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Research report

Proper name anomia with preserved lexical and semantic knowledge after left anterior temporal lesion: A two-way convergence defect

Thomas Busigny [a,b,*], *Xavier de Boissezon* [c,d], *Michèle Puel* [c,d], *Jean-Luc Nespoulous* [e] *and Emmanuel J. Barbeau* [b]

[a] *Institute of Psychology, Université Catholique de Louvain, Louvain-la-Neuve, Belgium*
[b] *Université de Toulouse, UPS & Centre de Recherche Cerveau et Cognition (Cerco, CNRS, UMR5549), Toulouse, France*
[c] *Centre Hospitalier Universitaire de Toulouse, Pôle Neurosciences, CHU Toulouse, Toulouse, France*
[d] *Université de Toulouse, UPS, Imagerie Cérébrale et Handicaps Neurologiques (UMR825), Toulouse, France*
[e] *Université de Toulouse, Octogone, Jacques Lordat, UTM, Toulouse, France*

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ABSTRACT

This article describes the case of a patient who, following herpes simplex encephalitis (HSE), retained the ability to access rich conceptual semantic information for familiar people whom he was no longer able to name. Moreover, this patient presented the very rare combination of name production and name comprehension deficits for different categories of proper names (persons and acronyms). Indeed, besides his difficulty to retrieve proper names, SL presented a severe deficit in understanding and identifying them. However, he was still able to recognize proper names on familiarity decision, demonstrating that name forms themselves were intact. We interpret SL's deficit as a rare form of *two-way lexico-semantic disconnection*, in which intact lexical knowledge is disconnected from semantic knowledge and face units. We suggest that this disconnection reflects the role of the left anterior temporal lobe in binding together different types of knowledge and supports the classical convergence-zones framework (e.g., Damasio, 1989) rather than the amodal semantic hub theory (e.g., Patterson, Nestor, & Rogers, 2007).

1. Introduction

There is now considerable evidence in the literature that proper names can be selectively impaired after acquired brain damage (e.g., Carney & Temple, 1993; Fery, Vincent, & Brédart, 1995; Harris & Kay, 1995; Hittmair-Delazer, Denes, Semenza, & Mantovan, 1994; Lucchelli & De Renzi, 1992; McKenna & Warrington, 1980; Saetti, Marangolo, De Renzi, Rinaldi, & Lattanzi, 1999; Semenza & Zettin, 1988, 1989; Shallice & Kartsounis, 1993; Miceli et al., 2000). This disorder has been

* *Corresponding author*. Cerco/Pavillon Baudot/CHU Purpan, Place du Dr Baylac, 31059 Toulouse, France.
E-mail address: busigny@cerco.ups-tlse.fr (T. Busigny).
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referred to as ‘proper name anomia’ and can be defined as the inability to retrieve proper names, mainly names of people but also sometimes names of places, monuments or brands, with intact ability of retrieving common names, and that cannot be explained by a general language or memory impairment. The reverse dissociation, common noun anomia without proper name anomia, was also described, providing evidence of a double dissociation between common and proper name retrieval (Lyons, Hanley, & Kay, 2002; Martins & Farrajota, 2007).

While proper name anomia generally involves people's names and other proper names, some rare cases demonstrated that people's names can be affected selectively, in the absence of impairment in naming places (e.g., Carney & Temple, 1993; Cohen, Bolgert, Timsit, & Chermann, 1994; Fery et al., 1995; Lucchelli, Muggia, & Spinnler, 1997; Reinkemeier, Markowitsch, Rauch, & Kessler, 1997; Verstichel, Cohen, & Crochet, 1996), monuments (Fery et al., 1995; Lucchelli et al., 1997; Verstichel et al., 1996) or brands (Lucchelli et al., 1997). However, Hanley and Kay (1998) suggested that the extension of the impairment to other proper name categories correlates with its severity and that selective people's names' anomia is observed only in the less severe cases.

Proper name anomia usually appears in the context of a cerebral infarct, in particular in the territory of the left middle cerebral artery (e.g., Crutch & Warrington, 2004; Kay & Hanley, 2002; McKenna & Warrington, 1980), the left posterior communicating artery (e.g., Hanley, 1995; Saetti et al., 1999) or the left thalamus (e.g., Cohen et al., 1994; Lucchelli & De Renzi, 1992; Lucchelli et al., 1997; Moreaud, Pellat, Charnallet, Carbonnel, & Brennen, 1995). The other two main causes are tumor resection surgery (e.g., Bi et al., 2011; Flude, Ellis, & Kay, 1989; Hittmair-Delazer et al., 1994) and herpes simplex encephalitis (HSE) (e.g., Geva, Moscovitch, & Leach, 1997). The damaged cerebral territories are always located in the left hemisphere and spread mainly in the temporal structures. They generally encompass the anterior temporal lobe, the middle temporal lobe, the parahippocampal gyrus and the thalamus (e.g., Bi et al., 2011; Cohen et al., 1994; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004; Fukatsu, Fujii, Tsukiura, Yamadori, & Otsuki, 1999; Saetti et al., 1999; Shallice & Kartsounis, 1993).

In this study, we explored a new case of proper name anomia, SL, following HSE. Since his neurological ailment, SL complains about persistent word production and comprehension difficulties for names of persons, places, acronyms and some infrequent common nouns.

1.1. *Varieties of proper name anomia*

From the neuropsychological as well as philosophical points of view, proper names are considered as “pure referring expressions” (Kripke, 1980), in the sense that they carry no sense and do not rely – or little if any – on sets of attributes. While common nouns refer to categories and entail a description of the entity they designate, proper names essentially refer to individuals and have an arbitrary relation with their references. As a consequence, the link proper names have with their reference might be particularly fragile.

In his recent reviews of twenty years of publications on cases of selective anomia, Semenza (2006; 2009) identified four varieties of proper name anomia. (1) *Anomia in accessing the phonological lexicon* is characterized by the disconnection between an intact phonological lexicon and an intact individual semantic system. (2) *Anomia due to loss of semantic information* is defined by a degradation of the individual semantics and the labels themselves. (3) In the *isolation of information about individual entities* profile, the individual semantic system is disconnected from the face units and person definitions, but still connected with people's name. (4) Finally, in *prosopanomia* only face units are disconnected from the phonological lexicon.

Although this classification seems exhaustive, it is reasonable to ask whether we could not observe another type of proper name anomia. For example, Verstichel et al. (1996) published an interesting case of a patient presenting combined production and comprehension deficits for people names. DEL was unable to retrieve the names of familiar people on presentation of their face or on verbal definition, while he had the preserved ability to provide rich and accurate biographical information on people he could not name. Moreover, while the output lexicon was intact, the patient presented a severe deficit in understanding people's names.

Semenza's taxonomy was concerned with patients who have only problems in retrieval. It might be useful, however, to add to this taxonomy also patients, like Verstichel's et al. and SL, who have a bi-directional deficit, showing additional problems in comprehension. For that purpose, we extensively investigated SL's recognition, comprehension and production of different categories of proper names, on verbal and visual input. We will present the results of 20 experiments that will allow us to define SL's cognitive profile and to determine the nature of his proper name anomia. To guide our investigations, we developed our experiments around four questions:

1. Is SL's deficit specific to people's names or does it spread to multiple categories of abstract and meaningless labels?
2. Did SL retain the ability to access specific and distinctive conceptual semantic information for the unique entities he is no longer able to name?
3. If biographical knowledge of people is intact, are these pieces of semantic information equally accessible on face and name confrontation?
4. Is the naming deficit due to a loss of verbal labels themselves or to a disconnection between labels and other individual knowledge?

1.2. *Anterior temporal lobe and proper names*

Existing empirical studies on proper names mainly state that proper name processing essentially takes place in the left hemisphere, mostly at the level of the anterior part of the infero-temporal lobe. The crucial role of the left temporal pole in proper name retrieval was indeed demonstrated in event-related potential (e.g., Proverbio, Lilli, Semenza, & Zani, 2001), neuroimaging (e.g., Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004; Gorno-Tempini et al., 1998; Tranel, 2009; Tsukiura et al., 2002), and neuropsychology studies (e.g., Damasio et al., 1996; 2004; Semenza, Mondini, & Zettin, 1995; Snowden, Thompson, & Neary, 2012; Tranel, 2006; 2009; Tsukiura et al., 2002). However, reviews on single case studies on proper name anomia suggest the involvement of a larger neural network in proper name production (Semenza, 2006; 2009; 2011; Yasuda, Nakamura, & Beckmann, 2000). Indeed these authors point out a set of critical areas involved in proper name anomia outside the left anterior temporal lobe: the left basal ganglia, the left thalamus, the posterior temporal lobe and the prefrontal cortex for example. Moreover, in a study on 139 unilateral brain-damaged patients (Damasio et al., 2004), while the maximum overlap of lesions involved in people's names retrieval deficit was located in the left anterior inferotemporal lobe, other regions were significantly associated with proper name anomia: the left anterior parahippocampal gyrus, the left anterior infero-temporal gyrus and the frontal operculum. Thus, the debate around the anatomical organisation of proper name retrieval is still open. In the current study, we will discuss what SL's single case study can teach us about the anatomico-functional organisation of proper names in light of the current literature.

1.3. *The "hub" theories*

It is now well known that semantic representations are not encapsulated in single, modular brain areas, but reflect the joint action of a widely distributed set of cortical regions (for a recent review, see Jefferies, 2013). Indeed, semantic information draws on a distributed network of sensory and motor representations (e.g., Barsalou, 1999; Binder, Desai, Graves, & Conant, 2009; Martin, 2007; Pulvermüller, 2005). Furthermore, some theorists have suggested that in addition to sensory, motor and language representations, conceptual categorization would require central amodal representations. Thus, they argued in favor of the existence of "convergence zones" or "hubs" where different types of information are combined into more abstract, multimodal semantic representations (e.g., Damasio, 1989; Patterson, Nestor, & Rogers, 2007). However, amongst these theories, there is a fundamental divergence: while some authors argue that multiple regions distributed across the cerebral hemispheres underpin the convergence of the different types of information (Binder & Desay, 2011; Damasio, 1989; Damasio & Damasio, 1994; Damasio et al., 2004; see also Jefferies, 2013), the others claim the existence of a single amodal hub that support the interactive activation of representations in all modalities, for all semantic categories (e.g., Patterson et al., 2007). We will discuss whether SL's results support one or another of these theories.

2. Methods

2.1. *SL's case description*

SL is a right-handed army colonel born in 1954 with a high educational level (17 years of education + numerous continuous trainings and high professional responsibilities in the French Army). He presented in April 2010 at the Neurology unit of Rangueil University Hospital (Toulouse, France) for HSE, which was immediately treated with aciclovir. The HSE was complicated with a hemorrhage in the territory of the left temporal lobe. Two weeks after, the patient completely recovered from HSE but he suffered from mixed verbal aphasia (with production and comprehension difficulties). Aphasia progressively disappeared and the residual complaint was a severe proper name anomia, a moderate common nouns anomia and some episodic memory difficulties. A first comprehensive neuropsychological assessment was conducted in July 2010 (see Table 1). The results indicated that SL had preserved abilities in most cognitive domains: executive functioning, praxis, and short-term memory. In contrast, the results showed a clear deficit in common and

Table 1 – Patient SL's general neuropsychological assessment.

	July 2010	October 2011
General		
WAIS-R		
Verbal IQ		99
Performance IQ		127
Full-scale IQ		111
MMSE		30/30
Visual perception		
BORB (object decision)		30/32
BECS (identity matching)		19/20
Benton Facial Recognition Test (BFRT)		48/54
Executive functioning		
Trail Making Test		
Part A	0 err	
Part B	0 err	
Wisconsin Card Sorting Test	6/6	
Praxis		
Rey-Osterrieth Figure (copy)	36/36	
Memory		
Short-term memory		
Forward span	6	
Backward span	6	
WMS-III		
Immediate verbal memory IQ		82
Delayed verbal memory IQ		76[a]
Immediate visual memory IQ		120
Delayed visual memory IQ		133
Language		
Oral production		
Semantic verbal fluency	24	28
Common names production (DO80)	71/80[a]	78/80
Famous people naming (TOP 30)	3/30[a]	8/30[a]
Semantic		
PPTT (visual)		51/52
PPTT (verbal)		52/52
BECS (semantic matching, visual)		40/40
BECS (semantic questions, visual)		235/250

MMSE = Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975); BORB = Birmingham Object Recognition Battery (Riddoch & Humphreys, 1993); BECS = Semantic Knowledge Assessment Battery (Merck et al., 2011); DO80 = Visual object naming (Deloche & Hannequin, 1997); TOP 30 = Famous people naming (Thomas-Antérion & Puel, 2006); PPTT = The Pyramids and Palm Trees Test (Howard & Patterson, 1992).

[a] Indicates impaired scores (SD < −2 or Pc < 5).

proper names production. SL underwent a follow-up and complementary neuropsychological evaluation in October 2011 (see Table 1). The results indicated preserved full-scale IQ, visuo-perceptual skills, semantic knowledge and visual memory. In contrast to an excellent visual memory, verbal memory was weak and even impaired in delayed memory. Proper names anomia was persistent, while common nouns naming recovered.

We met SL in January 2012 (almost two years after his encephalitis). He was complaining about persistent word finding difficulties for names of persons, places (cities and rivers), acronyms and some rare difficulties with infrequent common nouns, which were all confirmed by his spouse. He had started a rehabilitation program with a speech therapist in order to help his word finding difficulties.

2.2. *Neuroradiological findings*

A high resolution MRI recording was acquired from SL in June 2012 with a 3-T imager (Achieva; Philips, Best, The Netherlands), located in the Unit INSERM UMR825, Toulouse, France. MRI scans were performed using a 3-D T1-weighted sequence (in-plane resolution 1 × 1 mm, slice thickness 1 mm, field of view 240 × 240 mm, and 170 contiguous slices acquired in the sagittal plane, repetition time/echo time 8.1/3.7 msec, flip angle 8°). Manual delineation of SL's brain lesion was performed by a single rater (TB). The boundary of the lesion was manually delineated directly on the individual native-space MRI image using MRIcron software (Rorden, Karnath, & Bonilha, 2007; www.mricro.com). The circled lesion was then automatically filled, and the resulting three-dimensional volume of interest (VOI), describing the direct lesion effect, was saved as an image volume. Then, the native original MR-image and the VOI were normalized in reference to the MNI template provided by SPM 8 (Statistical Parameter Mapping version 8 – Wellcome Trust Centre for Neuroimaging, London, UK). The lesion was present on a total of 62 axial slices, 57 sagittal slices and 66 coronal slices, for a total normalized three-dimensional volume of 60.49 cc. Finally, we calculated the percentage of overlap between SL's normalized VOI and each of the Talairach regions according to the AAL atlas provided by MRIcron (Anatomical Automatic Labelling, Tzourio-Mazoyer et al., 2002). The lesions were unilaterally located in the left hemisphere and damaged principally the anterior temporal regions and the limbic system. The main damaged areas were the anterior temporal lobe (middle temporal pole: 95.3%; superior temporal pole: 93.3%), the amygdala (72.1%), the parahippocampal gyrus (51.7%) and the anterior part of the hippocampus (35.9%). The superior (32.3%), inferior (24.4%) and middle (13.9) temporal gyri were also damaged, as well as the anterior part of the fusiform gyrus (27.5%). Finally, some minor damage was found in the insula, the inferior orbitofrontal gyrus, the olfactory gyrus and the rolandic operculum (see Fig. 1). These regions correspond to the areas classically damaged by HSE virus (Damasio & Van Hoesen, 1985).

2.3. *General methodological considerations*

SL was administered with a set of 20 behavioral tasks conducted between February and September 2012. SL was 58 at the time of the study. Eight healthy male participants were tested as controls. They were matched in terms of age (mean: 60.4; age range: 54–66) and had a high educational level (average years of education: 18.5; educational range: 17–20). They all had no history of neurological or vascular disease, head injury or alcohol abuse, and did not have cognitive complaints. Each of the 20 experiments was performed by five participants amongst these eight normal controls. SL and all control participants gave informed consent. Experiments were conducted in accordance with the principles of the Declaration of Helsinki.

To compare the results of SL to the control participants, the modified T-test of Crawford and Howell (1998) for single case studies was used with a .05 *p*-value within the framework of a unilateral hypothesis. Consequently, all scores associated with a *p*-value under .05 were considered as reflecting an abnormal result. Analyses were conducted with a computerized version of Crawford & Howell's method: *SINGLIMS.EXE: Point estimate and confidence limits on the abnormality of a test score* (Crawford & Garthwaite, 2002).

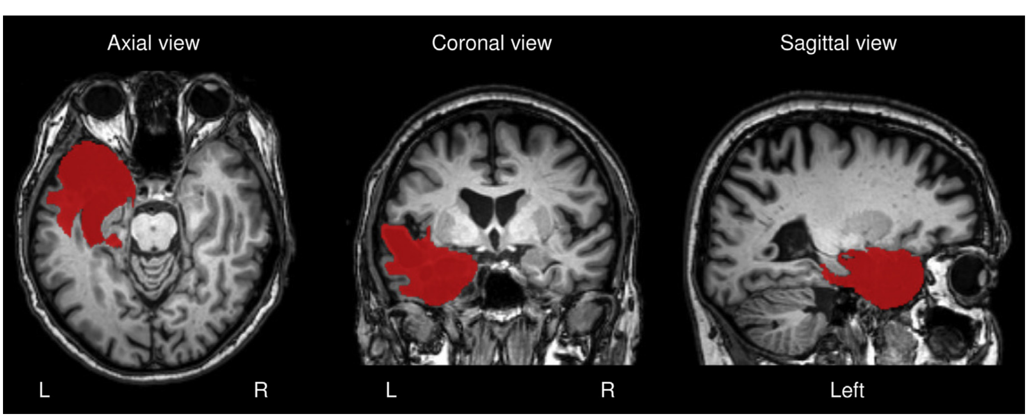

Fig. 1 – SL's anatomical brain lesions. The lesions were unilaterally located in the left hemisphere and damaged principally the anterior temporal regions and the limbic system: anterior temporal lobe, amygdala, parahippocampal gyrus and anterior part of the hippocampus.

3. Experiments

3.1. Famous people

3.1.1. Familiarity judgment

3.1.1.1. Face familiarity. *Procedure*. This first experiment aimed at assessing recognition of famous faces among unknown faces. Ninety famous celebrities were selected (actors, singers, politicians, sportsmen and TV show presenters from 1950 to 2000 and of different nationalities; see Busigny, Robaye, Dricot, & Rossion, 2009). The pictures of these ninety celebrities were paired with ninety photographs of unknown people found on the web (of the same gender and approximately the same age as the famous people). These 180 faces were randomly presented in the center of the screen. Participants were asked to determine whether each face was familiar or not by pressing a corresponding key (right key if familiar; left key if unfamiliar).

Results. SL's performance was similar to control participants ($t_4 = .44$; $p = .34$) (Fig. 2).

3.1.1.2. Name familiarity. *Procedure*. The names of the same ninety celebrities were selected and paired with ninety unknown names (created with respect to the composition and the sonority of the famous name, e.g., Bill Clinton *vs* Phil Benton; see Busigny et al., 2009). These 180 names were randomly presented in the center of the screen and were read aloud at the same time by the experimenter. Participants were asked to determine whether each name was familiar or not by pressing the same keys as in the previous task of familiarity judgment. To avoid a priming effect of the first task to the second, the familiarity task with names was administered several weeks after the familiarity task with faces.

Results. Like with faces, SL did not have any difficulties and performed at the same level as controls ($t_4 = .34$; $p = .38$) (Fig. 2). These two first experiments show that SL has a preserved representation in memory of the faces and the names of celebrities.

3.1.2. Knowledge of people from faces and names (verbal production)

3.1.2.1. From face (GRETOP). *Procedure*. This experiment consists of a battery of tasks dedicated to assess semantic knowledge of celebrities (GRETOP, Puel et al., in preparation).

Fig. 2 – SL's and controls' results in Experiments 3.1.1.1. and 3.1.1.2. (face familiarity and name familiarity). SL and controls were not different. Error bars represent controls' standard deviations.

Two versions of the battery were created: one on face input, the other one on name input. The two versions were equalized in terms of difficulty. In the face version, twelve celebrities well known to French people were selected (ex: Barak Obama, Jacques Chirac, Marilyn Monroe), belonging to music, cinema and politic areas. For each celebrity, 5 steps were followed. (1) *Recognition*. Each celebrity's face was presented together with three visually similar unknown faces. Participants had to choose the face they were familiar with. (2) *Naming*. Then, the famous face was presented alone and participants had to provide his/her full name. (3) *Verbal description*. In a third step, participants had to provide as much information as possible about the celebrity. They were not limited in the quantity of information provided. This step allowed calculating two scores. An *identification* score was calculated as giving one point to each definition that would be sufficient for an external blind judge to identify the celebrity if provided with this definition (e.g., "silent film actor, usually wearing a hat and a cane" was accepted as a correct definition of Charlie Chaplin and provided one point for the identification score). The second score, the *semantic/production* score, was calculated by summing all the pieces of significant and distinctive information provided in the definition (e.g., "silent film – actor – usually wearing a hat – and a cane" would provide 4 points). A maximum of ten pieces of information were counted for each celebrity. (4) *Questions*. Then, 5 multiple-choice questions were asked about the celebrity. The first question asked whether the celebrity was dead or alive, the second and the third questions were about nationality and profession (3 choices per question), and the two last questions asked specific details about the celebrity (e.g., How did she die; 3 choices). This step allowed the calculation of a *semantic/recognition* score as the sum of all the correct answers to the multiple-choice questions. (5). *Face-name matching*. Finally, participants had to pick the correct name of the celebrity (e.g., Lady Diana) among three semantically related distractors (e.g., Hilary Clinton, Caroline de Monaco, Camilla Parker Bowles).

In total, six scores were calculated. *Recognition*, *naming*, *identification* and *matching* scores were calculated on a maximum of 12 points, *semantic/production* score was calculated on a maximum of 120 and *semantic/recognition* score on a maximum of 60. For clarity of visualization, results are expressed in percentages in Fig. 3.

Results. As already demonstrated in Expt. 3.1.1.1., SL's facial recognition was good ($t_4 = .65$; $p = .28$). His identification score was perfect ($t_4 = .67$; $p = .27$) and he provided as much semantic information as controls when giving a spontaneous definition ($t_4 = 1.17$; $p = .15$) or when asked specific questions ($t_4 = .48$; $p = .33$) (Fig. 3). SL even had a trend to give more specific details than normal controls. We were actually astonished by the precision and the accurateness of his definitions. Here is for example the definition he provided for Lady Diana – whom he could not name: English princess, former wife of the heir to the England's throne, they had two children, she was very loved by the English nation, she was involved in African healthcare associations, she separated from her husband, she had an affair with a very rich Egyptian guy, one night in Paris they were chased by journalists, the car crashed in a bridge, they died, at her funeral a great singer made a song

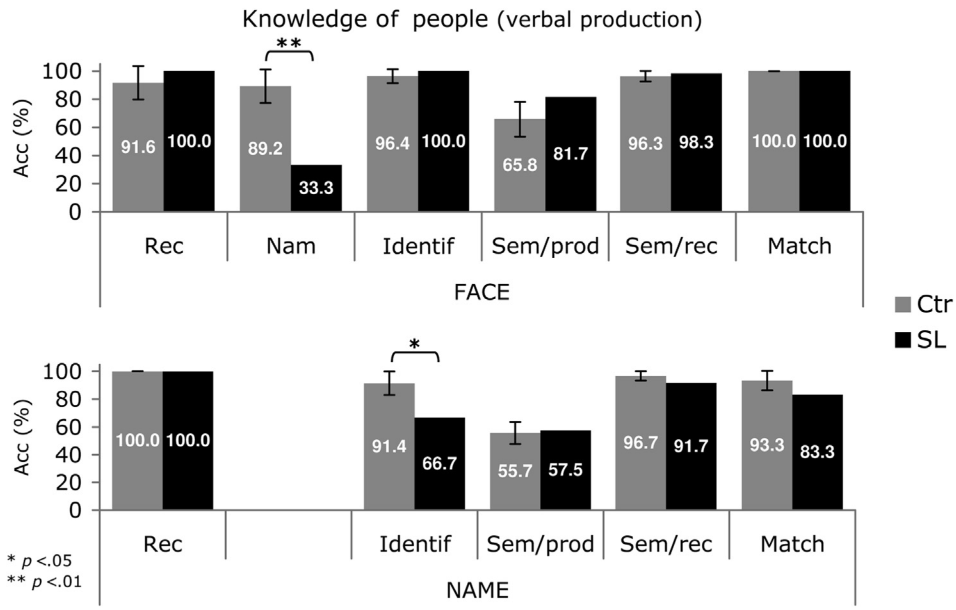

Fig. 3 – SL's and controls' results in Experiments 3.1.2.1. and 3.1.2.2. (GRETOP – knowledge of people from faces and names). SL was impaired in the naming task (from face) and the name identification task (from name). Error bars represent controls' standard deviations (Rec = Recognition; Nam = Naming; Identif = Identification; Sem/prod = Semantic/production; Sem/rec = Semantic/recognition; Match = face-name and name-face Matching).

for her. SL provided lots of unique and specific details, while he failed to provide any proper names (in this example, Prince Charles, William and Harry, Dodi Al-Fayed, Elton John). This observation was objectivised by SL's severely impaired naming score ($t_4 = 4.27$; $p < .01$). However, he was still able to correctly match celebrities' faces with their corresponding name. These results, in line with Expt. 3.1.2.2., confirm that the verbal labels are intact but cannot be accessed spontaneously.

3.1.2.2. FROM NAME (GRETOP). *Procedure*. A parallel version of the battery was created with the names of twelve other celebrities (matched with the face items in terms of nationality, profession, period of fame and difficulty). The same steps were followed (except the naming one): *recognition* among four names, *verbal description*, *questions* and *name-face matching*. Similar scores as for the face battery were calculated.

Results. Again, and in line with Expt. 3.1.2.2., SL's name recognition was normal. However, this time, his identification score was significantly impaired ($t_4 = 2.65$; $p < .05$). His semantic/production and semantic/recognition scores were in the normal range (respectively: $t_4 = .21$; $p = .42$ & $t_4 = 1.37$; $p = .12$), but they were lower than in the face version of the battery (Fig. 3). Indeed, in comparison to his performance in the face battery, SL's identification score was significantly lower in the name battery ($Chi^2 = 4.8$; $p < .05$), as well as his semantic/production score ($Chi^2 = 16.56$; $p < .001$). One could argue that the name items were more difficult than the face items, however the controls performed equally well in the two versions, obtaining similar identification scores (Wilcoxon $Z = .92$; $p = .36$), and similar semantic/production scores (Wilcoxon $Z = 1.21$; $p = .23$). Finally, as in the face version of the battery, SL's name-face matching was normal ($t_4 = 1.31$; $p = .13$).

3.1.2.3. TOP 30. *Procedure*. A third test aimed at assessing semantic knowledge from faces of celebrities. This task (TOP 30, Thomas-Antérion & Puel, 2006) consisted of 30 faces of internationally famous celebrities (e.g., Winston Churchill, Edith Piaf, Charlie Chaplin) and was divided into four steps. (1) First, participants had to provide the profession of the celebrity (on verbal production and recognition amongst three possibilities); (2) Then they had to provide his/her name (again on verbal production and recognition amongst three possibilities); (3) The third step consisted of two open questions about precise details on the celebrity (considering the proper name retrieval difficulties of the patient, the questions for which the answer consisted in the production of proper names were not taken into account); (4) Finally, participants had to temporally locate the event on a graduated time line. This battery assessed the level of semantic details participants could retrieve on famous celebrities. Given that this task was published with norms, we used the matched controls of the test.

Results. SL was in the range of normal controls at almost each step of the test: profession production ($t_2 = 1.00$; $p = .21$), profession recognition ($t_2 = 1.00$; $p = .21$), name recognition ($t_2 = .50$; $p = .33$), questions ($t_2 = 1.29$; $p = .16$), and datation ($t_2 = .99$; $p = .21$) (Fig. 4). The only impaired score was in the name production step ($t_2 = 6.03$; $p < .05$). These results completely replicated SL's results obtained in the face subtest of the GRETOP battery.

Altogether the results obtained in the face and name batteries provide three pieces of evidence: (1) While SL cannot

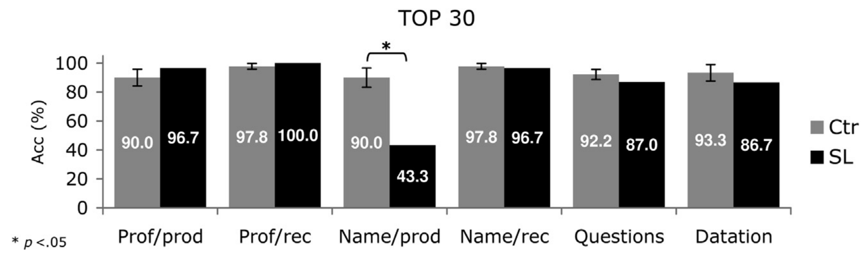

Fig. 4 – SL's and controls' results in Experiment 3.1.2.3. (TOP 30 – knowledge of people from faces). SL was impaired in the name production task. Error bars represent controls' standard deviations (Prof/prod = Profession production; Prof/rec = Profession recognition; Name/prod = Name production; Name/rec = Name recognition).

spontaneously access proper names, verbal labels themselves seem preserved since he can recognize them and correctly associate them to the corresponding face; (2) SL has preserved semantic knowledge of people, even regarding unique and specific details; (3) SL's access to semantic information is better on the basis of faces than on names.

3.1.3. *Knowledge of people (without production)*

3.1.3.1. Semantic judgment of faces. *Procedure*. In this last set of experiments evaluating knowledge of people, we aimed at assessing SL's abilities without asking him for verbal productions. We designed three experiments. The first one was a semantic decision task based on pictures. We created triplets of famous faces and the task was to find the odd one according to its relation with the two others. Indeed, in each triplet, two celebrities were semantically closer that the third one. We created four categories of increasing difficulty. In category 1, the odd celebrity to find was of different nationality and profession (e.g., Elton john, Robert Redford, David Bowie). In category 2, the odd celebrity was of the same nationality than the two others, but had a different profession (e.g., Nancy Reagan, Hillary Clinton, Meryl Streep). In category 3, the odd celebrity had the same profession but was of different nationality (e.g., Winston Churchill, John Kennedy, Richard Nixon). Finally, in category 4, the three faces had the same profession and nationality, but the odd one was of a different style (in terms of political orientation, cinematographic style, or musical stream) (e.g., Robin Williams, Dustin Hoffman, Sylvester Stallone). There were 9 trials per category, and for each trial the position of the three stimuli was randomly distributed on the screen. To succeed at the task, participants needed to have access to their semantic knowledge about celebrities even if they did not have to produce it verbally.

Results. In this task, SL performed globally at the same level as controls ($t_4 = .65$; $p = .28$) (Fig. 5). If we consider SL's performance at each level of difficulty, he was each time in the range of controls: category 1 ($t_4 = .41$; $p = .35$), category 2 ($t_4 = .14$; $p = .45$), category 3 ($t_4 = .00$; $p = .5$), and category 4 ($t_4 = .00$; $p = .5$).

3.1.3.2. Semantic judgment of names. *Procedure*. This experiment was exactly the same as the previous one, but this time we used names instead of faces. Since the triplets were the same as in the previous experiment, we administered the name version several weeks latter.

Results. In comparison to controls' global performance, SL was significantly impaired ($t_4 = 2.16$; $p < .05$) (Fig. 5). Interestingly, while the controls showed a decrease of performance across the four categories (categ1: 97.8%; categ2: 95.6%; categ3: 73.3%; categ4: 73.3%; $Chi^2 = 10.64$; $p < .05$), SL obtained equally low performance in the four categories (categ1: 66.7%; categ2: 66.7%; categ3: 66.7%; categ4: 55.6%; $Chi^2 = .361$; $p = .95$). In consequence, SL was impaired in the two easiest categories: category 1 ($t_4 = 5.71$; $p < .01$) and category 2 ($t_4 = 2.65$; $p < .05$). He was however in the normal range for categories 3 ($t_4 = .26$; $p = .40$) and 4 ($t_4 = .87$; $p = .22$). These results demonstrate that the problem in SL is not a loss of semantic information but an impaired access to this semantic information from the verbal label. Otherwise, SL would have shown a much stronger deficit with trials of high semantic specificity, but this was not the case. Furthermore, in comparison to the previous experiment, SL's performance was not better in the name version than in the face version ($Chi^2 = 1.05$; $p = .31$), while the normal controls obtained better performance in the name version than in the face version (Wilcoxon $Z = 2.03$; $p < .05$). We cannot be sure that this better performance on names in controls is not due to a repetition effect (since the controls performed the face version a few weeks before), but in any case this potential repetition effect did not prevent SL from obtaining weaker performance the second time, with the name version.

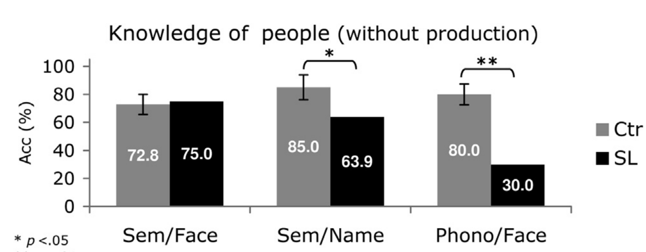

Fig. 5 – SL's and controls' results in Experiments 3.1.3.1. (semantic judgment of faces), 3.1.3.2. (semantic judgment of names) and 3.1.3.3. (phonological judgment of faces). SL was impaired for semantic judgment on names and phonological judgment on face. Error bars represent controls' standard deviations (Sem/Face = semantic judgment on face; Sem/Name = semantic judgment on name; Phono/Face = phonological judgment on face).

3.1.3.3. Phonological judgment of faces. *Procedure*. For this last experiment, we created 30 new triplets of famous faces. This time, the odd item was different in terms of the phonological aspect of its name. In each of the triplets, the names of two celebrities had the same last syllable, while the odd one did not (e.g., Elvis Presley, Mel Gibson, George Clooney). Participants had to choose the celebrity that had a name that did not rhyme with the two others. To succeed the task, participants needed to have access to the verbal label of the celebrity even if they did not have to produce it verbally.

Results. In this task, SL's performance was at chance level, and in consequence he was strongly impaired in comparison to controls ($t_4 = 6.13$; $p < .01$) (Fig. 5). These results demonstrate that SL no longer has access to the verbal label of celebrities' names, irrespectively of whether he has to produce it verbally or not.

Altogether, these results confirm that SL has preserved semantic knowledge of people, but with impaired access when he is provided with the name. Furthermore, his proper name anomia is not due to a problem of verbal production, but of memory access of the verbal labels.

3.2. *Other unique entities*

SL was not only complaining about people's name retrieval but also about other name categories, such as geographical places and acronyms. We thus designed a set of experiments aiming at assessing other unique entities' name retrieval in order to observe whether the impaired mechanisms observed with people's name are the same for other unique categories. We started with three tasks assessing acronym recognition, identification and production.

3.2.1. *Acronyms*

3.2.1.1. Familiarity judgment. *Procedure*. While talking about his daily life difficulties, SL complained of abbreviation and acronym retrieval. His difficulties concerned institutions' acronyms (e.g., UNICEF, HBO, NBA), as well as abbreviations that were introduced as common names in everyday language (e.g., VAT, AIDS, GMO). We administered a first experiment to assess recognition of acronyms and abbreviations. Thirty pairs were created, in which each acronym was presented together with a distractor containing the same number of vowels and consonants but not referring to a real label in French (e.g., FBI *vs* SPU). For each trial, participants had to select the real acronym.

Results. Like with people's names, SL obtained results in the normal range ($t_4 = .22$; $p = .42$) (Fig. 6).

3.2.1.2. Definition of names. *Procedure*. In this second experiment, we established a list of 30 acronyms and abbreviations (e.g., UNESCO, HIV, HTML) and we asked participants to give a definition of the label. They were allowed to define each letter of the acronym or give a general definition of the concept. Two judges decided whether the definitions were correct or not.

Results. In comparison to controls, SL obtained impaired performance ($t_4 = 4.50$; $p < .01$) (Fig. 6). Half of his definitions were vague or inaccurate, and he could almost never give the nouns corresponding to the letters of the acronym.

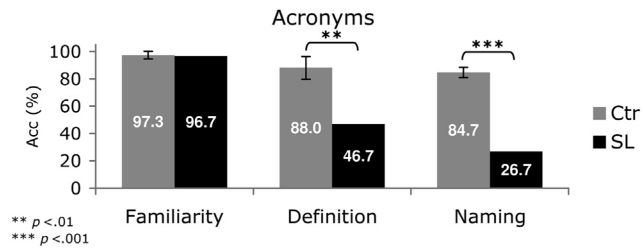

Fig. 6 – SL's and controls' results in Experiments 3.2.1.1. (acronyms familiarity), 3.2.1.2. (acronyms definition), and 3.2.1.3. (acronyms naming). SL was impaired for acronyms definition and naming. Error bars represent controls' standard deviations.

3.2.1.3. Naming on definition. *Procedure*. This last experiment consisted of a list of 30 definitions of acronyms and abbreviations. Participants had to provide the label corresponding to each of these definitions (e.g., "molecule that encodes the genetic instruction" required the answer "DNA").

Results. While controls performed quite well in this task, SL was able to provide only a quarter of the labels and was in consequence severely impaired ($t_4 = 13.93$; $p < .001$) (Fig. 6).

In conclusion, these results replicated exactly SL's profiles with people's names: he can recognize acronyms similarly as accurately as people's names, he is severely impaired at producing the label, and he has significant difficulties in accessing the semantic concept from the verbal label.

3.2.2. *Monuments*

3.2.2.1. Familiarity judgment. *Procedure*. Since people's names' anomia is frequently associated with places' and monuments' names' anomia (e.g., Ellis, Young, & Critchley, 1989; Harris & Kay, 1995; Otsuka et al., 2005) and given that SL is complaining about places' name retrieval difficulties, we decided to test monuments' and sites' names. In a first experiment (see Busigny et al., 2014), 60 pictures of monuments were presented: 15 were famous international monuments and buildings (e.g., Pisa Tower, Tower Bridge, the White House), 15 were famous French monuments and sites (e.g., The Louvre, Pont du Gard, Mont Saint-Michel), and the 30 others were unknown monuments and sites that were visually matched. Each picture was presented one by one and participants had to decide whether they were famous or not.

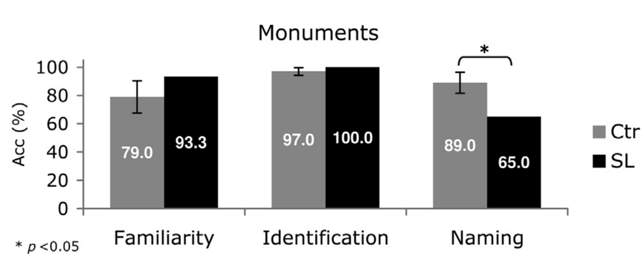

Fig. 7 – SL's and controls' results in Experiments 3.2.2.1. (monument familiarity) and 3.2.2.2. (monument identification and naming). SL was impaired for monuments naming. Error bars represent controls' standard deviations.

Results. Like in other tasks of familiarity judgment, SL was highly accurate ($t_4 = 1.15$; $p = .16$) (Fig. 7).

3.2.2.2. Identification and naming. *Procedure.* In the second experiment, SL was presented with 20 pictures of famous monuments and sites (international and national; see Busigny et al., 2009). This time, participants were asked first to provide a semantic definition of the monument (identification score) and then to name it (naming score).

Results. SL named 13 monuments out of 20, which was better than his naming performance with faces or acronyms, but still impaired in comparison to controls ($t_4 = 2.95$; $p < .05$) (Fig. 7). In contrast, he was able to accurately describe all the monuments he could not name ($t_4 = .99$; $p = .19$), confirming his good visual identification ability.

In conclusion, this third set of experiments confirms that SL's proper name anomia is not specific to people's name but also involves other unique labels, such as acronyms' and monuments' names. While SL is totally unimpaired at visual recognition of monuments and sites, he is impaired at naming them, but the deficit seems less severe than with faces and acronyms.

3.2.3. *Flags and capitals*

3.2.3.1. Flag naming. *Procedure.* Country and city name retrieval is also often impaired in proper name anomia (Harris & Kay, 1995; Moreaud et al., 1995; Otsuka et al., 2005; Semenza & Zettin, 1988; 1989). Since SL was interested in geography before his neurological disease, we decided to test him with these two categories. The first task consisted in 30 flags to name, from all over the world: Europe (e.g., Greece, Sweden, Poland), Asia (e.g., India, China), South America (e.g., Jamaica, Brazil) and Africa (e.g., Senegal).

Results. Surprisingly enough, SL's performance in this task was almost perfect, and even almost significantly better than controls ($t_4 = 1.73$; $p = .08$) (Fig. 8). The only two flags that were not named were The Netherlands and Senegal.

3.2.3.2. Capital naming. *Procedure.* Here, participants were provided the name of 30 countries for which they had to give the capitals. Again, capitals were from Europe (e.g., Kiev, Lisbon, Copenhagen), South America (e.g., Lima) and the Middle East (e.g., Kabul, Baghdad).

Results. SL's results were again surprisingly good ($t_4 = .57$; $p = .30$) (Fig. 8). He was able to name 23 capitals out of 30. While he named quite common capitals (e.g., Brussels, London, Washington), he was also able to provide names of much less common capitals (e.g., Varsovie, Oslo, Budapest, Helsinki). These results are particularly interesting and demonstrate that SL's proper name retrieval difficulties are not linked to the labels' frequency. Indeed, while SL was impaired at retrieving some proper names largely used in the media, such as Barack Obama or Nicolas Sarkozy, he was able to retrieve much less frequent unique labels as Helsinki.

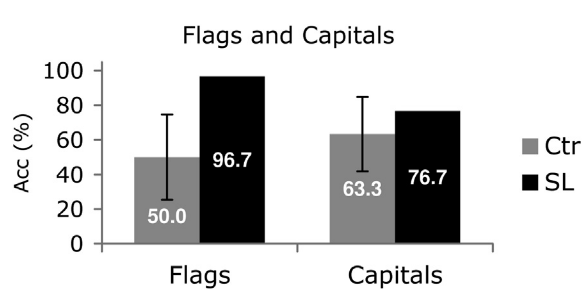

Fig. 8 – SL's and controls' results in Experiments 3.2.3.1. (flag naming) and 3.2.3.2. (capital naming). SL and controls were not different. Error bars represent controls' standard deviations.

3.2.4. *Historical and geographical knowledge*

This last group of experiments regarding knowledge of unique concepts aimed at assessing SL's semantic information retrieval about historical facts and geographical knowledge.

3.2.4.1. Famous events (EVE 10). *Procedure.* This experiment assessed semantic information retrieval on famous events (EVE 10, Thomas-Antérion & Puel, 2006). The task consisted of 10 international historical events (e.g., Watergate, Tchernobyl, World Trade Center) and was divided into four steps. (1) First, participants had to give a definition of the event. (2) Then they had to choose the good definition among three. (3) The third step consisted in two open questions about precise details of the event. (4) Finally, participants had to temporally locate the event on a graduated time line. This battery assessed the level of semantic details participants can retrieve on unique famous events. Given that this task was published with norms, we used the matched controls of the test.

Results. SL was in the range of normal controls at each step of the test: definition ($t_2 = .94$; $p = .22$), recognition ($t_2 = .00$; $p = .50$), questions ($t_2 = .14$; $p = .45$), and datation ($t_2 = .09$; $p = .47$) (Fig. 9). These results demonstrate that SL is able to retrieve specific semantic details about unique famous events when provided with the verbal label of the event.

3.2.4.2. History (HIS 10). *Procedure.* This test assesses semantic knowledge about historical characters (HIS 10, Thomas-Anterion et al., unpublished). The task consists of naming ten historical French and international characters of different periods of time (e.g., Joan of Arc, Napoleon, Christopher Columbus). Like for EVE 10, the task was divided in four steps: definition, recognition among three suggestions, two specific questions and dating on a time line.

Results. SL was in the normal range across the four levels of the task ($t_4 = 1.06$; $p = .18$) (Fig. 10). Furthermore, it is of interest to report that when SL failed to answer a specific question, it concerned almost each time the production of a proper name.

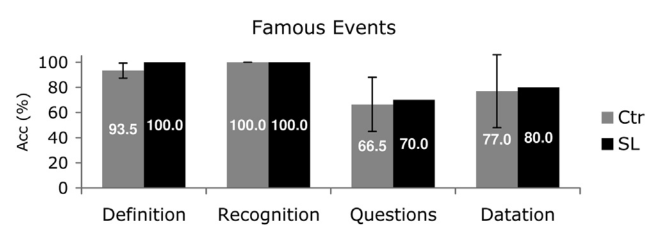

Fig. 9 – SL's and controls' results in Experiment 3.2.4.1. (famous events). SL and controls were not different at any level. Error bars represent controls' standard deviations.

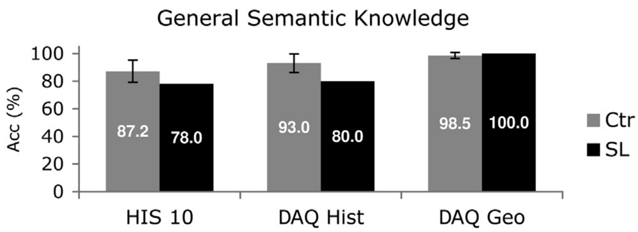

Fig. 10 – SL's and controls' results in Experiments 3.2.4.2. (HIS 10 – history questionnaire) and 3.2.4.3. (DAQ – history and geography didactic acquisition questionnaire). SL and controls were not different at any level. Error bars represent controls' standard deviations.

3.2.4.3. History and geography didactic acquisition questionnaire (DAQ). *Procedure*. The history and geography DAQ was designed in order to assess basic knowledge about historical and geographical facts learned in primary and secondary school (see Barbeau et al., 2012). It consisted of 20 questions about French history and 20 questions about French geographical knowledge (name of rivers, mountains, cities).

Results. SL was in the normal range for the historical part ($t_4 = 1.77$; $p = .08$) and the geographical part ($t_4 = .61$; $p = .29$) (Fig. 10). As for the previous experiment, SL lost his only points on the historical questionnaire when he was required to produce people's names. However, he was able to produce all the geographical names.

This last set of experiments regarding unique entities demonstrates several things: SL has preserved semantic knowledge about specific and unique events, historical facts and geographical places; he is still able to produce names of rivers, mountains, cities and to some extent of historical characters. It is worthwhile to note that, while SL was impaired in GRETOP (Experiment 3.1.2.2.) in retrieving semantic information from celebrities' names, he can here retrieve semantic information from historical people's names. Thus, his retrieval of semantic information from the name of historical characters seems better preserved than from the name of contemporary celebrities, a profile that was already reported in the literature for some proper name anomic patients (Lucchelli et al., 1997; Saetti et al., 1999; Shallice & Kartsounis, 1993).

3.3. *Common nouns*

Procedure. In his first neuropsychological assessments, SL sometimes demonstrated some mild difficulties in producing common nouns. However, his last neuropsychological assessment did not report common noun anomia anymore and at the moment we conducted our study, he was no longer complaining about common name retrieval difficulties. Thus, in order to discard a more general deficit in noun production, we assessed SL with the colorized version of the Snodgrass and Vanderwart's object battery (Rossion & Pourtois, 2004). This battery consisted of 260 objects to name (166 non-living; 54 living animate; 40 living inanimate).

Results. The results of SL were entirely normal, regardless of whether he had to name non-living ($t_4 = .00$; $p = .50$), living animate ($t_4 = 1.45$; $p = .11$), or living inanimate ($t_4 = .36$; $p = .37$) objects (Fig. 11). Moreover, in this task we recorded response times. SL was as fast as controls in naming each category of stimulus: non-living (SL: 2610 msec; controls' mean: 2047 msec; $t_4 = .75$; $p = .25$), living animate (SL: 2770 msec; controls' mean: 1916 msec; $t_4 = 1.68$; $p = .08$), and living inanimate (SL: 3018 msec; control's mean: 1878 msec; $t_4 = 1.30$; $p = .13$).

3.4. *New vocabulary*

Even if SL does not present with common noun anomia any longer, he was still complaining about some difficulties in infrequent words retrieval. We decided to test him in a task of new vocabulary, since two previous proper name anomic patients presented difficulties with new words (Moreaud et al., 1995; Shallice & Kartsounis, 1993).

Procedure. The task consists in 22 nouns recently introduced in the French dictionary (Thomas-Antérion et al., 2010). Half of the nouns appeared during the 1996–1997 period (e.g., tofu, DRH, internaute), the other half in the 2006–2007's (e.g., blog, USB, TOC). For each item, participants had to provide a definition, choose from two definitions the correct one, and find one sentence in which the word was correctly used.

Results. SL was impaired for the nouns introduced between 1996 and 1997 ($t_4 = 7.19$; $p < .01$) as well as for the nouns introduced from 2006 to 2007 ($t_4 = 7.19$; $p < .01$) (Fig. 12). These results are interesting. Even if SL was not asked to produce the name, he was in difficulty to link the label to its semantic concept. This corroborates with the results obtained with people's name and acronyms, and demonstrates that the deficit spreads to other labels that are probably still abstract and not frequently used in the common vocabulary. Furthermore, we have to note that some of the names used in the task were actually acronyms (e.g., DRH, USB, TOC) which could explain the increased difficulty for SL in this task.

4. Discussion

To sum up the data (see Table 2), we demonstrated in our study of patient SL that:

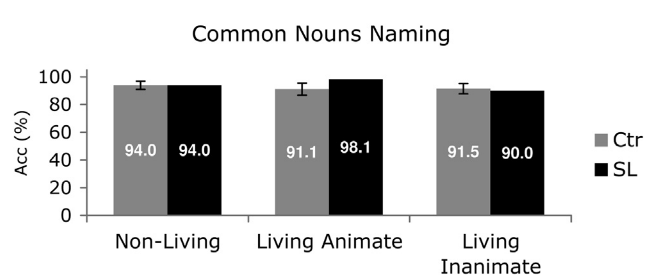

Fig. 11 – SL's and controls' results in Experiment 3.3. (common nouns naming). SL and controls were not different at any level. Error bars represent controls' standard deviations.

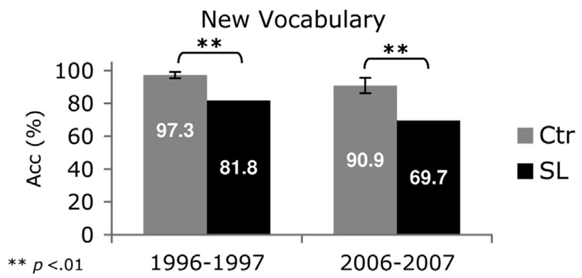

Fig. 12 – SL's and controls' results in Experiment 3.4. (new vocabulary). SL was impaired for both 1996–1997's and 2006–2007's vocabulary. Error bars represent controls' standard deviations.

- His proper name anomia is not specific to people's names but encompasses other unique and abstract labels, such as acronyms and monuments' names.
- Semantic knowledge on people but also on other unique entities (monuments, famous events, historical facts, geography) is preserved, even when SL is required to retrieve highly unique and specific details.
- Preserved biographical facts on people are better accessible on face confrontation than on name confrontation.
- Proper name labels are impaired in production and in comprehension, even if the impairment is stronger in production. Labels themselves are intact, since familiarity judgment is preserved.
- Retrieval of common nouns and even of some proper name categories (countries, capitals, geographical places, historical characters) is preserved.

In summary, SL presents a production and comprehension deficit for unique and abstract verbal labels. These observations are in line with previous patients presenting impairment in retrieving meaningless labels together with preserved ability to access unique biographical facts (Hanley, 1995; Harris & Kay, 1995; Hittmair-Delazer et al., 1994; Lucchelli & De Renzi, 1992; Moreau et al., 1995; Otsuka et al., 2005; Saetti et al., 1999; Semenza & Zettin, 1988; 1989; Shallice & Kartsounis, 1993). The very specificity of SL is that his semantic access to individual knowledge is preserved for faces but compromised for names. This is a very rare trait observed in the literature (Eslinger, Easton, Grattan, & Van Hoesen, 1996; Verstichel et al., 1996) since retrieval of biographical information is generally easier from name cues than from faces (e.g., Haslam, Kay, Hanley, & Lyons, 2004; Langlois, Fontaine, Hamel, & Joubert, 2009) presumably because faces are less stable than names.

4.1. *Which kind of proper name anomia?*

In the introduction, we briefly presented the four varieties of proper name anomia described by Semenza (2006; 2009). We will detail here each variety and try to verify whether SL can be classified by one of them. (1) *Anomia in accessing the phonological lexicon* is characterized by an inability to access proper name labels together with the integrity of the labels themselves (positive effect of phonological cueing, intact recognition and preserved access to person identity from name). Patients cannot retrieve proper names on picture confrontation or verbal definition. This profile is considered as a post-semantic anomia, given that all the semantic knowledge is preserved. The common denominator of this first type of proper name anomia is an inability to retrieve purely referential semantic relations. (2) *Anomia due to loss of semantic information* is defined by a degradation of the labels themselves (inability to retrieve and recognize proper names). The anomic impairment is accompanied by a loss of semantic information of people. The damage is at the level of conceptual knowledge. (3) In the *isolation of information about individual entities* profile, patients cannot retrieve either the name or the semantic information from people's faces or person definition. However, semantic information can be retrieved if provided with people's names. In addition there is generally a disturbed connection between individual semantics and general semantics. (4) Finally, *prosopanomia* is defined as the isolated inability to retrieve proper names on face confrontation. Name retrieval on verbal definition is preserved. Semantic information on face confrontation may be correctly retrieved, but in a way that may be insufficient to select the correct name.

Does patient SL fit with one of these four varieties? SL's profile is close to the *anomia in accessing the phonological lexicon* (type 1) since he cannot retrieve purely referential verbal labels (people's names, acronyms, monuments' names). However, his access to semantic information from proper name labels is also impaired. Thus, his impairment cannot be considered only as a specific deficit in label retrieving. SL is also close to presenting an *isolation of information about individual entities* (type 3). However, instead of presenting a disconnection between semantic information and face units, SL instead suffers from a disability to connect semantic information to proper names. Third, SL does not certainly show an *anomia due to loss of semantic information* (type 2) given the high precision of his semantic knowledge on people. And finally, he does not present either a *prosopanomia* (type 4) given that his name retrieval on verbal definition (even if not formally tested) is not preserved and that his deficit extends beyond people's names. In conclusion, SL would present a fifth variety of proper name anomia that could be defined as a *two-way lexico-semantic disconnection*. This profile would be characterized by a partial disconnection between semantic knowledge and the lexicon of proper name labels. The deficit is ‘two-way’ since the proper names cannot be accessed by semantic knowledge and semantic knowledge is not accessed by proper names. Indeed, first SL was unable to retrieve people's names on face confrontation while he retrieved all the biographical knowledge on these people. Thus having access to people's face and biographic details did not lead to proper name activation. Second, while provided with the verbal labels (people's names, acronyms), SL hardly had access to the related semantic knowledge. However, name labels and semantic knowledge themselves are preserved, as was demonstrated by SL's flawless performance on name recognition tasks and on semantic definition on visual confrontation. This is a very rare profile since previous patients described with production and comprehension of proper names' impairment

Table 2 – Summary of SL's results amongst the experiments, classified according to the nature of the task (recognition, comprehension, name retrieval) and the nature of the input (verbal or visual). Impaired results are symbolized by a red cross; unimpaired results are symbolized by a green '*v*'.

	Recognition		Comprehension		Name retrieval	
	Visual input	Verbal input	Visual input	Verbal input	Visual input	Verbal input
People						
Task 3.1.1.1.	✓					
Task 3.1.1.2.		✓				
Task 3.1.2.1.	✓		✓		✗	
Task 3.1.2.2.		✓		✗		
Task 3.1.2.3.			✓		✗	
Task 3.1.3.1.			✓			
Task 3.1.3.2.				✗		
Task 3.1.3.3.					✗	
Acronyms						
Task 3.2.1.1.		✓				
Task 3.2.1.2.				✗		
Task 3.2.1.3.						✗
Monuments						
Task 3.2.2.1.	✓					
Task 3.2.2.2.			✓		✗	
Flags						
Task 3.2.3.1.					✓	
Capitals						
Task 3.2.3.2.						✓
History						
Task 3.2.4.1.				✓		
Task 3.2.4.2.				✓		
Task 3.2.4.3.						✓
Geography						
Task 3.2.4.3.						✓

Table 2 – (*continued*)

	Recognition		Comprehension		Name retrieval	
	Visual input	Verbal input	Visual input	Verbal input	Visual input	Verbal input
Common nouns						
Task 3.3.					✓	
New vocabulary						
Task 3.4.				✗		

generally present damaged verbal labels (Eslinger et al., 1996), damaged semantic knowledge (Miceli et al., 2000) or both (Ellis et al., 1989; Hanley, Young, & Pearson, 1989). Only one case of such bilateral disconnection between intact biographical and lexical knowledge was previously described (DEL, Verstichel et al., 1996). Like SL, DEL presented associated production and comprehension deficits for people's names. He was unable to retrieve the names of familiar people on presentation of their faces or on verbal definition, while he had the preserved ability to provide rich and accurate biographical information on people he could not name. Moreover, while the input and output lexicon was intact, the patient presented a severe deficit in understanding people's names. The authors concluded that there was a “mirror disconnection between input forms and biographical knowledge”. In consequence, on the basis of SL's and DEL's cases, we propose completing Semenza's taxonomy with this *two-way lexico-semantic disconnection* variety. We represented in Fig. 13 the five varieties of proper name anomia in a model of disconnections inspired by the functional model of face and name recognition of Valentine, Brédart, Lawson, and Ward (1991), Valentine, Brennen, and Brédart (1996) and Semenza's information processing model for proper name production and understanding (2006, 2009). For the clarity and conciseness of the model, we focused on people's names. In this model, access to stored individual semantic knowledge is achieved after face, name or definition recognition. The activation of this semantic store is a mandatory mediation to access the phonological lexicon. Indeed, until now, no convincing neuropsychological case of intact naming in the absence of personal semantic knowledge has been reported. Brennen, David, Fluchaire, and Pellat (1996) presented a case of Alzheimer dementia who sometimes was able to name a face she could not describe, but the patient presented strong name retrieval difficulties and her rare name retrievals were aleatory and occurred only for three celebrities. In our model, proper name anomia can be due to disconnections or destructions of semantic and lexical representations. (1) In *anomia in accessing the phonological lexicon*, the output labels are disconnected from the individual semantic system. (2) In *anomia due to loss of semantic information*, individual semantics are destroyed. (3) The *isolation of information about individual entities* is characterized by a disconnection of the individual semantic system from face units and verbal definitions. (4) *Prosopanomia* is a specific disconnection between face units and individual semantics. (5) Finally, the *two-way lexico-semantic disconnection* is characterized by a disconnection between individual semantics and both output and input name labels. All these five varieties have as a consequence a proper name retrieval deficit.

4.2. *Proper name organisation*

How are proper names processed in the brain? As mentioned in the introduction, event-related potentials, neuroimaging and neuropsychology studies all agree that proper names are essentially processed in the left hemisphere, mostly at the level of the anterior part of the temporal lobe (Damasio et al., 1996; 2004; Gorno-Tempini et al., 1998; Proverbio et al., 2001; Semenza et al., 1995; Snowden et al., 2012; Tranel, 2006; 2009; Tsukiura et al., 2002). However, considering the variety of proper name anomias just described above, there are reasons to believe that different aspects of proper name retrieval may be sustained by different structures of a complex network. Indeed, reviews on proper name anomia defined a set of critical areas involved in proper name anomia outside the left anterior temporal lobe: the left basal ganglia, the left thalamus, the posterior temporal lobe, and the left prefrontal cortex for example (Semenza, 2006; 2009; 2011; Yasuda et al., 2000). Moreover, a study on 139 unilateral brain-damaged patients (Damasio et al., 2004) demonstrated that lesions involved in people's names' retrieval deficit were located in the left temporal pole, the left anterior parahippocampal gyrus, the left anterior infero-temporal gyrus and the frontal operculum. However, the maximum overlap of lesions was located in the left anterior inferotemporal lobe, and these observations were confirmed by a PET experiment conducted in the same study (Damasio et al., 2004). Thus, the left temporal pole seems crucial in people's name retrieval, or at least is the most efficient and effective normal path (albeit perhaps not the only one). But how are the proper names connected to other types of individual knowledge in this temporal pole?

In the late eighties, Antonio and Hanna Damasio (e.g., Damasio, 1989; 1990; Damasio & Damasio, 1994; Damasio, Damasio, Tranel, & Brandt, 1991; 2004; Meyer & Damasio, 2009) introduced the concept of *convergence zones*. According to this concept, complex representations are stored in geographically separate regions that are bound in hierarchically organized *convergence zones*. These convergence zones correspond to different domains of knowledge and are anatomically distinct. None of these convergence zones store permanent memories of words and concepts, but instead record the probable combination between them in terms of 'temporal coincidence'. In other terms, they hold information about how knowledge fragments must be combined to

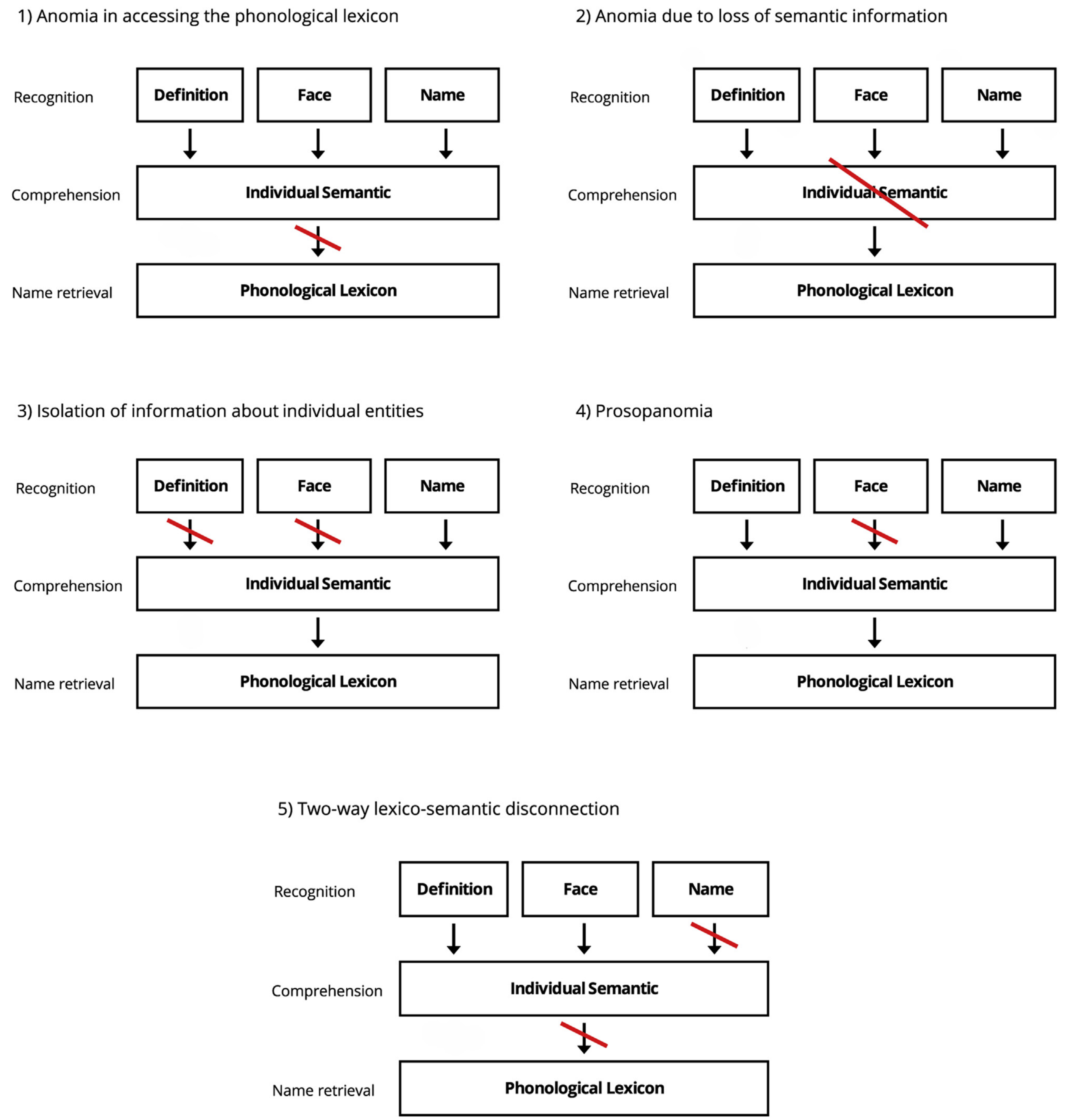

Fig. 13 – Model of proper name anomia inspired by Semenza's classification (2006; 2009) and completed with SL's functional damage. For the conciseness of the model, we focused it on persons' names. (1) In *anomia in accessing the phonological lexicon*, the output labels are disconnected from the individual semantic system. (2) In *anomia due to loss of semantic information*, individual semantics are destroyed. (3) The *isolation of information about individual entities* is characterized by a disconnection of the individual semantic system from face units and verbal definitions. (4) *Prosopanomia* is a specific disconnection between face units and individual semantics. (5) Finally, the *two-way lexico-semantic disconnection* is characterized by a disconnection between individual semantics and both output and input name labels.

represent a concept comprehensively. Damasio suggested that the *most anterior portion of the inferotemporal lobe* would be a good candidate to be a convergence zone for unique entities and events. The anterior temporal lobe would not store names or concepts themselves but would rather register linkages between them, supporting a 'mediational' or a 'combinatorial' role. As Damasio and Damasio suggested: "*Access to*, leading to *retrieval of*, must be distinguished from *represented at*. The knowledge that can be accessed from anterior temporal cortex is not fully represented in anterior temporal cortex in the sense that no "image" is likely to be there" (Damasio & Damasio, 1994, p. 68). This theory was supported by a set of numerous empirical data that demonstrated that higher-order convergence systems are sustained by temporal poles of both hemispheres.

In their study on the 139 unilateral brain-damaged patients, Damasio et al. (2004) demonstrated that while the maximum overlap of lesions involved in *people's names'* retrieval deficit was located in the *left* anterior inferotemporal lobe, *people's conceptual knowledge* retrieval defects are generally associated with lesions in the *right* anterior inferotemporal lobe. These findings were completed by studies on semantic dementia (e.g., Gainotti, Ferraccioli, & Marra, 2010; Snowden, Thompson, & Neary, 2004; 2012) demonstrating the importance of the anterior, inferolateral parts of the left temporal lobe in name recognition and the corresponding parts of the right temporal lobe for faces. Indeed, these studies demonstrated that semantic dementia patients with predominant left temporal lobe atrophy showed better recognition and identification of faces than names, whereas patients with right temporal predominance showed the reverse pattern. A set of fMRI studies (e.g., Tsukiura, Suzuki, Shigemune, & Mochizuki-Kawai, 2008) confirmed that the left ATL mediates associations between names and person-related semantic information, whereas the right ATL mediates the association between faces and person-related semantic information. A recent study of Marconi et al. (2013) further demonstrated that while inferential tasks (e.g., naming from a verbal definition) engage specific activations mainly in the left hemisphere, referential tasks (e.g., picture naming) recruit additional specific processing resources in right hemispheric areas.

Do Damasio's theories account for SL's two-way lexico-semantic disconnection? We know that in SL's case, name labels are intact since he can recognize them in familiarity tasks. We also know that all his individual semantics are preserved. If the connection between names and individual semantics occurs in the left temporal pole in a normal brain, it would explain why people's names and individual semantics are disconnected since SL's left temporal pole is completely destroyed. In contrast, SL is still totally able to achieve individual semantic information from face units, which could be explained by the intactness of his right temporal pole. Thus, SL's profile seems highly compatible with Damasio's convergence zones theories. Moreover, SL's two-way lexico-semantic disconnection is even further in accordance with the bi-directional principle defined within Damasio's theoretical framework: according to this theory, the convergence zones function as *two-way relays* and support the process of triggering word form retrieval given conceptual knowledge, and the process of triggering conceptual knowledge retrieval given word forms (Marinkovic, 2004; Tranel, 2009). SL's bi-directional lexico-semantic disconnection as the consequence of a left convergence zone defect therefore completely fits this framework.

However, in accordance with Semenza (2006), we acknowledge that such a profile could occur in the absence of lesions in the left temporal pole. Verstichel and colleagues' (1996) patient, DEL, who showed a clinical profile very close to SL, indeed presented quite different lesions in comparison to SL. DEL's lesions encompassed the left lateral and mesial occipito-temporal cortex (amygdala, hippocampus, parahippocampal, lingual and fusiform gyri) and the postero-lateral part of the left thalamus, sparing the left anterior temporal lobe. This discrepancy of lesions' localisation between patients presenting such a similar impaired cognitive profile is challenging. However, according to Damasio and colleagues' theories, while large-scale convergence regions would be localized in relatively large neural sectors, relatively identical across individuals, micro-scale convergence zones of higher resolution would not be expected to be in equal sites across individuals. According to them, the process of anatomical selection of convergence zones both during learning and subsequent operations is probability-driven, flexible and individualized (Tranel, 2009). This would explain why we can observe similar fine cognitive profiles in presence of different lesions' localization. Considering all these subtleties, we have to acknowledge that we still do not completely understand all the various aspects of proper name processing and that future case studies will be required to disentangle what is probably a complex left interconnected hemispherical network.

4.3. *Supramodal or amodal hub?*

Recently, an alternative was proposed to Damasio's convergence-zones hypothesis: the *semantic hub-plus model* proposed by Patterson and colleagues (e.g., Patterson et al., 2007; Pulvermüller et al., 2010; Rogers et al., 2004). While Damasio suggests the existence of multiple specialized convergence zones, Patterson and colleagues argue in favor of a single unified and *amodal semantic hub* independent of modality. According to them, this single hub, located in the anterior temporal lobe, would support the interactive activation of representation in all modalities, for all semantic categories. The authors built their model on the observation that semantic dementia patients generally present semantic impairment that affects all modalities of reception and expression. Another support to the amodal hub theory was added by recent TMS studies that showed that stimulation applied to the left or right temporal pole disrupts semantic processing of words and pictures to a comparable degree (e.g., Pobric, Jefferies, & Lambon Ralph, 2010). From this perspective, damage to this single amodal hub should produce a semantic impairment that is independent of the modality of input (objects, pictures, words,...). However, SL clearly does not support this theory given that he presents a semantic impairment dependant to the modality. While his conceptual knowledge of people is no longer accessible from people's names, it still is accessible from people's faces. SL's case demonstrates that a selective impairment of semantic access from a specific modality is possible and contradicts Patterson and colleagues' predictions. Our observations argue more, as Damasio has suggested, in favor of the existence of several supramodal convergence zones that bind representations from specific modalities: while SL's convergence zone, binding verbal labels to people's biographical facts (presumably located in the left anterior temporal lobe), is damaged, his convergence zone binding face units to these biographical facts (presumably located in the right anterior temporal lobe), still works perfectly. In accordance with recent studies (e.g., Gainotti et al., 2010; Marconi et al., 2013; Snowden et al., 2012), SL's study challenges the amodal semantic hub theories which view the anterior temporal lobes as an area of convergence in which semantic information is represented in amodal form. Rather, SL's case supports the view that the temporal anterior convergence zones are subdivided according to the input modality and can be selectively disconnected (for a review of this question, see Gainotti, 2011). Of course, as Gainotti et al. (2010) noted, the existence of different supramodal hubs in the left and the right hemisphere does not imply that different semantic knowledge is accessible by the face or the name. In a normal brain, this information is systematically and continuously integrated between both hemispheres. In the case of a unilateral anterior temporal lesion however, different paths to individual semantic knowledge can be disrupted, depending on the damaged side.

5. Conclusion

In conclusion, we presented the case of a patient who, following HSE, retained the ability to access rich conceptual semantic information for familiar people and concepts he was no longer able to name. Most importantly, this patient presented an intriguing combination of name production and name comprehension deficits, together with intact recognition of verbal labels, suggesting a rare form of *two-way lexico-semantic disconnection*, in which intact lexical knowledge is disconnected from semantic knowledge and face units. We suggest that this disconnection reflects the role of the left anterior temporal lobe in binding together different types of knowledge and supports the classical convergence-zones theory rather than an amodal semantic hub theory. This case study demonstrates that the single case study approach is still in 2014 a rich and powerful method to test anatomo-functional models and to improve our understanding of cognitive processing.

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