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Proper name anomia after right-hemispheric lesion: a case study

Cornelia Geukes[a]* and Horst M. Müller[a,b]

[a]*Experimental Neurolinguistics Group, Faculty of Linguistics and Literary Studies, Bielefeld University, Bielefeld, Germany;*
[b]*Collaborative Research Center 'Alignment in Communication' (SFB 673), Bielefeld University, Bielefeld, Germany*

This study describes the case of CH, a 68-year-old left-handed woman who suffered a right temporo-parieto-occipital infarct in the territory of the middle cerebral artery and who exhibits severe proper name anomia. During the acute stage, CH was diagnosed with severe amnestic aphasia (Aachen Aphasia Test). Her lesion mirrors those of left hemisphere impairing the processing proper names, without an aphasic language disorder in general. Seven weeks later, language improved to a mild amnestic aphasia that currently does not interfere with her daily life. However, the use of proper names in both the visual and auditory modalities was still impaired and showed no improvement after 6 months of speech therapy. While not being able to name family members or familiar persons, she was, however, still able to describe the persons' backgrounds along with some additional semantic information. Furthermore, in a simple semantic design test, CH was selectively impaired in correctly classifying proper names into their respective word classes. Conversely, she was able to correctly name and classify other word categories (e.g., common nouns). In the subsequent study, we assessed the modalities "auditory comprehension," "picture naming," and "reading comprehension" and classified her responses in the categories "correctly named," "correctly classified," "correctly described attributes" (e.g., occupation) and "falsely named." The results were compared with those of an age-matched healthy control group. In the visual task, CH correctly named 80% of the visualized objects, 3% of the familiar persons and 15% of the familiar city views.

Keywords: proper names; common nouns; stroke; lexicon; single case study; right hemisphere

Aphasic syndromes often involve word retrieval impairment, which is demonstrated by patients who are not able to retrieve a particular word despite knowing the meaning of the word that they are searching for. For this reason, patients produce words with phonematic and semantic deviations (paraphasias). Moreover, word recognition impairments may appear in different semantic categories such as animated and non-animated objects (Laiacona, Capitani, & Caramazza, 2003), body parts (Suzuki, Yamadori, & Fuji, 1997), colors (Nagaratnam, Barnett, & Yeoh, 1999), buildings, vehicles, toys and furniture (Barbarotto, Capitani, Spinnler, & Trivelli, 1995), or food, animals, and flowers (Warrington & McCarthy, 1983). Beyond the impaired retrieval of grammatical word classes (e.g., concrete and abstract word categories; Warrington & Shallice, 1984), the retrieval of proper names (Crutch & Warrington, 2004; Martins & Farrajota, 2007; Neininger & Pulvermüller, 2003; Yasuda & Ono, 1998) may also be reduced as a result of aphasia. The inability to accurately process proper names can be found in both the auditory and the visual modality to varying degrees of severity. In many lesion studies, researchers have described cases in which proper name anomia occurred after left-hemispheric injuries (e.g., Crutch & Warrington, 2005; Hittmair-Delazer, Denes, Semenza, & Mantovan, 1994; Martins & Farrajota, 2007; Semenza &

Zettin, 1988; Yasuda & Ono, 1998). Only rarely have researchers found impairments in proper name processing resulting from lesions in the right hemisphere (Gainotti, Barbier, & Marra, 2003; Gentileschi, Sperber, & Spinnler, 2001; Mc Neil, Cipolotti, & Warrington, 1994; Ohnesorge & Van Lancker, 2001; Tsukiura et al., 2002). One reason for these results may be because language is left lateralized in 96% of strong right-handed and in 27% of strong left-handed persons (Knecht et al., 2000). However, lesion studies also show that the right hemisphere is able to assume cognitive demands that are generally dominated by the left hemisphere. Detailed electroencephalographical (EEG) studies show that in cases of left-hemispheric injuries, the right hemisphere adopts left-hemispheric tasks especially regarding proper name processing, underlining the brain's ability for cognitive plasticity (Finger, Buckner, & Buckingham, 2003; Thiel et al., 2006).

According to theoretical approaches in the philosophy of language and linguistics (e.g., Van Langendonck, 2007), common nouns and proper names represent distinct groups within the mental lexicon and undergo different processes that have been reviewed in many studies (see Müller, 2010; Müller & Kutas, 1996; Semenza, Mondini, & Zettin, 1995; Yasuda, Beckmann, & Nakamura, 2000). The Baker–Baker phenomenon, which describes the fundamental differences between remembering proper names

and describing occupations, highlights the existence of functionally different processing pathways, because proper names act as pure referring expressions (Mc Weeny, Young, Hay, & Ellis, 1987).

Evidence for the theoretical idea of right-hemispheric proper name processing or at least right-hemispheric support during the comprehension of proper names can be found in few studies. In a visual field task, Bradshaw, Gates, and Nettleton (1977) investigated the recognition of reading proper names and found no significant differences between the hemispheres. In an EEG-coherence study, Weiss and Müller (2003) found a comparable increase in right-hemispheric neural synchronization during proper name processing and a comparably higher left-hemispheric synchronization during common noun processing. Van Lancker, Klein, Hanson, Lanto, and Metter (1991) found that the right hemisphere is involved in the retrieval of relevant personal information. Additionally, fMRI and EEG studies have found evidence for right-hemispheric activation in face recognition in the fusiform face area (FFA) (e.g., Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005).

The extent to which the right hemisphere is involved in proper name processing remains unclear. Similar controversial findings regarding hemispheric lateralization cite patients with a familiar people recognition disorder (acquired prosopagnosia) following a right or, occasionally, left anterior temporal lesion (for review see Gainotti, 2007).

In this case study, we present a left-handed patient ("CH") with an unknown language lateralization who shows right-hemispheric involvement in proper name processing. We examined CH's noun processing abilities in an auditory and a visual task 4 weeks after her stroke and in a 6-month follow-up. Additionally, her results were compared with those of an age-matched healthy control group.

Materials and methods

Case report

CH is a 68-year-old left-handed woman. She had 10 years of education, raised three children and was in a long-term relationship. Due to a right-hemispheric stroke, she developed a language disorder. After the acute stage, CH went to a rehabilitation center for 3 weeks to recover. Afterward, she got 6 months of speech therapy.

Handedness

According to a Coren (1992) test, CH scored 17/36, which indicates a moderate degree of left-handedness. As is typical of her generation, she uses her right hand for writing. CH is the only left-handed member of her family – her parents, sisters, brother, and children are not left-handed.

Neuroimaging

Magnetic resonance imaging (MRI) showed a right temporo-parieto-occipital infarct in the territory of the middle cerebral artery (MCA) that predominantly affected the insular cortex and the temporal lobe. Additionally, small lacunar infarcts were found in the posterior MCA and the anterior MCA regions (see Figure 1). There were no indications for lesions within the left hemisphere.

Neuropsychological examination

CH suffered from a cardioembolic infarct in the MCA territory of the right hemisphere. On the day of hospital admittance, CH showed decreased attentional abilities and appeared to be in a diffuse state of alertness with a lack of motivation. She also seemed to be disoriented in time, place, and situation. In a speech therapy diagnostic session, she showed significant impairments in comprehension, naming, and reading tasks. Motor or sensory deficits could not be found. All of the symptoms ameliorated within the first 4 weeks after the injury. Only an amnestic aphasia was diagnosed with the AAT (Aachen Aphasia Test; Huber, Poeck, Weniger, & Willmes, 1983; see Table 1) 4 weeks after stroke. CH's aphasia improved within 7 weeks after stroke onset to a very mild amnestic aphasia (see Table 2). CH showed no obvious difficulties in speech or motor actions that are relevant to her everyday life. Furthermore, she was not impaired in recognizing familiar people, showing no signs for an acquired prosopagnosia, which may occur in approximately 50% of right-hemispheric stroke survivors (Cousins, 2013).

Naming

After her stroke, CH showed persistent impairments in proper name processing. She complained about having extreme difficulties in naming familiar persons, including her children and husband. She was, however, able to note the members of her family on pictures and to access respective semantic information (e.g., "This is my son," "This is my husband," etc.). Furthermore, she was not able to name familiar persons on the basis of semantic information (e.g., "Who is your neighbor?").

Procedure

CH was evaluated at 4 weeks (Evaluation 1) and 6 months post stroke (Evaluation 2). We tested CH's picture naming, comprehension of nouns, and reading ability. There were two different tasks: The first task was an auditory task that involved the categorization of 161 nouns such as person names ($n = 73$), city names ($n = 15$), and common nouns ($n = 73$). The second task involved naming of 264 pictures showing familiar persons ($n = 52$), well-known city views ($n = 13$), and high-frequency objects ($n = 199$) and
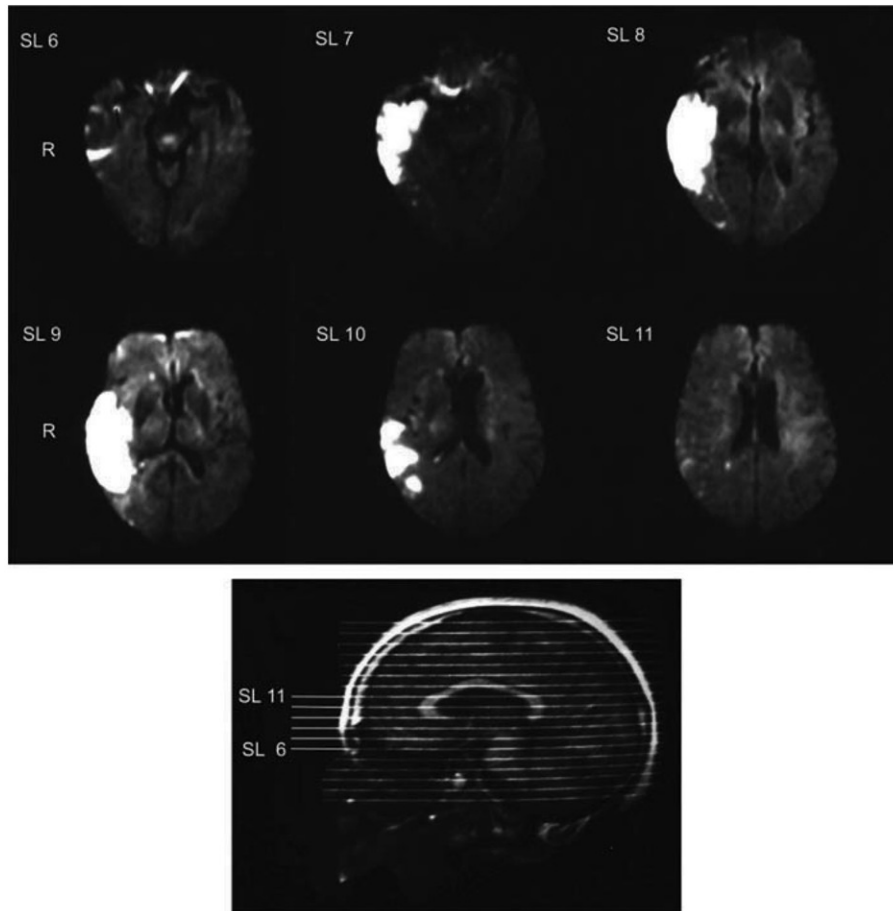
Figure 1.   Horizontal MRI images based on a diffusion weighted imaging sequence show the affected brain areas of the middle cerebral artery territory of the right hemisphere. The inset indicates the position of the axial slices 6–11.

Table 1.   Aachen Aphasia Test analysis 4 weeks after stroke onset.

Subtest	Points	Percentile rank	Severity grade general	Severity grade syndrome
Token test	34	39	MI	S
Repetition	124	66	M × L	S
Written language	57	59	M	S
Confrontation naming	93	68	M × L	S × M
Comprehension	85	59	M × L	S

Notes: Diagnosis: 100% amnestic aphasia. S = severe, M = medium, L = mild, MI = minimal.

Table 2.   Aachen Aphasia Test analysis 7 weeks after stroke onset.

Subtest	Points	Percentile range	Severity grade general	Severity grade syndrome
Token test	45	16	S	S
Repetition	150	99	L × MI	L
Written language	87	97	L × MI	L
Confrontation naming	117	99	MI	L
Comprehension	118	100	MI	L

Notes: Diagnosis: 100% amnestic aphasia. S = severe, M = medium, L = mild, MI = minimal.

classifying them into one of three word classes (name, city, and object). Both tasks were self-paced tasks in which CH defined the inter-stimulus range herself. We also tested CH's reading comprehension, which involved 60 words such as person's first names ($n = 20$), city names ($n = 20$), and common nouns ($n = 20$).

Materials and methods

We presented 161 items auditorily and 264 pictures and 60 written words visually via computer (Mac OS) and a presentation software (Psyscope). Auditory stimuli were spoken by a professional female speaker with natural intonation and recorded in a sound studio. The visual stimuli were taken from different object recognition tests. All items were high-frequency two-syllable words (except for the familiar persons) that were matched in word frequency and without emotional effective load.

Auditory:

- 73 person's first names, e.g., Bernhard, Silke, Hermann
- 73 common nouns, e.g., Hose (*pants*), Apfel (*apple*), Brötchen (*bread roll*)
- 15 city names, e.g., London, Sydney, Berlin

Visual:

- 52 familiar persons, e.g., Julia Roberts, Günther Jauch, Heidi Klum
- 199 objects, e.g., Nüsse (*nuts*), Igel (*hedge hog*), Zeitung (*newspaper*)
- 13 unique city views, e.g., Pisa, New York, Athens

Reading comprehension:

- 20 person's first names, e.g., Ingo, Gerhard, Klara
- 20 common nouns, e.g., Krone (*crown*), Honig (*honey*), Trommel (*drum*)
- 20 city names, e.g., Bagdad, Bochum, Hamburg

Due to the small sample size, we used Fisher's exact test to determine the significance of performance in Evaluation 1 and Evaluation 2.

Evaluation of performance

Auditory

Answers in which the item was correctly understood even if parts of the answer were wrong (e.g., *Snake*: "an animal that stabs you") were counted as correctly classified. Answers that involved no reaction at all or an incorrect reaction (e.g., a semantically correct description but a false classification; e.g., *bag*: "for the holidays. That is a name.") were counted as falsely classified.

Visual

Items that were correctly named/identified were counted as correctly named. Items that were not named at all or named in a false way even if semantic information was accessed (e.g., Lady Diana: "I know her, she's dead, car accident") were counted as incorrectly named items.

CH answered quickly. If she knew the answer, she did not need time to think and could directly name the target item. There were no indications for impairments in word retrieval.

Reading

Items that were correctly read without a delay were counted as correctly read. Answers that include the correct understanding of an item even if parts of the answer were wrong were counted as correctly understood. Answers that involved no reaction at all or an incorrect reaction (e.g., a semantically correct description but a false classification) were counted as incorrectly understood.

Results

Four weeks after stroke onset (Evaluation 1), CH was able to correctly classify 64% of the proper names in the auditory task (Table 3). The remaining 36% of the presented items were not correctly classified or were left unanswered (e.g., "I don't know"). Regarding the class of personal names, CH was able to provide semantic information by naming the gender of the items 86% of the time. Regarding the class of the common nouns, CH was able to correctly identify the word class 77% of the time. Here, the remaining 23% were also either incorrectly classified into their respective word classes or left unanswered. In the semantic information task, 91% of the common nouns were correctly named. In the class "cities," she was able to classify 13% correctly.

Six months after stroke onset (Evaluation 2), CH correctly classified only 61% of the personal names. Her results in the class of the common nouns, however, improved to 82% correct answers. In the category "cities," she was able to correctly classify 60% of the items. Again, the residual percentages were false answers or no answers.

In the second task (visual task) of Evaluation 1, CH was able to correctly name only 3% of the famous persons. The resulting 97% were answered with "I don't know" ($\chi^2 = 72.95$ (1), $p = .001$). For 34% of the items, she was able to provide semantic information about the person she saw on the screen (e.g., "That is the coach of Germany's national soccer team"). In the class of common nouns, CH was able to correctly name 71% and to provide correct semantic information for approximately 83% of the items ($\chi^2 = 49.14$ (1), $p = .001$), i.e., she was able to explain what purpose the object served (e.g., "You can cut something

Table 3. Results from the visual and auditory task from both measurements, 4 weeks (Evaluation 1) and, respectively, 6 months (Evaluation 2) after stroke onset.

	Reaction	Evaluation 1		Evaluation 2		Overall presented
		Reaction	Percent	Reaction	Percent	
Visual						
Familiar persons	Correct naming	2	3	0	0	52
	Incorrect naming	4	7	32	60	52
Cities	Correct naming	2	15	1	7	13
	Incorrect naming	11	84	12	92	13
Objects	Correct naming	143	71	160	80	199
	Correct description	24	12	7	3	199
	Incorrect naming	30	15	7	16	199
Auditory						
Person names	Correct classification	47	64	45	61	73
	Incorrect classification	14	19	22	30	73
City names	Correct classification	2	13	9	60	15
	Incorrect classification	10	66	6	40	15
Common nouns	Correct classification	38	52	60	82	73
	Incorrect classification	13	17	13	17	73

with it"). The resulting 29% of answers were false answers or no answers. In the class containing cities, CH was able to correctly name only 15% of the items ($\chi^2 = 19.07$ (1), $p = .001$). She could not provide any semantic information about the cities (e.g., "capital city of ....").

Approximately 6 months after her stroke (Evaluation 2), CH was not able to name any of the famous persons presented ($\chi^2 = 80.49$ (1), $p = .001$), although she could provide some semantic information about the familiar persons 39% of the time. CH's ability to name/categorize items in the common noun category improved: She was able to correctly name 80% of the items ($\chi^2 = 24.37$ (1), $p = .001$) and could provide correct semantic information for 84% of the items. In the class containing cities, she named 7% correctly ($\chi^2 = 22.27$ (1), $p = .001$). The remaining answers were false answers or no answers (see Table 3).

Figure 2 provides a diagram of the results from the visual task (picture naming). No answers show phonematic or semantic paraphasias. Initial auditory cues (e.g. "Barack Oba...") did not help CH to correctly name the target items.

In the reading comprehension task, CH was able to read aloud 100% of the items correctly. However, she could only correctly describe 51% of the common nouns, 34% of the person's first names and 36% of the city names. The remaining items were either incorrectly classified into their respective word classes or left unanswered.

Results of the control group

The control group comprised four healthy, age-matched participants (two women and two men, 63–71 years) who were tested with the same test that was used for CH. The control group correctly identified an average of 86.5% of
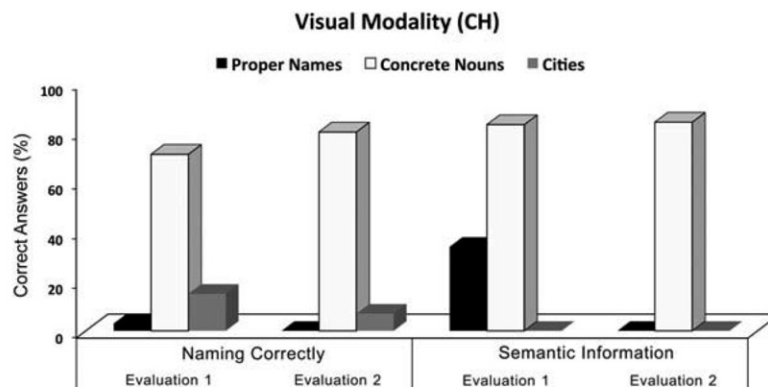

Figure 2. Results from the visual task of both measurements, 4 weeks (Evaluation 1) and, respectively, 6 months (Evaluation 2) after stroke onset.

Table 4. Results of the visual task for the four participants of the control group in percentages.

Participant	1	2	3	4	Mean
Person names	91	75	93	87	86.5
City names	100	100	100	100	100.0
Common nouns	97	99	96	97	97.3

the person names, 97.3% of the common nouns and 100% of the cities (see Table 4). The residual percentages were either falsely answered or left unanswered. Figure 3 is a diagram of the results from the visual task.

Discussion

After the acute phase (7 weeks after onset), CH showed considerable improvements and exhibited no impairments in speech production or perception; she was diagnosed as having mild amnestic aphasia (AAT). CH did, however, exhibit a severe, chronic proper name anomia. Although CH showed stable performances in the visual modality in the category "common nouns" between the first (4 weeks after stroke) and second evaluation times (6 months after stroke), her performance worsened in the category "proper names." CH's results are significantly worse compared with the results obtained from the control group, which was able to correctly categorize 100% of the items in the auditory task. In the visual task, the control group had 86.5% of correct answers for proper names and 97.3% for common nouns (see Table 4). CH showed a category-specific impairment for proper name processing.

Because CH had a right-hemispheric stroke, the question of her hemispheric language dominance remains. CH's left-handedness increases the chance that her right hemisphere is more dominant in language processing (Knecht et al., 2000). However, CH is the only left-handed person in her family, which in contrast reduces the possibility of a right-hemispheric dominance for language.

Additionally, CH's MRI revealed a large temporo-parieto-occipital lesion of her right hemisphere, which led to a mild amnestic aphasia only and improved within few weeks after the stroke. Knecht et al. (2000) concluded that a right-hemispheric dominance exists for only 4% of strongly right-handed persons, for 15% of ambidextrous persons and for only 27% of strongly left-handed persons. Additionally, for the left-handed subjects, those with a familiar history of left-handedness showed a higher incidence of right-hemispheric dominance for language (Knecht et al., 2000). Because of CH's mild amnestic aphasia, a strong right-hemispheric dominance for language appears to be unlikely. Furthermore, findings from patients with acquired prosopagnosia show that left-handed persons do not demonstrate a mirrored FFA (middle fusiform gyrus) in general, suggesting a relationship between language and face lateralization (Bukowski, Dricot, Hanseeuw, & Rossion, 2013). However, a bilateral representation of language for CH could be possible.

Van Lancker and Klein (1990) describe patients with preserved functions for proper name processing after having lesions in the left hemisphere. Furthermore, Verstichel, Cohen, and Crochet (1996) presented a patient who showed selective impairments in retrieving and understanding person names after a lesion in the left hemisphere. While the majority of studies concentrate on left-hemispheric proper name processing (e.g., Crutch & Warrington, 2004; Martins & Farrajota, 2007; Mc Neil et al., 1994; Verstichel et al., 1996), our single case study demonstrates the possibility of right-hemispheric involvement in proper name processing.

This case may support a dissociation between proper name and common noun processing. For theoretical reasons in the philosophy of language, based on empirical data on the cortical representation of the lexicon and based on patient studies, one could hypothesize two separate pathways – one for proper name processing and one for common noun processing (Semenza, 2009; see also Crutch & Warrington, 2003; Finger et al., 2003; Müller
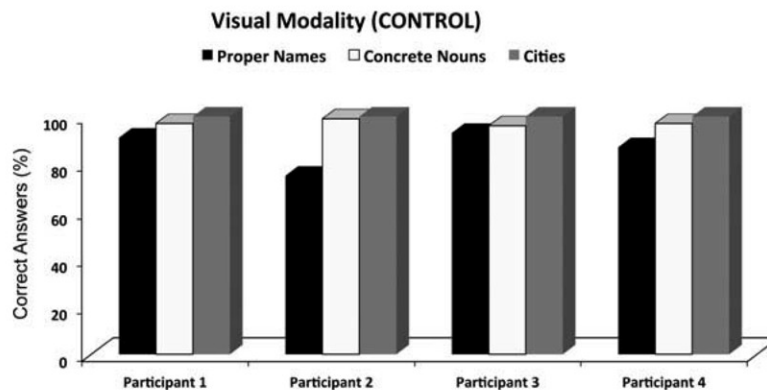

Figure 3. Results of visual task of the control group.

& Kutas, 1996; Schweinberger, Landgrebe, Mohr, & Kaufmann, 2002; Warrington & McCarthy, 1987; Weiss & Müller, 2003). Additionally, one could suggest the existence of specific semantic access for proper names within the semantic system, which is in contrast with common noun categories, which do not require a person's identity-specific semantics. Semenza, Zettin, and Borgo (1998) described a case in which "identity-specific semantic information seems to be totally disconnected from the face recognition system." In the case of CH, the semantic information system appears to be intact because CH was able to give a person's semantic identity information in a picture naming task.

The hypothesis about the participation of the right hemisphere being selective to proper noun processing is supported by findings from face processing studies and case studies of patients with an impaired recognition of familiar faces (prosopagnosia). In an fMRI and EEG study, Henson et al. (2003) found that face processing occurs in different regions of the right hemisphere and in medial regions. They also found higher hemodynamic activity in regions of the right temporal lobe, medial frontal area, and the orbito-frontal cortex during face perception, face recognition, and face repetition tasks. The lacunar infarcts revealed in CH's MRI in posterior regions such as the FFA could therefore explain CH's difficulties in picture naming tasks. Douville et al. (2005) also found higher activity in the left and right temporal lobes and hippocampal structures, indicating the left- and right-hemispheric processing of the name recognition of famous persons. These results could support the hypothesis that there is a bilateral network of information that is associated with individual persons (Douville et al., 2005; Ganel et al., 2005). In another case study, the authors provided evidence for a conceptual information network that caused a proper name anomia in a patient after left-hemispheric damage (Miceli et al., 2000). Additionally, the left temporal lobe theory assumes that this region of the cortex generates a connection between names and individual semantic information (Semenza, 2011). These regions of the left temporal lobe could also generate the association between faces and individual semantic information (Semenza, 2011). This approach would explain CH's severe difficulties in visual tasks (e.g., picture naming) compared with the control group.

CH's impairments could be embedded in the cognitive neuropsychological model of proper name processing (Semenza, 2006). This model assumes differently organized mechanisms for proper names and common nouns. Different features are separated into two distinct semantic categories: individual and general. The features "person definition," "name recognition," "face recognition," and "unique object recognition" influence individual semantics, whereas general semantics receive information from the "person definition," "face recognition," "unique object recognition," and "object recognition" mechanisms. Individual and general semantics mutually exchange and transmit information to the phonological output lexicon for both proper names and common nouns. Our data suggest an impairment in CH's ability to access individual semantics. The "person definition" and "name recognition" mechanisms are severely affected. CH's individual semantic lexicon could only receive information from "face recognition" and "unique object recognition" features. Because this important information about persons and the names of individuals was inhibited, we assume that the semantic lexicon cannot activate the phonological output lexicon.

With respect to its localization, the patient's right-hemispheric lesion mirrors its counterpart in the left hemisphere. However, since the patient's language abilities are nearly intact, the observed impairment shows at least the possibility of a dissociation between the processing of proper names and common nouns within the right hemisphere.

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