Clinical Linguistics & Phonetics, 2014; Early Online: 1–14

ISSN: 0269-9206 print / 1464-5076 online
DOI: 10.3109/02699206.2014.991450

informa
healthcare

Cerebral processing of proper and common nouns: Perception and production following left hemisphere damage

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(*Received 14 September 2014; revised 16 November 2014; accepted 20 November 2014*)

Abstract
The goal of this study was to further investigate hemispheric specialization for proper and common nouns by examining the ability of individuals with left hemisphere damage (LHD) to perceive and verbally reproduce famous names and matched common names compared with the performance of matched healthy controls (HC). Ten individuals with LHD due to stroke and 16 age- and education-matched HC completed recognition and production tasks of famous proper and common nouns. All tasks were designed as split-visual field experiments, modelled after the study done by Ohnesorge and Van Lancker. Results contribute to a better understanding of hemispheric roles in perception and production of famous proper nouns, suggesting that (1) both hemispheres can recognize famous proper nouns, possibly due to a right hemisphere role in personal relevance and (2) production of proper nouns as well as common nouns is associated with left hemisphere.

Keywords: Aphasia, proper noun, left hemisphere, personal relevance, right hemisphere

Background

It is generally agreed that proper nouns occupy a linguistic status that distinguishes them from common nouns (Kripke, 1980; Searle, 1958). While common nouns denote general semantic characteristics (attributes, concepts and categories) of items, proper nouns refer to individual entities (Ohnesorge & Van Lancker, 2001; Semenza, 2009; Tranel, 2006; Van Lancker & Ohnesorge, 2002). Such entities have unique conceptual and lexical associations and thus have been termed semantically unique items (Gorno-Tempini & Price, 2001). Proper nouns and common nouns also differ in text frequency and phonological complexity. Proper nouns are generally more phonologically complex and have lower text frequency compared to the majority of common nouns (Van Lancker & Klein, 1990).

Many clinical and experimental studies have consistently shown differences between processing of proper names and of common nouns, leading to the belief that proper nouns possess a special neuropsychological status. Some neuroimaging studies and lesion studies

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indicated a critical role of the left hemisphere (LH) in processing and retrieving proper names and famous landmarks (Bredart, Brennen, & Valentine, 1997; Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004; Lyons, Hanley, & Kay, 2002; Pavão Martins & Farrajota, 2007; Schmidt & Buchanan, 2004; Semenza, 2006; Snowden, Thompson, & Neary, 2012; Tranel, 2006). Some neuroimaging studies indicated a critical role of the left temporal pole (LTP) in recognizing and retrieving proper nouns (Damasio et al., 1996, 2004; Gainotti, 2014; Simmons & Martin, 2009; Simmons, Reddish, Bellgowan, & Martin, 2010; Tranel, 2006; Waldron, Manzel, & Tranel, 2014; Yasuda, Nakamura, & Beckman, 2000). A functional imaging study utilizing the PET procedure suggested that the perceptual analysis of faces (irrespective of whether they are famous or non-famous) is modulated by the right hemisphere (RH), and the LH is responsible for famous stimuli (faces and names; Gorno-Tempini et al., 1998). Studies in which oral picture naming tasks have been administered to large cohorts of brain-damaged patients have shown that impaired access to proper nouns for unique persons is associated with LTP lesions (Damasio et al., 1996, 2004). Impaired naming of famous landmarks was also associated with damage to LTP areas (Tranel, 2006).

Similarly, selective deficits in proper noun naming in word retrieval tasks have been associated with left hemisphere damage (LHD; Damasio et al., 1996; Hanley, 2014; Robson, Marshall, Pring, Montague, & Chiat, 2004; Semenza, 2006, 2011; Semenza & Zettin, 1989; Tranel, 2006). Various types of proper name anomia following LHD have been reported (Lyons et al., 2002; Pavão Martins & Farrajota, 2007). The implications of selective proper noun anomia have been considered for the linguistic representation of proper nouns, the processes involved in word retrieval and the anatomical bases of language. Geographical and topographical names were also reported to be impaired in individuals with brain damage (Harris & Kay, 1995; Semenza & Zettin, 1989).

Although there are several accounts of selective proper noun anomia after LH brain damage, the opposite dissociation has been reported for recognition. Although lexical processing is associated with left-hemisphere function, especially for less frequently occurring words, persons with severe aphasia have been observed to recognize famous proper nouns. Persons with global aphasia performed similarly to healthy controls (HC) on proper name recognition tasks, including famous landmarks (Van Lancker & Nicklay, 1992), but performed poorly in tasks requiring them to identify common nouns (Goodglass & Wingfield, 1993; Van Lancker & Klein, 1990). Geographical names produced a similar effect (Goodglass & Wingfield, 1993; Yasuda & Ono, 1998; Yasuda et al., 2000). Spoken and/or written geographical names were recognized more often than common nouns on picture identification tasks; participants with Wernicke's and global aphasia demonstrated more problems with pointing to a picture depicting body parts than when asked to indicate a particular place on a map (Goodglass & Wingfield, 1993). In addition, written production of proper nouns was spared in a patient with aphasia in contrast to written common nouns (Cipolotti, McNeil, & Warrington, 1993; Schmidt & Buchanan, 2004). These studies have provided evidence of the possible RH involvement in recognizing and writing proper nouns. For further support of a RH involvement, in a group study of unilaterally brain-damaged persons, RH damage was associated with impaired recognition of famous names (Van Lancker et al., 1991). Some of these observations may be attributable, in part, to a specialization of the RH for personally relevant phenomena (Van Lancker, 1991).

Lateralized visual presentation techniques have provided further evidence of the RH involvement in the processing of proper nouns. Using a split-visual field presentation design in healthy participants, proper nouns presented in the left visual field/RH (LVF/RH) were recognized significantly better than common nouns (Ohnesorge & Van Lancker, 2001). In that study, greater accuracy in the right visual field/LH (RVF/LH) was found for common nouns and unknown proper nouns, while performance for famous proper nouns in the two visual fields was not

significantly different. It was also reported that famous proper nouns were more accurately recognized in both visual fields than common nouns. It was concluded from these results that both hemispheres process famous proper names, and the RH contributes to recognition of person names, possible due to a specialization of the RH for personally relevant phenomena (Ohnesorge & Van Lancker, 2001; Van Lancker, 1991). The broad connotative information associated with famous proper names is likely to provoke an emotional reaction in the individual: this reaction may support recognition by the RH (Semenza, 2009), believed to modulate emotional experiencing (Adolphs, Damasio, Tranel, & Damasio, 1996; Blonder, Bowers, & Hailman, 1991; Borod, Koff, & Caron, 1983; Gazzaniga & LeDoux, 1978; Ohnesorge & Van Lancker, 2001; Van Lancker, 1991).

Theoretical and empirical arguments support a RH involvement in the processing of proper nouns, but controversy remains about whether the RH makes a distinct or superior contribution to the recognition of proper nouns. The results for a RH effect for proper noun comprehension (Ohnesorge & Van Lancker, 2001; Van Lancker, 1991) were disputed by Schweinberger, Landgrebe, Mohr, and Kaufmann (2002), who reported a strong RVF/LH advantage for the recognition of famous proper nouns and no evidence for a distinct role of the RH in the recognition of names. These arguments were countered by Van Lancker and Ohnesorge (2002), who proposed that the RH's ability to recognize famous proper nouns was tied to familiarity with the items.

The question of whether proper nouns are processed in comprehension tasks successfully by the neurologically intact RH still does not have a definite answer. Furthermore, fewer studies have examined the production of proper nouns by people with acquired language impairments. There is evidence, mostly from the single case studies reviewed above, that the LH plays a strong role in production modes for familiar proper nouns. This study was designed to further investigate the ability of persons with LHD to recognize and verbally reproduce famous names and matched common nouns presented to the LVF or RVF, compared with performance by matched HC. Despite their phonological complexity, proper nouns are likely to be processed holistically without being analyzed, whereas common nouns have a greater possibility of compositionality. To further investigate the role of phonological elements of the stimuli, participants' productions of entire words and/or letters belonging to the stimuli were analyzed to provide more evidence of holistic versus sequential processing of proper versus common nouns. Based on the previous studies on proper nouns, it was hypothesized that the RH would be involved in the recognition of proper nouns, while the production of proper nouns would be performed more efficiently for stimuli presented to the LH.

Methods

Participants

Participants were 10 individuals with left-hemisphere damage (LHD) and 16 age- and educational-matched non-brain-damaged HC, all of whom were right-handed native speakers of English with normal or corrected-to-normal vision. There is no statistically significant difference between individuals with LHD and HC for either age or education. Participants were recruited from the Memory and Education Research Initiative program, which operates through the Nathan S. Kline Institute for Psychiatric Research in Orangeburg, NY, from the Helen Hayes Hospital in Haverstraw, NY, and also from the Speech and Language Disorders Clinic at New York University in New York, NY. This study received institutional review board (IRB) approval from these institutions, and participants signed a written consent form approved by the IRB.

Table 1. Information about participants with left hemisphere damage (LHD).

Subject	Age (years)	Sex	Education (years)	Post onset time (years: months)	BNT	FANFAT (%)	WAB (AQ)	RCBA-2	Threshold	Lesion
1	56	Male	16	3:2	25	83.33	69.6	96	94	Anterior
2	61	Male	12	2:0	40	87.5	50.2	84	94	Posterior
3	67	Female	16	5:6	7	58.33	80.2	66	141	Posterior
4	53	Male	16	1:11	57	91.67	90.2	98	94	Anterior
5	50	Male	16	5:7	28	75	58.3	93	94	Posterior
6	54	Male	16	12:0	3	66.67	60.4	74	141	Anterior
7	52	Male	18	0:8	3	95.83	53.8	46	141	Posterior
8	63	Female	16	1:1	29	N/A	93	98	188	N/A
9	57	Female	18	2:5	50	N/A	91	96	141	Anterior
10	75	Male	12	1:7	N/A	91.67	22.4	61	141	Anterior/ posterior
Mean	58.8		15.6	3:6	26.9	81.25	66.91	81.2		
(SD)	(7.77)		(2.07)	(3:5)	(19.87)/60	(13.36)	(22.45)/100	(18.5)/100		
Range	50–75	3 females/ 7 males	12–18	0:8–12:0	3–50	58.33–95.83	22.4–93	46–98	94–188	

BNT, Boston Naming Test; FANFAT, Famous Names and Faces Recognition Test; WAB (AQ), Western Aphasia Battery (Aphasia Quotient); RCBA-2, Reading Comprehension Test for Aphasia, 2nd edition; and threshold, exposure time selected.

Individuals with left-hemisphere damage (LHD)

A total of 10 individuals with LHD (three females and seven males) participated in this study. The mean age of individuals with LHD was 58.8 years (range: 50–75), with a mean education of 15.6 (range: 12–18) years. Individuals with LHD had suffered a single unilateral lesion due to stroke and ranged in time post-onset of stroke from 8 months to 12 years with a mean of 2:10 (years:months). Individuals with LHD were administered the *Reading Comprehension Battery for Aphasia – Second Edition* (RCBA-2; LaPointe & Horner, 1998) and the *Boston Naming Test* (BNT; Kaplan, Goodglass, & Weintraub, 2001) to better determine their language abilities. The *Famous Names and Faces Recognition Test* (FANFAT, Van Lancker, 1992), a test of famous face recognition was administered to confirm their abilities to recognize facial patterns and probe visual acuity. LHD participants' performance on these tests was carefully monitored for signs of possible visual field impairment and none was in evidence. The severity of the aphasia, as determined by the Aphasia Quotient (AQ) of the *Western Aphasia Battery* (Kertesz, 1982), was mild to severe for all participants with LHD (AQ range: 22.4–93 with a mean of 66.91). Participants with LHD met the inclusion criteria by obtaining 50 (100 is fully correct) or higher RCBA-2, and at least 50% identification on the FANFAT (chance = 25%). These criteria were selected as reasonable indicators of adequate preservation of two important cognitive abilities pertinent to our tasks: visual acuity and accuracy in reading words, and processing of the notion of familiarity. Demographic information and standardized test scores for the participants with LHD are listed in Table 1.

Non-brain-damaged HC

A total of 16 individuals (5 females and 11 males) were recruited as controls. The mean age of the HC participants was 62.7 (range: 56–71) years, with a mean education of 14.8 (range: 12–16)

Table 2. Information about healthy control participants (HC).

HC	Age (years)	Sex	Education (years)	BNT	FANFAT	Threshold
Mean (SD)	62.7 (8.73)	–	14.8 (1.98)	58.8 (3.72)	95.4 (7.24)	–
Range	56–71	5 females/ 11 males	12–16	56–60	87.5–100	94–188

BNT, Boston Naming Test and FANFAT, Familiar Names and Faces Recognition Test.

Table 3. Examples of stimuli for common and proper nouns.

Stimuli types	Proper noun	Common noun
Examples	BRAD PITT	BED SHEET
	MAGIC JOHNSON	MUDDY WATER
	VANNA WHITE	WALKING SHOE
	BILL GATES	BELT BUCKLE
	BOB DOLE	BOW TIE
	DUSTIN HOFFMAN	DRINKING FOUNTAIN
	MAE WEST	MILK SHAKE
	PETER FALK	PAPER BAG

years. They reported no history of major medical, neurological or psychiatric conditions. The HC participants were administered the BNT (Kaplan et al., 2001) and the *Famous Names and Faces Recognition Test* (Van Lancker, 1992). Demographic information and standardized test scores for the HC are listed in Table 2.

Stimuli

Three different sets of 200 stimuli were utilized, including 100 common nouns and 100 proper (famous) nouns in each set. Stimuli were obtained from a rating study by Ohnesorge and Van Lancker (2001) with a cohort matched in age to the stroke population. Ohnesorge and Van Lancker (2001) conducted a large-scale rating study on famous proper nouns (please see Appendices in Ohnesorge & Van Lancker, 2001). Nouns were first rated on two scales, familiarity and frequency, each with choices from 1 to 7, with 1 being least familiar/frequent and 7 being most familiar/frequent. The first three-hundred items from the rank-ordered familiarity/frequency ratings were selected for use as stimuli. Common nouns were also ranked by frequency of occurrence and matched to proper nouns by syllable number, syllable length and word accent. All stimuli were also ranked for emotionality, and correlations between these two ranked parameters were undertaken (please see Appendices in Ohnesorge & Van Lancker, 2001). For this study, stimulus sets were culled and controlled for temporal and geographical appropriateness to the cohort being tested. All stimuli consisted of two words and were presented in uppercase letters in randomized order. Examples of target stimuli of common and proper nouns used in the study are listed in Table 3.

Procedures

Participants were tested in two sessions of approximately two hours each. Testing was conducted over two days separated by about one week. Task order for each task and session is outlined in Table 4.

Table 4. Task order for all participants.

Session	Tasks
Session 1	Consent procedures
	Subject information
	Protocols administered:
	The Boston Naming Test (BNT)
	LHD: The Western Aphasia Battery (WAB)
	LHD: The Reading Comprehension Battery for Aphasia – 2nd Edition (RCBA-2)
	The Famous Names and Faces Test (FANFAT)
Session 2	The duration threshold task
	Proper/Common noun recognition and production tasks:
	Manual task (I)
	Yes/no verbal response task (II)
	Verbal production task (III)

Two protocols (WAB and RCBA-2) were given to LHD participants to determine language and reading disability.

Proper/common noun recognition and production tasks were designed as split-visual field experiments, modelled after Ohnesorge and Van Lancker (2001). The experiment was designed and implemented using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993), running on a Macintosh computer. Participants were instructed that they would be shown famous proper nouns and common nouns on the computer screen and that they should determine whether the word on the computer screen is a proper or common noun.

A fixation cross was presented at the centre of the computer monitor throughout the experiment. This fixation cross was temporarily replaced by a stimulus (a common noun or a proper noun) shown either in the LVF or the RVF. The stimuli were presented horizontally such that the midpoint of each stimulus fell at 4° lateral displacement from the central fixation cross. This allowed us to present longer stimuli horizontally with maximum lateral displacement on the computer screen.

To accommodate variability in cognitive function, exposure duration thresholds in each participant were assessed by presenting five blocks of 20 stimuli at one of the five presentation rates (94, 141, 188, 235 or 282 milliseconds), using stimuli similar but not identical to those in the actual experiment. The duration threshold was set at the 75% criterion level of correct response for each participant. No participant received exposure longer than 188 milliseconds for actual testing.

Three different sets of 200 stimuli were used to allow for the three response tasks: manual task (I) using a button press response, yes/no verbal response task (II) and verbal production task (III). For the manual task (I), a response box with two button choices was provided. Participants were instructed to press one button of the response box on seeing a common noun and another button on seeing a proper noun. Side of button (left or right) was alternated across subjects. Half of the HC participants exclusively used the left hand to respond, and the other half used the right hand to respond, in order to determine the relationship between limb movement and performance. Individuals with LHD exclusively used the left hand to respond. For the yes/no verbal response task (II), verbally produced yes/no responses were utilized. The participants were instructed to respond ''yes'' or ''no'' to the query ''is this a famous name'' in order to provide a response not dependent on limb movement. Performance data were recorded by the examiner. For the verbal production task (III), all participants first indicated whether the stimulus was a proper or common noun verbally, and then produced the word or name briefly presented on the computer screen. This task (III) was designed to compare speech production abilities for proper and common nouns

Table 5. Response types and examples for the production task of the verbal production task.

Response types	Examples (target stimulus: Michael Jackson)
Correct response	Michael Jackson
No response	–
Incorrect response	Brooke Shields
Response with the first half correct	Michael
Response with the second half correct	Jackson
Response with the first 1–2 letters correct	M, I
Response with the first three or more letters correct	M, I, C, H

presented to the LVF or RVF. Two of 10 participants (7, 10 from Table 1) with LHD did not complete the verbal production task (III) due to nonfluent aphasia.

Responses were scored correct or incorrect for each of the three response tasks. For the verbal production task (III), the responses were also scored in terms of seven criteria: correct responses, incorrect responses, no response, responses with one or two letters correct, responses with three or more letter correct, responses with the first half of the whole stimuli correct and responses with the second half of the whole stimulus correct. The response types and examples are summarized in Table 5.

Data analysis

The average percentages of correct responses were calculated for the three different tasks and across tasks of the recognition protocol. Repeated-measures of ANOVAs were conducted for visual field (LVF and RVF) and noun type (common and proper) as within subject variables and groups as between subject variables. Post-hoc tests performed to follow up on significant main effects or interactions demonstrated by ANOVAs utilized alpha levels adjusted by the Bonferroni procedure. The Wilcoxon signed-rank test was conducted for the verbal production task. Alpha levels less than 0.05 were considered significant.

Results

Recognition tasks

Performance on the recognition tasks is summarized in Figure 1. Repeated measures of ANOVAs revealed main effect of noun types across tasks (manual, yes/no verbal response and verbal production tasks) [$F\ (1, 24) = 20.017$; $p < 0.001$]. Performance measures on the three recognition tasks were compared, and there was no significant difference across tasks. Since the performance across tasks in both groups of participants was not significantly different, measures from the three tasks are combined in Figure 1.

The performance in the recognition of stimuli was compared between HC who exclusively used the left hand and ones who exclusively used the right hand to respond for the manual task. There was no significant difference in the recognition of stimuli between these two groups. The performance measures in the three proper noun recognition tasks were compared for LHD participants with anterior damage and those with posterior damage, and no statistical differences in recognition of stimuli were found between these two groups.

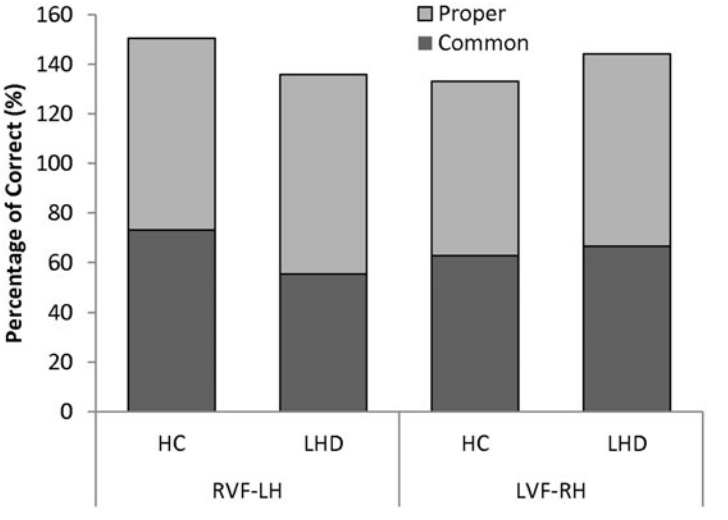

Figure 1. Results of recognition tasks.

Noun type

Participants with LHD recognized famous proper nouns more often than common nouns across all tasks, as seen in Figure 1 (80.27% vs. 55.63% presented in RVF/LH and 77.55% vs. 66.63% presented in LVF/RH). Famous proper nouns were also recognized more often than common nouns by HC participants (77.38% vs. 73.13% presented in RVF/LH and 70.31% vs. 62.82% presented in LVF/RH). Repeated measures of ANOVAs revealed interactions between group × noun in the manual task (I) [F (1, 24) = 5.131; $p = 0.033$] and the verbal production task (III) [F (1, 23) = 15.392; $p = 0.001$]. *Post hoc* comparisons confirmed that participants with LHD recognized proper nouns significantly more often than common nouns. In contrast, the differences in recognition between common and proper nouns in HC participants were not significant. *Post hoc* comparisons also confirmed that decreased performance in correctly recognizing common nouns was observed in participants with LHD compared to the HC group in all tasks ($p = 0.049$ for the manual task (I); $p = 0.004$ for the yes/no verbal task (I); $p = 0.043$ for the verbal production task (III)). However, for proper nouns, performance by participants with LHD was at a similar level to the HC group in all tasks.

Visual field

Repeated measures of ANOVAs revealed an interaction between group × visual field in all tasks [F (1, 24) = 17.035, $p < 0.001$]. *Post hoc* comparisons confirmed that participants with LHD exhibited better performance on recognizing stimuli presented to the LVF/RH than those presented to the RVF/LH across all noun types (proper and common nouns) in the manual task (I) and the identification portion of the verbal production task (III). Contrary to the participants with LHD, HC participants showed better performance on recognizing stimuli presented to the RVF/LH than those presented to the LVF/RH across all noun types (proper and common nouns) in the yes/no verbal task (II) and the verbal production task (III). As would be expected, HC participants showed better performance in recognizing stimuli presented to the RVF/LH compared to participants with LHD, which was also confirmed by *post hoc* comparisons.

To explore the possibility of greater RH recovery in longer-term chronic participants, a correlation analysis was conducted, examining a possible relationship between time post onset of

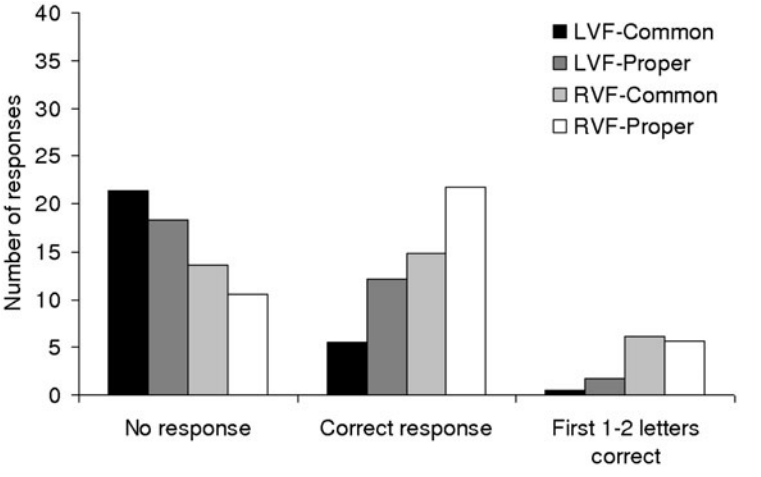

Figure 2. Results of HC subjects: production of proper/common nouns presented in the right/left visual field (LVF-common, common nouns presented to the left visual field; LVF-proper, proper nouns presented to the left visual field; RVF-common, common nouns presented to the right visual field; and RVF-proper, proper nouns presented to the right visual field).

stroke and performance in stimulus recognition. A Pearson correlation analysis (two-tailed) was conducted comparing time post-onset (in months) with performance measures averaged from the three proper noun recognition tasks. The r value was -0.145, revealing no significant correlation between time post onset of stroke and LVF/RH performance on stimulus recognition.

Recognition task summary

Proper nouns were recognized more often than common nouns by both LHD and HC groups. Whereas participants with LHD showed decreased performance in correctly recognizing common nouns compared to the HC group, they correctly recognized proper nouns at a similar level to HC participants. As for the visual field, participants with LHD exhibited better performance on recognizing stimuli presented to the LVF/RH than those presented to the RVF/LH. However, HC participants showed better performance on recognizing stimuli presented to the RVF/LH than those presented to the LVF/RH.

Production task

For the verbal production task (III), seven measures were performed on subjects' verbal responses. Comparisons of noun type and visual field were made for (1) a correct production of the entire proper or common noun presented, (2) non-response to the stimulus, (3) incorrect responses, (4) production of the beginning each word (1–2 letters), (5) production of the beginning each word (three or more letters) and (6) the first word and for the second word of the two-word stimulus (Figures 2 and 3). The results of correct responses, no responses and production of the beginning each word (1–2 letters correct) are reported in this study. No difference emerged for other measures.

Correct responses

Participants with LHD and HC correctly produced proper nouns more often than common nouns within each visual field. However, as expected, correct productions of both proper and common

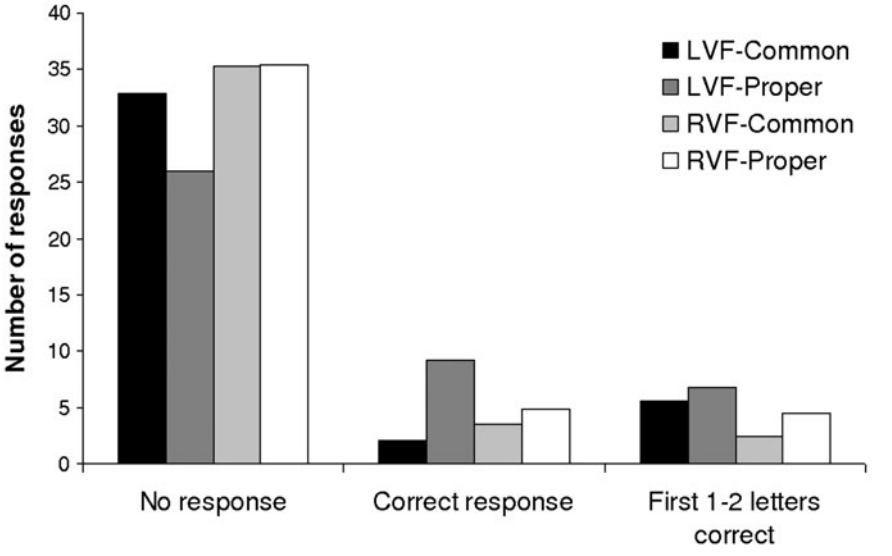

Figure 3. Results of LHD: Production of proper/common nouns presented in the right/left visual field (LVF-common: common nouns presented to the left visual field; LVF-proper, proper nouns presented to the left visual field; RVF-common, common nouns presented to the right visual field; and RVF-proper, proper nouns presented to the right visual field).

nouns were decreased in participants with LHD compared with the HC group. The Wilcoxon signed-rank test showed a significant difference in correct responses of stimuli between individuals with LHD and HC groups ($p < 0.001$ for common nouns in both visual fields, and for proper nouns in RVF/LH). Further analyses revealed that HC participants exhibited better performance on producing stimuli presented in the RVF/LH correctly than stimuli presented in the LVF/RH across both noun types. In contrast, LHD participants correctly produced proper nouns presented in the LVF/RH more often than ones presented in the RVF/LH ($p = 0.001$).

No responses

Participants with LHD failed to produce stimuli more often than the HC group ($p = 0.001$ for both common and proper nouns in both visual fields). HC participants failed to respond to common nouns more often than proper nouns presented to both visual fields ($p = 0.011$ for the LVF; $p = 0.043$ for RVF). As for the visual field, HC participants failed to respond to stimuli presented to the LVF/RH more often than stimuli presented to the RVF/LH ($p = 0.019$ for common nouns; $p = 0.017$ for proper nouns).

Responses with the first one or two letters correct

HC participants correctly produced the first one or two letters of common nouns more often than those of proper nouns presented to the RVF/LH ($p = 0.042$).

Production task summary

Significantly decreased performance in correctly producing both proper and common nouns was noted in participants with LHD. However, proper nouns were correctly produced more often than common nouns in participants with LHD. Results from the production task in HC participants suggest that proper nouns were correctly produced more often than common nouns. HC participants exhibited better performance in producing proper nouns presented to the RVF/LH

compared with the LVF/RH. Letters of the target words were produced more often for common nouns compared with proper nouns in HC participants.

Discussion

The greater accuracies for famous proper nouns presented to both visual fields/cerebral hemispheres in HC participants are consistent with previous findings. This result was originally surprising, as proper nouns would appear to be more difficult to process than common nouns, given their uniqueness, phonological complexity and infrequency of occurrence. Word recognition was overall better in the LH, and proper noun accuracies were higher in both hemispheres in HC participants. Although proper nouns in the RH were recognized at a same level to the LH, common nouns were recognized better in the LH than the RH in HC participants. For the production task, HC participants correctly produced famous proper nouns more often than common nouns and they made more errors on producing common nouns than famous proper nouns in both hemispheres. However, HC participants correctly produced letters of target words more often for common nouns than for famous proper nouns. Word production was overall better in the LH than in the RH of HC participants.

The greater accuracies for famous proper nouns presented to both cerebral hemispheres were also found in individuals with LHD. However, contrary to HC participants, and as would be expected in subjects with LHD, word recognition was overall better in the RH. Individuals with LHD demonstrated better performance on producing proper nouns than common nouns across all tasks. Participants with LHD also produced stimuli correctly more often in the LVF/RH than in the RVF/LH. Although the rate of the overall recognition of common nouns presented to both hemispheres decreased in individuals with LHD compared with HC participants, proper nouns presented to the LH were recognized by participants with LHD at the similar level as HC participants, and proper nouns presented to the RH were recognized by participants with LHD better than HC participants. Proper nouns were produced correctly more often than common nouns by both HC and LHD participants. Although HC participants produced more words presented to the LH, individuals with LHD produced more words presented to the RH.

The results from this study are consistent with the findings from Ohnesorge and Van Lancker (2001) in that famous proper nouns were recognized more often than common nouns presented to both visual fields, and common nouns were recognized more often in the RVF/LH than in the LVF/RH. The findings of no visual field superiority for famous proper nouns and the significant RVF/LH superiority for common nouns in HC participants suggest that famous proper nouns are recognized in both hemispheres that the LH is specialized for common nouns, and that famous proper nouns are represented cerebrally differently from common nouns. The findings of the spared ability to recognize proper nouns and decreased performance to recognize common nouns subsequent to LHD also confirm the previous findings from Ohnesorge and Van Lancker (2001) in that famous proper nouns are represented cerebrally differently from common nouns.

The significantly lower production rate of famous proper nouns in participants with LHD suggests that the LH is specialized for the production of proper nouns, whereas both hemispheres process recognition of famous proper nouns, in agreement with the results of various lesion studies and brain imaging studies (Rotshtein, Henson, Treves, Driver, & Dolan, 2005; Semenza, 2006; Semenza & Zettin, 1988; Snowden et al., 2012; Tranel, 2006). Selective deficits in proper noun naming in word retrieval tasks have been reported in individuals with LHD (Semenza, 2006). Brain-imaging studies confirmed a critical role of the left temporal polar region for retrieving proper names (Grabowski et al., 2003; Rotshtein et al., 2005; Semenza, 2006; Simmons & Martins, 2009; Simmons et al., 2010; Tranel, 2006; Waldron et al., 2014). The left temporal polar

region is important for the retrieval of names for unique entities, such as proper names (Tranel, 2006).

Poor performance in producing and recognizing common nouns in participants with LHD suggests that the LH modulates the production as well as the recognition of common nouns. These results are consistent with the results of published lesion and brain imaging studies (Antonucci, Beeson, & Rapcsak, 2004; Antonucci, Beeson, Labiner, & Rapcsak, 2008; Friedman et al., 1998; Gorno-Tempini et al., 1998). Damage to left inferior temporal cortex has been associated with naming deficits (Damasio et al., 1996, 2004).

Letters of target words were correctly produced by HC participants more often for common nouns than for famous proper nouns, which is in contrast with the findings that proper nouns were produced more often than common nouns. Proper nouns were likely to be perceived as a whole, unanalyzed unit, whereas common nouns have a greater possibility of compositionality. That is, proper names are likely to be processed holistically without being analyzed as linguistic sequences. The findings of this study are consistent with previous information on the properties of proper and common nouns.

In sum, the findings in this study provide more evidence that impaired production of proper nouns is associated with LHD. The results add to the growing body of research indicating a RH association with recognition of famous proper nouns, possibly due to a specialization of the RH for personally relevant phenomena (Cutting, 1990; Van Lancker, 1991). Further studies probing abilities of individuals with RH damage are needed to further understanding of cerebral processing of famous proper nouns.

Acknowledgements

We appreciate the contribution of C. Ohnesorge to this study.

Declaration of interest

All authors listed have contributed sufficiently to the project to be included as authors, and all those who are qualified to be authors are listed in the author byline. To the best of our knowledge, no conflict of interest, financial or other, exists.

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