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AN EXAGGERATED EFFECT FOR PROPER NOUNS IN A CASE OF SUPERIOR WRITTEN OVER SPOKEN WORD PRODUCTION

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We describe a brain-damaged subject, RR, who manifests superior written over spoken naming of concrete entities from a wide range of conceptual domains. His spoken naming difficulties are due primarily to an impairment of lexical-phonological processing, which implies that his successful written naming does not depend on prior access to the sound structures of words. His performance therefore provides further support for the "orthographic autonomy hypothesis," which maintains that written word production is not obligatorily mediated by phonological knowledge. The case of RR is especially interesting, however, because for him the dissociation between impaired spoken naming and relatively preserved written naming is significantly greater for two categories of unique concrete entities that are lexicalised as proper nouns—specifically, famous faces and famous landmarks—than for five categories of nonunique (i.e., basic level) concrete entities that are lexicalised as common nouns—specifically, animals, fruits/vegetables, tools/utensils, musical instruments, and vehicles. Furthermore, RR's predominant error types in the oral modality are different for the two types of stimuli: omissions for unique entities vs. semantic errors for nonunique entities. We consider two alternative explanations for RR's extreme difficulty in producing the spoken forms of proper nouns: (1) a disconnection between the meanings of proper nouns and the corresponding word nodes in the phonological output lexicon; or (2) damage to the word nodes themselves. We argue that RR's combined behavioural and lesion data do not clearly adjudicate between the two explanations, but that they favour the first explanation over the second.

INTRODUCTION

In recent neuropsychological research on the architecture of the lexical system, two questions that have received increasing attention are as follows: (1) What is the relationship between the phonological and orthographic output lexicons? In particular, during language production tasks, does access to a word node in the orthographic output lexicon depend on prior access to

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the corresponding word node in the phonological output lexicon, or can the orthographic word node be accessed independently of the phonological one? (2) What is the internal organisation of the phonological and orthographic output lexicons? Are word nodes undifferentiated, or are they functionally segregated according to linguistic variables such as grammatical and semantic[1] categories? The purpose of this paper is to report a case study that bears on both of these questions.[2] Before describing the brain-damaged subject who is the focus of the investigation, we first elaborate the main theoretical issues in greater detail.

The relationship between the phonological and orthographic output lexicons

Does the ability to write words that are stored in long-term lexical memory depend on phonological knowledge and processing? According to the "obligatory phonological mediation hypothesis" (OPMH), the answer is yes. Thus, in a written picture naming task, the assumption is that after the correct lexical-semantic structure has been activated, it is first mapped onto the appropriate word node in the phonological output lexicon, and then this in turn is mapped onto the corresponding word node in the orthographic output lexicon. However, according to the "orthographic autonomy hypothesis" (OAH), the answer is no. This hypothesis maintains that a processing pathway exists that enables lexical-semantic structures to be mapped onto orthographic word nodes without phonological intervention.[3] Early studies favoured the OPMH (Frith, 1979; Geschwind, 1969; Grashey, 1885; Head, 1926; Hecaen & Angelergues, 1965; Hotopf, 1980; Lichtheim, 1885; Luria, 1966; Wernicke, 1886/1989), and a few contemporary scholars still champion this view (Perfetti, 1997; Van Orden, Jansen op de Haar, & Bosman, 1997), but there is now considerable evidence supporting the OAH. Individuals who are congenitally deaf can nevertheless learn to read and write printed words. Furthermore, many brain-damaged subjects have been described who exhibit significantly impaired spoken word production but relatively preserved written word production. These subjects fall into three major classes based on their predominant type of error in the oral modality.

The first class is noteworthy because, unlike the other two, it consists of subjects whose performance profiles are *not* actually incompatible with the OPMH. In order for a case of superior written over spoken word production to constitute a serious challenge to the OPMH, it is necessary to demonstrate that the deficit in the oral modality reflects an impairment of the phonological output lexicon or access to it, as opposed to an impairment restricted to postlexical phonological or articulatory processing, i.e., procedures for generating segmental, syllabic, metrical, and ultimately

[1] A note on terminology: There is currently some confusion over the proper use of the terms "semantic" and "conceptual" (see the discussion in Nickels, 2001). This debate addresses important issues regarding the relation between language and thought that are being actively investigated in cognitive science (e.g., Gentner & Goldin-Meadow, 2003) and that deserve serious consideration in neuropsychology, as we have suggested elsewhere (e.g., Kemmerer & Tranel, 2003; Kemmerer, Tranel, & Barrash, 2001; Tranel & Kemmerer, 2004). However, the debate is not directly relevant to the present paper, so we will simply state that we use "semantic" to refer to aspects of meaning that are clearly encoded by lexical items, and "conceptual" to refer to aspects of meaning that are not necessarily encoded by lexical items.

[2] Another important question involves how many levels of representation are involved in lexical access. Does access to modality-specific word nodes depend on prior access to abstract word nodes (sometimes called lemmas) in a modality-neutral lexicon, or can modality-specific lexical representations be accessed without this intermediate level? This is currently a very controversial issue (e.g., Caramazza & Miozzo, 1998; Levelt, Roelofs, & Meyer, 1999; Nickels, 2001, 2002; Roelofs, Meyer, & Levelt, 1998), and we will not directly address it here because the data we present can be accommodated within either approach, especially if certain assumptions about processing dynamics are changed for the lemma model (cf. Hillis, 2001, p. 192).

[3] Although the OAH claims that lexical-orthographic representations can be accessed from the semantic system independently of lexical-phonological representations, this does not necessarily imply that phonology-to-orthography conversion mechanisms do not exist at the lexical level. For a review of evidence suggesting that they do, see Tainturier and Rapp (2001).

phonetic and motor representations for speech production. The first class of subjects who display superior written over spoken word production do not satisfy this criterion because they generate postlexical phonological errors, such as paraphasias and neologisms, when attempting to say words, while performing accurately when writing words. For example, JBN said "nishraffe" but wrote "giraffe" in response to a picture of a giraffe, and said "lawnerjot" but wrote "leg" in response to a picture of a leg (Hillis, Boatman, Hart, & Gordon, 1999). Her distribution of errors was simulated by reducing the connection strength between word-level and subword-level phonological units in Dell's (1986) computer model. The upshot is that subjects like JBN are still consistent with the OPMH since they allow for the possibility that successful written naming is guided by the initial retrieval of word nodes in the phonological output lexicon, which then trigger activation of the corresponding word nodes in the orthographic output lexicon.

In contrast, the other two classes of subjects who display superior written over spoken word production are genuinely problematic for the OPMH because the origin of the deficit in the oral modality can be clearly established as being primarily or even exclusively lexical rather than postlexical in nature. The first of these two classes consists of subjects who are profoundly anomic in oral naming tasks. For example, MH could say the names of only 1/20 depicted objects, and produced circumlocutions for only 2/20 items (matches → "something to put fire"; rain falling → "water, no, not water, something like water, I can't tell you"), but she could write the names of 15/20 items (Bub & Kertesz, 1982). Her omissions were presumably not due to a disorder of postlexical phonological or articulatory processing because her spontaneous speech, albeit semantically rather empty, was phonologically correct and well articulated. The authors argue that her oral naming difficulties arose from a severe impairment of lexical-phonological representations or access to them, an interpretation supported by recent research on omission errors in aphasic subjects, which suggests that they are probably often caused by the inability of phonological word nodes to reach a critical threshold of activation, either because they are destroyed or because their input is insufficiently strong (Laine, Tikkala, & Juhola, 1998; Ruml, Caramazza, Shelton, & Chialant, 2000; see also Dell, Lawler, Harris, & Gordon, 2004, for computer simulations). The most plausible account of MH's successful written naming is therefore that it was not mediated by lexical-phonological knowledge (contrary to the OPMH) but was instead enabled by an independent pathway leading from the meanings of words to their lexical-orthographic representations (consistent with the OAH). The type of performance profile exhibited by MH is somewhat rare, however, having been described for (to our knowledge) only three other subjects, all of whom made entirely, or almost entirely, omission errors in just the oral modality (Hier & Mohr, 1977; Levine, Calvino, & Popovics, 1982; Tainturier, Moreaud, David, Leek, & Pellat, 2001).

The final class consists of subjects who generate predominantly semantic errors in spoken word production but have relatively preserved written word production. For example, in an oral picture naming task, RGB made over 30% errors, roughly half of which were semantic coordinates (e.g., celery → "lettuce") or associated names (e.g., waist → "belt") and the other half of which were definitions or descriptions of the item (e.g., pajamas → "what you wear at night"); however, he did not produce any such errors in a written picture naming task with the same items (Caramazza & Hillis, 1990). His semantic errors in the oral modality were clearly not due to an impairment of the semantic system itself. Instead, the authors argue that the errors arose from an impairment of lexical-phonological access; more precisely, they propose that when the target word nodes were relatively unavailable, semantically related ones that were engaged through a normal process of cascading activation were produced instead (for computer simulations, see, among others, Rapp & Goldrick, 2000). The OPMH predicts that semantic errors in spoken output would necessarily carry over to written output as well. The fact that this did not occur therefore constitutes evidence against the OPMH and in favour of the OAH. Several other subjects with performance profiles similar to that of RGB have also been reported (e.g., Beaton, Guest, & Ved, 1997; Ellis, Miller, & Sinn, 1983; Miceli, Benvegnu, Capasso, & Caramazza, 1997; Nickels, 1992; Rapp, Benzing, & Caramazza, 1997; Shelton & Weinrich, 1997).

The internal organisation of the phonological and orthographic output lexicons

Within each modality-specific output lexicon, are word nodes arranged in an unsystematic manner, or are they arranged systematically in terms of linguistic variables such as grammatical and semantic categories? One source of data regarding this question comes from brain-damaged subjects with word production deficits that are specific not only to a particular output modality—spoken vs. written—but also to a particular grammatical category—e.g., closed-class vs. open-class items, or within the open class, nouns vs. verbs (Alario & Cohen, 2004; Assal, Buttet, & Jolivet, 1981; Berndt & Haendiges, 2000; Berndt, Mitchum, Haendiges, & Sandson, 1997; Caramazza & Hillis, 1991; DeRenzi & Di Pellegrino, 1995; Hillis & Caramazza, 1995; Hillis, Tuffiash, & Caramazza, 2002; Hillis, Wityk, Barker, & Caramazza, 2003; Patterson & Shewell, 1987; Rapp & Caramazza, 1997, 1998, 2002). To take an especially striking example, a double dissociation of grammatical category by modality was observed in a single subject—KSR—since she had greater difficulties with nouns than verbs in oral word production, but greater difficulties with verbs than nouns in written word production (Rapp & Caramazza, 2002). Cases like this raise many interesting questions about the relation between meaning, grammar, and the modality-specific output lexicons, but here we focus on just the issue of whether or not the word nodes comprising each lexicon are systematically organised. As Rapp and Caramazza (2002) point out, the data from KSR are consistent with both possibilities. On the one hand, if the word nodes comprising each lexicon are undifferentiated, KSR's performance profile could be explained along the following lines: (1) the meanings of nouns and verbs are represented in separate semantic subsystems based partly on the object/action distinction; (2) each semantic subsystem projects to both of the modality-specific output lexicons; (3) KSR has two disconnections—one involving the pathway that projects from the meanings of nouns to the phonological output lexicon, and another involving the pathway that projects from the meanings of verbs to the orthographic output lexicon. On the other hand, if the word nodes within each lexicon are functionally segregated according to grammatical category, KSR's performance profile could be explained either in terms of the disconnection hypothesis outlined above (since the input pathways from the semantic subsystems are still assumed to be distinct processing streams that could be independently impaired) or in terms of selective damage to particular sets of word nodes in each lexicon—specifically, the noun component of the phonological output lexicon and the verb component of the orthographic output lexicon.

Although the results from KSR do not clearly adjudicate between the two theories, evidence favouring the view that the modality-specific output lexicons have complex internal organisations comes from research on the neural correlates of lexical access. There is increasing evidence that subjects with noun production disorders usually have left frontotemporal lesions, whereas subjects with verb production disorders usually have left frontoparietal lesions (for reviews, see Cappa & Perani, 2003; Shapiro & Caramazza, 2003). More importantly for present purposes, a few studies suggest that naming deficits can selectively affect quite fine-grained classes of words. For example, Damasio et al. (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004) report that the retrieval of lexical-phonological structures for particular classes of nouns can be disrupted by focal lesions in discrete regions of the left temporal lobe. Specifically, accessing proper nouns for persons is often impaired by damage in the temporal pole; accessing common nouns for animals is often impaired by damage in the middle sector of the inferior temporal gyrus; and accessing common nouns for tools/utensils is often impaired by damage in the posterior sector of the inferior temporal gyrus. Damasio et al. argue that lesions in these cortical areas do not significantly affect visual object recognition or concept retrieval because subjects can still provide accurate verbal descriptions of the stimuli that they cannot orally name correctly. For example, a picture of a skunk might be described as follows: "Oh, that animal makes a terrible smell if you get too close to it; it is black and white, and gets squashed on the road by cars sometimes." In addition, the authors present convergent PET data indicating that the same cortical areas are activated in normal subjects in the same category-specific ways during oral picture naming tasks.[4] Taken together, these findings strongly support the possibility that, at least regarding the phonological output lexicon, word nodes are functionally segregated according to a combination of grammatical and semantic parameters. It must be acknowledged, however, that the findings do not completely exclude the alternative possibility that word nodes are not systematically organised, because it is still conceivable that the relevant cortical areas contribute to some degree to category-specific semantic processing as opposed to category-specific lexical processing (Caramazza, 1996).

Perhaps the strongest available evidence that the modality-specific output lexicons have complex internal organisations comes from a few reports of brain-damaged subjects who produce phonological paraphasias or neologisms that are restricted to certain classes of words. For example, in a series of oral picture naming tests, DPI generated abundant phonological paraphasias when saying words for animals, fruits/vegetables, tools/utensils, body parts, and colours, but was flawless when saying words for numerals, days of the week, and months of the year (Bachoud-Lévi & Dupoux, 2003; see also Cohen, Verstichel, & Dehaene, 1997). The fact that DPI's postlexical errors involving phoneme selection and sequencing were confined to a semantically limited range of word classes supports the hypothesis that the functional-anatomical compartmentalisation of different conceptual domains (cf. Forde & Humphreys, 2002; Martin & Caramazza, 2003) is propagated via independent processing streams down to the level of the modality-specific output lexicons, leading to roughly similar topographic arrangements of word nodes reflecting higher-level semantic category distinctions. According to this view, DPI's performance profile could have arisen from a lesion that selectively disrupted the pathways that project from certain semantically defined regions of the phonological output lexicon to the subword level of phonological processing. Along these same lines, evidence that grammatical category distinctions are also respected at the level of the modality-specific output lexicons comes from Friederici and Schoenle's (1980) report of a brain-damaged subject who made postlexical phonological errors for open-class words but not for closed-class words. Much more research is obviously needed, though, to explore these issues further.

The case at hand

We describe a brain-damaged subject, RR, who manifests superior written over spoken naming of concrete entities from a wide range of conceptual domains. Although he has a moderate impairment of postlexical phonological processing, his spoken naming difficulties are due primarily to an impairment of lexical-phonological processing, which implies that his successful written naming does not depend on prior access to word nodes in the phonological output lexicon. His performance therefore provides additional evidence against the OPMH and in favour of the OAH. The case of RR is especially interesting, however, because for

[4] Other PET studies are also relevant: the left temporal pole is activated during oral naming of not only famous faces but also famous landmarks (Grabowski, Damasio, Tranel, Ponto, Hichwa, & Damasio, 2001); the middle sector of the left inferior temporal gyrus is activated during oral naming of animals not only from pictures but also from characteristic sounds (Tranel, Damasio, Eichhorn, Grabowski, Ponto, & Hichwa, 2003a); and the posterior sector of the left inferior temporal gyrus is activated during oral naming of tools not only from pictures but also from characteristic sounds (Tranel, Grabowski, Damasio, Lyon, & Koenigs, 2003b).

him the dissociation between impaired spoken naming and relatively preserved written naming is significantly greater for two categories of unique concrete entities that are lexicalised as proper nouns—specifically, famous faces and famous landmarks—than for five categories of nonunique (i.e., basic level) concrete entities that are lexicalised as common nouns—specifically, animals, fruits/vegetables, tools/utensils, musical instruments, and vehicles. Furthermore, RR's predominant error types in the oral modality are different for the two types of stimuli: omissions for unique entities vs. semantic errors for nonunique entities. Although many cases of proper noun anomia have been previously documented (for a review, see Semenza, 1997; see also Brédart, Brennen, & Valentine, 1997; Damasio et al., 1996, 2004; Kay, Hanley, & Miles, 2001; Miceli, Capasso, Daniele, Esposito, Magarelli, & Tomaiuolo, 2000), we are aware of only one other case in which proper noun retrieval was shown to be disrupted in the oral modality but intact in the written modality—patient MED (Cipolotti, McNeil, & Warrington, 1993). In the General Discussion, we compare RR's performance profile with MED's, and we consider how RR's significantly worse oral access to proper nouns than common nouns bears on the theoretical question of how word nodes are organised in the modality-specific output lexicons.

MEDICAL HISTORY

RR is a fully right-handed (+100 on the Geschwind-Oldfield scale) man who obtained a master's degree in international affairs. Early in his career he was the mayor of a small town, and subsequently he spent roughly 40 years involved in foreign business. He was the president of a consulting company serving printing and publishing committees in worldwide marketing operations, and he lived abroad for a total of 24 years, much of the time in Rio de Janeiro, Brazil. In January, 1991, at the age of 62, he suffered a left-hemisphere CVA. His lesion is depicted in Figure 1, which shows a three-dimensional reconstruction with Brainvox based on an MRI scan. The damage affects most of the cortex and white matter in the supramarginal and angular gyri, and the posterior part of the superior temporal gyrus—i.e., nearly all of what is usually demarcated as Wernicke's area. There is an additional, smaller area of damage in the left prefrontal region, in the pars opercularis.[5] Initially he displayed global aphasia, but this gradually resolved. In fact, by the time he initially came to our laboratory in 1995, his general communication abilities were remarkably effective, even though his performance on formal language tests remained for the most part impaired, as described below.

Table 1 shows RR's performance on a battery of standardised neuropsychological tests that are commonly used in the Benton Neuropsychology Laboratory and that give a comprehensive overview of his mental capacities (Tranel, 1996). His performance IQ was quite high (132), and he obtained superior scores on many of the subtests of the WAIS-III. He also achieved a score above the 95th percentile on Raven's Progressive Matrices, a measure of nonverbal intelligence. On the WRAT-III, he had borderline reading performance. In the domain of nonverbal anterograde memory, his scores were normal to borderline. Focusing on linguistic abilities, many subtests from the Multilingual Aphasia Examination and the Boston Diagnostic Aphasia Examination were administered, and he was impaired on all of them except for the two basic reading measures. Note, however, that although his ability to comprehend written words was fairly well

[5] The first and second anterior coronal cuts appear to indicate additional damage in the cortex and white matter of the anterior tip of the left temporal pole. However, this is misleading. Actually, the discrepancy between the left and right temporal poles in these coronal cuts reflects a substantial reduction in the rostral extension of the left polar region relative to the right, most likely due to atrophy. This can also be perceived in the lateral view of the left hemisphere, where close inspection reveals that the vertical line demarcating the second coronal cut is slightly behind the tip of the left temporal pole, whereas the vertical line demarcating the first coronal cut is slightly behind the tip of the right temporal pole; in fact, the only reason the right temporal pole is visible in the left lateral image is because it has greater rostral extension than the left one. We are grateful to Hanna Damasio for these observations.

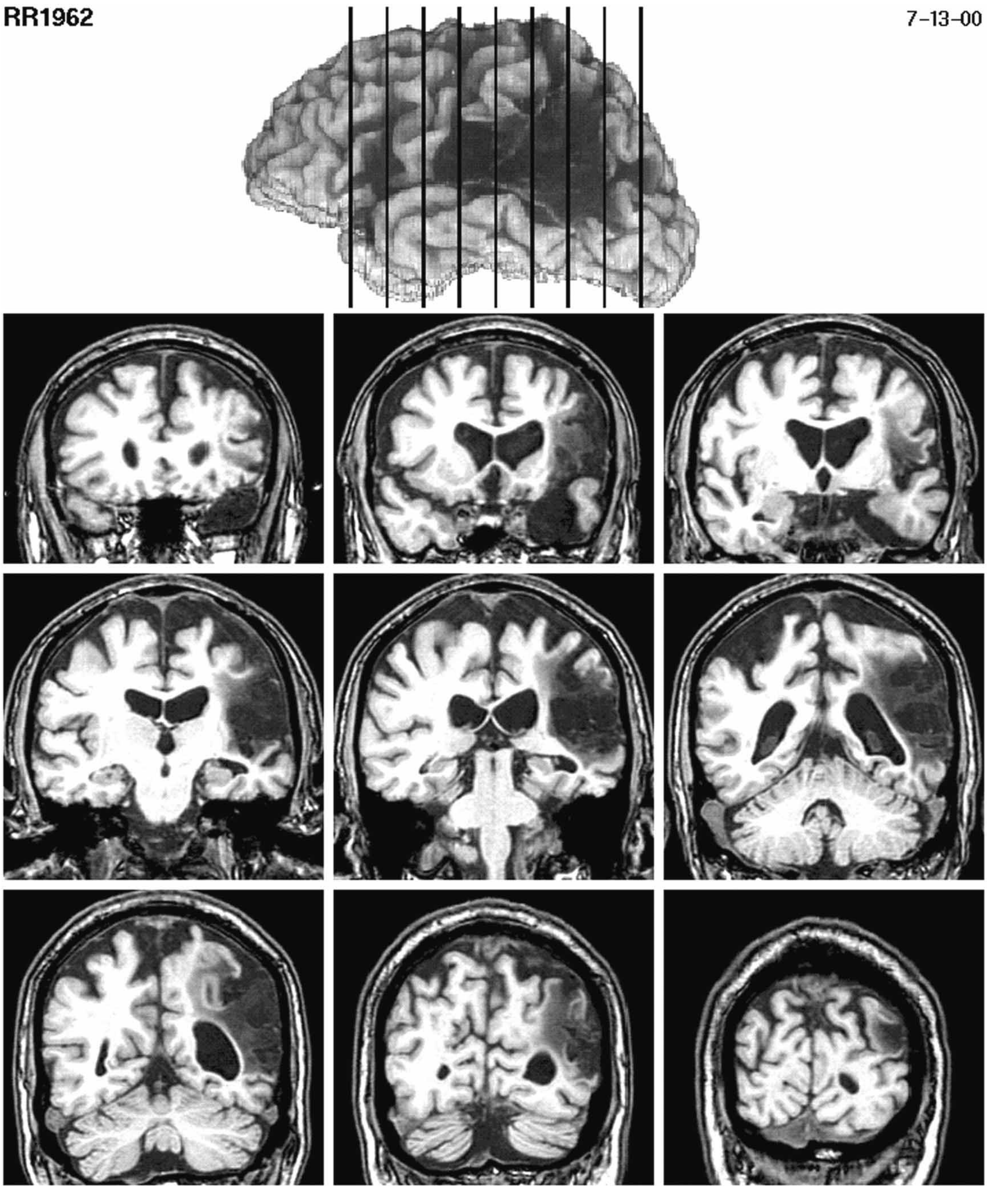

Figure 1. *Lesion reconstruction for RR from a magnetic resonance imaging scan.*

Table 1. *Comprehensive neuropsychological assessment for RR*

	Score	*Interpretation*
Intellect and academic achievement		
Wechsler Adult Intelligence Scale-III (Scaled Scores)		
Performance IQ	132	Superior
Picture completion	16	Superior
Digit symbol-coding	10	Average
Block design	12	High average
Matrix reasoning	17	Superior
Picture arrangement	17	Superior
Object assembly	15	Superior
Wide Range Achievement Test-III (standard scores)		
Reading	68	Borderline
Nonverbal anterograde memory		
Benton Visual Retention Test (correct/errors)	8/3	Normal
Standardised assessment of language		
Multilingual Aphasia Examination (Percentiles)		
Controlled oral word association	$< 1^{st}$ %ile	Defective
Visual naming	$< 1^{st}$ %ile	Defective
Sentence repetition	$< 1^{st}$ %ile	Defective
Token Test	$< 1^{st}$ %ile	Defective
Aural comprehension	$< 1^{st}$ %ile	Defective
Reading comprehension	59^{th} %ile	Normal
Boston Diagnostic Aphasia Examination		
Boston naming (#/60)	9	Defective
Responsive naming (#/30)	6	Defective
Reading (#/10)	9	Normal
Iowa-Chapman Speed of Reading (#/25)	10	Defective
Visuospatial perception/construction		
Facial Discrimination	$> 99^{th}$ %ile	High normal
Judgment of Line Orientation	40^{th} %ile	Normal
Complex Figure Copy (#/36)	31	Normal
Three-Dimensional Block Construction (#/29)	29	Normal
Executive function		
Wisconsin Card Sorting Test		
Categories completed	6	Normal
Perseverative errors	7	Normal

preserved, his reading speed was defective. Shifting to visuospatial perception and construction, his scores were consistently in the normal to high-normal range. Finally, his executive functions were intact, as measured by the Wisconsin Card Sorting Test. In sum, the neuropsychological data portray a subject who was highly intelligent, and whose left-hemisphere stroke caused specific language defects but spared the essence of his intelligence, as well as virtually all higher-order cognitive abilities that are not language-dependent.

From the beginning, it was apparent that RR had better written than spoken word production abilities. Indeed, this was one of his most conspicuous traits, and it was especially prominent in ordinary conversational settings. He was a very well-informed man and could participate in thoughtful and complex discussions about a variety of topics, such as politics, history, culture, and sports. However, he often experienced severe difficulty retrieving the phonological forms of words, particularly concrete nouns. He compensated for this deficit by always carrying around a pen and a pad of paper, which he would use as a back-up communication system. Whenever a particular word proved to be too hard for him to say, he would switch to the orthographic modality and quickly write it down. In this manner he was able to hold up his end of the conversation, and the listener rarely had significant trouble understanding what he was trying to express. Witnessing his behaviour gave one the impression that during his moments of word-finding difficulty, the spoken form of the desired word was so elusive that he could only grope for it in vain, but the written form was readily available and could be produced at any time without effort.

RR's word retrieval deficit is clearly revealed in his description of the Cookie Theft picture from the BDAE on 2/13/95:

The children are, they'd like to have some, uh, they'd like to have some, this, uh, thing. Uh, but they're going to fall down because the, uh, the. . . . I take it you don't want me to run. . . . The thing is falling apart, the falling apart, the, uh, uh, sssstool. Uh, the same way the mother is forgetting of something and as a result of that the, water sss-, came out and is falling all over the place. Um, the um um. . . . Do you mean everything or just the. . . . I mean, uh. . . . Okay, so there's a two, kids, the girl and boy, um. . . . They have st- shoes and stockings, um. . . . She has, uh. . . . (sigh) Well, that's what normally do is girls do. . . . And he had a, is a (cough) I can't think think um. . . . She's at the process she was after lunch she was doing that, this was the, um. . . . She, shoot, that and, uh, I have this. . . . And this was the, uh, she'd normally she's got a, a little m- ssskirt. . . . And I, uh, have got, uh, I sh. . . . Can't, uh, what they were doing there.

He was obviously able to describe many aspects of the scene, and the grammatical structures are, for the most part, correct, but the narrative is replete with gaps where he could not access certain content words, usually nouns for concrete objects. As a result, minimal information is conveyed. However, his speech production was mostly well articulated and contained only a few phonological errors, as confirmed by a speech pathologist who phonetically transcribed and analysed an audio recording of the narrative. Although there are some indications here, and we provide further evidence below, that his post-lexical processing was not completely normal, his impairment in this domain appeared to be only moderate, especially compared to his far more severe impairment of lexical-phonological processing.

In order to investigate more carefully RR's dissociation between poor spoken naming and good written naming, an experiment was conducted in July 1997.[6]

EXPERIMENTAL INVESTIGATION

Materials and procedure

An ongoing research project in the Benton Neuropsychology Laboratory is the investigation of the neural systems that enable the retrieval of semantic and lexical knowledge for various categories of concrete entities (for a review, see Damasio et al., 2004). RR is one of over 150 brain-damaged subjects who have participated in this project.

Two sets of stimuli were used in separate testing sessions (on 21 and 24 July 1997). The first set consisted of 160 line drawings of nonunique concrete entities belonging to the following categories: animals ($N = 41$), fruits/vegetables ($N = 32$), tools/utensils ($N = 63$), vehicles ($N = 12$), and musical instruments ($N = 12$). These pictures were taken from the Snodgrass and Vanderwart (1980) inventory, and also from our own lab (Tranel, Logan, Frank, & Damasio, 1997b). The second set of stimuli consisted of 133 photographs of famous faces taken from the Boston Famous Faces Test ($N = 56$) and the Iowa Famous Faces Test ($N = 77$).

In each testing session, the pictures were shown in random order one-by-one on a Caramate 4000 slide projector. For each stimulus, RR was asked to first say the correct name of the picture and then

[6] See also Kemmerer (2004), Kemmerer and Tranel (2000a, 2000b, 2003), and Kemmerer et al. (2001) for reports on RR's processing of verbs and prepositions, as well as Kemmerer (2000a, 2000b, 2003) and Kemmerer and Wright (2002) for reports on RR's processing of semantic structures that are relevant to certain grammatical constructions. He is referred to as 1962RR in most of these papers.

to write it. If he produced a vague or superordinate response (e.g., "Something you can work with"), he was prompted to "be more specific; indicate exactly what you think that thing is." Responses were recorded in writing and also on audiotape.

Our scoring procedure is explained in Damasio et al. (2004). In brief, if an item was named correctly (via either the spoken or the written modality, in this case), it was scored as having been recognised correctly. If it was not named correctly, the subject's description of the item was transcribed and presented to two raters, who were asked to determine what the stimulus was from the description alone, without having in front of them either the stimulus or its name. If either or both raters could identify the entity from the subject's description, the item was scored as a correct recognition. If neither rater could identify the entity from the subject's description, the item was scored as an incorrect recognition, and it was not used in calculating the naming score.[7]

Results

Nonunique entities

RR failed to recognise only 7 of the 160 nonunique concrete entities, and his errors were distributed fairly evenly across the different semantic categories (Table 2). All of his recognition scores were well within normal limits, as determined by comparison with normative data that we have published previously (Damasio et al., 2004; Tranel et al., 1997b). In most of the categories, in fact, RR performed close to ceiling, which is actually somewhat above typical normal performance. These data suggest that his conceptual knowledge about these different types of objects was preserved. In evaluating the accuracy of his spoken and written naming responses, we only considered responses for the 153 objects that he recognised correctly (Table 2). His oral naming was quite poor, averaging 44% correct across the various categories (range 25–65%, *SD* = 17.5%). In striking contrast, his written naming was quite good, averaging 92% correct (range 82–100%, *SD* = 6.5%). To identify the source(s) of his spoken word production deficit, several error analyses were conducted (see Appendix A for a complete list of RR's errors). These analyses revealed two separate impairments: a moderate one affecting post-lexical phonological processing, and a severe one affecting lexical-phonological processing.

Two findings suggest that RR had a moderate impairment of postlexical phonological processing. First, of his 89 spoken naming errors, 21 (23%) were phonological in nature (Table 3). As shown in Appendix A, 11 of these errors involved very fragmentary access to the phonemic content of the target word (e.g., flashlight → "fla"), which may

Table 2. *Number and percentage correct for recognition as well as spoken and written naming of nonunique concrete entities from different semantic categories (N = 160)*

				Naming of recognised items			
		Recognised items		*Spoken*		*Written*	
Semantic category	*N*	*N*	*%*	*N*	*%*	*N*	*%*
Animals	41	36/41	88	17/36	44	34/36	94
Fruits/vegetables	32	31/32	97	19/31	65	29/31	94
Tools/utensils	63	62/63	98	18/62	29	51/62	82
Vehicles	12	12/12	100	7/12	58	11/12	92
Musical instruments	12	12/12	100	3/12	25	12/12	100
Total	160	153/160	96	64/153	44	137/153	92

[7] This method has limitations, but they are probably not significantly detrimental to this report because, as described below, RR's written naming performance was excellent and hence serves as a reliable indicator of well-preserved object recognition.

Table 3. *Distribution of RR's 89 oral naming errors for nonunique concrete entities*

	Phonological errors		*Semantic errors*		*Omission errors*	
Semantic category	*N*	*%*	*N*	*%*	*N*	*%*
Animals	5/19	26	14/19	74	0/19	0
Fruits/vegetables	6/12	50	4/12	33	2/12	17
Tools/utensils	7/44	16	28/44	64	9/44	20
Vehicles	0/5	0	4/5	80	1/5	20
Musical instruments	3/9	33	5/9	56	1/9	11
Total	21/89	23	55/89	62	13/89	15

reflect successful retrieval of the phonological word node but disruption of the subsequent process of "spelling out" the complete, distributed representation of subword phonological segments. The other 10 errors involved paraphasias (e.g., hippopatamus → "potapotamus"), which may reflect various kinds of distortions of subword phonological information. It is worth noting that of the 21 pictures for which RR produced phonologically incorrect spoken names, he generated correct written names for all but one, and it was a recognisable misspelling (cauliflower → "cauliforia").

Second, the probability of RR naming a picture correctly in the oral modality depends on the length of the target word. All of the target words were classified according to number of syllables: one vs. two vs. three or more. RR exhibited a significant effect of word length $F(2, 150) = 4.6$, $p < .05$, performing better on monosyllabic words (58% correct) than on either bisyllabic words (33% correct) or words with three or more syllables (34% correct). Length effects on spoken word production in aphasic subjects have generally been attributed to impairments in the postlexical processes of segmental spell-out and/or syllabification (e.g., Beland, Caplan, & Nespoulous, 1990; Ellis, Miller, & Sinn, 1983), so these results suggest that RR has a disturbance of one or both of these processes. This interpretation converges with the fact that RR produced a number of phonemic paraphasias in both the picture naming task and the Cookie Theft narrative. However, RR's postlexical phonological processing difficulties appear to be rather moderate and cannot explain the full range of his spoken naming errors.

Two additional findings point to another, more severe impairment affecting lexical-phonological processing. First, 55 (62%) of RR's 89 spoken naming errors—which is by far the majority—were essentially semantic, since they consisted of (sometimes rather lengthy) comments about the depicted objects, comments that were not only conceptually pertinent but also, for the most part, free of phonological or articulatory mistakes (Table 3).[8] Twenty-three of these comments were descriptions that included a name bearing close semantic relation to the target, such as superordinate (e.g., woodpecker → "bird, makes a hell of a noise") or coordinate (e.g., red cabbage → "carrot, nope, in Brazil, nope") (Table 4; see also Appendix A). The other 32 comments did not include such direct naming attempts or semantic substitutions but were instead more like definitions (e.g., level → "to make things exactly even") or personal associations (e.g., suitcase → "I've had a lot when traveling") (Table 5; see also Appendix A). For all 55 items, it is important to emphasise that, like RGB (Caramazza & Hillis, 1990), RR seemed to be quite aware that his oral responses were technically errors. Furthermore, of the 55 pictures for which he produced semantic errors, he generated correct written names for all but 10. Four of his 10 written errors were semantic in nature (e.g., vise → "clamp"), three were minor

[8] Note also that, as shown in Appendix A, several of RR's errors that were classified as phonological in nature co-occurred with semantic descriptions (e.g., armadillo → "arpa, around Texas, fall like this" [RR rolls his hands]).

Table 4. *Examples of RR's oral descriptions that include semantic substitutions for the target word*

Picture	*Spoken response*
parakeet	bird, parrot, nope, little one, small thing
woodpecker	bird, makes a hell of a noise
rhinoceros	something like a lotomus
sheep	lamb, but more than that
red cabbage	carrot, nope, in Brazil, nope
plane	we had it before, bird, nope
toothbrush	teeth
hacksaw	saw
sledgehammer	very large hammer
tea kettle	cup, cup of tea, it's a

Table 5. *Examples of RR's oral descriptions that do not include semantic substitutions for the target word*

Picture	*Spoken response*
panda bear	from China, but it's a, can't do it
otter	might be a, comes out in water, cups like this on its back
drill	everybody needs one, to take things out or put things in
level	to make things exactly even
vise	need this to ensure to hold onto it
needle	you need a thing underneath it
pitcher	put milk in it
umbrella	if it's raining you've got to have one
buggy	if you've got a baby you have one
suitcase	I've had a lot when traveling

misspellings (e.g., aardvark → "aardvack"), and two were omissions.

Second, frequency values for the target words in the picture naming test were obtained from Carroll, Davies, and Richman (1971),[9] and a *t*-test revealed that the 89 words that RR failed to produce correctly in the oral modality have significantly lower frequencies than the 64 words that he did produce correctly ($p = .003$). Frequency effects in normal speakers probably arise at the level of word nodes in the phonological output lexicon, giving high-frequency word nodes a higher resting state of activation compared to low-frequency word nodes (Caramazza, Costa, Miozzo, & Bi, 2001), and it has been argued that exaggerated frequency effects in aphasic subjects are more likely to reflect deficits in lexical than in postlexical processing (e.g., Butterworth, 1992; Rapp et al., 1997). Thus, the finding of a large frequency effect for RR constitutes further evidence that lexical-phonological processing was especially degraded for him.

Famous faces

RR recognised 114/133 (86%) of the famous faces that were presented to him (Table 6). Normal subjects recognise on average about 101/133 faces (mean = 75.7%, *SD* = 6.7; see Damasio et al., 2004), so RR's recognition score is more than 1.5 *SD*s *above* normal. This is obviously quite impressive, and it is also consistent with RR's high intelligence and world knowledge. Even more striking is the following result. Of the 114 faces that he recognised correctly, he was able to say the names of only 7 (6%), which is is in sharp contrast to his significantly better, albeit still severely impaired, oral naming of nonunique entities (mean = 44% correct; $\chi^2(3) = 92.1$, $p < .0001$). On the other hand, RR correctly wrote the names of 85/114 (75%) faces. Normal subjects orally name on average about 93 persons out of the roughly 101 that they recognise (mean = 92.3%, *SD* = 6.2; see Damasio et al., 2004). Thus, while RR's oral naming score was 13.1 *SD*s below normal, his written naming score was only 2.8 *SD*s below normal.

Yet another remarkable aspect of RR's performance is that virtually all of his spoken naming errors—101/107 (94%)—were omissions (Table 7). In contrast, only 13/89 (15%) of his spoken naming errors in the test involving nonunique concrete entities were of this type (Table 3). (A comparison of RR's overall performances on the tests involving nonunique concrete entities and famous faces is shown in Table 8.) Of the 101 famous faces for which RR gave no response (or the equivalent of a "don't know" response) in the oral modality, he wrote the correct name for 82, and almost all of his written errors consisted of fairly trivial misspellings (e.g., Lyndon B. Johnson → "Lydon B. Johnson").

[9] Compound words were not considered because of uncertainties concerning their frequency.

Table 6. *Number and percentage correct for recognition as well as spoken and written naming of famous faces (N = 133)*

				Naming of recognised items			
		Recognised items		*Spoken*		*Written*	
Test	*N*	*N*	*%*	*N*	*%*	*N*	*%*
Boston Famous Faces	56	47/56	84	1/47	2	35/47	74
Iowa Famous Faces	77	67/77	87	6/67	9	50/67	75
Total	133	114/133	86	7/114	6	85/114	75

Table 7. *Distribution of RR's 107 oral naming errors for famous faces*

	Phonological errors		*Semantic errors*		*Omission errors*	
Test	*N*	*%*	*N*	*%*	*N*	*%*
Boston Famous Faces	2/46	4	3/46	7	41/46	89
Iowa Famous Faces	1/61	2	0/61	0	60/61	98
Total	3/107	3	3/107	3	101/107	94

Table 8. *Comparison of RR's overall performances on tests assessing recognition as well as oral and written naming of nonunique concrete entities and famous faces*

	Nonunique concrete entities	*Famous faces*
Overall N	160	133
Recognised items	153/160 (96%)	114/133 (86%)
Naming of recognised items		
Spoken	64/153 (44%)	7/114 (6%)
Written	137/153 (92%)	85/114 (75%)
Distribution of spoken errors		
Phonological	21/89 (23%)	3/107 (3%)
Semantic	55/89 (62%)	3/107 (3%)
Omisson	13/89 (15%)	101/107 (94%)

His other six spoken naming errors were divided equally between phonological and semantic errors (Table 7). Three of them were classified as phonological because RR was able to say only part of the person's name; similar limited access was manifested in written output for two of these items, and there was a minor misspelling for the third. His successive spoken and written responses for these three items were as follows: (1) Woody Allen → (spoken) "not Woody Guthrie, plays clarinet, just married a girl"[10]; (written) "Woody"; (2) Mary Tyler Moore → (spoken) "Mary Tyler something"; (written) "Mary Tyler ___"; (3) Bridgitte Bardot → (spoken) "Bridgitte"; (written) "Bridget Bardot." The remaining three spoken naming errors were classified as semantic because they contained information about the profession of the depicted person; for these items RR also made errors in written naming, but his errors in this modality involved either partial orthographic access or misspellings. His successive spoken and written responses were as follows: (1) Liza Minelli → (spoken) "Judy Garland's daughter, I don't know her last name"; (written) "Liza Mett"; (2) Tom Selleck → (spoken) "can't say his name, a lot of TV shows, starts with 's' "; (written) "s"; (3) Lee Iacocca → (spoken) "was at Ford and then he was Chrysler"; (written) "Lee Icacco."

As an addendum to the summary of RR's performance on famous faces, we would like to mention that he also displayed a dissociation between

[10] Note that this spoken response could also be treated as a semantic error since it includes accurate biographical information about the person.

extremely impaired spoken naming and relatively preserved written naming for another category of unique concrete entities that are lexicalised as proper nouns—specifically, famous landmarks, some of which are natural (e.g., the Grand Canyon, the Matterhorn, the White Cliffs of Dover), and some of which are artifactual (e.g., Big Ben, the Eiffel Tower, the Great Wall of China). On a standardised test involving photographs of 60 landmarks (Tranel, Enekwechi, & Manzel, in press), RR recognised 47 (77%) of the items. This score is substantially *above* normal (normative male data: mean = 61%), which is quite remarkable, but in keeping with both his unusually high level of recognition of faces and his broad cultural and geographical experience. Of the 47 items that he recognised, he was able to say the names of only 9 (19%). Thus, his oral naming of landmarks was almost as poor as his oral naming of faces (6%), and it was worse than his oral naming of all the different categories of nonunique concrete entities. The 38 oral naming errors were distributed as follows: 2 (5%) were phonological; 18 (46%) were semantic; 16 (42%) were omissions; and 2 (5%) were classified as "other" since they were essentially descriptions of the picture itself. In striking contrast, RR wrote the correct names of 28 (60%) of the 47 landmarks that he recognised. Of his 19 written errors, 5 (26%) were merely spelling mistakes, so if we assume that for these 5 items the appropriate word nodes were in fact activated in the orthographic output lexicon (prior to postlexical disturbances yielding spelling errors), then the total number of items for which RR successfully retrieved lexical representations in the written modality increases to 33/47 (70%). While the discrepancy between RR's spoken and written naming for landmarks is not as great as that for faces, it is still extremely large. These findings therefore constitute evidence that RR's especially profound difficulties in accessing the spoken forms of proper nouns are not restricted to the names of persons, but extend more generally to include the names of landmarks. The results should, however, be interpreted with the following caveat in mind: The landmark test was administered 3 years after the other studies were conducted, and also after RR had suffered a second left-hemisphere stroke. The second stroke was minor, however, and according to a radiologist who compared the MRI scans of RR's brain before and after it, the lesion was not noticeably different.

DISCUSSION

Further support for the OAH

We have documented the case of RR, a man who, following a left-hemisphere CVA that damaged the inferior parietal lobe, posterior superior temporal gyrus, and posterior inferior frontal gyrus, exhibited significantly better written than spoken naming for a wide range of object categories: animals, fruits/vegetables, tools/utensils, vehicles, musical instruments, and especially famous faces and landmarks. The presence of phonological errors, and a significant effect of word length, suggest that RR's spoken word production difficulties are due in part to a moderate impairment of postlexical phonological processing. This kind of impairment is consistent with the fact that his lesion includes a neuroanatomical region that probably contributes to the selection and sequencing of phonemes during word production—namely, the inferior margin of the left posterior superior temporal gyrus (Whatmough & Chertkow, 2002). However, several other findings—specifically, a significant effect of word frequency for nonunique entities, a prevalence of semantic errors for nonunique entities, and an overwhelming preponderance of omission errors for famous faces—are all indicative of an additional and much more severe impairment of lexical-phonological processing. For the relatively small number of test items that elicited phonological errors, RR was presumably able to retrieve the target word nodes in the phonological output lexicon. Hence, like JBN (Hillis et al., 1999), his successful written naming for these items could have been mediated by lexical-phonological knowledge, which is compatible with the OPMH. But for the much larger number of items that elicited semantic and omission errors, it is reasonable to assume that RR could not access the phonological form of the target word. Hence, like RGB (Caramazza & Hillis, 1990) and MH (Bub & Kertesz, 1982), he could not have used this information to guide written naming, which goes against the OPMH and instead supports the OAH.

Differences between spoken naming of famous faces and nonunique concrete entities

RR's written naming of famous faces and nonunique concrete entities was within normal limits, but his spoken naming of both types of stimuli was significantly below normal. What is most interesting, however, is that his spoken naming deficit was manifested in different ways for the two types of stimuli. Not only did he exhibit far worse naming of faces than of nonunique entities, but in addition his errors for faces were predominantly omissions whereas his errors for nonunique entities were predominantly semantic paraphasias. In the following subsections, we first address each of these findings in turn, then we briefly discuss another case of modality-specific proper noun retrieval impairment (Cipolotti et al., 1993), and finally we elaborate and evaluate two alternative explanations for RR's extreme difficulty in producing the spoken forms of proper nouns: (1) a disconnection between the meanings of proper nouns and the corresponding word nodes in the phonological output lexicon; or (2) damage to the word nodes themselves.

Different degrees of deficit: Significantly worse spoken naming of famous faces than of nonunique concrete entities

RR's spoken naming of nonunique concrete entities averaged 44% correct, but his spoken naming of famous faces dropped precipitously to 6% correct. In considering this dissociation, it is important to note that proper noun retrieval is known to be more difficult than common noun retrieval for normal subjects. For example, proper nouns are the elusive targets of the majority of naturally occurring tip-of-the-tongue experiences (TOTs), especially among the elderly (Burke, MacKay, Worthley, & Wade, 1991; Evrard, 2002; Rastle & Burke, 1996). Moreover, the same word is harder to recall when presented as the name of a person than when presented as the name of an occupation—the so-called *Baker-baker* paradox (Burke, Locantore, Austin, & Chae, in press; Cohen, 1990; McWeeny, Young, Hay, & Ellis, 1986).

Why are proper nouns intrinsically hard to retrieve? Most researchers agree that it is because they have only token reference, which is simply another way of saying that they designate unique entities (e.g., Brédart & Valentine, 1998; Burke et al., 1991; Cohen, 1990; Semenza & Zettin, 1989; Valentine, Brennen, & Brédart, 1996; see Semenza, 1997, for a review). This is quite different from common nouns, which in isolation (that is, independently of determiners that code definiteness and specificity) have only type reference, designating potentially infinite classes of entities defined by certain shared features. Proper nouns that rigidly pick out particular individuals are an integral part of human social communication, and they probably have single connections to corresponding person nodes in the semantic system, which themselves operate like tabs for indexing what Pinker (1994, p. 420) calls the mental Rolodex: "a database of individuals, with blanks for kinship, status or rank, history of exchange of favors, and skills and strengths, plus criteria that valuate each trait" (see also Miceli et al., 2000, for arguments that knowledge of conspecifics is a specialised cognitive adaptation). When one intends to produce the name of a familiar individual—e.g., "Lyle Lovett"—the relevant person node in the semantic system may receive abundant excitatory input from a variety of different features that constitute one's knowledge of the individual's identity; however, if there is only one connection from the person node to the appropriate word node in the phonological output lexicon, this pathway would be highly vulnerable, giving rise to frequent TOTs (MacKay, 1987). In contrast, common nouns are assumed to receive much greater top-down excitation from a multiplicity of converging semantic connections, and hence they are not as susceptible to TOTs. Interestingly, some proper nouns have strong inherent semantic associations because they are unusually descriptive (e.g., "Snow White"), and they are more easily accessed than other proper nouns that are equally familiar but more arbitrary (e.g., "Peter Pan") (Brédart & Valentine, 1998).

A related observation is that proper nouns differ from common nouns not only semantically but also grammatically. For example, in accord with their semantic function of identifying unique individuals, proper nouns generally do not take either determiners or modifiers, and when they do co-occur with these elements, they either lose their token referential role—e.g., "I didn't see the tall Fred Jones, I saw the short Fred Jones"—or else the modifier can only be interpreted nonrestrictively— e.g., "A tired Fred Jones arrived home from work" (Van Valin & LaPolla, 1997, p. 59).[11]

Returning to RR, it is likely that the intrinsic difficulty of proper noun retrieval contributed to his profound oral naming deficit for famous faces, but the precise extent of this influence is not clear. For the sake of argument, it is worthwhile considering the possibility that this factor can *completely* explain the difference between RR's naming of faces and his naming of nonunique entities. According to this interpretation, the damage responsible for RR's impaired oral access to proper nouns is not essentially different from the damage responsible for his impaired oral access to common nouns, and the exaggerated effect for proper nouns arises from the "superadditive" combination of the damage itself plus the intrinsic difficulty of proper noun retrieval. Although this account is not implausible, we find it unlikely that superadditivity could generate a dissociation of the magnitude displayed by RR, whose oral naming of faces (6% correct) was 38 percentage points worse than his average oral naming of nonunique entities (44% correct). Computational modelling might ultimately support the viability of the superadditivity interpretation of RR's performance profile, but until such modelling is done, we consider it more intuitively reasonable to assume that the intrinsic difficulty of proper noun retrieval only accounts for a relatively modest amount of RR's extremely severe deficit for this particular class of words.

Different error types: Predominantly omissions for famous faces versus predominantly semantic paraphasias for nonunique concrete entities

Another key finding is that RR's spoken naming of famous faces and nonunique concrete entities differed in terms of predominant error type: 94% omissions for faces versus 62% semantic errors for nonunique entities. RR's copious semantic errors for nonunique entities cannot be due to a central disorder of semantic knowledge because his written naming of the same items was superb. Instead, these errors must reflect some kind of disturbance of the process of mapping lexical-semantic structures onto the appropriate lexical-phonological structures. One possibility, which was originally proposed by Caramazza and Hillis (1990) to account for the modality-specific semantic errors observed in RGB, is that in the normal situation semantic representations activate phonological word nodes to a degree proportional to their shared semantics, so that, for example, when one intends to say "tiger," word nodes for semantic coordinates like "lion" and "leopard," as well as for more descriptive, definitional features like "striped" and "jungle," will also be activated. Against this background, it is conceivable that if the connections feeding into the phonological output lexicon were rendered pathologically noisy by brain damage, target word nodes might occasionally be unavailable, and semantically related ones might be selected instead (for computer simulations, see, e.g., Rapp & Goldrick, 2000).

Turning to RR's pervasive omission errors for the tests of orally naming famous faces, we should

[11] Van Valin and LaPolla (1997, pp. 59–60) point out, however, that some languages, such as German, Modern Greek, and Mandarin Chinese, are more flexible in allowing proper names to take modifiers.

acknowledge at the outset that "don't know" responses (or some equivalent thereof) in naming tests are often difficult to interpret because they could arise from an impairment at virtually any level of processing; they could even reflect a deliberate strategy of refraining from producing an incorrect response, based on an intact self-monitoring system (e.g., Mitchum, Ritgert, Sandson, & Berndt, 1990; Schwartz & Brecher, 2000). Although RR appeared to have a very well-preserved self-monitoring system, we believe it is unlikely that he regularly applied a strategy of inhibition when he felt that any attempt to produce the target name would be incorrect. By all indications he was a highly cooperative, collaborative subject, and although we never technically cued him—e.g., by giving him the first phoneme of a target word[12]—we repeatedly prompted him to produce any version of the spoken name that he could formulate, so that we could determine whether he had any access to the phonological content. To be sure, it is rather odd that when RR could not generate the spoken name of a person who he clearly recognised, he rarely proceeded to give circumlocutionary verbal descriptions of the person's identity. This contrasted with his tendency to provide semantic information about the nonunique concrete entities that he could not name orally. One might suppose that on the day that we administered the famous faces tests, he simply did not want to struggle with the challenge of assembling utterances, but this would be inconsistent with the fact that he was usually highly motivated to perform as well as he could.

Some insight about the underlying cause of RR's omission errors may come from the fact that, as mentioned above, proper nouns for unique individuals have a paucity of inherent semantic content and, as a consequence, also have sparser semantic neighbourhoods than common nouns for nonunique concrete entities. The sparseness of the semantic neighbourhoods for proper nouns in turn implies that these word nodes do not receive much top-down semantic information, and this may have the effect of reducing the opportunities for semantic errors and promoting the likelihood of omission errors—hence the unusual susceptibility of proper nouns to TOTs in normal subjects. Thus, RR's nearly ubiquitous omission errors for proper nouns could be understood as an extreme form of the normal error type for this class of words.[13] In this context, it is important to add that, as we pointed out in the Introduction, recent research on omission errors in aphasic subjects suggests that they often arise when the target word nodes can no longer reach a critical threshold of activation (Dell et al., 2004; Laine et al., 1998; Ruml et al., 2000). This could happen either because the word nodes do not receive sufficiently strong top-down excitatory input, or because the word nodes themselves are damaged. We return to this distinction later.

Patient MED: Another case of modality-specific proper noun retrieval impairment

Besides RR, one (and, to our knowledge, only one) other brain-damaged subject—MED—has been reported who displayed superior written over spoken naming of famous faces (Cipolotti et al., 1993). Like RR, her retrieval of common nouns for nonunique concrete entities was also impaired in the oral modality, but unlike RR, her performance on nonunique entities was not significantly different from her performance on faces. On the other hand, shifting to the orthographic modality, her successful written naming of faces (and also of countries, another category of unique entities lexicalised as proper nouns) was vastly better than her written naming of nonunique entities. Indeed, although her lexical-semantic representations of nonunique entities appeared to be intact, as indicated by flawless performance on a word–picture

[12] Wingfield, Goodglass, and Smith (1990) have argued that phonemic priming is not a reliable reflection of the tacit phonological activation resulting from an anomic subject's attempt to name an object.

[13] We thank two anonymous referees for these observations.

matching test,[14] she was profoundly impaired at accessing the corresponding word nodes in both of the modality-specific output lexicons. Thus, like RR, she exhibited a significant modality-specific dissociation between proper nouns and common nouns, but for her the modality in which the dissociation was manifested was the orthographic output lexicon, not the phonological output lexicon, and moreover the dissociation itself involved better retrieval of proper nouns than common nouns, not the reverse.

Alternative interpretations of RR's exaggerated effect for proper nouns

How does RR's performance profile bear on the theoretical question of whether or not the word nodes comprising the modality-specific output lexicons are functionally segregated according to semantic and grammatical variables? In light of the foregoing considerations, it appears that the behavioural results—taken by themselves, that is, independently of anatomical data—are compatible with both possibilities, much like the data from KSR (Rapp & Caramazza, 2002). First, suppose that the word nodes within each lexicon are *not* systematically organised. Then RR's performance profile could be explained as follows. Assume that the semantic subsystem which represents the meanings of proper nouns for unique individuals has different neural underpinnings from the various semantic subsystems that represent the meanings of common nouns for diverse categories of nonunique concrete entities (Damasio et al., 2004; Forde & Humphreys, 2002; Gainotti, Barbier, & Marra, 2003; Martin & Caramazza, 2003; Miceli et al., 2000; Tranel et al., 1997a). Assume as well that each of these semantic subsystems has independent connections with both of the modality-specific output lexicons. Given these assumptions, it is conceivable that all of the pathways leading from the multiple semantic subsystems to the phonological output lexicon have been rendered dysfunctional for RR; however, the pathway that maps the meanings of proper nouns onto the corresponding phonological word nodes has been damaged more severely than the pathways that map the meanings of common nouns onto the corresponding phonological word nodes. According to this interpretation, the fact that RR made significantly more errors in naming famous faces than nonunique concrete entities is due to the postulated difference in the severity of the disconnections, and the fact that his errors for faces were predominantly omissions instead of semantic paraphasias is due to a combination of factors: First, faces tend to elicit TOTs in normal subjects because of the sparseness of the semantic neighbourhoods; and second, the postulated severe disconnection between the meanings and the phonological word nodes for proper nouns greatly exacerbated the vulnerability of those word nodes to not receiving enough semantic input to reach the critical threshold for activation.

RR's behavioural results are also compatible with the alternative hypothesis that the word nodes comprising the modality-specific output lexicons *are* systematically organised. With respect to RR's performance profile, the key assumption here is that within each lexicon the word nodes for proper nouns occupy a different region from the word nodes for common nouns—a view that receives some support from the studies by Damasio et al. (1996, 2004; see also Footnote 4). Given this kind of architecture, the data from RR could be explained in either of two ways. One possibility involves essentially the same kind of disconnection scenario outlined above: severe damage to the pathway leading from the meanings of proper nouns to the corresponding phonological word nodes, but

[14] As pointed out by Brédart et al. (1997), the interpretation of MED's data is complicated by the fact that a subsequent study found her comprehension of common nouns to be impaired (McNeil, Cipolotti, & Warrington, 1994). This raises a question about the true status of MED's lexical-semantic knowledge for common nouns in the first study. It may be that her knowledge was impaired to some extent during that study, and the word–picture matching test was not sensitive enough to detect the deficit. However, if MED did have a deficit then, it was probably not very severe, because if it had been, she would presumably not have been able to achieve a score of 100% on the matching test, but would instead have performed off the ceiling.

only moderate damage to the pathway leading from the meanings of common nouns to the corresponding phonological word nodes. The other possibility, which is only allowed by the hypothesis that word nodes are functionally segregated, is that RR's profoundly impaired spoken naming of famous faces relative to nonunique entities is the result of severe damage to the proper noun region of the phonological output lexicon, but only moderate damage to the common noun region.

Since RR's behavioural data cannot adjudicate between the different interpretations, it is worthwhile to consider the potential relevance of his lesion data. As noted earlier, lesion studies as well as functional neuroimaging studies (Damasio et al., 1996, 2004; Grabowski et al., 2001; Tranel et al., 2003a, 2003b) suggest that within the phonological output lexicon nouns for different categories of concrete entities are anatomically organised as follows: Proper nouns for unique individuals are implemented in the left temporal pole; common nouns for animals are implemented in the middle sector of the left inferior temporal gyrus; and common nouns for tools/utensils are implemented in the posterior sector of the left inferior temporal gyrus. None of these neural structures are infarcted in RR's brain, but the left temporal lobe appears to be atrophic relative to the right, especially in the polar region (see Figure 1 and Footnote 5). Thus, the precise status of the cells in RR's left inferotemporal cortices is not entirely clear. On the one hand, it is possible that they have been rendered dysfunctional due to atrophy, with the cells subserving proper nouns suffering more than those subserving common nouns. On the other hand, it is also conceivable that the cells are still intact, and that RR's lesion (perhaps together with the atrophy) rendered them difficult to activate from semantic input, with the connections feeding into proper nouns being impaired more severely than those feeding into common nouns. In conclusion, then, this study must remain equivocal regarding the specific cause of RR's exaggerated effect for proper nouns.

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APPENDIX A

Comprehensive list of the 89 nonunique concrete entities that RR recognised correctly but named incorrectly in the oral modality

Picture	*Spoken response*	*Written response*
	Phonological error—fragmentary access	*Correct*
seal	sss, sss, that is a sss, sss	seal
acorn squash	a, I can do them, sss	squash
screwdriver	sss	screwdriver
whistle	sss	police whistles
harp	ha	harp
piano	pi	piano
cantaloupe	kind of a melon, cammer	cantaloupe
armadillo	arpa, around Texas, fall like this [rolls his hands]	armadillo
zebra	sss, sib	zebra
flashlight	fla, fla	flashlight
	Phonological error—fragmentary access	*Spelling error*
cauliflower	cooli, the other president didn't like 'em, cooli	califoria
	Phonological error—Paraphasia	*Correct*
bottle	bot	bottle
llama	lam, from near Brazil	llama
snow shovel	stover, stovel	snow shovel
pumpkin	pumpin	pumpkin
almond	amond	almonds
ladder	lighter, lighter, nope, you need it to go up	ladder
bell	sail, no, sell	bell
cherry	stem, sterry	cherry
hairbrush	bus	hairbrush
hippopatamus	potapotamus	hippo

(Appendix continues overleaf)

Picture	*Spoken response*	*Written response*
	Description including a name related to the target	*Correct*
parakeet	bird, parrot, nope, little one, small thing	parakeet
blue jay	bird, blue bird	blue jay
woodpecker	bird, makes a hell of a noise	woodpecker
gull	bird, looks like, over the sea, nope	gull
road runner	bird, looks like, running around	road runner
airplane	we had it before, bird, nope	plane
sheep	lamb, but more than that	sheep
red cabbage	carrot, nope, in Brazil, nope	red cabbage
rhinoceros	something like a lotomus	rhinoceros
wrench	ratchet	wrench
toothbrush	teeth	toothbrush
washer (appliance)	washing, that's the closest I can get	washer
French horn	horn	French horn
pinecone	cone of a, nope	cone (pine)
garbage can	garbage	garbage can
hacksaw	saw	hacksaw
sledgehammer	very large hammer	sledgehammer
tea kettle	cup, cup of tea, it's a	tea kettle
seahorse	it's a, in the sea, looks like a little horse	seahorse
brussel sprouts	brussel, near to it, little bit of a	brussel sprouts
crowbar	looks like starts with a bird, crow	crowbar
	Description including a name related to the target	*Related name*
nail file	nail, don't know what	nail sharpener
staplegun	staples	staples hammer
	Description not including a name related to the target	*Correct*
panda bear	from China, but it's a, can't do it	panda bear
otter	might be a, comes out in water, cups like this on its back	otter
kangaroo	from New Zealand	kangaroo
opossum	puppies are around inside, I'm not getting it	opossum
bat	it's then upside down, lots of them	bat
needle	you need a thing underneath it	needle
paintbrush	to change the	paintbrush
rolling pin	in the kitchen	rolling pin
refrigerator	first one on top is hot, cold, frosting on top	refrigerator
wheelbarrow	nope, throw things in it	wheelbarrow
level	to make things exactly even	level rule
broom	you need it to get the stuff around	broom
drill	everybody needs one, to take things out or put things in	drill machine
suitcase	I've had a lot when traveling	valise, bag
clamp	you need this if it's falling apart	clamp
top	children, all the time	top
shovel	you need to take everything out	shovel
pitcher	put milk in it	pitcher
police car	car used by the people who have the, when Lila had her accident they were the first ones	police car
buggy	if you've got a baby you have one	buggy
guitar	use it to sing and play and instrument	guitar
tuba	when you have a, very large and go around it	tuba
saxophone	just like the president has	saxophone
drum	bum, bum, bum	drum

Picture	*Spoken response*	*Written response*
	Description not including a name related to the target	*Related name*
watering can	put water in, quietly, around them	rinse can
vise	need this to ensure to hold onto it	clamp
	Description not including a name related to the target	*Spelling error*
aardvark	a big one, maybe an ant thing	aardvack
Phillips screwdriver	looks like, the other kind	scewdriver (Phippes)
umbrella	if it's raining you've got to have one	umbellas
	Description not including a name related to the target	*Omission*
koala	from Australia, can't remember name	DK
lawnmower/tractor	I take it, taking out grass or getting rid of snow	DK
spreader	to put fertilizer around	DK
	Omission	*Correct*
blackberries	DK	blackberries
mushroom	DK	mushroom
wrench	DK	wrench
nut (tool)	DK	nut
wrench	DK	wrench
wire cutters	DK	wire cutters
spool	DK	thread, spool
bowl	DK	bowl
screw	DK	screw
motorcycle	DK	motorcycle
accordion	DK	accordion
	Omission	*Related name*
trowel	DK	shovel
clothespin	DK	clip

Spoken responses are organised according to error type. Written responses are included as well, classified as either correct or belonging to one of several error types. DK = "don't know" (or some equivalent thereof).