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Running Title: Central deep dyslexia
Abstract

A case study is reported of a female patient (JAH), who following a left middle cerebral artery infarct, presented with the cardinal symptoms of deep dyslexia and deep dysphasia (semantic errors when reading and repeating words aloud, respectively). Detailed assessment revealed impaired performance across modalities for many tasks, but particularly those tasks that depend on an intact store of semantic knowledge. Her acquired dyslexia is best characterised as deep dyslexia of a central sub-type.
Introduction

Of the central dyslexias (deep, phonological and surface dyslexia) deep dyslexia is surrounded by the most controversy. This particular acquired dyslexia, first documented by Marshall & Newcombe (1966), has many of the following characteristics (Coltheart, 1980):

- A problem with deriving phonology from print, sub-lexically (e.g., impaired non-word reading) and, usually, lexically (e.g., impaired rhyme judgements).
- A word-class effect in which the reading of nouns is superior to the reading of other syntactic classes of words (although this effect may be reducible to an effect of word concreteness, Barry & Richardson, 1988).
- No (or much impaired) function word reading with the presence of substitution errors, such as reading \( is \)¹ as ‘on.’
- A concreteness (and imageability) effect with concrete words read better than abstract words.
- The occurrence of semantic substitutions in oral reading (e.g., reading house as ‘garden’).
- Visual errors, where the response is visually similar to the target.
- Morphological errors, particularly with bound morphemes (e.g., pluralisations)
- Context effects; for example the better reading of closed class words in a phrasal context (Silverberg et al., 1998) than single closed class word reading.
- Impaired auditory-verbal short-term memory.
- Difficulties with writing.

¹ Throughout this report a target item is italicised
Although semantic errors when reading aloud are of “central importance” (Coltheart, 1980) deep dyslexic patients show a remarkable diversity in the range and severity of their deficits and it may be useful to describe deep dyslexia as a ‘weak syndrome’ (Caramazza, 1984). For example, the deep dyslexic JA (Katz & Lanzoni, 1997) was given 60 object names to read, taken from the Boston Naming test (Kaplan, Goodglass et al., 1983) and 19% of the substantive errors were semantic substitutions. In contrast KE (Hillis et al., 1990) made 31% semantic errors when asked to read 144 words taken from 10 different semantic categories and PS (Shallice and Coughlan, 1980) made just 10% semantic errors. Similar disparities between patients are evident when other characteristics of deep dyslexia are considered. For example, function word reading may be completely abolished (KE; Hillis et al., 1990) or severely impaired. FD (Friedman & Perlman, 1982) correctly read 12% of function words and made 79% substitution errors while PS (Shallice and Coughlan, 1980) read 40% of function words. A similar degree of variability in the performance of patients is noticeable when the word-class effect is reviewed. BL (Klein et al., 1994) successfully read 97% of nouns but only 80% of verbs whilst KF (Shallice and Warrington, 1975) read 43% and 7% of nouns and verbs respectively.

To explain this apparent heterogeneity in performance Shallice and Warrington (1980) suggested that deep dyslexia is a ‘multi-component syndrome’ with three distinct sub-types, reflecting different loci of functional damage. An input problem, with accessing a specific semantic representation, a central semantic deficit, or a post-lexical output problem at phonological retrieval. Each of these sub-types makes different predictions when considering the lexical performance of deep dyslexics.
Deep dyslexia of the input type is characterised by difficulties restricted to a single modality - assuming a single amodal semantic system (cf. Shallice, 1987). Secondly, as the problem is thought to be one of accessing an intact lexicon some general semantic information may be available. Presumably the specificity of the information available would be a function of the resting activation of the concepts in semantic memory. Only information that has a high threshold (e.g., concrete concepts) would be activated by weak or noisy access procedures. The deep dyslexic PS (Shallice & Coughlan, 1980) has been characterized as being of the input type (Newton & Barry, 1997) and in tests of picture-name and synonym matching PS performed significantly better with auditory than with visual presentation. In semantic categorization tasks performance was superior for distinct categories (e.g., boys names vs. girls names) than for less distinct (abstract) semantic categories such as pleasant vs. unpleasant words, indicating the availability of some general semantic information.

Deep dyslexics of a central type are proposed to have severe comprehension problems and as the problem is thought to be one of degraded semantic knowledge, deficits should be evident across different modalities and different tasks (e.g., word reading and object naming). In the last twelve years only one deep dyslexic has met the criteria of central deep dyslexia. Hillis et al., (1990) describe a patient KE whose performance on tasks of oral reading, picture naming, written picture naming and writing to dictation yielded a mean error rate of 44% with approximately 33% semantic errors across all tasks. These deficits across modalities and tasks are explicable by appealing to a problem within a semantic system common to all tasks.
However, KE did show some knowledge of the superordinate characteristics of items but not of detailed knowledge. His performance at sorting pictures and words into appropriate superordinate categories (e.g., body parts, transport, fruits) was at ceiling for the pictorial stimuli and only slightly worse with words (99%).

Output deep dyslexics are thought to have full access to an intact lexicon but the transmission of information fails to activate the correct target in the phonological output lexicon. This is the ‘response blocking’ hypothesis of Morton & Patterson (1980) whereby the correct semantic code passes to the output lexicon but due to a raised threshold of the target item a similar response is chosen. Thus, the target and paralexic response are similar (e.g., cup → ‘tea’). Morton & Patterson (1980) make the point that if a correct response is blocked and not due to a faulty semantic code then there should be a sufficient difference between the target and response for a patient to distinguish between them on subsequent tests. A response blocking account would also predict the occurrence of semantic errors with any task that requires phonological output (e.g., picture naming, spontaneous speech and word repetition). A rather different account of output deep dyslexia (Buchanan et al., 2000) attributes the problem not to response blocking but to one of response selection in the phonological output lexicon. The authors suggest that patients show a lack of ‘sensitivity’ to the most highly activated word (the target) in the phonological lexicon. Furnishing a phonemic cue should enhance the probability of a correct response by advantaging the selection of the target word and inhibiting a contending response. Buchanan et al. (2000) verified this by testing their patient SD on oral naming with and without a phonemic cue. With a cue SD correctly named 18/22 (82%) items compared to 19/44 (41%) without a phonemic cue.
Output deep dyslexia is by far the most common type and there are several examples in the recent literature (e.g., Buchanan et al., 2000; Katz & Lanzoni, 1997; Laine et al., 1990). Laine et al. (1990) document a Swedish-speaking patient whose profile of results fits closely the output type of deep dyslexia. VJ’s performance on both oral reading (10%) and picture naming (33%) was grossly impaired with a preponderance of semantic errors. To determine if VJ had access to the correct semantic representation of a word he was asked to read and draw thirty-one concrete nouns. For the eleven semantic reading errors produced VJ gave a correct drawing response for each one. For example, when the target word was scissors the verbal response was ‘knife’ but an identifiable drawing of scissors was made. These results demonstrated that VJ did have access to the correct semantic representation even when a semantic error in reading was made, indicating a problem at lexical retrieval rather than one within the semantic store itself.

The division of deep dyslexia into sub-types may help understand and account for the slightly different clinical profiles across different patients (e.g., the variable rates of semantic substitutions when reading) but it cannot completely account for the constellation of symptoms seen in deep dyslexia. Indeed, there is some support for deep dyslexia being part of a general language impairment (Friedman & Perlman, 1982; Nolan & Caramazza, 1982). For example, the deep dyslexic BL (Nolan & Caramazza, 1982) exhibited equivalent deficits in both the visual and auditory modalities. Thus BL was both deep dyslexic and deep dysphasic (Michel & Andreweski, 1983). Deep dysphasia is characterised by semantic substitutions in repetition, an inability to repeat non-words, an auditory-verbal short-term memory
(STM) deficit and often imageability effects in repetition (see Martin, 1996 for a review). Any attempt to explain both deep dyslexia and deep dysphasia within a model such as the logogen model (Morton & Patterson, 1980) is problematical requiring many separate deficits, consequently Nolan & Caramazza (1982) invoked a dual deficit model to explain BL’s language processing problems. In this model there is a single amodal phonological system used for both addressed and assembled phonology. A problem within this system would have severe consequences for phonological processing irrespective of input modality; hence BL had similar problems with reading and repetition. A second proposed locus of difficulty, in the model, is an abnormally high recognition threshold in the lexicon, biasing the processing of concrete words. A high recognition threshold coupled with a criterion shift is able to account for several different types of error made by BL. For example, if the recognition threshold for a word is abnormally high then lowering the selection criterion may result in a similar (e.g., visually related) although wrong word being chosen.

The patient of Nolan & Caramazza (1982) is by no means unusual and several other deep dyslexics have multiple deficits that are difficult to fully explain within a traditional model of deep dyslexia. Gerhand et al. (2000) document a patient who made semantic errors in reading, indicative of deep dyslexia, and regularization errors that are characteristic of surface dyslexia (Marshall & Newcombe, 1973). To account for this pattern of performance Gerhand et al. (2000) appealed to a connectionist model of reading (Patterson & Lambon-Ralph, 1999) rather than a more traditional model (Morton & Patterson, 1980).
In the present paper we present the results of a detailed assessment of JAH, a deep dyslexic of a relatively rare central sub-type (Shallice & Warrington, 1980). Of further interest is the finding that JAH is also deep dysphasic, with severe problems in word and non-word repetition and the presence of semantic substitutions. These impairments are discussed in relation to two different models of linguistic processing.

Case report

JAH, a 31-year-old right-handed woman, suffered a left middle cerebral artery infarct four days post-partum. A CT scan revealed an ill-defined area of decreased density in the area of the left-middle cerebral artery and compression of the frontal horn of the left lateral ventricle. JAH presented with an extensive expressive dysphasia, mild dysarthria, right facial weakness and right hemiparesis. Spoken responses were restricted to ‘Yes’ and ‘No’ but she did show some understanding of meaning as evidenced by carrying out simple commands. Initial neuropsychological testing took place 4 months post-stroke. She was alert and aware of her surroundings. Retrieval of autobiographical memory was impaired and the few correct answers given were retrieved very slowly. Immediate memory (digit span) was severely impaired with just two digits forward (after two attempts) and none backwards. There was no evidence of visual neglect and she performed normally on line bisection, figure bisection and letter cancellation tasks. Letter reading was severely impaired with the same level of performance for upper and lower case letters (1/26; 3.8%) and she was unable to give any alphabetic sounds to letters. However, letter discrimination was better but still impaired; matching upper to lower case letters 18/26 (69%) and
matching lower case to upper case letters 20/26 (77%). Discriminating letters from their mirror images demonstrated a good awareness of a letter’s canonical position, 35/36 (97%). Initially, JAH was given 22 words to read (taken from PALPA; Kay et al., 1992) with no time limit. She correctly read 5/22 words (23%). The majority of errors were non-responses (12) with three semantic errors (car → ‘boat’, house → ‘garden’, ship → ‘boat’), one neologism (cup → ‘tock’) and one visual error (square → ‘squash’).

**Oral word reading**

The following tests were used to assess any possible effects of imageability, concreteness and word-class on reading accuracy.

*Imageability*

JAH was given 80 words (PALPA-test 31; Kay et al., 1992) half of which are high in imageability (20 high frequency and 20 low frequency words) and half low in imageability (20 high frequency and 20 low frequency words). JAH showed a statistically significant effect of imageability (Fisher’s Exact Test p< 0.001) with 26/40 (65%) words high in imageability correctly read but just 8/40 (20%) words low in imageability correctly read. Word frequency was not a significant factor (Fisher’s Exact Test p>0.05) with 16/40 (40%) high frequency and 18/40 (45%) low frequency words correct. There were 22/80 (27%) omissions and 24 substantive errors, with 6 (25%) semantic errors (battle → ‘axe’, coffee → ‘tea’, night → ‘bed’, plane → ‘airplane’, student → ‘school’, pill → ‘headache’), 9 (37%) visual errors (gravy → ‘grave’, opinion → ‘onion’, principle → ‘prince’, theory → ‘theatre’, dogma → ‘dog’, gravity → ‘gravy’, irony → ‘iron’, plea → ‘peas’, realm → ‘real’), 5 (21%) neologisms
and a further 4 (17%) unclassifiable errors (potato → ‘paper’, crisis → ‘spoon’, deed → ‘sea’, satire → ‘is’).

Concreteness

A further 120 words (MRC Psycholinguistic database, Coltheart, 1981) were given to JAH to read aloud. Half of the words were of high frequency of occurrence (Kucera & Francis, 1967) (mean=50.4) and half were of low frequency (mean=4.8). Both the high and low frequency words were further divided into concrete words, with a high concreteness rating (Pavio, et al., 1968; Gilhooley & Logie, 1980) (mean=6.17), and abstract words with a low concreteness rating (mean=3.6). JAH read significantly more words high in concreteness (35/60; 58%) than words low in concreteness (11/60; 18%), Fisher’s Exact Test p<0.001. However, the frequency of occurrence of a word did not contribute to reading accuracy (Fisher’s Exact Test p>0.05). Twenty-six percent (10/39) of the substantive errors were judged to be semantic substitutions (e.g., blouse → ‘cloth’, door → ‘shut’), 10% were visual then semantic (beef → beer → ‘cider’, talk → tall → ‘ladder’, sold → gold → ‘ring’, rare → hare → ‘rabbit’), 36% were visual (e.g., belt → ‘bell’, sell → ‘spell’), 5% were neologisms (swift → ‘waem’, slang → ‘slanger’), 18% were unclassifiable (e.g., barn → ‘screw’, cannon → ‘camel’) and 5% were morphological (bagpipe → ‘pipe’, thrill → ‘thriller’). In line with previous findings (e.g., Newton & Barry, 1997) the words correctly read had higher concreteness ratings (mean=5.54) than those words not responded to (mean=4.24), t=5.302, df=79, p<0.001.

Word-class
To assess any effects of grammatical class on word reading JAH was asked to read aloud 60 words (taken from PALPA-test 32; Kay et al., 1992) consisting of equal numbers of functors, nouns, verbs and adjectives. JAH found this task particularly difficult and her performance was very poor with just 7/60 (12%) words correctly read; functors 0/15, nouns 3/15 (20%), verbs 2/15 (13%) and adjectives 2/15 (13%). The majority of errors to the words were non-responses (63%) and of the attempts she did make 9/22 (41%) were unclassifiable, often with the initial phoneme maintained, (e.g., wisdom → ‘wood’, shrink → ‘spoon’), 2/22 (9%) were morphological (myself → ‘self’, image → ‘imagine’) 1/22 (5%) was semantic (grief → ‘peace’), 3/22 (14%) were neologisms (e.g., carry → ‘crary’), 4/22 (18%) were visual (e.g., hence → ‘fence’, task → ‘cask’), one perseveration (ancient → ‘spoon’) and one real word substitution (ignore → ‘nor’). When JAH failed to respond to a word she was given a phonemic cue consisting of the initial two phonemes of the target word but this procedure failed to elicit any further responses.

To summarise, the results of these tests of oral reading fit the criteria for deep dyslexia; JAH’s reading was affected by the concreteness and imageability of the words and the substantive errors contained a reasonably high percentage of semantic substitutions. Although her performance with words taken from different grammatical classes was at floor not a single function word was read.

**Non-word reading**

The ability to read aloud non-words and convert letters to sound is thought to depend on the integrity of grapheme-phoneme conversion procedures (Coltheart, 1981). As JAH was unable to convert letters to sound it was thought that non-word reading
would also be impaired. JAH was asked to read aloud twenty-four non-words (PALPA-test 36; Kay et al., 1992) that varied in length. This task was very demanding and she was unable to pronounce any of the items and made no classifiable attempts. This result confirms that the processes of grapheme-phoneme conversion are severely compromised.

**Word and non-word repetition**

To determine if JAH also had problems in a different modality she was asked to repeat aloud several items that were previously used to test her word reading (i.e. words that differed in imageability (PALPA-test 31) and non-words (PALPA-test 36). Significantly more words (Fisher’s Exact Test $p< 0.008$) high in imageability (18/40; 45%) were repeated than those rated low in imageability (6/40; 15%), with no effect of word frequency (Fisher’s Exact Test $p>0.05$). A majority of the error responses were neologisms (54%; e.g., *character* → ‘ta’, *potato* → ‘tato’, *irony* → ‘arony’), 27% semantic substitutions (*coffee* → ‘tea’, *onion* → ‘orange’, *slope* → ‘soap’), and 18% unclassifiable errors (*pill* → ‘pea’, *elephant* → ‘spinach’). Non-word repetition was impaired (8/24; 33%) with two substantive errors that were lexicalisations (*ked* → ‘ken’, *dringe* → ‘drink’). On the basis of these tests JAH appears to display the characteristics of deep dysphasia, the auditory analogue of deep dyslexia.

The problems JAH has with oral word reading may be due to either impaired access to orthographic representations or impaired phonology. These alternatives were addressed with the following assessments.

**Visual lexical decision**
JAH was administered a visual lexical decision task (PALPA-test 25; Kay *et al.*, 1992) that consisted of sixty words in four sets; high imageability-high frequency words, high imageability-low frequency words, low imageability-high frequency words and low imageability-low frequency words. JAH had some difficulty in deciding whether a letter string was a word or non-word with 48/60 (80%) words correctly selected and 21/60 (35%) correct rejections of non-words. The finding of a significant effect of imageability (Fisher’s Exact Test p< 0.025) with 28/30 (93%) high imageability and 20/30 (67%) low imageability words chosen, suggested that JAH was addressing semantic memory to make a lexical decision. There was no significant effect of word frequency (Fisher’s Exact Test p>0.05) with 23/30 (76%) high frequency and 25/30 (83%) low frequency words selected.

**Auditory lexical decision**

The same lexical decision task was presented auditorily four weeks later and JAH had to decide after each item was read aloud if it was a word or non-word by replying ‘Yes’ or ‘No’. The modality of input seemed not to have an effect and JAH had similar problems across both the visual and auditory modalities. A total of 53/60 (88%) of words was correctly identified and 24/60 (40%) of non-words were rejected as words. The effect of imageability was significant (Fisher’s Exact test p< 0.01) with 30/30 (100%) high imageability and 23/30 (76%) low imageability words correctly identified. The number of words selected did not differ (Fisher’s Exact test p>0.05) as a function of frequency (28/30; 93% high frequency and 25/30; 83% low frequency words). The effects of imageability and frequency did not differ across input modality (χ² = 0.031, df =1 and 0.243, df =1, both p>0.05, respectively).
Phonological processing

To assess JAH’s ability to access addressed phonology a word rhyme judgment task was given in a written form and auditorily on separate occasions. PALPA-test 15 (Kay et al., 1992) consists of four sets of words; rhyming pairs that have the same orthographic ending (e.g., town-gown), non-rhyming pairs that have the same orthographic ending (e.g., down-flown), rhyming pairs with different orthographic endings (e.g., shoe-screw) and non-rhyming pairs with different orthographic endings (e.g., hoe-chew). Her performance on the visual form of the task was reliably superior (Fisher’s Exact Test p<0.025) when the item-pairs rhymed and were visually similar (14/15; 93%) than for the pairs that rhymed but were visually dissimilar (7/15; 47%). Clearly JAH adopted a visual strategy to complete this task and based her decisions on a word’s orthography and not phonology. Performance with the non-rhyming pairs, visually similar (8/15; 53%) and visually dissimilar (10/15; 66%) did not differ (Fisher’s Exact Test p>0.05). With auditory presentation although her performance was impaired JAH correctly identified significantly more (Fisher’s Exact Test p<0.001) rhyming word pairs (24/30; 80%) than non-rhyming pairs (7/30; 23%).

JAH exhibited impaired performance on tasks designed to assess both orthography (lexical decision) and phonology (word-rhyme). The following tasks were administered to determine the integrity of semantic memory.

Word comprehension

A similar procedure to Kapur & Perl (1978) was adopted to determine if when a reading error occurred JAH understood the correct answer to be the target word or her paralexic response. In a printed-word to spoken-matching task JAH was shown an incorrect response, from a previous test, coupled with a question. For example,
JAH gave the spoken response ‘orange’ to the target word *onion*, so in the present test she was shown the word ‘orange’ and asked ‘Is this orange or onion?’ On half the trials the target was presented first and the paralexic response on the other half. Performance on this task was very poor with JAH selecting the correct word at less than a chance level (24/55; 44%).

**Homophone definition**

PALPA-test 38 (Kay *et al*., 1992) consists of twenty homophones (10 regular and 10 irregular) that have to be defined and then read aloud. JAH was poor at this task reading correctly 3/10 (33%) regular and 5/10 (50%) irregular words. She appeared not to understand any of the irregular words only attempting a single incorrect definition (*roll* → ‘boots’). However, correct definitions were given to two paralexic responses. The target word *break* was misread as ‘bread’ and defined as ‘toast’ and *dough* misread as ‘doughnut’ and defined as ‘eat it’. Two responses to regular homophones were examples of the concept rather than strictly definitions (*pain* → ‘headache’, *week* → ‘Saturday’) but were counted as being correct. As JAH found this task so difficult, after presentation of the first two items, if she hesitated, two alternative definitions of a word were given from which to choose (e.g., *mail* – ‘Post or a boy?’); this procedure did not help, suggesting a problem other than accessing the output phonological lexicon.

**Synonym judgements**

A synonym judgement task was presented in the visual and auditory modalities on separate occasions. These tasks (PALPA-tests 49 & 50) require a decision as to whether two words are related in meaning (e.g., *story-tale*) or unrelated (e.g., *flower-boat*). Half of the stimulus word-pairs were high in imageability and half were rated
low in imageability. With visual presentation JAH indicated the correct meaning to 20/30 (66%) high imageability word-pairs and 17/30 (57%) low imageability word-pairs (Fisher’s Exact Test p>0.05). Performance with auditory presentation was equivalent; 23/30 (77%) and 16/30 (53%) for high and low imageability word-pairs respectively (Fisher’s Exact Test p>0.05).

**Word semantic association**

To assess the ability to associate words on the basis of their meaning PALPA-test 51 (Kay *et al*., 1992) requires a word to be selected (non-verbally) which is semantically related to a target word from four alternatives; the correct response, a semantic foil and two unrelated foils (e.g., *comb*: brush, tweezers, door, gate,). Half of the stimulus words were high in imageability and half were rated low imageability words. JAH found this task particularly difficult and correctly identified 1/15 (7%) high imageability words and 6/15 (40%) low imageability words.

**Semantic categorisation**

Further tests of the integrity of semantic memory were conducted in the form of categorisation tasks presented visually and auditorily across a period of many weeks. With visual presentation JAH was asked to sort the words into two appropriate piles and with auditory presentation a word was spoken aloud and JAH indicated by pointing to the words ‘Yes’ and ‘No’ printed on a sheet of paper if a word belonged to the appropriate category. With auditory presentation JAH was given the two categories in the form of a question (e.g., ‘Is it a boy’s name or a girl’s name?’) before the presentation of the stimulus word. The selection of the items used in
these tasks was not constrained by word length or frequency but just on the basis of the categorisation criteria (e.g., surnames, girl’s names etc).

In the first categorisation task (girl’s vs. boy’s Christian names) JAH achieved a comparatively high level of accuracy with both visual (58/60; 97%) and auditory (55/60; 92%) presentation (Fisher’s Exact Test p>0.05). Performance categorising Christian names from surnames was not as good (42/59; 72%) and (45/59; 76%) visually and auditorily respectively, but equivalent across the two modalities (Fisher’s Exact Test p>0.05).

A further categorisation task required a discrimination between line drawings (Snodgrass & Vanderwart, 1980) of living items (e.g., cat, zebra) and man-made items (e.g., chair, car). JAH was impaired in this task selecting 25/30 (83%) correct items. When the task was repeated auditorily an equivalent level of performance ensued (24/30; 80%) (Fisher’s Exact Test p>0.05). JAH was also given the semantic categorisation task taken from BORB (Riddoch & Humphreys, 1993) in three different formats; visually, using pictures and words, and auditorily. In this task a target item must be coupled with one of two alternatives (e.g., train-road-rail). In the auditory format the three items were repeated twice. The pictorial version of this task revealed the best score (23/30; 76%), although much impaired (controls; 27.5 correct), whilst the lexical (14/30; 46%) and auditory (15/30; 50%) versions were similar and did not differ (Fisher’s Exact Test p>0.05). The superior performance with line drawings may reflect the amount of visual information available in a picture. To assess this possibility JAH was given another task in which she was required to discriminate between items that are usually eaten (e.g., grapes, melon, cow) and
those that are not usually eaten (e.g., crocodile, penguin, elephant). This task needs perhaps a finer discrimination based more on conceptual than visual knowledge. To evaluate her performance across different input modalities this task was repeated using drawings, words and with auditory presentation. Although her performance was impaired across all three formats (drawings, 12/50; 24%; words, 41/50; 82% and auditorily, 39/50; 78%) it was much worse for the drawings ($\chi^2=44.247$, df =2, $p<0.001$), than with either the lexical or auditory versions.

The results of these categorisation tasks strongly suggest that irrespective of input and output modalities JAH is impaired at extracting detailed categorical knowledge from semantic memory, but performance worsens when a correct response depends on accessing conceptual knowledge from pictures.

**Confrontation naming**

JAH was asked to name line drawings of animate and inanimate items (BORB-Riddoch & Humphreys, 1993) and in another testing session to read aloud the written names of a subset of these items. Performance on both tasks was severely impaired (8/35; 23% for picture naming and 15/29; 52% for name reading) but significantly worse with the pictorial stimuli (Fisher’s Exact Test $p<0.025$). Substantive errors when naming the line drawings were a mix of semantic (6/8 ; 75%); *knife* → ‘spoon’, *beetle* → ‘spider’, *hand* → ‘nails’, *axe* → ‘hammer’, *fork* → ‘spoon’ *penguin* → ‘Pingu’ (a children’s television character), visual (1/8 ;12%); *mushroom* → ‘stool’) and one perseveration (*table* → ‘spoon’). The majority of errors when reading aloud the objects’ names were also semantic (7/8; 87%); *penguin* →
'Pingu', *table → ‘salt’, *cup → ‘tea’, *candle → ‘light’, *nail → ‘varnish, *lamp → ‘light’, *mushroom → (toad) ‘stool’) with one neologism (*swan → ‘wan’). The striking similarity in the error data, across modalities, strongly suggests that the semantic system is being addressed in both tasks. The superior reading of the object’s names may reflect additional information from non-semantic reading processes.

**Gestures**

The ability to be able to correctly gesture an object’s use depends on access to functional knowledge concerning the object in question. JAH was shown the same stimulus items in two different formats (pictures and words) across a twelve-week period. The pictures (Snodgrass & Vanderwart, 1980) were of common objects that required an unambiguous gesture to demonstrate their use (e.g., comb, axe, telephone). In the lexical version JAH was required to read the names initially and then make the appropriate gesture. JAH demonstrated an equivalent performance for both versions of the task, 24/26 (92%), indicating a high degree of preserved functional knowledge. With pictures no response was made to the drawing of a violin and she named it as a ‘file’ and the actions of a fork were made to the drawing of a knife. JAH correctly read 17/26 (65%) of the objects’ names and managed to correctly gesture the use of all but two of the items she could not name (*violin → ‘violent’ → she made a violent action, *sewing needle → ‘spoon’ → no response).

**Discussion**

We have described a patient who demonstrated many of the characteristics of deep dyslexia. JAH was unable to read non-words, closed-class words, and was impaired in the reading of open-class words with her performance affected by the
concreteness of the words (concrete words read better than abstract words), but not their frequency of occurrence. When reading, a preponderance of the substantive errors were classified as semantic substitutions (e.g., coffee → ‘tea’). To determine if this deep dyslexia may be characterised as one of the given sub-types (Shallice and Warrington 1980) JAH was presented with many tasks designed to assess the integrity of the semantic system (e.g., word comprehension, homophone definition, semantic categorisation). These tasks were presented across modalities and in different formats (pictures and words) with similar results; in all tasks performance was impaired. However, when categorising Christian names on the basis of gender and gesturing the use of objects her performance approached normal limits. The relatively successful categorisation may reflect the familiarity of Christian names or the accessibility of broad categorical information (Shallice and Warrington 1980), although similar information concerning surnames was not as available and performance was much impaired on this task. The ability to gesture the use of an object may not be an effective measure of semantic knowledge (cf. Farah, 1995) and indeed this preserved ability may reflect strong visual and motor links (Humphreys & Riddoch, 1999). Miming the use of a visually presented object or drawing may reflect a direct route from a store of visual knowledge to actions. However, this would not explain the equivalent performance with lexical items. Notwithstanding the relatively preserved categorisation and gesturing abilities the findings strongly suggest that JAH has a problem with stored semantic knowledge. Given that similar problems occurred across modalities and tasks it is unlikely that the semantic system is intact with a problem arising in the transmission of a full semantic code to the phonological output lexicon (i.e. an output problem). Neither does the clinical profile suggest deep dyslexia of an input type, where problems would be restricted to a single modality.
The profile of results strongly indicates deep dyslexia of a central type, similar to Hillis (1990) et al's patient KE. In addition to problems with reading JAH also had problems with the repetition of words and non-words; word repetition was strongly affected by imageability. Although the majority of her responses when asked to repeat words were neologisms, a substantial proportion of the responses were semantic substitutions. These problems are indicative of deep dysphasia. Impaired semantic knowledge is not exclusive to deep dyslexia and deep dysphasia and cannot explain the myriad of symptoms seen in these disorders; other aspects of lexical processing are also affected. We attempt to interpret these problems by appealing to current cognitive neuropsychological models of lexical processing.

A model of lexical processing originally proposed by Morton & Patterson (1980) and subsequently modified (e.g., Patterson & Sherwell, 1987) offers a framework in which to understand the acquired dyslexias. This model posits several different processing routes for reading and has given a good account of surface and phonological dyslexia (e.g., Coltheart & Byng, 1989; Funnel, 1983) but explaining deep dyslexia within such a model is problematic requiring many distinct functional lesions. For example, using a traditional model (Patterson & Sherwell, 1987) the reading and repetition performance of JAH may be explained, in general terms, by suggesting at least five different loci of damage, excluding the problem with stored semantic knowledge. The impaired identification and case matching of letters indicates a problem within the orthographic analysis module. Although there was a problem with abstract letter identification, knowledge of letter orientation was good. This result mirrors that found with object identification where object identity appears to be separate from knowledge concerning the canonical orientation of objects.
Given that non-words may only be read by the application of grapheme – phoneme conversion rules (cf. Kay & Marcel, 1981), the inability of JAH to read a single non-word and to give alphabetic sounds to single letters suggests this route is inoperable.

A problem within the semantic system may account for her poor lexical decision performance. Judgments on the familiarity of a lexical item (lexical decision) have been shown to be affected by the concreteness and imageability of a word, particularly for low frequency words (James, 1975). The presence of concreteness/imageability effects in visual and auditory lexical decisions indicates that lexical decisions were mediated by lexical meanings. Accurate rhyme decisions depend on a correct phonological entry being activated. When asked to make visual rhyme judgments it was clear that JAH was using a visual strategy to complete this task. A visual strategy may be an option when there is a problem with contacting intact phonological representations and her poor performance on an auditory version of the task confirmed this. This deficit may be attributable to a faulty semantic code and the lack of facilitation when given a phonemic cue in reading words from different grammatical classes, the very few phonemic paraphasias made throughout the assessment and the lack of any word frequency effect reinforce this suggestion.

The model may also account for the characteristics of deep dysphasia. Damage to the auditory input lexicon and possibly the route between this and the phonological output lexicon would explain the problem with word repetition. If this route is malfunctioning then information may have to go via the damaged semantic system, which would predict the imageability effects and the semantic paraphasias found in this task. Non-word repetition requires an acoustic - to - phonological conversion and
as JAH repeated just a third of the non-words we assume that this route is less than intact.

Considering the clinical profile of JAH within the framework of a traditional model has given a good account of both the deep dyslexic and deep dysphasic symptoms she displayed. Whilst patients such as JAH help to verify the existence of representations and procedures responsible for language processing little is explained in terms of a specific description of processing. Although a certain degree of interactivity is implicit in a traditional model (Hillis & Caramazza, 1991) it is not well characterised. An alternative explanation of JAH’s performance is given by a more interactive model (e.g., Patterson & Lambon-Ralph, 1999). In the fully interactive ‘triangle model’ of single word reading processing occurs across three layers of units (O) orthography, (S) semantics and (P) phonology, and their connections. To explain the profile of JAH we assume that damage has introduced a high level of ‘noise’ in the system affecting all layers and connections, but particularly affecting the semantic layer. This noise could be the result of removing units, cutting connections between them or a change in the weights on the connections (Valdois & Carbonnel et al., 1995). In this model the selection of a correct pronunciation from visual input (via the O→P connections) may be aided by activation from the S layer using the S→P link. If JAH has a problem activating a phonological representation from visual input then additional information concerning word meaning might be necessary. Given the hypothesised damage to the S layer, and less than normal activation of the S→P connection, reading errors may manifest themselves as semantic paraphasias. It is assumed that concrete words have more semantic features than abstract words and therefore would be more resilient to damage; JAH correctly read significantly more
words of a high concreteness rating than those with a lower concreteness rating. The same loci of damage (S layer and S→P link) may also account for the poor lexical decision performance.

The lack of any word frequency effect in the performance of JAH may be explained by the model as being a result of impaired O→P or S→P connections, with the advantage for high frequency words lost. With non-word reading, the O→P connections would not be helped by additional input from the S→P links and a worse performance than with words would be expected, as was found.

The role of JAH's verbal STM deficit in linguistic processing is unclear but may affect the maintenance of phonological activation; this could occur either by an activation pattern having a fast rate of decay (Martin & Saffran, 1992) or activation failing to reach a threshold value. Either of these alternatives would explain the poor performance in any task with spoken output. Weak activation of a phonological representation could be boosted via the S→P connections and hence phonological output would be created from meaning. Consistent with this was the finding of imageability effects in word repetition.

The performance of JAH who presented with deep dyslexia of a central sub-type and deep dysphasia has been briefly explored within the framework of a traditional model (Patterson & Sherwell, 1987) and an interactive processing model (Patterson & Lambon-Ralph, 1999). A traditional model has the disadvantage of requiring many separate functional deficits to explain deep dyslexia and deep dysphasia whereas an interactive model can explain the same deficits on the basis of a single problem - introducing a high level of noise into the network. An interactive account of reading
also has the benefit of being able to encapsulate other deficits not restricted to linguistic processing (e.g., an auditory verbal STM deficit).

References


Humphreys GW, Riddoch MJ. Impaired development of semantic memory: Separating semantic from structural knowledge and diagnosing a role for action in establishing stored memories for objects. Neurocase 1999; 5: 519-532.


