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Word Meaning Blindness: A New Form of Acquired Dyslexia

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We report the case of a patient, JO, who showed intact perception and comprehension of spoken words but who was impaired at accessing the meanings of words she was required to read silently. Letter recognition and written lexical decision were both intact, as was her reading aloud of both words and nonwords. JO's visual comprehension deficit suggests an impairment in mapping between representations in the visual input lexicon and the semantic system. This appears to be the counterpart in reading of "word meaning deafness" (a disorder of spoken word recognition in which patients can perceive spoken words and make auditory lexical decisions but have problems comprehending heard words, despite good comprehension of written words). Hence we refer to this new form of acquired dyslexia as "word meaning blindness." JO's comprehension of words she read aloud was much better, presumably because recoding print into sound enabled her to use her preserved auditory comprehension processes to access meanings. She seemed unable, however, to use "inner speech" to access speech comprehension processes covertly, and further testing indicated a separate impairment of inner speech, which had the effect of making her word meaning blindness more apparent.

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INTRODUCTION

In this paper we describe a new form of acquired dyslexia, which we have termed "word meaning blindness." In order to understand this form of acquired dyslexia it is useful to refer to a closely analogous disorder of speech comprehension known as word meaning deafness. The term "word meaning deafness" refers to a particular form of acquired language disorder in which patients can comprehend written but not spoken words (Franklin, 1989; Franklin, Howard, & Patterson, 1994a; Kohn & Friedman, 1986). Word meaning deaf patients can perceive speech sounds adequately, an ability which differentiates them from patients with "word sound deafness" in whom the processing of the sound of words is impaired (Morris et al., in press; Phillips & Farmer, 1990). Patients with word meaning deafness can also perform auditory lexical decision well, a capacity which distinguishes them from cases of "word form deafness" who, though able to discriminate between speech sounds, fail to recognise many strings of sounds as familiar words, suggesting an impairment to the representations of spoken word forms in the auditory input lexicon (Franklin, 1989; Howard & Franklin, 1988; Kohn & Friedman, 1986).

Despite good perception of speech sounds and good auditory lexical decision skills, word meaning deaf patients have difficulty understanding spoken words, though they are good at comprehending written words. In terms of a standard model of word recognition and production such as that shown in Fig. 1 (cf. Ellis & Young, 1988; Patterson & Shewell, 1987), preserved perception of speech sounds in word meaning deafness implies intact acoustic analysis, preserved auditory lexical decision implies an intact auditory input lexicon, and preserved comprehension of written words implies intact visual analysis, visual input lexicon, and semantic system. As all of the postulated cognitive components thought to be involved in auditory word comprehension seems to be intact, theorists have suggested that word meaning deafness is caused by faulty links between the auditory input lexicon and the semantic system (Allport & Funnell, 1981; Ellis, 1984; Franklin, 1989; Franklin et al., 1994a; Howard & Franklin, 1988; Kohn & Friedman, 1986).

If this interpretation of word meaning deafness is accepted, then Fig. 1 predicts the occurrence of an analogous impairment of reading caused by a deficit affecting the links between the visual input lexicon and the semantic system—a hypothetical (until now) form of acquired dyslexia that we might term "word meaning blindness." The characteristics of word meaning blindness would be as follows:

1. Intact letter recognition (a responsibility of the visual analysis system).

FIG. 1. A simple representation of spoken and written word processing (postulated lesion sites for JO are denoted by the asterisks).

2. Intact lexical decision for written words (on the assumption that lexical decisions can be based on accessing entries in the visual input lexicon, even when the meanings of those words cannot be accessed in the semantic system).

3. Good comprehension of spoken words (because auditory analysis, the auditory input lexicon, the semantic system, and all their connecting pathways are preserved).

4. Impaired comprehension of written words as a result of the disconnection (which could be partial or complete) of the visual input lexicon from the semantic system.

Point (4) needs a little elaboration. According to one possible interpretation of Fig. 1, a patient with a deficit affecting the link between the visual input lexicon and the semantic system should still be able to read aloud familiar words. This would be achieved using the route from print to speech afforded by the connections between the visual input lexicon and the speech output lexicon supplemented, perhaps, by knowledge of sublexical letter-sound correspondences (represented in Fig. 1 by the connections between visual analysis and the phoneme level). The assumption that nonsemantic processes can sustain high levels of competence in reading aloud is by no means universally adopted. For example, Patterson and Hodges have proposed a theory to account for a common co-occurrence between semantic impairment and surface dyslexia (Patterson & Hodges, 1992; Patterson, Graham, & Hodges, 1994). This theory closely reflects aspects of the performance of a connectionist model of "normal" and impaired reading (see Plaut, McClelland, Seidenberg, & Patterson, 1996). According to the Patterson and Hodges theory, there is a mechanism that directly computes phonology from orthography. This direct computation is capable of reliably translating print into sound for all words with regular, consistent spellings. It can also accurately convert frequently encountered irregular words from print to sound. In the case of less common irregular words, however, the direct mapping process requires support from the semantic representations of those words if they are to be pronounced correctly. In the absence of such support irregular words will tend to be regularised, i.e. a patient with semantic impairment will be a surface dyslexic. On this view, disconnecting the visual input lexicon from the semantic system will create problems for the reading aloud of at least some (low-frequency, irregular) words.

If a patient with word meaning blindness is permitted to read words aloud, then he or she should be able to use the intact speech comprehension processes to comprehend those words. That is, the patient would read a word aloud, listen to their own speech, and understand the word just as if it had been spoken by someone else. This

is analogous to a patient with word meaning deafness comprehending a heard word by writing it down then reading and understanding it, a strategy documented by Bramwell (1897). It is not even clear that a word meaning blind patient would have to read a word aloud in order to access preserved auditory comprehension processes: The patient might be able to access the spoken form of a written word internally (at, say, the phoneme level) then feed the spoken form back covertly using "inner speech," gaining access to meaning that way. This procedure is represented in Fig. 1 by the feedback loop connecting the phoneme level to the auditory analysis system, the idea being that one's own speech output can be recycled internally and "heard" as if it came from an external source. Thus, a patient with pure word meaning blindness might easily go unnoticed: Such a patient might show some slowness in accessing meaning from print; otherwise the only detectable symptom should be problems in the comprehension of written homophones. If a patient is reliant on the sounds of words to access their meanings, then he or she should be able to translate the written word REIGN into its spoken form, but would not then know whether to assign in the meaning of "reign" or the meaning of "rain" or even "rein."

However, unless the assessment battery given to a patient included a test of silent homophone comprehension (an unlikely event, we would suggest), then the semantic access problem suffered by the patient with pure word meaning blindness would probably be missed. This may be why such a case has yet to be reported. If, however, the word meaning blindness was accompanied by an inner speech deficit that prevented the internal recycling of spoken word-forms back to the speech comprehension processes, then the patient would be impaired at comprehending words read silently. In contrast, the comprehension of words read aloud should only be marred by the problem with homophone comprehension mentioned earlier.

We report just such a case here. We believe it to be the first clear description of word meaning blindness. This is not to say that ours is the first report of a patient with problems accessing semantics from print. Warrington and Shallice (1979) described the case of patient AR, who they described as having "semantic access dyslexia." AR could sometimes gain partial access to the meaning of a written word he read incorrectly. For example, when shown the word cereal, AR said, "It is something you eat" and added, "It seems as if I am almost there, but it seems as if I can't go over the last little bit and finally grasp it." In addition, AR was helped in reading aloud by semantic prompts, and could categorise the meaning of a written word at an accuracy above that expected by chance—both features that Warrington and Shallice argue would be expected in a patient with semantic access problems.

There are several respects, however, in which AR falls short of the description of word meaning blindness given here. We have suggested that an "ideal" case would have intact comprehension of spoken words whereas AR made substantial numbers of errors in spoken word-to-picture matching tasks as well as in written word-to-picture matching tasks. We have also suggested that reading aloud could be preserved in a case of word meaning blindness whereas AR was only able to read between 35% and 50% of words aloud. Finally, a case of word meaning blindness should be good at identifying, naming, and matching individual letters whereas AR was poor at all of these. Hence, while problems in accessing semantics from print may have formed a part of AR's overall pattern, he undoubtedly had a range of additional deficits, including a central semantic impairment and a severe visual analysis impairment, which complicated the interpretation of his symptoms.

Rapp and Caramazza (1989) described a patient, JE, who showed poor reading aloud but sufficient access to semantics to complete various categorisation tasks at a level above chance. However, like that of AR, JE's data does not seem to fit the description of word meaning blindness that we have put forward. For example, although JE showed good access to semantics for spoken words, he was very poor at reading aloud, only managing to read 6% of a word and nonword reading list. Without further information from tasks that measure letter and word recognition, it is not possible to reject the possibility that JE's poor reading for meaning and reading aloud were due, at least in part, to impairment at the level of visual analysis.

Shallice and Coughlan (1980) have suggested that semantic access problems form a part of the overall picture in some deep dyslexic patients. Their patient, PS, was worse at gaining access to the meaning of words when presented in written than in spoken form. However, many of our comments on patient AR apply equally to this case. In particular, PS showed poor reading aloud, making a large number of visual errors (51%), and he was unable to complete written lexical decision successfully. If deep dyslexia is to be properly understood as the performance of damage to the normal reading system rather than as the performance of a secondary reading system housed in the right hemisphere (Coltheart, 1980; Patterson, Vargha-Khadem, & Polkey, 1989), then an impairment affecting connections between the visual input lexicon and the semantic system can only be one of several deficits (Morton & Patterson, 1980; Shallice & Warrington, 1980).

Finally, it has been noted that in some cases of surface dyslexia, patients misdefine irregular homophones despite reading some of them aloud correctly (Coltheart et al., 1983; Coltheart & Funnell, 1987). For example, Coltheart et al (1983) note that their patients CD and AB

occasionally made homophone confusions to irregularly spelt homophones (e.g. *bury* → “a fruit on a tree” [cf. *berry*]; *bowled* → “fierce, big” [cf. *bold*]). This has been interpreted in terms of correct activation within the visual input lexicon, good translation to output for correct reading aloud, but poor communication between the visual input lexicon and the semantic system—the very deficit that we have suggested lies at the core of word meaning blindness. However, it is not clear from the published reports how often these confusions were made. Even if these homophone errors were a stable part of their deficits and a consequence of word meaning blindness, CD and AB are not pure cases. They are surface dyslexics, showing regularity effects in reading aloud and copious regularisation errors. Hence we would suggest that, in addition to any problems of mapping between the visual input lexicon and the semantic system, these individuals must have had other impairments, perhaps at the visual input lexicon itself, which led to their surface dyslexia.

So, to repeat, a case of word meaning blindness must show impaired access to meaning from print in the context of intact letter recognition, intact visual lexical decision, and intact perception and comprehension of spoken words. Depending on one’s view of the processes mediating reading aloud, that ability may or may not be expected to be preserved. We present such a case here.

CASE HISTORY

JO was originally referred for medical assessment in June 1994, aged 73 years, with complaints of “memory problems.” She is right-handed and received a formal education until the age of 14. During the Second World War she served as a nurse and following her marriage she maintained her family and household. A CT scan in November 1994 revealed a degree of general atrophy within the normal range for her age. An MRI scan (see Plates 1a and 1b) taken during the phase of tests reported revealed some generalised atrophy, with the temporal lobes being particularly affected plus multiple small well-defined foci of high signal density within the basal ganglia.

Initial medical assessment highlighted a degree of word-finding difficulty in spontaneous speech. Assessment by a clinical psychologist suggested that JO’s memory was normal (long-term memory, short-term memory, recalling newly learnt information) apart from occasional word-finding problems.

JO was referred for assessment with one of the present authors (KS). A pure-tone audiogram covering frequencies from 500Hz to 6000Hz revealed a 30–60dB loss in both ears, suggesting a mild hearing deficit. During all tests involving auditory processing she wore a Sarabec hearing aid. Her

eyesight was corrected to normal with spectacles. JO's spontaneous speech was found to be free from syntactical or phonological errors but showed word-finding problems. On the Boston Naming test she named 48/59 items, placing her just outside the normal range (49–59). Also, JO showed a reduced letter fluency, producing a total of 29 items for the 3 letters f, a, s (Benton, 1968), which places her in the range of "mild dementia." Additionally, JO complained about problems with reading books and writing. She had always been a keen letter writer and reader, helping out in her spare time with a community library. In particular, she seemed to have difficulties comprehending the text she was trying to read, commenting, "I read but there's nothing coming in and I have to stop and start again." This apparent reading problem seemed to affect her writing. When asked about letter writing she replied, "I haven't written a letter for ages. I can't read the words."

Further Neuropsychological Testing

All tests reported here were carried out between March and September 1995.

NART and IQ. JO scored 29 on the National Adult Reading Test (NART: Nelson, 1982), suggesting a premorbid IQ in the "high average" range. This was commensurate with her Performance IQ of 105 on the WAIS-R, though her verbal IQ was significantly lower (verbal IQ = 73).

Long-term Memory. JO's long-term memory was tested using the Autobiographical Memory Interview (Kopelman, Wilson, & Baddeley, 1989). Despite her word-finding problems in spontaneous speech, she was able to score within the normal range for the autobiographical incident section of the test, for all three epochs (childhood—6, normal cut-off > 3; adulthood—5, normal cut-off > 3; recent—6, normal cut-off > 5). However, on the personal semantic memory scale she scored outside the normal range (childhood—5.5, normal cut-off > 12; adulthood—5.5, normal cut-off > 15; recent—7.5, normal cut-off > 18).

Object Naming. Tests of picture naming again found evidence of anomia in JO. A re-administration of the Boston Naming test (six months on from the first) revealed a drop in performance to 40/59 correctly named. Her error pattern was dominated by circumlocutions and semantic errors. These were also found when she was asked to name a set of 240 line drawings. She named 184 items correctly, with 27 semantic errors, 9 circumlocutions, 16 no responses, 1 visual error, and 3 other errors. When asked to write the names of a subset of these pictures, she correctly wrote

32/40, with 2 semantic errors, 2 morphological errors (foot to feet, screw to screws), 3 phonologically plausible spelling errors, and a combined semantic and spelling error (tiger spelt as leopard). In spelling these same words to dictation, she made no semantic errors, rather only four phonologically plausible spelling errors.

Category Fluency. JO showed a drop in fluency in generating items from six out of eight semantic categories tested (items produced in one minute: birds= 5, sea creatures= 3, household items= 8, vehicles= 1, musical instruments= 5, and boats= 3). Her performance on animals and types of dog was just over a two standard deviation cut-off (animals= 10, cut-off 9; dogs= 5, cut-off 4: norms from Hodges, Patterson, Oxbury, & Funnell, 1992).

Object and Face Recognition

JO showed intact visual recognition of objects and faces. On a test of matching different views of objects (minimal feature test: Riddoch & Humphreys, 1993) she scored within the normal range (20/25; normal range 18–25). On two tests requiring the subject to say whether an object/animal is “real” or “made-up” (object decision: Riddoch & Humphreys, 1993) she was within or just outside the normal range (Test B: easy—28/32, norms 28–32; Test A: easy—21/32, norms 22–32). On a forced-choice face recognition test, she correctly picked 45/48 famous faces, which is within the normal range (45–48 correct; A. Young, personal communication).

Pyramid and Palm Trees Test (Howard & Patterson, 1992). The all-picture version of the Pyramid and Palm Trees test requires the subject to match a target picture to one of two other pictured objects, only one of which is associatively related to the target item. Thus, the subject is required to pick the palm tree, and not the fir tree, in response to a picture of a pyramid. JO scored 48/52 correct, which is just outside the normal range for this task (normal controls make 0–3 errors).

BORB Association Match Test (Riddoch & Humphreys, 1993). This test is very similar to the Pyramid and Palm Trees test. JO scored 26/30 on this test, which is well within the normal range (21–30).

LETTER RECOGNITION

A case of word meaning blindness should show intact processing of letters. JO was given a number of tests from the PALPA battery (Kay et al., 1992),

which assess letter recognition. The first requires the subject to say whether the presented letter is written correctly or is reversed (test 18). Two further tests ask the subject to match a letter to one of two alternatives presented in another case. One requires the subject to match lower to upper case (test 19) and the other to match from upper to lower case (20). In test 22 the subject names all the letters of the alphabet in both upper and lower case. The last test administered requires the subject to pick a letter from an array in response to a spoken target letter (test 23). JO made no errors on any of these tasks, indicating preserved letter recognition.

VISUAL LEXICAL DECISION

A case of word meaning blindness should show intact lexical decision for written words. Two written lexical decision tests were given to JO, both taken from the PALPA battery (Kay et al., 1992). In each she was shown randomly interleaved words and nonwords and was asked to indicate whether each item was “real” or “made-up” by placing each item (written on individual cards) on one of two piles, one for words and the other for nonwords. The experimenter instructed JO not to read the items aloud, but rather to perform the task silently.

The PALPA Imageability × Frequency Lexical Task (Test 25). This test varies the frequency of occurrence and the imageability of 60 word targets. The 60 nonwords in this task are all legal and word-like. JO scored 120/120 correct.

The PALPA Regularity Lexical Decision Task (Test 27). This test has 30 words varying on spelling-sound regularity and 30 nonwords, with half the nonwords being pronounced like real words (pseudohomophones, e.g. *brume*) whereas the other half are simple nonwords (e.g. *durl*). JO scored 60/60 correct.

RECOGNITION OF SPOKEN WORDS

A case of word meaning blindness should show intact perception and comprehension of heard words. This was assessed in JO using tasks involving the perception of speech sounds, word and nonword repetition, auditory lexical decision, and spoken word comprehension.

Speech Perception

Word Minimal Pairs (ADA Task P3; Franklin, Turner, & Ellis, 1992). Minimal pairs tasks require the patient to indicate whether

pairs of auditorily presented items are the same or different. The stimuli for the word minimal pairs task were all CVC words. There were 20 “same” pairs and 20 “different” pairs. The different pairs differed on one phoneme (either the initial or the final phoneme) and by one or two distinctive features (e.g. “dug”—“duck”; “cup”—“sup”). The pairs were spoken in a female voice (by the second author). JO scored 39/40, which is within the normal range.

Nonword Minimal Pairs (ADA Task P1; Franklin et al., 1992). This task was the same as the previous task except that the items were all CVC nonwords such as “dack” and “gep.” JO scored 37/40. This is outside the range for normal young adults (39–40) but represents an impressive level of performance for a woman in her 70s with a hearing loss.

Repetition of Words and Nonwords

Word and Nonword Repetition Test (ADA Battery Test R; Franklin et al., 1992). The stimuli for this test comprise 20 short (1-syllable) words, 20 long (2-syllable) words, 20 short nonwords, and 20 long nonwords. The items are interleaved in a random order and spoken once by the experimenter before being repeated by the patient. JO’s scores were: short words 15/20, long words 19/20, short nonwords 16/20, and long nonwords 9/20. Her overall score of 59/80 and her scores on the individual sets of items are all within the normal range for young adults.

Auditory Lexical Decision

ADA Battery Test L1 Part 1; Franklin et al., 1992. This test requires the subject to discriminate spoken words from nonwords that differ from words by a single phoneme. JO scored 38/40, which is within the normal range (normal subjects make 0 to 7 errors). Her two errors were false positives to nonwords.

Auditory Word Comprehension

The PALPA Word-to-picture Matching Task (Kay, Lesser, & Coltheart, 1992). In the spoken word-to-picture matching version of this task (test 47) the experimenter says the name of an object which the subject must then select the picture of from a choice of five. The five pictures depict the target word (e.g. button), a close semantic distractor (zip), a more distant semantic distractor (bow), a visually similar object (a coin), and an unrelated object (a banknote). JO scored 36/40, making 3 close semantic errors and 1 visual error. This is within the normal range (35–40).

The ADA Synonym Judgement Task (Franklin et al., 1992). This task requires the patient to say whether two heard words are similar in meaning (e.g. “magician”—“wizard”) or are different (e.g. “bowl—“lady”). The 160 items in the test are split into 2 halves. In one half the items are either high or low in frequency (matched for imageability and phoneme length) while in the other they vary on imageability (matched for frequency and phoneme length). JO obtained an overall score of 152/160, which is within the normal range for young normal subjects (0–8 errors). She showed no apparent effects of either frequency (high frequency 37/40; low frequency 39/40) or imageability (high imageability 39/40; low imageability 37/40).

COMPREHENSION OF WRITTEN WORDS

A case of word meaning blindness should show impaired comprehension of words the patient is required to read silently.

The PALPA Word-to-picture Matching Task (Kay et al., 1992). In the written word-to-picture matching version of this task an object name is printed in the centre of the page and the subject must point to the appropriate picture from the set of five that surround the name. JO performed the task silently throughout. She scored 22/40, which is well outside the normal range (35–40; mean = 39.4) and is significantly worse than her performance in the spoken word-to-picture matching version of the same task reported earlier (McNemar Test: $\chi^2 = 10.6$, $P < 0.005$). Her errors on this task comprised of incorrectly selecting nine close semantic foils, four distant semantic foils, four visual foils, and one unrelated foil.

The ADA Synonym Judgement Task (Franklin et al., 1992). In the written version of this task the subject says whether two written words are similar or different in meaning. JO was instructed not to read the words aloud. She obtained an overall score of 109/160, which is severely impaired (normal range 0–5 errors) and is significantly worse than her score on the spoken version of this task reported earlier (McNemar Test: $\chi^2 = 30.9$, $P < 0.005$).

READING ALOUD

Thus far, JO corresponds closely to the pattern expected of a patient with word meaning blindness, showing impaired comprehension of written words in the context of preserved letter processing, written lexical decision, and spoken word perception and comprehension. We argued in the Introduction that a patient with a disconnection of the visual input lexicon

from the semantic system (complete or, as in JO's case, partial) might still remain able to read words aloud at normal levels. The following tests assessed JO's reading aloud of words and nonwords.

Word Reading

Shallice, Warrington, and McCarthy (1983) Levels of Regularity List. Words in the Shallice et al. (1983) list vary on their spelling-sound regularity, from regular, through "mildly irregular," to very irregular. JO read 115/120 correctly. This score is within the normal range for older subjects (2–6 errors; Lambon Ralph et al., 1995).

Strain, Patterson, and Seidenberg (1995) Regularity, Frequency, and Imageability List. Strain et al. (1995) provide two word lists. List 1 orthogonally varies the regularity of the items, their frequency of occurrence, and their imageability. List 2 varies imageability and regularity for a set of low-frequency words (items are balanced across sets for frequency).

On list 1, JO read 96/96 correctly (normal range 0–2 errors). On List 2 she read 61/64 correctly (normal range 1–5 errors: norms from Lambon Ralph et al., 1995).

Nonword Reading

Most models of reading would also predict that the reading of unfamiliar nonwords could survive the partial disconnection of the visual input lexicon from the semantic system. This would be true whether one believes in a separate "sublexical" route for converting letter strings to sound, represented in Fig. 1 by the connection between visual analysis and the phoneme level (cf. Coltheart, Curtis, Atkins, & Haller, 1993), or thinks that nonword reading draws upon links between elements in more distributed orthographic and phonological systems (cf. Seidenberg & McClelland, 1989; Plaut et al., 1996).

PALPA Nonword Reading Test 36 (Kay et al., 1992). JO was asked to read aloud a set of 24 nonwords, varying in length from 3 to 6 letters. She read 17/24 nonwords correctly, which is exactly 2 standard deviations below the mean for normal readers. On a second administration her score improved to 22/24, which is a normal level of performance. We suspect that this slight improvement in performance was due to her increasing familiarity with nonword stimuli through experience of these items in reading and other tasks involving nonwords. For both administrations, her errors were lexicalisations of the nonwords.

COMPREHENSION OF WORDS READ ALOUD

If JO's capacity to read words aloud is intact, and if her comprehension of spoken words is also intact, then with certain limitations (see following) she should be able to overcome her problems in understanding written words by reading them aloud and listening to her own speech. This possibility was assessed in the next set of tests.

PALPA Spoken Word to Written Word Matching Task 52 (Kay et al., 1992). The spoken-word-to-written-word matching test assesses the subject's ability to match a heard word to the same word in written form. Each target word (e.g. abdomen) is accompanied by a synonym (e.g. stomach), a semantic foil (e.g. lung) and an unrelated item (e.g. meadow). JO was required to complete the task silently on one occasion and with reading aloud on another.

JO scored 8/15 (with 6 synonym errors and 1 semantic error) in the silent condition and 15/15 for the reading aloud condition (normals perform at ceiling). The difference between conditions is significant (Binomial test, $P = 0.007$).

PALPA Word Semantic Association Task 51 (Kay et al., 1992). In the word semantic association task, the subject is required to read a word and then indicate which word from a set of four is closest in meaning. For each test item (e.g. fog) there is the target word (mist), a semantically related foil (steam) and two unrelated items which are always semantically related to each other (bolt and lock). Half the test items have high imageability and the other half low imageability. JO performed the task silently in one session. In another session she read all the items aloud.

In the silent reading word association task, JO scored 5/15 for the concrete items (errors being 9 semantic foils and 1 unrelated) and 7/15 for the abstract items (errors being 3 semantic foils and 5 unrelated). In the reading aloud condition she scored 10/15 for the concrete items (5 semantic errors) and 12/15 on the abstract (3 semantic errors). Her performance in the reading aloud condition is significantly better than in the silent reading condition (Binomial test, $P = 0.001$), and is near or within the normal range (a 2 SD cut-off; for the concrete items the cut-off is 11/15; for abstract items the cut-off is 9/15).

Defining Words Read Silently or Aloud

JO was asked to give some sort of definition to a subset of words taken from list 2 of Strain et al. (1995), described earlier. These were all low-frequency, exceptionally-spelt words, half of which have high imageability,

the other half low. JO was first asked to read each word silently and then to define it. Up to one minute was given for each word before she was asked to read the word aloud and give a second definition.

Even though a lenient criterion was adopted for scoring the definition task, JO only managed to attempt any sort of indication of the meaning of two words when reading them silently (*suave* → “someone who is...” and *dove* → “a bird”). However, when permitted to read them aloud first, she could give an acceptable definition for 23/32 of the words, her 9 errors being no responses. Examples of JO’s definitions to words read aloud are *boulder* → “a round stone,” *soot* → “chimneys ... black ...,” and *pear* → “a fruit.”

Accessing the Meanings of Homophones Read Aloud

If JO’s comprehension of words read aloud is mediated primarily by their spoken forms, then she should show problems accessing the correct meanings of homophones.

Defining Homophones. JO was given a list of 20 homophones to define (taken from the PALPA homophone definition test 38: Kay et al., 1992). Half the homophones have exceptional spellings, the other half are regular. She was asked to read each word aloud and then give a definition.

JO correctly read aloud all 20 homophones. Due to her word-finding difficulties her definitions were not easy to score. However, she seemed to make three homophone definition errors (*mail* → “a male ... or a man”; *week* → “not very ... doing anything”; *loan* → “a lone figure”). One other definition might have been a homophone error (*steel* → “steal/steel work and steal/steel a knife or a fork”), but this is open to interpretation. As JO always used words correctly in terms of their grammatical class, it could be argued that she is using the word as a verb and consequently with the meaning of “steal.” However, if using it as an adjective or providing an associative relationship, then it could be equally argued that she correctly defined the word as *steel*. She was able to give a correct indication of meaning for the remainder of words.

TESTS OF “INNER SPEECH”

If JO can benefit from reading words aloud, why does she not use a strategy of saying the words to herself and, in effect, listening to her own inner speech? One possibility is that those inner speech processes are themselves impaired. The following tests investigate the status of inner

speech in JO using tasks in which she must reflect upon the sound patterns of words.

PALPA Rhyme Judgement Test No. 15 (Kay et al., 1992). This test requires the subject to say whether two written words rhyme. Half of the pairs rhyme and half do not. Within the rhyming and nonrhyming sets, half the pairs have similar written endings (e.g. *town—gown*; *down—flown*) and the other half do not (e.g. *shoe—screw*; *hoe—chew*). For successful completion of the entire test the subject must be able to derive the sound of each word rather than rely on visual similarity as a guide.

In the silent condition JO scored 43/60 (chance = 30), making errors across all types of word pairs. This is clearly severely impaired, though it is significantly above chance (a score of 38 or more is significant at the $P = 0.05$ level). When she first read the pairs aloud she scored 54/60, which is significantly better than her performance on the same test under silent reading conditions (McNemar test: $\chi^2 = 9.6$, $P < 0.005$).

Pseudohomophone Decision Task (Howard & Franklin, 1987). The pseudohomophone decision test requires the subject to pick which of two visually presented nonwords sounds like a real word (where the target and foil differ only by one letter). For example, the subject is required to pick *chuze* and reject *thuze*. Again, JO was required to read the items silently on one occasion and aloud on another for each task.

In the silent condition, JO achieved a score of 29/39. This score is significantly above chance (binomial, $P = 0.002$) but outside the normal range (33–38; D. Howard, personal communication). In contrast, when asked to read the items aloud first, JO scored 37/39. This is significantly greater than her silent performance (binomial, $P = 0.01$) and within the normal range.

JO was reasonably good at both rhyme judgements and pseudohomophone decisions when she was permitted to read the words aloud. Thus there would appear to be nothing inherently faulty about her appreciation of rhyme or her ability to access lexical representations via sound for an unfamiliar letter string. In contrast, when she was required to do these tasks silently her performance was very poor. This supports the suggestion that the ability to utilise inner speech to feed the sounds of words back internally to auditory word recognition processes is severely impaired. In this context it is interesting to note that JO had a reduced digit span (her repetition forward digit span was four). Furthermore, when trying (unsuccessfully) to recall a digit length greater than four she seemed to be using overt rather than covert rehearsal, repeating the numbers out loud to herself.

DISCUSSION

In the Introduction we specified that a case of word meaning blindness should show impaired access to meaning from print in the context of intact letter recognition, intact visual lexical decision, and intact comprehension of spoken words. JO fits these requirements well. She was able to recognise both letters and words and to distinguish the latter from nonwords. Her perception and repetition of spoken words and nonwords was good. Her comprehension of spoken words was within the normal range both for word-to-picture and synonym judgement tasks. On the written versions of these tasks she performed poorly when required to read the words silently.

We also noted in the Introduction that a patient with word meaning blindness might benefit from being permitted to read words aloud because this recoding would provide access to auditory word recognition processes. This proved to be true for JO: Across a number of tasks that require access to meaning from written input, JO's performance was poor when she was required to perform the tasks silently, but it rose to a level within the normal range when she read the words aloud. She demonstrated further evidence of access to meaning via phonology in as far as she made a number of homophone errors in definition. Thus JO conforms closely to the pattern predicted for a patient with an impairment to the connections between the visual input lexicon and the semantic system. As far as we are aware, no patient has been reported before who shows word meaning blindness in anything like as clear a fashion as JO. In the remainder of this Discussion we will discuss a number of the issues and ramifications that arise from a consideration of this new form of acquired dyslexia.

The Status of JO's Semantic Representations

JO's errors in silent matching of written words to pictures or to spoken words typically involved her picking semantically related foils. This suggests that when she was unable to access semantics from print correctly, she was often able to gain at least partial access to meaning. Some of her definitions might be construed as indicating incomplete semantic access (e.g. *pear* → "a fruit"), though it is difficult to exclude the alternative possibility that word-finding problems make her definitions less precise than they otherwise might have been. JO also made semantic errors in both spoken and written naming. Her preserved autobiographical memory and nonverbal intelligence argue against a diagnosis of Dementia of Alzheimer Type, but she has features in common with reported cases of "semantic dementia," a disorder characterised by selective impairment of semantic memory causing severe anomia and impaired single word comprehension, reduced generation of exemplars in category fluency

tests, relative sparing of syntax and phonology, relatively normal perceptual skills and nonverbal problem solving abilities, and relatively preserved autobiographical memory (e.g. Hodges, Patterson, Oxbury, & Funnell, 1992; Snowden, Goulding, & Neary, 1989).

We have already noted JO's anomia and problems of written word comprehension. She also showed reduced category fluency, and her spontaneous speech was reasonably fluent with no sign of syntactic or phonological problems. JO's recall of personal semantic information on the Autobiographical Memory Interview was poorer than her recall of episodic information (though again it may be that word-finding difficulties leave her more able to convey episodic than detailed semantic information) and she had relatively preserved perceptual and problem-solving skills. All these features she shares in common with semantic dementia.

Other features, however, clearly differentiate JO from previously reported cases of semantic dementia. In particular, her auditory word comprehension was within the normal range, and her performance on all-picture comprehension tasks was either within (BORB Association Match) or just outside (Pyramids and Palm Trees) the normal range. These aspects of JO's performance are incompatible with a central semantic impairment and suggest instead that she had problems accessing semantics from print, and problems accessing phonological and orthographic output lexicons in speech and writing (cf. Caramazza & Hillis, 1990). It may be that JO simply does not belong with cases of semantic dementia, or it may be that the syndrome of semantic dementia is headed, like so many before it, for fractionation (cf. Ellis, 1987). It will be interesting to follow JO's longitudinal development to see if her profile becomes closer to that of semantic dementia with time (e.g. to see if her comprehension of spoken words declines to a level comparable with that presently shown for written words).

The Role of Semantics in Reading Aloud

Another symptom said to characterise semantic dementia, which was not present in JO, is surface dyslexia (impaired reading aloud of words with irregular or exception spellings, which patients tend to regularise, for example misreading COLONEL as "kollonel"). Surface dyslexia has been claimed by Patterson and Hodges (1992) and Hodges, Patterson, and Tyler (1994) to be a reliable feature of semantic dementia, and empirical data from normal studies indicates that some contribution from semantic representations is necessary for correct reading of irregular words, especially ones of low frequency and imageability (cf. Strain et al., 1995).

JO had severe problems gaining access to meaning from print, and could only do this reliably when permitted to read words aloud.

Nevertheless, she was *not* surface dyslexic: Her reading aloud of irregular or exception words was normal. Thus, she made only 3 errors in reading 64 low-frequency regular and exception words from Strain et al (1995), where matched controls make from 1 to 5 errors. When asked to give an indication of the meaning of these words she could only give any sort of definition for two of them when reading silently but she could give adequate definitions when she read aloud or heard the words. Words that she could read aloud but not define without auditory recoding included low-frequency abstract words such as *toughness*, *stingy*, *scarce*, *chasm*, and *cache*. JO's ability to read aloud low-frequency, abstract, exception words that she could not define casts doubt upon the theory of Patterson and Hodges (1992) and Plaut et al. (1996) that a contribution from semantics is necessary if such words are to be read correctly. Further counter-evidence from patients with preserved reading aloud in the context of impairments to central semantics has been reported by Cipolotti and Warrington (1995) and Lambon Ralph, Ellis, and Franklin (1995).

Theoretical Interpretation

In terms of the model presented in Fig. 1, JO's preserved speech perception and spoken word comprehension imply that acoustic analysis, the auditory input lexicon, and the central semantic system are intact. Good repetition of words and nonwords suggests that the phoneme level is normal and that her problems with word finding (which we have not explored here) are due to either damage to the speech output lexicon or problems in gaining access to that lexicon from semantics. Normal (or virtually normal) performance on picture comprehension tasks implies preserved object recognition and comprehension, and is incompatible with any suggestion that pictures and printed words share an access route to semantics (see Farah, 1990, for further discussion).

Normal performance on letter recognition tasks implies preserved visual analysis of letter strings, and good visual lexical decision indicates that JO's visual input lexicon is intact and working (and can sustain a high level of performance on the lexical decision task in a patient who is unable to access semantics from print). Good reading aloud of both words and nonwords implies that the connections between the visual input lexicon and the speech output lexicon, and between visual analysis and the phoneme level, are intact. As outlined in the Introduction, the root cause of JO's word meaning blindness would seem, therefore, to lie in a *partial disconnection of the visual input lexicon from the semantic system*. She can define very few words read silently, and is very impaired at silent word-to-picture matching and silent synonym and word association judgements. We suggest that the disconnection is partial rather than complete because

her level of performance on word-to-picture tasks is above that expected by chance and her predominant error is to pick semantically related foils, which one would expect if some semantic information is still being activated. This partial information may be sufficient to assist her in differentiating between the meanings of written homophones: Having read the homophone aloud correctly, JO should have accessed the different meanings of the spoken word (her central semantics are undamaged), so that one candidate can be selected from these various meanings with reference to the partial activation from direct visual input.

Unlike patients with word meaning deafness, whose access to semantics for spoken words is reported to be better for concrete than abstract words (Franklin et al., 1994a; Franklin, Turner, & Morris, 1994b), no effect of imageability on JO's reading comprehension could be detected. It may be, however, that her very low overall level of performance on silent comprehension tasks prevented an effect of imageability from being manifested.

The disconnection of the visual input lexicon from the semantic system was not JO's only deficit. Her impaired naming may be due to some form of damage between the semantic system and the speech output lexicon, as highlighted in Fig. 1. Her very poor level of performance on rhyme judgements and pseudohomophone decisions also indicates a severe impairment of "inner speech" (represented in Fig. 1 by the feedback loop from the phoneme level to acoustic analysis). Our view is that the inner speech impairment is functionally separate from the disconnection of the visual input lexicon from the semantic system that gave rise to her word meaning blindness. Nevertheless, her consequent inability to employ a strategy of silent phonological access made her word meaning blindness much easier to detect. As we noted in the Introduction, a patient with pure word meaning blindness (i.e. only a disconnection of the visual input lexicon from the semantic system) might be fractionally slower to comprehend written words than a normal reader, but the only real way one would know that there was anything wrong would be that the patient should have difficulty assigning the correct meanings to homophones. We doubt that such a deficit would be detected very often, which may be why word meaning blindness has not been reported before now.

We have assumed that JO's lack of covert phonological access had the effect of making her word meaning blindness more apparent. Some theorists may, however, be tempted to argue that "direct" semantic access from orthography is inherently weak, that good semantic access requires a substantial phonological input even in normal readers, and that what we are seeing in JO is nonphonological semantic access from print laid bare in all its inadequacy (cf. Van Orden, 1987, 1991). Arguments against the basic assertion that a substantial phonological contribution is necessary

for adequate semantic access from print can be found in Jared and Seidenberg (1991) and Coltheart, Patterson, and Leahy (1994), but from a cognitive neuropsychological perspective we would suggest that such a view can be countered by reference to patients with word meaning deafness. As we have seen, these patients are effectively the mirror image of JO: Their pattern of preserved and impaired abilities suggests a disconnection of the auditory input lexicon from the semantic system. If speech comprehension processes were required for the understanding of *written* words, then the ability of such patients to comprehend written words should also be impaired (Allport & Funnell, 1981), yet it is not: The word meaning deaf patients reported by Franklin et al. (1994a, 1994b) showed very precise comprehension of written words.

Simple functional models like that in Fig. 1 predict a great many qualitatively different patterns of breakdown. Over the years, many of these patterns have been reported (Ellis & Young, 1988; McCarthy & Warrington, 1990). The one described here—disconnection of the visual input lexicon from the semantic system—has been predictable from cognitive models of word recognition and production for at least 25 years (some would say more like 100 years; Morton, 1984). Yet as far as we are aware, ours is the first clearly documented case. Perhaps there is life in the old models yet.

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(a) Horizontal section.

(b) Cross section.

PLATE 1. MRI scans showing some generalised atrophy with the temporal lobes being particularly affected.