a new element to be included within the structure of a category will have (Barsalou, 2005).

Thematic relations are defined as complementary relations between objects, people or events that interact or co-occur in time and space (Lin & Murphy, 2001). Those are contextual relations between objects that are not of the same kind but can be found in the same schemes. Therefore, thematic relations involve space–time relations between objects and actions experienced. This type of categories allows to organise experience contextually and to make predictions in similar future situations through the inference mechanism of pattern completion (see Barsalou, 2005).

There are studies that suggest that taxonomic and thematic relations are processed in partially independent brain areas, but there is some controversy in the existing scientific literature on which brain areas are involved. Recent studies suggested that taxonomic relations rely heavily on the left anterior temporal lobe and thematic relations on the left temporo-parietal junction (Schwartz et al., 2011). A number of studies concurred that taxonomic relations require a greater effort to be processed than thematic relations (Peraita & Moreno, 2006) and, therefore, greater brain activation (Jackson, Hoffman, Pobric, & Lambon Ralph, in press; Sachs, Weis, Zellagui, et al., 2008). Simultaneously, some studies stated that taxonomic relations require greater right hemisphere activation because of their complexity (Kotz, Cappa, von Cramon, & Friederici, 2002) while others agreed that the activation is mainly in posterior brain areas, such as the posterior cingulate, precuneus and cuneus (Kalénine et al., 2009; Kuchinke, van deer Meer, & Krueger, 2009; Sachs, Weis, Krings, Huber, & Kircher, 2008). However, there is a paper by Khateb et al. (2003) that indicated that the processing of taxonomic conceptual relations depends primarily on the left hemisphere.

Moreover, recent studies indicate a distinct possibility that taxonomic and thematic relations would not be independent processes but rather would be part of the same unified semantic system (Jackson et al., in press). This implies that different patterns of errors

observed in stroke aphasic and semantic dementia patients may reflect graded differences in task difficulty.

Early studies done in post-stroke patients suggested that patients with Wernicke's aphasia tend to have greater difficulty in establishing taxonomic relations as opposed to thematic ones (Bisiacchi et al., 1976; Gardner & Zurif, 1976; Semenza et al., 1980). Meanwhile, Semenza (1999) and Semenza, Bisiacchi, and Romani (1992) argued that patients with lesions on the posterior areas of left hemisphere have significantly more problems in establishing categorical classifications, while patients with lesions in the anterior brain areas often present the opposite pattern showing difficulties in establishing thematic relations. Besides, it was found that patients with intact taxonomic classification ability often prefer to classify according to thematic criteria (Zurif, Caramazza, Myerson, & Galvin, 1974).

Recent research done with individuals with anomic aphasia has particularly studied the categorisation performance of these patients varying the number of dimensions that shared the category items. They found that the degree of categorisation impairment was predicted by naming performance but independent of the lesion size and location (Lupyan & Mirman, 2013). They interpreted these results under the hypothesis that language supports cognitive functioning, particularly the ability to select task-relevant stimulus features.

On the other hand, some recent clinical reports also provided evidence for the dissociation of taxonomic and thematic relations in patients with focal brain damage (Kalènine, Mirman, & Buxbaum, 2012). Particularly, a single case study reported by Davidoff and Roberson (2004) described a patient with Wernicke aphasia, which presented an impaired perceptual and taxonomic categorisation but with a preserved thematic categorisation. In another study carried out by Cuetos-Vega and Castejón (2005), they described a stroke patient with an extensive left parietal-temporal-occipital lesion that showed a clear impairment of conceptual knowledge and used thematic relations to offset the deficits in tasks that required taxonomic responses, especially when the patient was required to access the superordinate category.

In summary, although there are many studies in conceptual deficits in aphasic patients, there are few recent studies specifically concerned about the processing of conceptual relations. There are also very few studies about non-fluent aphasic patients. Moreover, most previous research has focused on forced-choice tasks (where constrained response options are available). These tasks do not allow to analyse the criteria used by the patient or the preference for certain type of categorisation. In some occasions apparent taxonomic relations (e.g., carrot and tomato) could be based on thematic criteria (e.g., "they can be used to make a salad") (Davidoff & Roberson, 2004). In this paper we analyse the taxonomic and thematic conceptual relations in patients with non-fluent and fluent aphasia through forced-choice and free-choice tasks, where there is the possibility of analysing the preferred categorisation criteria. In addition, we take into account tasks that involve different presentation modes (verbal and pictorial) to be able to study conceptual deficits with independence of language.

Methods

Participants

This study and the informed consent form were approved by the Ethics Committee of the Institutional Review Board for Research Studies of the Hospital Privado de Comunidad (HPC) and Research Committee of the Hospital Interzonal General de Agudos (HIGA).

We recruited 25 participants with left unilateral stroke lesion (44% woman) who had been acutely diagnosed with aphasia from the Neurology Services Registry of the HPC and the HIGA of Mar del Plata city (Argentina). We also recruited 30 age- and education-matched controls (53% woman). All participants were right handed and native Spanish speakers.

Inclusion criteria for patients were: (1) to have suffered a stroke, (2) to be oriented in time and space, (3) to have normal vision or corrected to normal, and (4) to understand simple commands (measured by the subtest of verbal word comprehension from Barcelona's battery, Peña-Casanova, 1991). Exclusion criteria for patients were: (1) to depend on artificial respiration, (2) to have previously dementia or cognitive impairment, (3) to have a severe mental illness. Exclusion criteria for control participants were: (1) to have dementia, (2) to have cognitive impairment from any cause, and (3) to have suffered a disease affecting the central nervous system.

Demographic data of patients and healthy controls are shown in Table 1. Neurological and neuropsychological background data and aphasia classification of each patient can be seen in Table 2.

Aphasia type was assessed by using the Brief Aphasia Assessment Test (Viglieccaet al., 2011). Then, participants were classified in two groups, fluent or non-fluent, according to the criteria proposed by Gozálezand Toledo (2007). While the criteria do not provide enough information about the characteristics of the aphasic syndrome presented by the patient, they are widely used for research purposes to obtain two broad categories of analysis (e.g., Barwood et al., 2011; Kambanaros, 2008; Mason-Baughman & Wallace, 2013).

According to Helo (2007) fluent aphasias are characterised by uninterrupted sequences of five or more words, well-articulated, showing difficulty in retrieving words, which is disproportionately impaired when compared with fluency. Wernicke's, Transcortical Sensory, Conduction, and Anomic aphasias are considered to fall within the category of fluent aphasia. Moreover, according to Toledo (2007), non-fluent aphasias are characterised by patterns of laborious speech production, usually with impaired ability to generate articulatory movements to produce words and they imply mainly impairment in the utterance. Broca's, transcortical, global, and mixed transcortical aphasias are considered non-fluent aphasias. In the present paper the variable "type of aphasia" was dichotomised taking into account this classification; as a result two groups of patients were formed: a group of fluent aphasia involving 8 patients and a group of non-fluent aphasia consisting of 17 patients.

Table 1. Socio-demographic data by group.

Group	Age	Education level	Gender
Stroke patients	73.96 (SD: 11.083)	61% elementary	32% F/58% M
		28% high school	
		7% higher education/university	
Control group	70.04 (SD: 15.428)	65% elementary	59% F/41% M
		26% high school	
		8,7% higher education/university	

F: Female; M: male; SD: standard deviation.

Table 2. Patient's neurological and neuropsychological background data.

Patients	Age	Sex	Educational level	Lesion localisation	Cortical-subcortical	Stroke type	Aphasia classification	Aphasia type	Brief Aphasia Assessment test	Comprehension	Word–picture matching	Naming
AM	46	F	2	L-ND	Cortico-subcortical	Haemorrhagic	Broca	Non-fluent	136	12/14*	12/12	23.50/24*
ASC	79	F	1	L-Parietal	Cortical	Haemorrhagic	Broca	Non-fluent	132	14/14	12/12	23.00/24*
ASI	78	M	4	L-Frontal	Cortical	Ischaemic	Transcortical motor	Non-fluent	125	10/14*	11/12*	24.00/24
BS	79	M	2	L-Occipital	Cortical	Haemorrhagic	Broca	Non-fluent	97	10/14*	7/12*	7.80/24*
BZ	87	F	1	L-ND	Cortico-subcortical	Ischaemic	Anomic aphasia	Non-fluent	138	12/14*	12/12	24.00/24
DE	72	M	1	L-ND	ND	Ischaemic	Transcortical motor	Non-fluent	140	14/14	12/12	24.00/24
EAL	77	M	2	L-ND	ND	Ischaemic	Broca	Non-fluent	140	14/14	12/12	24.00/24
EC	81	F	1	L-ND	Subcortical	Ischaemic	Wernicke	Fluent	119	14/14	12/12	24.00/24
ELE	82	F	2	L-Frontal	Cortico-subcortical	Ischaemic	Transcortical motor	Non-fluent	138	14/14	12/12	22.05/24*
ELU	53	M	3	L-Fronto-temporal	Cortico-subcortical	Ischaemic	Broca	Non-fluent	90	10/14*	10/12*	–
FR	84	F	3	L-Fronto-parietal	Subcortical	Haemorrhagic	Wernicke	Fluent	89	10/14*	12/12	4.00/24*
FT	59	M	3	L-Temporo-parietal-occipital	ND	Ischaemic	Wernicke	Fluent	96	12/14*	12/12	5.60/24*
GG	72	M	1	L-ND	Subcortical	Ischaemic	Broca	Non-fluent	139	14/14	12/12	24.00/24
JP	54	M	1	L-Basal ganglia	ND	Ischaemic	Broca	Non-fluent	126	12/14*	12/12	22.30/24*
JS	79	M	3	L-Fronto-parietal	Subcortical	Ischaemic	Wernicke	Fluent	120	12/14*	12/12	19.30/24*
LS	70	M	4	L-Capsular	Cortical	Ischaemic	Transcortical motor	Non-fluent	115	10/14*	12/12	20.00/24*
MC	63	M	2	L-Parietal-occipital	Cortico-subcortical	Ischaemic with haemorrhagic transformation	Wernicke	Fluent	110	10/14*	12/12	5.00/24*

(*continued*)

Table 2. (*Continued*).

Patients	Age	Sex	Educational level	Lesion localisation	Cortical-subcortical	Stroke type	Aphasia classification	Aphasia type	Brief Aphasia Assessment test	Comprehension	Word–picture matching	Naming
MPR	77	F	2	L-ND	Cortico-subcortical	Ischaemic	Broca	Non-fluent	128	12/14*	12/12	24.00/24
MR	92	F	3	L-Fronto-parietal	Cortical	Ischaemic	Broca	Non-fluent	132	14/14	12/12	23.80/24*
NA	84	F	1	L-Temporo-parietal	Cortico-subcortical	Ischaemic	Broca	Non-fluent	112	10/14*	10/12*	10.50/24*
RA	74	M	1	L-Frontal	Cortical	Ischaemic	Transcortical motor	Non-fluent	136	12/14*	12/12	22.00/24*
SR	73	F	3	L-ND	ND	Ischaemic	Wernicke	Fluent	130	14/14	12/12	24.00/24
TM	74	M	2	L-Fronto-parietal	Cortical	Ischaemic	Transcortical motor	Non-fluent	142	14/14	12/12	24.00/24
VC	86	M	1	L-Talamic	Subcortical	Haemorrhagic	Broca	Non-fluent	132	14/14	12/12	24.00/24
VP	75	F	1	L-ND	Subcortical	Ischaemic	Transcortical sensorial	Fluent	138	12/14*	12/12	24.00/24

*Scores significantly lower than controls, $p < .05$, according to case-controls analysis developed by Crawford et al. (2010).ND: no data.

General neuropsychological assessment

The following tests and scales were administered in order to ensure that patients and controls followed the inclusion/exclusion criteria: Minimental (Butman et al., 2001), Anxiety and Depression Goldberg' scale (Montón et al., 1993), short version of the Reporter Test (Morales, González-Montalvo, Bermejo, & Del Ser, 1995), word–picture matching and visual confrontation naming from EMSDA battery (Peraita, González-Labra, Sánchez Bernardos, & Galeote, 2000) and subtest of verbal word comprehension from Barcelona's battery (Peña-Casanova, 1991). In the case of the aphasic patients it was also considered the clinical history information in order to ensure they did not have previous dementia. Background neuropsychological data can be seen in Table 2.

Experimental tasks

Three tasks were administered to assess conceptual relations. The first two were equivalent in terms of the arrangement of the stimuli and the instructions. They had a triadic comparison display requiring forced-choice response, i.e., they admit only one correct answer. They were presented in verbal and pictorial display. In turn, there was a pictorial free-choice task, in which the response could be either taxonomic or thematic (PICTURE SORTING).

Forced-choice task to assess taxonomic conceptual relations: verbal and pictorial

TAXON-VERBAL and TAXON-PICTORIAL: This is a task that was designed in a triadic comparison format, meaning that there are three stimuli, two below and one above in the middle and the person must decide which of the two below is more associated with the one above. There is only one correct answer. The stimuli are words or pictures of the same semantic category with different degrees of proximity to one another (one of the items is semantically closer to the target while the other is further away). It is comprised of 18 items belonging to the categories of clothing, animals, fruits/vegetables, furniture, tools and transportation. Its design is described in detail in Appendix 1.

Forced-choice tasks to assess thematic conceptual relations: verbal and pictorial

Pyramids and Pharaohs verbal and pictorial (THEMATIC-VERBAL and THEMATIC-PICTORIAL): This is a short version of the Argentinean adaptation of the Pyramids and Palm Trees Task of Howard and Patterson (1992) made by Martinez-Cuitiño and Barreyro (2010). This task assesses the ability to detect thematic relations. This is a triadic comparison task (matching-to-sample), where there are two stimuli below and one above and the person must decide which of the two below is more associated with the one above. The test consists of 19 items. The Argentinean version of this test has a specificity of 98.8% and a sensitivity of 85% to detect individuals with semantic difficulties.

Free-choice task for the assessing of conceptual relationships

A pictorial free-choice task was administered: PICTURE SORTING. This task belongs to the EMSDA battery (Peraita et al., 2000). The stimuli are 18 line drawings in the

categories of food, clothing, furniture, animals, vehicles and plants. Despite the fact that the correct response in these tasks is taxonomic, they have potential thematic links too and the instructions do not make explicit the requirement to establish any kind of relations. Participants are told to organise pictures by grouping them according to the criteria they want and then they must justify their choice. The criteria used by the participants were classified into taxonomic, thematic or otherwise. Thus, this task provides additional information as it allows to assess if the participants have a tendency or preference for one type of relation over another.

Procedures

Patients were assessed individually by an experienced neuropsychologist. The interview took place following an assessment by a neurologist. After obtaining informed consent, each patient was assessed individually. The tasks required two separate sessions of approximately 30 minutes each. The control group participants were tested individually in two separate sessions of approximately 30 minutes each, after obtaining informed consent and verifying that the inclusion criteria were met. The administration of tasks A and B was done through *Presentation* 10.1 software package (Neurobehavioral Systems, http://www.neurobs.com/). Verbal and pictorial versions of both tests were administered in separate sessions. Individual patient's performance in the experimental tasks alongside with the statistical comparison (according to the method proposed by Crawford, Garthwaite, & Porter, 2010) between each one and the control sample is shown in Table 3.

Results

Scores obtained in the five tasks were transformed to *z* scores. Descriptive results by group are shown in Table 4. In the first place control participants' scores were analysed in order to see if there were any difficult differences between presentation modality (verbal/pictorial), type of relation (thematic/taxonomic) and free-choice and forced-choice tasks in normal population. As can be seen in Table 5, there were no significant differences according to a related measures *t*-test. However, as many patients performed at ceiling level we also took notice and analysed response latencies. They obtained significantly lower scores both in THEMATIC verbal than TAXON verbal ($t = 3.771$; $p = .007$) and in the pictorial version of THEMATIC task ($t = -2.85$; $p = .025$). Differences between TAXON and THEMATIC pictorial were near significance ($t = 2.231$; $p = .061$) with lower scores in THEMATIC pictorial, while there were no statistically significant differences between pictorial and verbal versions of TAXON ($t = -.904$; $p = .396$). With regard to patient's response latencies, significantly lower scores in THEMATIC VERBAL than TAXON VERBAL ($t = 2.922$; $p = .022$) were detected, while the differences between THEMATIC PICTORIAL and VERBAL were near significance ($t = -2.096$; $p = .074$), with lower scores in the pictorial modality.

After that, we focused on patient's performance. A three-way repeated-measures ANOVA was used to investigate the main effects and interactions in forced-choice tasks for type of aphasia (fluent vs. non-fluent), type of semantic relation (taxonomic vs. thematic) and presentation modality (verbal vs. pictorial). Patient's *z* scores were considered. Results showed a significant main effect for type of relation; $F(1, 21) = 7.924$, $p = .01$, Eta = .274. Complete results can be seen in Table 6.

Additionally, we ran the same analysis but taking into account lesion location instead of aphasia type. We classified the sample in frontal and non-frontal following Stuss et al.

Table 3. Patient's individual scores in experimental tasks.

Patients	Aphasia type	TAXON VERBAL	THEMATIC VERBAL	TAXON PICTORIAL	THEMATIC PICTORIAL	PICTURE SORTING
AM	Non-fluent	17	19	18	19	18
ASC	Non-fluent	12*	13***	15	19	8***
ASI	Non-fluent	8***	12***	12*	14***	0***
BS	Non-fluent	11***	10***	10***	12***	4***
BZ	Non-fluent	9***	9***	10***	10***	10*
DE	Non-fluent	–	–	17	16*	16
EAL	Non-fluent	15	18	14	18	18
ELE	Non-fluent	13*	15***	14	17	18
ELU	Non-fluent	-	-	16	19	6***
GG	Non-fluent	16	17	17	17	16
JP	Non-fluent	14	13***	14	13***	16
LS	Non-fluent	10***	13***	12*	13***	16
MPR	Non-fluent	12*	16*	16	15***	9**
MR	Non-fluent	15	19	17	19	15
NA	Non-fluent	9***	9***	9***	7***	0***
RA	Non-fluent	10***	17	11**	17	14
TM	Non-fluent	15	18	16	18	16
VC	Non-fluent	11**	10***	11**	12***	15
EC	Fluent	14	17	12*	19	14
FR	Fluent	16	17	16	18	14
FT	Fluent	13*	11***	13	13***	12
JS	Fluent	15	17	15	15***	11*
MC	Fluent	14	17	17	19	17
SR	Fluent	15	18	17	19	13
VP	Fluent	6***	13***	8*	12***	2***

*Scores significantly lower than controls, $p < .05$, according to case-controls analysis developed by Crawford et al. (2010).
** $p < .01$.
*** $p < .001$.

(2000). Patients showing frontal lesion with a minor overlap with non-frontal areas were also considered in the frontal group. Results can be seen in Table 7. As can be seen, only an effect in Type of Relation was observed. Lesion localisation did not show a statistically significant effect.

To go deeper into the analysis of the effect of type of relation an individual patient's analysis was performed. The Revised Standardised Difference Test by Crawford et al. (2010) was used. Results are shown in Table 8. Looking at non-fluent patients, we realised that many of them showed a dissociation between taxonomic and thematic tasks with lower scores in the latter. All of these patients had posterior lesions (i.e., non-frontal). RA was the only non-fluent aphasic patient who obtained a classical dissociation with lower scores in the taxonomic verbal task. This patient had a frontal lesion. Regarding fluent aphasic patients the pattern was not homogeneous: four patients did not show dissociation, while patients FT and JS (both with lesions including parietal lobe) showed a similar

Table 4. Participant's performance on experimental tasks.

			TAXON-VERBAL	THEMATIC-VERBAL	TAXON-PICTORIAL	THEMATIC-PICTORIAL	PICTURE SORTING
Control sample (n = 30)	Scores	Media	15.63	17.8	15.9	18.3	15.37
		SD	1.474	1.031	1.826	.988	2.399
	Response latencies[a]	Media	61275	54159	58652	48205	-
		SD	11259	12005	19590	10548	-
Non-fluent (n = 16)	Scores	Media	12.31	14.25	13.83	15.28	11.94
		SD	2.774	3.587	2.854	3.511	6.073
	Response latencies	Media	166920	102150	120089	72701	-
		SD	81235	44896	91724	60112	-
Fluent (n = 7)	Scores	Media	13.29	15.71	14	16.43	11.86
		SD	3.352	2.628	3.266	3.047	4.741
	Response latencies	Media	17896	101987	139228	57688	-
		SD	76856	34445	99635	54629	-

SD: Standard deviation
[a] Values are expressed in milliseconds.

pattern to non-fluent patients, and EC showed a classical dissociation with lower scores in the taxonomic task just in pictorial presentation modality.

Furthermore, patients' performance in free-choice task was taken into account. Two aspects were analysed: the total score and the classification criteria. A non-parametrical test comparing both groups of patients and control participants considering their z scores was performed. Only fluent aphasic patients showed significant differences with the control group, $U = 47.5$; $p = .009$, and no significant differences between aphasic groups were observed, $U = 53$; $p = .544$. When analysing the second aspect, classification criteria, the aphasic patient's profile differed in comparison with control group. It was observed that non-fluent aphasic patients showed no significant differences with the control group neither in taxonomic, $U = 136.500$, $p = .063$, nor in thematic criteria, $U = 146.500$, $p = .080$. Meanwhile, fluent aphasic patients obtained significant differences in both taxonomic, $U = 24.500$, $p < .005$, and thematic criteria, $U = 31.500$, $p < .01$. As can be seen in Figure 1, participants with fluent aphasia obtained significantly lower scores than the control group in the taxonomic criteria but also obtained higher scores in the thematic criteria.

A correlation analysis to compare patients' performance in background neuropsychological tests and experimental tasks was also conducted. As can be seen in Table 9, the background test that most correlated with experimental tasks was Word–picture matching, while Comprehension only reached a significant correlation with the free-choice task but was marginally associated with most forced-choice tasks.

Discussion

As previous studies indicated aphasic patients can show non-verbal conceptual disorders with relative independence of their language impairment (for a review, see Gainotti, 2014). The current paper focused particularly on the processing of conceptual relations (taxonomic and thematic) in verbal and non-verbal tasks in patients with fluent and non-fluent aphasia.

Table 5. Comparison between tasks in the control group.

	TAXON-VERBAL vs. THEMATIC VERBAL	TAXON PICTORIAL vs. TAXON VERBAL	TAXON PICTORIAL vs. THEMATIC PICTORIAL	THEMATIC PICTORIAL vs. THEMATIC VERBAL	PICTURE SORTING vs. TAXON VERBAL	PICTURE SORTING vs. TAXON PICTORIAL	PICTURE SORTING vs. THEMATIC VERBAL	PICTURE SORTING vs. THEMATIC PICTORIAL
Z	–.463[a]	–.484[a]	–.175[b]	–.649[b]	–.339[b]	–.339[b]	–.031[b]	–.134[b]
Asympt. Sig.	.643	.629	.861	.516	.734	.734	.975	.894

[a]Based on positive range.[b]Based on negative range.

Table 6. Results of three-way repeated-measures ANOVA with aphasia.

Source	*F*	Sig.	Partial eta squared
Type of relation[a]	**7.924**	**.010**	**.274**
Presentation modality	.676	.420	.031
Aphasia	.404	.532	.019
Type of relation × aphasia	1.527	.230	.068
Presentation modality × aphasia	.758	.394	.035
Type of relation × presentation modality	2.410	.136	.103
Type of relation × presentation modality × aphasia	.036	.851	.002

[a] Type of relation: taxonomic or thematic.

Table 7. Results of three-way repeated-measures ANOVA with lesion localisation.

Source	*F*	Sig.	Partial eta squared
Type of relation[a]	**7.453**	**.021**	**.427**
Presentation modality	1.352	.272	.119
Localisation[b]	3.339	.098	.250
Type of relation × localisation	.808	.390	.075
Presentation modality × localisation	.017	.898	.002
Type of relation × presentation modality	.881	.370	.081
Type of relation × presentation modality × localisation	1.255	.289	.111

[a] Type of relation: taxonomic or thematic.
[b] Localisation: frontal versus non-frontal lesion.

In the first place, it is important to consider control group's performance on experimental tasks. It was found out that they showed no differences in performance in their scores in the five tasks. However, as can be seen in Table 4, they got lower scores in taxonomic and free-choice tasks. Moreover, in the forced-choice tasks (where response time was available), they showed slower response latencies in thematic than in taxonomic tasks and also in pictorial versus verbal modality in the thematic tasks. This last result is in accordance with previous research which suggests that pictorial modality is faster than verbal modality (Paivio, 1986). Regarding taxonomic versus thematic differences, the results suggest that taxonomic tasks are more difficult. Such finding was unexpected as some taxonomic pair of stimuli inevitably had also thematic relations and it could be hypothesised that this would increase similarity judgement (Golonka & Estes, 2009). However, there are also many recent studies that claim that taxonomic relations are more complex and require more abstract processing than thematic ones (Kotz et al., 2002; Peraita & Moreno, 2006; Sachs et al., 2008).

Focusing on patient's group analysis, it was found that there was an effect of relation type in the participant's performance, perhaps indicating a poorer performance in thematic relative to taxonomic tasks. A closer individual patient's analysis can shed light in this regard which will be shown later. It is also interesting to note the absence of presentation modality effect, as this indicates that aphasic patients obtained similar scores either in verbal or in non-verbal tasks. They did not show a poorer performance in verbal conceptual tasks, as could be hypothesised because of their linguistic problems. These

Table 8. Within subjects comparison between taxonomic and thematic tasks.

Patients	Aphasia type	Lesion location	TAXON VERBAL vs. THEMATIC VERBAL	TAXON PICTORIAL vs. THEMATIC PICTORIAL
AM	Non-fluent	ND	*T* = .178	*T* = .346
ASC	Non-fluent	Posterior	*T* = 1.667	*T* = .942
ASI	Non-fluent	Anterior	*T* = .342	*T* = 1.737
BS	Non-fluent	Posterior	***T* = 3.357****	***T* = 2.463****
BZ	Non-fluent	ND	***T* = 3.065****	***T* = .4.039****
DE	Non-fluent	ND	–	***T* = 2.295***
EAL	Non-fluent	ND	*T* = .473	*T* = .578
ELE	Non-fluent	Anterior	*T* = .708	*T* = .216
ELU	Non-fluent	Anterior/posterior	–	*T* = .513
GG	Non-fluent	ND	*T* = .781	*T* = 1.503
JP	Non-fluent	ND	***T* = 2.696***	***T* = 3.382***
LS	Non-fluent	Posterior	*T* = .636	***T* = 2.528****
MPR	Non-fluent	ND	*T* = .545	***T* = 2.658***
MR	Non-fluent	Anterior/posterior	*T* = 1.201	*T* = .083
NA	Non-fluent	Posterior	***T* = 3.065****	***T* = 5.959****
RA	Non-fluent	Anterior	***T* = 2.312***	*T* = 1.072
TM	Non-fluent	Anterior/posterior	*T* = .473	T = .281
VC	Non-fluent	Posterior	***T* = 3.357****	***T* = 2.891****
EC	Fluent	ND	*T* = .251	***T* = .228***
FR	Fluent	Anterior/posterior	*T* = .781	T = .281
FT	Fluent	Posterior	***T* = 3.649****	***T* = 2.956***
JS	Fluent	Anterior/posterior	*T* = .265	***T* = 2.23***
MC	Fluent	Posterior	*T* = .251	*T* = .083
SR	Fluent	ND	*T* = .473	*T* = .083
VP	Fluent	ND	*T* = 1.427	*T* = 1.607

*Classical dissociation between tasks according to Revised Standardized Difference Test (RSDT) by Crawford and Garthwaite (2005).**Strong dissociation between tasks according to Revised Standardized Difference Test (RSDT) by Crawford and Garthwaite (2005).ND: no data.

results also seem to support the claim that they could have non-verbal conceptual deficits. As regards the absence of type of aphasia significant effect, this indicates that there are no clear group differences. However, looking at individual patients' performance we were able to observe dissociations as was analysed earlier. Regarding lesion localisation, no significant effect was detected considering frontal versus non-frontal lesions. Besides, it is important to note that few patients counted on detailed lesion localisation data, so it was difficult to find regularities in this regard.

After group analysis, a detailed analysis of individual's scores was carried out to compare individual performance with control group performance in each task. Such analysis showed dissociations in patients' performance and indicated that those patients that had a dissociated performance (significantly lower scores in thematic versus taxonomic tasks) had posterior lesions. No exclusively anterior lesion patient showed this dissociation. Most of these patients were non-fluent aphasic patients, although two fluent aphasic patients with posterior lesions also showed this dissociation. Considering that the control group indicated

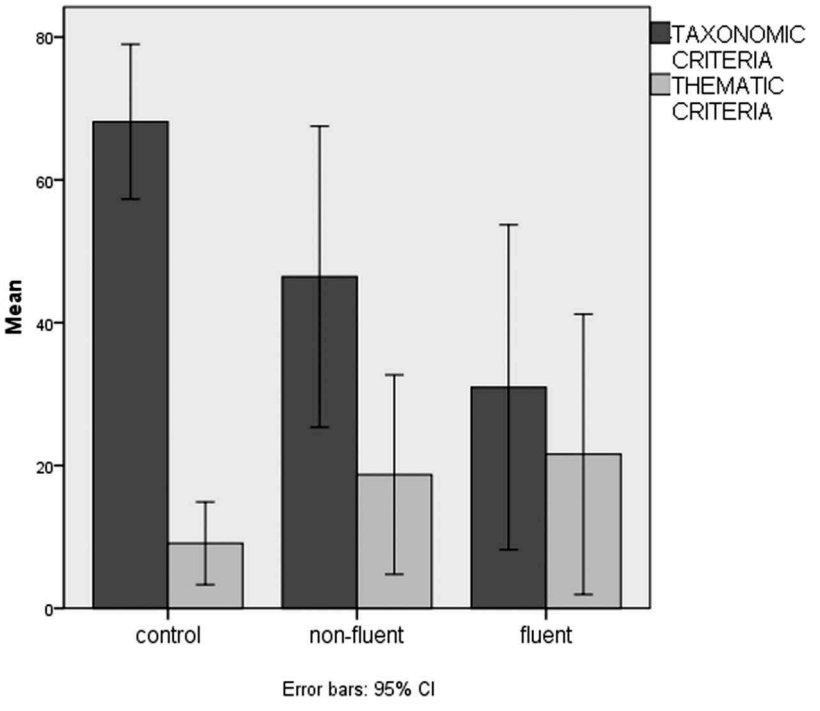

Figure 1. Proportion of use of taxonomic and thematic criteria in PICTURE SORTING.

Table 9. Correlations between background neuropsychological tests and experimental tasks.

			TAXON Ver	PyPh Ver	TAXON Pict	PyPh Pict	PS
Spearman's Rho	Comprehension	Correlation coefficient	.403	.403	.325	.402	**.557***
		Sig. (bilateral)	.097	.097	.161	.079	**.011**
	Naming	Correlation coefficient	−.043	.161	.059	.059	.018
		Sig. (bilateral)	.845	.464	.786	.785	.932
	WPM	Correlation coefficient	**.440***	**.496***	**.446***	**.439***	**.553****
		Sig. (bilateral)	**.035**	**.016**	**.029**	**.032**	**.005**

* Correlation is significant at $p < .01$ level.
** Correlation is significant al $p < .05$ level.
WPM: word–picture matching; TAXON Ver: Taxonomic relation task in verbal display; PyPh Ver: Pyramids and Pharaos verbal display; TAXON Pict: Taxonomic relation task in pictorial display; PyPh Pic: Pyramids and Pharaos pictorial display; PS: Picture sorting.

that there were no significant differences between taxonomic and thematic tasks, our results support the claim that thematic relations are processed separately of taxonomic relations and consequently can be impaired independently. It is also important to note that we have detected two patients with the opposite dissociation, showing more difficulty in taxonomic

tasks, indicating the presence of a double dissociation. Consequently, the results seem to be consistent with some recent models of conceptual processing which indicate that both types of relations, taxonomic and thematic, can be differently affected and that there actually exist two parallel complementary semantic systems devoted to process both types of information (Chen et al., 2013; Kalénine et al., 2009; Mirman & Graziano, 2012; Sachs, Weis, Krings et al., 2008; Schwartz et al., 2011).

The finding that those patients who obtained significantly lower scores in thematic relations all showed to have posterior lesions is also consistent with previous studies which suggests that this type of relations are processed in posterior temporo-parietal areas (de Zubicaray, Hansen, & McMahon, 2013; Schwartz et al., 2011). In the research we have conducted, there were no anterior temporal lesion patients and few exclusively frontal lesion patients, which could explain the small number of patients with dissociations showing a poor performance in taxonomic tasks.

Another purpose of our research was to analyse patients' performance in a free-choice task where response options were not constrained. This task enabled us to analyse how the participants classified the objects choosing their preferred criteria. As was observed patients with fluent aphasia used significantly less taxonomic criteria than the control group in the free-choice task, but they also followed significantly more thematic criteria indicating a preference for this type of classification. In other studies, single case reports also showed evidence that these patients use thematic relations to make up for the difficulties they face with the taxonomic relations (Cuetos-Vega & Castejón, 2005; Davidoff & Roberson, 2004).

Patients' performance in background neuropsychological testing was analysed to see if other language functions were associated with conceptual tasks. Previous research showed to exist an association between poor naming ability and the loss of taxonomic classification (Davidoff & Roberson, 2004; Lupyan & Mirman, 2013; McCleary, 1988; Semenza, Bisiacchi, & Romani, 1992) adding to the claim that language supports extra-communicative cognitive functions. Moreover, some authors suggest that, as verbal category labels enhance categorical representations, it is very likely that naming deficit would affect this task (Lupyan & Spivey, 2010). In the current research there was no association between the naming task and conceptual relations tasks. Instead, a significant association between word–picture matching and conceptual tasks and a marginal relation with comprehension was detected. This would indicate that conceptual deficits could be associated with a difficulty in accessing semantic memory, rather than in the output (as would suggest a naming deficit).

Relation with recent conceptual organisation theories

Recent "dual-hub" theories of conceptualisation propose that there exist two independent neuroanatomical locations that subserve taxonomic and thematic relations (Schwartz et al., 2011). They claim that left anterior temporal lobe is specialised for taxonomic relations while left temporo-parietal junction is for thematic relations. Our results go in the same direction as it supports the claim that there could be a dissociated impairment within conceptual relations and consequently that they are probably processed in independent brain areas.

On the other hand, the single "hub-and-spoke" proposal (Jackson et al., in press; Patterson, Nestor, & Rogers, 2007) contends that both types of conceptual relations rely on the same cortical network, integrated by the anterior temporal lobe, posterior temporal and inferior frontal cortex. Consequently, it was claimed that the increase in associative (or thematic in our case) errors occurred only in relation with category errors, while in other studies "the ratio of different semantic error types was the same that observed in neurologically intact participants" (p. 11). However, we found double dissociations through which the

free-choice task fluent aphasic patients generate significantly more thematic responses in comparison with the control group, while non-fluent aphasic patients, although showing some thematic responses did not reach significance. This does not seem totally coherent with the idea that "features and associations are one and the same thing" (p.12). Moreover, the single "hub-and-spoke" proposal asserts that temporal-parietal cortex in direct relation with left prefrontal areas would constitute a distributed network essential for semantic control (Noonan, Jefferies, Corbett, & Lambon Ralph, 2010). Consequently, it could be argued that the current results of posterior lesion patients would be due to semantic control deficits. However, the participants in the present sample showed particular difficulty with thematic relations. If that would be the case of a semantic control deficit, they would be expected to show deficits in both kind of relations, or at least in the more difficult one. The scientific literature supports the claim that taxonomic relations would be more complex and consequently require more cortical activation than thematic ones (Sachs et al., 2008; Kotz et al., 2002). Also thematic relations would activate faster and more automatically (Santos, Chaigneau, Simmons, & Barsalou, 2011; Wamain, Pluciennicka, & Kalénine, 2015). Moreover, control group responses showed longer response latencies to establish taxonomic relations, which seem to indicate that these tasks require an additional cognitive effort. For this reason it does not seem correct to suppose that the present sample performance could be explained as a semantic control deficit. It seems more likely a specific deficit on the processing of thematic relations, which would probably validate Schwartz et al. (2011) and Kalènine et al. (2012) proposal of a dual system.

Clinical implications

Our results have direct clinical implications for the neuropsychological assessment of patients with semantic deficits. Commonly used forced-choice tests, such as Pyramids and Palm Tree or Camel and Cactus, actually evaluate only thematic relations. Meanwhile, taxonomic relations are usually assessed by free-choice tasks. It would be of interest to have a forced-choice test for taxonomic relations enabling the neuropsychologist to appraise both kinds of relations in a comparable way. It would be also very fruitful to record and classify patient's justifications of their answers in free-choice tasks, not just if they give right or wrong responses. Two different patients can, for example, put together a tomato and a lettuce, but while one could use a taxonomic criterion ("they are vegetables") the other could justify his/her answer by saying that both are used in salads (suggesting a thematic criterion). Such type of answers could give the clinician supplementary information regarding the patient's preferred classification criteria.

Conclusions

The study of conceptual relations can give us valuable information about the conceptual processing carried out by patients after suffering a stroke and allow us to describe more accurately the impairment of such processing. Although one should be careful about the results of our research because of the small sample size, this study seems to provide evidence for the likelihood of a dissociated performance in taxonomic and thematic conceptual relations tasks.

The present paper also showed a way to assess patient's preference to group stimuli according to taxonomic or thematic criteria. It would be interesting to include psychometric tools for both types of conceptual relations in the assessment of aphasic patients' profile. It would be also interesting to analyse if there is a correspondence between the preference to certain kind of categorisation and the stimuli domain (living vs. non-living) as previous research has shown differences in this regard (Antonucci, 2014).

In the study we did not count on precise information regarding lesion location, so we only considered in our analysis the presence of anterior and posterior lesions. Although we consider that behavioural data are more relevant than lesion data to determine the patient's cognitive profile, it would be of interest to establish the precise correlations between lesion location and conceptual deficit, particularly to corroborate the hypothesis about the association between the anterior temporal lobe with taxonomic relations and posterior temporal-parietal areas with thematic relations.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was accomplished with funding from the National University of Mar del Plata (research fellowship) and as part of a doctoral fellowship granted by the Education Ministry of Argentine and Caroline Foundation.

References

Antonucci, S. (2014). What matters in semantic feature processing for persons with stroke-aphasia: Evidence from an auditory concept–feature verification task. *Aphasiology*, *28*, 823–839. doi:10.1080/02687038.2014.913769

Barsalou, L. W. (2005). Situated conceptualization. In H. Cohen & C. Lefebvre (Eds.), *Handbook of categorization in cognitive science* (pp. 619–650). St. Louis, MO: Elsevier.

Barwood, C. H., Murdoch, B. E., Whelan, B.-M., Lloyd, D., Riek, S., O'Sullivan, J. D., … Wong, A. (2011). Modulation of N400 in chronic non-fluent aphasia using low frequency Repetitive Transcranial Magnetic Stimulation (rTMS). *Brain and Language*, *116*, 125–135. doi:10.1016/j.bandl.2010.07.004

Bay, E. (1964). Principles of classification and their influence on our concepts of aphasia. In A. V. S. Reuck & M. O'Connor (Eds.), *Disorders of language* (pp. 122–142). London: Churchill.

Bisiacchi, P., Denes, G., & Semenza, C. (1976). Semantic field in aphasia: An experimental investigation on comprehension of the relation of class and property. *Archives Suisses de Neurologie, Neurochirurgie et Psychiatric*, *118*, 207–213.

Butman, J., Arizaga, R. L., Harris, P., Drake, M., Baumann, D., & de Pascale, A., … Ollari, J. A. (2001). El Mini-mental State Examination en español. Normas para Buenos Aires. *Revista Neurológica Argentina*, *26*, 11–15. doi:10.1007/BF01067920

Chen, Q., Li, P., Xi, L., Li, F., Lei, Y., & Li., H. (2013). How do taxonomic versus thematic relations impact similarity and difference judgments? An ERP study. *International Journal of Psychophysiology*, *90*, 135–142. doi:10.1016/j.ijpsycho.2013.06.015

Corbett, F., Jefferies, E., & Ralph, M. A. (2011). Deregulated semantic cognition follows prefrontal and temporo-parietal damage: Evidence from the impact of task constraint on nonverbal object use. *Journal of Cognitive Neuroscience*, *23*, 1125–1135. doi:10.1162/jocn.2010.21539

Crawford, J. R., & Garthwaite, P. H. (2005). Testing for suspected impairments and dissociations in single-case studies in neuropsychology: Evaluation of alternatives using Monte Carlo simulations and revised tests for dissociations. *Neuropsychology*, *19*, 318–331. doi:10.1037/0894-4105.19.3.318

Crawford, J. R., Garthwaite, P. H., & Porter, S. (2010). Point and interval estimates of effect sizes for the case-controls design in neuropsychology: Rationale, methods, implementations, and proposed reporting standards. *Cognitive Neuropsychology*, *27*, 245–260. doi:10.1080/02643294.2010.513967

Cuetos-Vega, F., & Castejón, L. (2005). Disociación de la información conceptual y lingüística a partir de un estudio de caso. *Revista de Neurología*, *41*, 469–474.

Cycowicz, Y. M., Friedman, D., Rothstein, M., & Snodgrass, J. G. (1997). Picture naming by young children: Norms for name agreement, familiarity, and visual complexity. *Journal of experimental child psychology, 65*, 171–237. doi:10.1006/jecp.1996.2356

Davidoff, J., & Roberson, D. (2004). Preserved thematic and impaired taxonomic categorisation: A case study. *Language and Cognitive Processes*, *19*, 137–174. doi:10.1080/01690960344000125

De Zubicaray, G. I., Hansen, S., & McMahon, K. L. (2013). Differential processing of thematic and categorical conceptual relations in spoken word production. *Journal of Experimental Psychology, General*, *142*, 131–142. doi:10.1037/a0028717

Duffy, J. R., & Watkins, L. B. (1984). The effect of response choice relatedness on pantomime and verbal recognition ability in aphasic patients. *Brain and Language*, *21*, 291–306. doi:10.1016/0093-934X(84)90053-1

Gainotti, G. (2014). Old and recent approaches to the problem of non-verbal conceptual disorders in aphasic patients. *Cortex*, *53*, 78–89. doi:10.1016/j.cortex.2014.01.009

Gainotti, G., D'Erme, P., Villa, G., & Caltagirone, C. (1986). Focal brain lesions and intelligence: A study with a new version of Raven's colored matrices. *Journal of Clinical and Experimental Neuropsychology*, *8*, 37–50. doi:10.1080/01688638608401295

Gardner, H. E., Lambon Ralph, M. A., Dodds, N., Jones, T., Ehsan, S., & Jefferies, E. (2012). The differential contributions of pFC and temporo-parietal cortex to multimodal semantic control: Exploring refractory effects in semantic aphasia. *Journal of Cognitive Neuroscience*, *24*, 778–793. doi:10.1162/jocn_a_00184

Gardner, H. E., & Zurif, E. B. (1976). Critical reading of words and phrases in aphasia. *Brain and Language*, *3*, 173–190. doi:10.1016/0093-934X(76)90015-8

Golonka, S., & Estes, Z. (2009). Thematic relations affect similarity via commonalities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 1454–1464. doi:10.1037/a0017397

González, R., & Toledo, L. (2007). *Diagnóstico diferencial de las afasias*. Santiago: Universidad de Chile.

Helo, A. (2007). Diagnóstico diferencial de las afasias fluentes. In R. González & L. Toledo (Eds.), *Diagnóstico diferencial de las afasias* (pp. 14–16). Chile: Universidad de Chile.

Hoffman, P., Jefferies, E., Haffey, A., Littlejohns, T., & Lambon Ralph, M. A. (2013). Domain-specific control of semantic cognition: A dissociation within patients with semantic working memory deficits. *Aphasiology*, *27*, 740–764. doi:10.1080/02687038.2012.751578

Howard, D., & Patterson, K. (1992). *Pyramids and palmtrees: A test of semantic access from words and pictures*. Bury St Edmunds, Suffolk: Thames Valley Test Company.

Jackson, R. L., Hoffman, P., Pobric, G., & Lambon Ralph, M. (in press). The nature and neural correlates of semantic association versus conceptual similarity. *Cerebral Cortex*. Advance online publication. doi:10.1093/cercor/bhv003

Jefferies, E., Baker, S. S., Doran, M., & Lambon Ralph, M. A. (2007). Refractory effects in stroke aphasia: A consequence of poor semantic control. *Neuropsychologia*, *45*, 1065–1079. doi:10.1016/j.neuropsychologia.2006.09.009

Kalènine, S., Mirman, D., & Buxbaum, L. (2012). A combination of thematic and similarity based semantic processes confers resistance to deficit following left hemisphere stroke. *Frontiers in Human Neurosciences*, *6*, 1–12. doi:10.3389/fnhum.2012.00106

Kalénine, S., Peyrin, C., Pichat, C., Segebarth, C., Bonthoux, F., & Baciu, M. (2009). The sensory-motor specificity of taxonomic and thematic conceptual relations: A behavioral and fMRI study. *Neuroimage*, *44*, 1152–1162. doi:10.1016/j.neuroimage.2008.09.043

Kambanaros, M. (2008). The trouble with nouns and verbs in Greek fluent aphasia. *Journal of Communication Disorders*, *41*, 1–19. doi:10.1016/j.jcomdis.2007.02.001

Khateb, A., Michel, C. M., Pegna, A. J., O'Dochartaigh, S. D., Landis, T., & Annoni, J.-M. (2003). Processing of semantic categorical and associative relations: An ERP mapping study. *International Journal of Psychophysiology*, *49*, 41–55. doi:10.1016/S0167-8760(03)00076-X

Kotz, S. A., Cappa, S. F., von Cramon, D. Y., & Friederici, A. D. (2002). Modulation of the lexical–semantic network by auditory semantic priming: An event-related functional MRI study. *Neuroimage*, *17*, 1761–1772. doi:10.1006/nimg.2002.1316

Kuchinke, L., van deer Meer, E., & Krueger, F. (2009). Differences in processing of taxonomic and sequential relations in semantic memory: An fMRI investigation. *Brain and Cognition*, *69*, 245–251. doi:10.1016/j.bandc.2008.07.014

Lhermitte, F., & Beauvois, M. F. (1973). A visual-speech disconnexion syndrome. Report of a case with optic aphasia, agnosic alexia and colour agnosia. *Brain*, *96*, 695–714. doi:10.1093/brain/96.4.695

Lin, E. L., & Murphy, G. L. (2001). Thematic relations in adults' concepts. *Journal of Experimental Psychology: General*, *130*, 3–28. doi:10.1037/0096-3445.130.1.3

Lupyan, G., & Mirman, D. (2013). Linking language and categorization: Evidence from aphasia. *Cortex*, *49*, 1187–1194. doi:10.1016/j.cortex.2012.06.006

Lupyan, G., & Spivey, M. J. (2010). Redundant spoken labels facilitate perception of multiple items. *Attention, Perception, & Psychophysics*, *72*, 2236–2253. doi:10.3758/BF03196698

Manoiloff, L., Artstein, M., Canavoso, M., Fernández, L., & Segui, J. (2010). Expanded norms for 400 experimental pictures in an Argentinean Spanish speaking population. *Behavior Research Methods*, *42*, 452–460. doi:10.3758/BRM.42.2.452

Martinez-Cuitiño, M. M., & Barreyro, J. P. (2010). ¿Pirámides y Palmeras o Pirámides y Faraones? Adaptación y validación de un test de asociación semántica al español rioplatense. *Interdisciplinaria*, *27*, 247–260.

Mason-Baughman, M. B., & Wallace, S. E. (2013). Semantic feature knowledge in persons with aphasia: The role of commonality, distinctiveness, and importance. *Aphasiology*, *27*, 364–380. doi:10.1080/02687038.2012.730602

McCleary, C. (1988). The semantic organization and classification of fourteen words by aphasic patients. *Brain and Language*, *34*, 183–202. doi:10.1016/0093-934X(88)90132-0

Mirman, D., & Graziano, K. M. (2012). Damage to temporo-parietal cortex decreases incidental activation of thematic relations during spoken word comprehension. *Neuropsychologia*, *50*, 1990–1997. doi:10.1016/j.neuropsychologia.2012.04.024

Montón, C., Pérez-Echevarría, M. J., Campos, R., García-Campayo, J., Lobo, A., & El Gzempp. (1993). Escalas de ansiedad y depresión de Goldberg, Una guía de entrevista eficaz para la detección del malestar psíquico. *Atención Primaria*, *12*, 345–349.

Morales, J.-M., González-Montalvo, J.-I., Bermejo, F., & Del Ser, T. (1995). The screening of mild dementia with a shortened Spanish versión of the "Informant Questionnaire on Cognitive Decline in the Elderly". *Alzheimer Disease & Associated Disorders*, *9*, 105–111. doi:10.1097/00002093-199509020-00008

Noonan, K. A., Jefferies, E., Corbett, F., & Lambon Ralph, M. (2010). Elucidating the nature of deregulated semantic cognition in semantic aphasia: Evidence for the roles of prefrontal and temporo-parietal cortices. *Journal of Cognitive Neuroscience*, *22*, 1597–1613. doi:10.1162/jocn.2009.21289

Paivio, A. (1986). *Mental representations*. New York, NY: Oxford University Press.

Patterson, K., Nestor, P. J., & Rogers, T. T. (2007). Where do you know what you know? The representation of semantic knowledge in the human brain. *Nature Reviews Neuroscience*, *8*, 976–987. doi:10.1038/nrn2277

Peña-Casanova, J. (1991). *Programa Integrado de Exploración Neuropsicológica "Test Barcelona"*. Barcelona: Masson.

Peraita, H., González-Labra, M. J., Sánchez Bernardos, M. L., & Galeote, M. (2000). Batería de evaluación del deterioro de la memoria semántica en Alzheimer. *Psicothema*, *12*, 192–200.

Peraita, H., & Moreno, F. J. (2006). Análisis de la estructura conceptual de categorías semánticas naturales y artificiales en una muestra de pacientes de Alzheimer. *Psicothema*, *11*, 492–500.

Sachs, O., Weis, S., Krings, T., Huber, W., & Kircher, T. (2008). Categorical and thematic knowledge representation in the brain: Neural correlates of taxonomic and thematic conceptual relations. *Neuropsychologia*, *46*, 409–418. doi:10.1016/j.neuropsychologia.2007.08.015

Sachs, O., Weis, S., Zellagui, N., Huber, W., Zvyagintsev, M., Mathiak, K., & Kircher, T. (2008). Automatic processing of semantic relations in fMRI: Neural activation during semantic priming of taxonomic and thematic categories. *Brain Research*, *1218*, 194–205. doi:10.1016/j.brainres.2008.03.045

Santos, A., Chaigneau, S. E., Simmons, W. K., & Barsalou, L. W. (2011). Property generation reflects word association and situated simulation. *Language and Cognition*, *3*, 83–119. doi:10.1515/LANGCOG.2011.004

Schwartz, M. F., Kimberg, D. Y., Walker, G. M., Brecher, A., Faseyitan, O. K., Dell, G. S., … Coslett, H. B. (2011). Neuroanatomical dissociation for taxonomic and thematic knowledge in the human brain. *Proceedings of the National Academy of Sciences*, *108*, 8520–8524. doi:10.1073/pnas.1014935108

Semenza, C. (1999). Lexical-semantic disorders in aphasia. In G. Denes & L. Pizzamiglio (Eds.), *Handbook of clinical and experimental neuropsychology* (pp. 215–244). Hove: Psychology Press.

Semenza, C., Bisiacchi, P., & Romani, L. (1992). Naming disorders and semantic representations. *Journal of Psycholinguistic Research*, *21*, 349–364. doi:10.1007/BF01067920

Semenza, C., Denes, G., Lucchese, D., & Bisiacchi, P. (1980). Selective deficit of conceptual structures in aphasia: Class versus thematic relations. *Brain and Language*, *10*, 243–248. doi:10.1016/0093-934X(80)90054-1

Stuss, D. T., Levine, B., Alexander, M. P., Hong, J., Palumbo, C., Hamer, L., … Izukawa, D. (2000). Wisconsin card sorting test performance in patients with focal frontal and posterior brain damage: Effects of lesion location and test structure on separable cognitive processes. *Neuropsychologia*, *38*, 388–402. doi:10.1016/S0028-3932(99)00093-7

Toledo, L. (2007). Diagnóstico diferencial de las afasias no fluentes. In R. González & L. Toledo (Eds.), *Diagnóstico diferencial de las afasias* (pp. 17–20). Chile: Universidad de Chile.

Vigliecca, N. S., Peñalva, M. C., Castillo, Molina, S. C., Voos, J. A., & Ortiz, M., et al. (2011). Brief aphasia evaluation (minimum verbal performance): Concurrent and conceptual validity study in patients with unilateral cerebral lesions. *Brain Injury*, *25*, 394–400. doi:10.3109/02699052.2011.556106

Wamain, Y., Pluciennicka, E., & Kalénine, S. (2015). A saw is first identified as an object used on wood: ERP evidence for temporal differences between thematic and functional similarity relations. *Neuropsychologia*, *71*, 28–37. doi:10.1016/j.neuropsychologia.2015.02.034

Wisniewski, E. J., & Bassok, M. (1999). What makes a man similar to a tie? Stimulus compatibility with comparison and integration. *Cognitive Psychology*, *39*, 208–238. doi:10.1006/cogp.1999.0723

Zurif, E., Caramazza, A., Myerson, R., & Galvin, J. (1974). Semantic feature representations for normal and aphasic language. *Brain and Language*, *1*, 167–187. doi:10.1016/0093-934X(74)90032-7

Appendix 1. Forced-choice triadic comparison tasks: TAXON-VERBAL and PICTORIAL

Given the lack of adapted and validated tests to assess the ability to establish intra-categorical taxonomic relations, in the present study a triadic comparison task with forced-choice response was developed in order to measure the ability to recognise taxonomic relations. This task is expected to be equivalent to Pyramids and Palm Trees test (Howard & Patterson, 1992), which assesses thematic relations. Furthermore, the choice of distracters is based on the task designed by Semenza and co-workers to assess this same construct in patients with aphasia (Semenza et al., 1992). It consists of a triadic comparison task (matching-to-sample). Triads were displayed on a computer monitor using the Presentation 10.1 software package (Neurobehavioral Systems, http://www.neurobs.com/). Each trial began with a fixation point for 500 ms immediately followed by a picture triad. Target pictures appeared at the top centre of the screen. Related and non-related pictures were presented either at the bottom left or bottom right of the screen, their relative position being counterbalanced across trials. Participants were asked to decide which one of the two bottom pictures was more associated with the target picture. The triads were made up of words or drawings belonging to the same semantic category, but with different degrees of association strength. The stimuli used to elaborate the triads were selected from the picture database from Cycowicz, Friedman, Rothstein and Snoodgrass (1997). There were selected pictures with medium and high degrees of familiarity with the corresponding name according to the name agreement of the Argentinean database of Manoiloff, Artstein, Canavoso, Fernández, & Segui (2010). To elaborate the triads a panel of judges (20 psychology students and 10 graduated psychologists) were asked to estimate the association strength between pairs of stimulus on a Likert scale that ranged from 1 to 7. Then, those pairs that had very high or very low association strength and high inter-rater estimation consistency (low variability) were selected. Then, triads of stimuli within the same semantic category were designed, with one element being very strongly associated with the target and the other being weakly associated. Moreover, items display was adjusted so that the verbal and pictorial presentations were similar and the words were not ambiguous. Face validity was studied by administering to a pilot sample consisting of 15 adult subjects with medium–high educational level without neurological disease. The functioning of the instructions and of the items were analysed. Furthermore, content validity was assessed by consulting an expert group made up of psychologists and linguists, and those items that had the majority agreement of the judges were selected. In the final version, they elaborated 18 items, yielding an equivalent number of items between the Pyramids and Pharaohs test and the task of taxonomic relations. The same number of items were chosen for each semantic category. Figure A1 shows an example of an item of the taxonomic relation task in their verbal and pictorial modes of presentation.

People were asked to say which of the two items below was more associated with the target. The instruction was the same as that used in the Pyramids and Pharaohs test. The stimuli used are detailed in the following table:

Stimulus of the TAXON task.

Target	Correct item	Distracter
DRESS	SKIRT	TIE
BUREAU	DESK	ARMCHAIR
CARROT	ONION	BANANA
EAGLE	DUCK	RHINO
TRUCK	BICYCLE	SAILING
COMB	HAIR BRUSH	FORK
TROUSER	JACKET	CAP
BENCH	ROCKING CHAIR	BED
PEAR	APPLE	LEMMON
HORSE	ZEBRA	LYON
BUS	MOTORBIKE	HELICOPTER
AX	SAW	SCREWDRIVER
JACKET	BLOUSE	SKIRT
CORN	TOMATO	GRAPES
LYON	CAT	PIG
PLANE	HELICOPTER	TRACTOR
SEAT	CHAIR	BED
PENCIL	SCISSORS	PAINTBRUSH

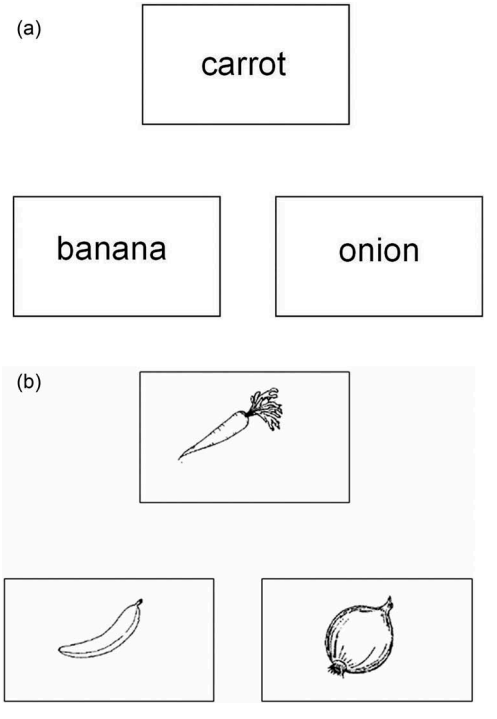

Figure A1. Examples of verbal and pictorial items belonging to the TAXON task.