

## Single-word semantic judgements in semantic dementia: Do phonology and grammatical class count?

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*Background:* Listeners make active use of phonological regularities such as word length to facilitate higher-level syntactic and semantic processing. For example, nouns are longer than verbs, and abstract words are longer than concrete words. Patients with semantic dementia (SD) experience conceptual loss with preserved syntax and phonology. The extent to which patients with SD exploit phonological regularities to support language processing remains unclear.

*Aims:* We examined the ability of patients with SD (1) to perceive subtle acoustic–phonetic distinctions in English, and (2) to bootstrap their accuracy of lexical–semantic and syntactic judgements from regularities in the phonological forms of English nouns and verbs.

*Methods and Procedures:* Four patients with SD made minimal pair judgements (same/different) for auditorily presented stimuli selectively varied by voice, place, or manner of the initial consonant (e.g., *pa* –*ba*). In Experiment 2 patients made forced-choice semantic judgements (abstract or concrete) for single words varied by (1) *concreteness* (abstract or concrete); (2) *grammatical class* (noun or verb); and (3) *word length* (one- or three-syllable words).

*Outcomes and Results:* The most semantically impaired patients paradoxically showed the highest accuracy of minimal pair phonologic discrimination. Judgements of word concreteness were less accurate for verbs than nouns. Among verbs, accuracy was worse for concrete than abstract items (e.g., *eat* was worse than *think*). Patients were more likely to misclassify longer concrete words (e.g., *professor*) as abstract, demonstrating sensitivity to an underlying phonologically mediated semantic property in English.

*Conclusions:* Single-word semantic judgements were sensitive to both grammatical class and phonological properties of the words being evaluated. Theoretical and clinical implications are addressed in the context of an anatomically constrained model of SD that assumes increasing reliance on phonology as lexical–semantic knowledge degrades.

Semantic dementia (SD) is a progressive neurodegenerative disease that affects inferior, ventral, and anterolateral portions of the temporal lobe (Grossman, 2002). The early stages of SD are associated with conceptual loss and concurrent language deficits that include anomia, impaired auditory comprehension, and surface dyslexia in the context of reasonably preserved syntactic and phonological abilities. From a theoretical standpoint, selective impairment of conceptual knowledge presents an *in vivo* model for examining the interaction of semantic memory with other linguistic

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processes such as phonology. From a clinical perspective, the development of an aetiologically-specific language rehabilitation for SD presents a major challenge. One important step towards development of such an intervention, we argue, is to better understand how preserved functions interact with degraded knowledge. Here we examined (1) the integrity of phonetic processing in SD, and (2) sensitivity to phonological regularities that mark semantic and syntactic distinctions between English nouns and verbs.

Figure 1 illustrates a general model of the cognitive-linguistic decline associated with SD. We assume three interacting levels of processing (semantic, lexical, and phonological). Under this model, degradation of language occurs with the disease progression in an orderly manner: semantic  $\rightarrow$  lexical  $\rightarrow$  phonological. These cognitive changes are correlated with cortical degeneration that begins with circumscribed atrophy in the left ventral temporal lobe, progressing posteriorly and laterally, ultimately involving the temporal lobes bilaterally (see also Lambon Ralph, McClelland, Patterson, Galton, & Hodges, 2001). Performance on variables associated with different aspects of language can provide converging evidence in support of an interactive model where “top-down” semantic functioning progressively declines, and “bottom-up” contributions from phonology assume an increasingly important role in language.

One core characteristic of SD illustrated in Figure 1 is that phonological perception is spared until the latest stages of the disease. This assumption of preserved phonological processing is supported by the particular distribution of atrophy incurred in SD, which typically spares superior temporal and inferior parietal lobe structures dedicated to auditory comprehension. We predict that as lexical-semantic comprehension is compromised, patients with SD will show an increasing reliance on phonological support for language.

Research has provided evidence in favour of phonological reliance in SD in a number of ways. In immediate serial recall, patients with advanced SD have shown rapid forgetting of early list items with preservation of terminal items, a pattern that is consistent with impaired semantic comprehension in the context of preserved phonology (Martin & Saffran, 1990; Reilly, Martin & Grossman, 2005; Saffran & Martin, 1990). Another source of evidence for phonological dependence in SD is the high frequency of surface dyslexia in this population (Jefferies, Lambon Ralph, Jones, Bateman, & Patterson, 2004), a disorder wherein reading is markedly impaired for orthographically irregular words (e.g., *yacht*) with preservation of regular grapheme–phoneme correspondence (e.g., *cat*), a process that is not dependent on lexical-semantic comprehension (Coltheart, Byng, Masterson, Prior, & Riddoch, 1983)

Phonological effects have been investigated in serial recall and reading in SD. However, few studies have examined the integrity of subtle acoustic perceptual distinctions such as voice onset time (i.e., phonemic categorical perception), and place and manner of articulation. In one such study, patients with severe semantic impairment showed a normal shift in phonemic categorical perception ( $b \rightarrow p$ ) as voice onset time was truncated in 10-ms increments from +120ms (always perceived by healthy listeners as /b/) to –120ms (always perceived as /p/) (Kwok, Reilly, & Grossman, 2006). In addition, participants with advanced SD successfully discriminated pairs of pure tones varied by frequencies of 0Hz, 25Hz, or 200Hz, demonstrating preserved auditory perception of nonlinguistic stimuli.

One aspect of phonology that has not been investigated in SD is pattern induction, or the ability to recognise and exploit phonological regularities in

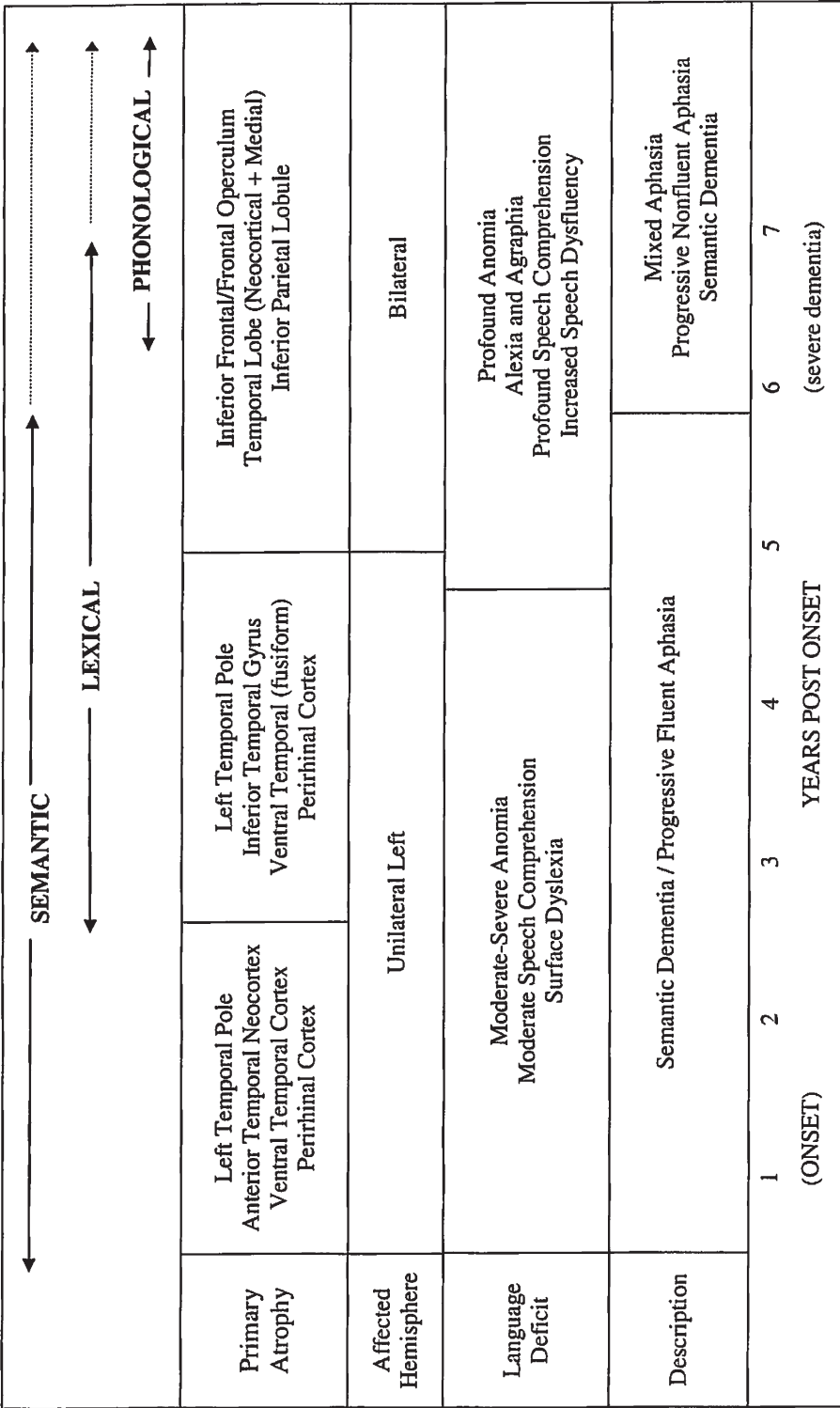


Figure 1. A model of the erosion of semantic-lexical-phonological support in semantic dementia.

language. Healthy listeners use statistical probabilities such as word length, phonotactic probability, and neighbourhood density to assign syntactic roles, parse word boundaries, and resolve semantic ambiguities (Saffran, Aslin, & Newport, 1996). Stress patterns tend to mark English nouns and verbs differently, and verbs tend to be shorter than nouns across many natural languages (Kelly, 2004; Langenmayr, Gozutok, & Gust, 2001). Similarly, phonological and morphological markers distinguish English abstract and concrete words. Concrete nouns tend to be shorter, more phonologically dense, and of higher cumulative phonotactic probability (Reilly & Kean, 2007). It is unclear whether patients with SD can make reliable decisions about phonology, and if so, whether they can use phonological patterns to bootstrap judgements of semantic and syntactic properties of words. One reason to investigate this issue is to determine whether reliable access to phonology can facilitate language processing in SD.

### DISTINCTIVENESS OF CONCRETENESS AND GRAMMATICAL CLASS

Different neurological substrates support fine-grained semantic processing and storage distinctions between abstract and concrete words (e.g., *truth* versus *dog*). This distinction is evident in functional-imaging investigations among healthy adults that have shown inferior and lateral ventral temporal lobe activation for concrete words relative to abstract words (Binder, Westbury, McKiernan, Possing, & Medler, 2006) and in naming deficits encountered in patients with circumscribed brain damage. In deep dyslexia, for example, abstract words are sometimes strikingly impaired relative to concrete words. In contrast, patients with damage to ventral visual association cortex have shown the opposite trend, with a naming deficit for concrete words relative to abstract (Bird, Lambon Ralph, Patterson, & Hodges, 2000; Breedin, Saffran, & Coslett, 1994; Yi, Moore, & Grossman, 2007). One explanation we favour for this *reverse concreteness effect* is that damage to visual association cortex disproportionately disrupts highly salient visual features that underlie concrete word representation, whereas abstract words are less visually and more verbally mediated (see also Paivio, 1985).

In addition to concrete–abstract word differences, neuropsychological and imaging findings also support an anterior–posterior distinction between verbs and nouns, with greater recruitment of the left inferior frontal gyrus and premotor cortex for action verbs relative to nouns (Friederici, Opitz, & von Cramon, 2000). Studies of verb processing in dementia are rare. However, one recent investigation showed marked impairment in word-to-definition matching for verbs relative to nouns in semantic dementia (Yi et al., 2007). The same patients showed a robust reverse concreteness effect, with impaired matching of action verbs (e.g., *eat*) relative to abstract verbs (e.g., *think*).

In summary, some core differences exist between nouns and verbs and abstract and concrete concepts. Furthermore, phonological form is predictive of both distinctions. The extent to which patients with SD rely on phonologically mediated semantic and grammatical regularities to support their language processing is unknown. Here we examined two hypotheses germane to this issue: (1) that phonological perception is preserved in SD, and (2) that patients with SD exploit phonological regularities such as word length in making probabilistic judgements of words varied by their semantic and grammatical properties.

## EXPERIMENT 1: MINIMAL PAIR JUDGEMENTS

## Method

*Participants.* Participants included four male, monolingual English speakers with no comorbid psychiatric illness (e.g., major depression) or history of cerebrovascular disease. Table 1 summarises relevant demographic and neuropsychological data for the following patients: RZ, JF, JR, and LL (average age = 70.5). Patients are all currently retired and living at home with spouses who assist with daily activities and communication. These patients represent a range of anomia from mild (RZ) to severe (JR), with speech characterised as fluent with the exception of word-finding pauses.

Diagnoses were derived from a combination of imaging, neuropsychological, and linguistic testing in accord with a modification of published criteria for SD (Grossman & Ash, 2004; Neary et al., 1998). Table 1 lists patients ranked by severity of semantic and naming impairment via  $z$ -scores of their Pyramids and Palm Trees test performance (words and pictures; Howard & Patterson, 1992) compared with 18 age-matched healthy controls (mean age = 70.3,  $\sigma = 8.0$ ), and by severity of naming impairment gauged by Boston Naming Test score (Goodglass & Kaplan, 1983) compared with 25 age-matched healthy controls (mean age = 66.76;  $\sigma = 9.8$ ). Each patient's  $z$ -score for naming and semantic categorisation was calculated based on the mean and standard deviation of the control group [(Observed Patient Score – Mean Score of Controls)/Standard Deviation of Controls].

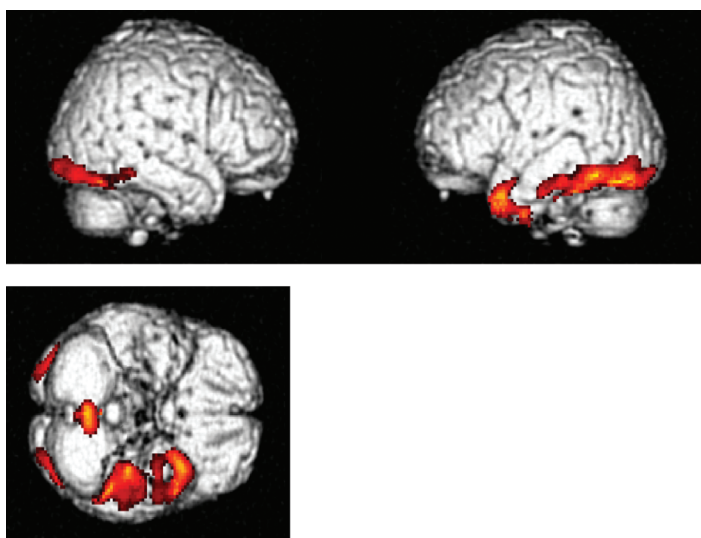
Figure 2 represents an illustrative voxel-based morphometric (VBM) image of patient LL, demonstrating areas of significant grey matter atrophy ( $p < .01$  corrected) compared with a local brain template of age-matched controls ( $N = 12$ ).

TABLE 1  
Patient demographic, naming, and neuropsychological data

ID	Age	Ed	Months		Animal fluency	BNT (of 15)		PPT (words)		PPT (pictures)	
			post	MMSE		Raw	Z-score	Raw	Z-score	Raw	Z-score
RZ*	76	12	72	25	18	15	0.63	50	-0.48	52	1.02
JF	63	12	60	21	4	9	-3.84	45	-5.72	40	-7.42
JR	80	16	60	6	2	3	-8.30	n/a	n/a	41	-6.71
LG	50	16	30	29	7	10	-3.10	42	-8.15	42	-6.01
LL	63	16	96	21	0	2	-9.06	37	-9.05	30	-14.44
SB	69	14	n/a	22	2	4	-7.56	24	-25.40	n/a	n/a

Age and Education are reported in years; n/a = Testresult not available; *Months post* = Months post onset of initial complaint; *MMSE* = MiniMental State Examination (Folstein, Folstein, & McHugh, 1975); *BNT* = BostonNaming Test Score for a subset of 15 low, medium, and high frequency (Goodglass & Kaplan, 1983); *PPT* = Pyramids & Palm Trees test (Howard & Patterson, 1992); *Animal Fluency* = Animals named in 60 seconds. Each patient's associated  $z$ -score is with reference to an age-matched control group (control means: BNT = 14.72; PPT words = 50.6; PPT pictures = 50.5).

\*RZ is a newly diagnosed SD patient. Although his semantic deficit is not evident on the BNT or PP tests, it is evident on MMSE and a different lexical categorisation task. When shown six vegetables, three fruits, and three tools, in both picture and word format, and asked "Is this a vegetable?", RZ classified all the fruits as vegetables (9/12 correct; control mean correct is 11.6 for words and 10.9 for pictures).



**Figure 2.** Voxel-based morphometric images (lateral and ventral) of Patient LL. Areas of higher intensity red to yellow indicate voxels with atrophy significant at  $p < .01$  (corrected).

LL's distribution of atrophy, typical of moderate SD, encompassed the left anterior temporal lobe and the entirety of the left inferior temporal neocortex. Grey matter atrophy extended posterior to temporo-occipital cortex and ventrally through the left fusiform gyrus. Superior temporal and inferior parietal structures critical for auditory perception (e.g., primary auditory cortex and Wernicke's area) and inferior frontal areas implicated in grammatical processing were spared.

*Experimental procedure.* We constructed 48 pairs of consonant+vowel(CV) stimuli, varying the initial consonant and holding the vowel constant (e.g., /pa/, /ma/, /na/). Of these minimal pairs, half were identical (e.g., *ma – ma*), whereas the remaining pairs differed selectively by only voice, place, or manner of articulation. That is, eight pairs of items differed only by the presence of voicing in the initial consonant (e.g., *pa – ba*), eight pairs differed by manner of articulation (e.g., *da – na*), and the remaining eight pairs differed by place of articulation (e.g., *ga – na*). Stimuli were recorded by a female speaker in a sound booth using a Marantz PMD 670 digital audio recorder (DAT). Individual wavefiles were matched to an identical volume (50dB) using the Praat waveform editor (Boersma & Weenink, 1996). Wavefiles were recorded in stereo (dual-channel) format using a 16-bit, 44100-Hz sampling rate, and then filtered for noise. Two independent judges confirmed intelligibility of these stimuli through 100% accurate repetition. Wavefiles were presented via Sennheiser stereo headphones that completely covered the ear.

Testing was completed in the patients' homes using a Dell Inspiron laptop computer while an examiner simultaneously heard stimuli via a headphone splitter. E-Prime presented auditory stimuli in randomly ordered pairs with a 1000-ms interstimulus interval. Participants were instructed to listen while viewing an unchanging monitor display that asked "*Are these the same?*". YES and NO were signalled by a keypress of either "M" (colour-coded green) or "Z" (colour-coded



red). Participants first completed a familiarisation sequence to a criterion of 75% correct where they made same/different judgements for eight pairs of CVC stimuli.

## Results

Patients performed more accurately in their minimal pair phonetic discrimination as a function of greater semantic impairment. This is confirmed by the negative correlation between minimal pair discrimination accuracy and each of the modalities of the Pyramids and Palm Trees tests, *Pearson*  $r = -.75$ ,  $p = .03$  (Howard & Patterson, 1992) (see Table 1 for *z*-scores on each measure). Milder patients showed phonetic discrimination not significantly different from chance, whereas more severe patients discriminated minimal pairs with higher accuracy (JF = 54%; RZ = 62%; JR = 73%; LL = 90%).

## Discussion

Patients showed a paradoxical trend in their discrimination accuracy for minimal pairs. Individuals with milder semantic impairment performed less accurately in their phonetic judgements than patients with more severe semantic impairment. One possible explanation is that residual lexical-semantic knowledge in milder patients may degrade their performance for minimal pairs constructed with sparse phonology (e.g., *ga*, *ta*, *ma*). CV stimuli often form legal words (e.g., *ma*, *pa*). Furthermore, many real words can be created through the addition, omission, or substitution of a single phoneme to the bigram *l#a*. This property, known as phonological neighbourhood density, produces wordlikeness or lexicality effects that may influence the accuracy of minimal pair phonologic discrimination (Gathercole, 1995; Luce & Pisoni, 1998). Aphasic adults show similar effects of lexical interference with an advantage in judgements of rhyming for pseudowords over real words (Kalinyak-Fliszar, Kohen, & Martin, 2006). SD patients with more advanced lexical-semantic degradation would theoretically not experience top-down lexical interference. These findings can therefore be interpreted in two ways: (1) patients with SD show poor phonetic perception, or (2) patients with milder SD show lexical interference effects for stimuli with high wordlikeness. We argue that the observed results support a lexical interference effect similar to that encountered in word and nonword rhyme judgements in aphasia (Kalinyak-Fliszar et al., 2006). This interference hypothesis is supported by these patients' performance on other paradigms that require intact phonological perception, such as auditory lexical decision wherein the individuals who performed at chance levels in their minimal pair discrimination here showed higher accuracy in judging nouns from plausible pseudowords (RZ = 84%; JF = 75%) (Reilly, Grossman, & McCawley, 2006). In contrast, the patients with the highest accuracy of minimal pair discrimination performed more poorly in making auditory lexical decisions (JR = 71%; LL = 71%). Thus, subtle deficits observed in acoustic perception in this patient sample may reflect lexical density effects for the patients with milder semantic impairment. Taken together, the current results interpreted in the context of preserved single-word repetition and auditory lexical decision abilities support grossly preserved phonological processing in this sample. However, a larger sample size and age-matched control group is necessary to assert this hypothesis with greater confidence.

## EXPERIMENT 2: SINGLE-WORD CONCRETENESS JUDGEMENTS

We examined sensitivity to phonological regularities that mark English abstract and concrete verbs and nouns, hypothesising that phonological form will influence accuracy of single-word judgements as a function of grammatical class (noun/verb) and concreteness (abstract/concrete). We tested this hypothesis via forced choice semantic judgements for verbs and nouns varied by length and concreteness. This experiment employed a 2 (noun/verb)  $\times$  2 (abstract/concrete)  $\times$  2 (short/long word length) within-subjects design. The dependent measure was accuracy of single-word concreteness judgements compared with adult norms from the Cambridge Psycholinguistic database (Coltheart, 1981).

### Method

*Participants.* Four male patients completed this experiment (JF, SB., LG, and RZ). Table 1 summarises relevant neuropsychological and demographic data. This sample includes two of the patients who completed Experiment 1 (RZ and JF) and two newly diagnosed SD patients (SB and LG). The two most semantically impaired patients from Experiment 1 (JR and LL) were excluded after multiple unsuccessful attempts at completing this experiment.

*Materials.* Stimuli included nouns ( $n = 40$ ) and verbs ( $n = 40$ ) matched for word concreteness using norms from the MRC Psycholinguistic database (Coltheart, 1981). Mean concreteness values on a 100–700-point scale were 376.33 and 429.18 for verbs and nouns respectively,  $t(64) = 1.90$ ,  $p = .06$ . Concrete versus abstract stimuli collapsed across grammatical class had average concreteness ratings of 316 ( $\sigma = 36.65$ ) and 486 ( $\sigma = 91.73$ ), with higher values associated with stronger word concreteness (e.g., *truth*  $\rightarrow$  *beach*) (Coltheart, 1981). These concreteness values were obtained from participants who were younger than the present SD sample. However, word concreteness has proven to be a stable construct with little known age-related variance across mature subjects within a single language (Barca, Burani, & Arduino, 2002; Kerr & Johnson, 1991).

Within each grammaticality and concreteness condition, half of the stimuli were three syllables in length, the remainder monosyllabic. Therefore, this factorial design employed eight cells with 10 stimuli per cell. Illustrative examples are as follows:

Abstract, 1 – syllable, Verb = *think*

Abstract, 3 – syllable, Noun = *attitude*

Concrete, 1 – syllable, Verb = *bake*

Concrete, 3 – syllable, Noun = *policeman*

Written frequencies of nouns and verbs were matched (Noun  $\mu = 37.08$  per million,  $\sigma = 4.0$ ; Verb  $\mu = 39.50$  per million,  $\sigma = 5.7$ )  $p > .05$  (Kučera & Francis, 1982). Stimuli were digitised as wavfiles using the identical audio sampling procedure, digital audio recording equipment, and female speaker described in Experiment 1. E-Prime software presented stimuli and logged responses using a Dell Inspiron laptop computer.

*Experimental procedure.* Participants were tested at a laptop computer equipped with stereo headphones, and were informed that they would hear words. Their task



was to answer the following question about each new word: “*Can you see, hear, or touch this?*” Participants signalled YES or NO by pressing either M or Z (colour-coded green and red). Prior to the experimental trial, participants completed a familiarisation sequence where they made concreteness decisions with feedback for five items (e.g., *rope, hat*). There was no time restriction for this task.

*Data analyses.* Accuracies were scored in relation to the MRC Psycholinguistic database norms (Coltheart, 1981). For example, a response of “NO” to “*Can you see, hear, or touch this?*” was scored as correct for abstract stimuli based on the grouping described above. Based on these accuracy scores, a proportion correct was calculated for each patient’s performance within each cell in the design. Contrasts were conducted on proportions using three within-subjects factors: (1) concreteness (abstract/concrete); (2) word length (short/long); and (3) grammatical class (noun/verb). An item analysis was also performed by calculating an average accuracy score for each stimulus item collapsed across patients.

## Results

*Subject analyses.* Group analyses conducted via a repeated measures within-subjects ANOVA revealed a significant two-way interaction between concreteness and word length,  $F(1, 3) = 49.00, p < .001$ .

One-syllable words were identified with similar accuracies regardless of whether they were abstract (58%) or concrete (55%). However, patients showed a stronger influence of phonology among three-syllable words, tending to misclassify longer concrete words (e.g., *professor, decorate*) as *abstract*. Accuracy for three-syllable abstract words was 66%, whereas accuracy for three-syllable concrete words was 46%. In addition to a phonological–semantic interaction, there was also a significant two-way interaction between word class and concreteness. Abstract verbs were identified with superior accuracy to concrete verbs (65% versus 36%); concrete and abstract nouns showed similar accuracies of identification (65% versus 59%)  $F(1, 3) = 10.5, p = .05$ .

*Item analyses.* Patients were impaired for verbs (36%) relative to nouns (65%)  $t(38) = 4.42, p < .01$ . However, this main effect occurred in the presence of a number of two-way interactions between word length, word class, and concreteness. First, there was a significant word length by concreteness interaction among response accuracies,  $F(1, 72) = 4.16, p = .05$ . This interaction was such that for three-syllable words, accuracy was significantly higher for abstract (66%) over concrete items (46%)  $t(32.5) = 2.89, p = .01$ . In contrast, one-syllable words showed similar accuracies regardless of their concreteness (58% abstract; 55% concrete)  $p > .05$ . Thus, the word length manipulation had a negative impact on judgement accuracies for concrete stimuli (e.g., *apartment* misclassified as abstract).

The second observed interaction was between concreteness and word class,  $F(1, 72) = 16.64, p = .01$ . Patients performed significantly more poorly for concrete verbs (36%) over abstract verbs (65%), tending to misclassify concrete verbs as *abstract*,  $t(38) = 5.04, p < .001$ . Within nouns, this effect was not as apparent, as similar item agreement was elicited between abstract (59%) and concrete nouns (65%).

## Discussion

These interactions suggest that lexical-semantic judgements are sensitive to the phonologic properties of words in SD. Patients were impaired for verbs relative to nouns. In addition, patients showed a reversal of the typical concreteness effect, with a disadvantage in identifying concrete over abstract verbs. These response patterns replicate the findings of Yi et al. (2007) who reported similar noun–verb discrepancies in a different paradigm (i.e., word-to-definition matching) where patients with SD showed disadvantages for verbs, and within verbs were less accurate for concrete than abstract items. The authors accounted for these effects via a distributed hierarchical model of semantic memory in which nouns share many overlapping visually salient semantic features across exemplars (e.g., tails, legs, snouts of ANIMALS), whereas verbs lack this level of redundancy. Therefore, in the face of degraded feature knowledge, shared features can compensate in part for degraded knowledge of a specific exemplar for nouns (e.g., *labrador retriever*) (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997). By comparison, the poorly structured hierarchical organisation of the verb semantic network limits the potential for shared features, resulting in greater difficulty for verbs than nouns.

In addition to grammatical class, listeners here showed an influence of word length in their judgement accuracies. Longer words were more likely to be classified as *abstract*, regardless of their actual semantic properties. This pattern is consistent with the phonological regularity in English abstract words, which are on average longer, more derivationally complex, and share fewer similar-sounding neighbours (Reilly & Kean, 2007). Thus, phonological manipulations also affected semantic judgement accuracy. We argue that these findings provide preliminary support for the active use of statistical regularities in language to aid in making higher-level semantic distinctions.

## GENERAL DISCUSSION

A temporally dynamic behavioural model is valuable towards tailoring interventions to strengths at different stages of the disease. Here we have argued for an interactive model of SD that assumes increasing dependence on phonology and phonological regularities within language as dementia severity worsens. Patients with SD have shown contributions of intact phonology through repetition, immediate serial recall, and in patterns of reading associated with surface dyslexia (Jefferies et al., 2004; Knott, Patterson, & Hodges, 1997; Reilly et al., 2005). Patients with highly degraded semantic comprehension in the current study paradoxically showed the highest accuracy of judging subtle phonetic cues in minimal pair stimuli. Further evidence for an augmented role of phonology in language processing was apparent in the moderating effects of word length when making single-word semantic judgements. That is, longer words were often erroneously misclassified as *abstract*. This phonological bootstrapping effect plays a significant role in normal speech perception, where word length and syllable stress permit the rapid assignment of syntactic and thematic roles during online sentence processing. Similar cues may also facilitate semantic processing, as revealed through corpus analyses of speeded naming latencies and age of acquisition where healthy adults showed strong interaction effects between word length and imageability (Reilly & Kean, 2007).

Listeners with intact lexical-semantic knowledge appear to seamlessly overcome phonological and prosodic irregularities in speech. For example, *canoe* and *guitar* have lexical stress patterns more typical of verbs. Although listeners comprehend these nouns, they also show longer latencies to name and identify them compared to words with prototypical stress (e.g., *doctor* and *lawyer*). Therefore, subtle phonological effects in healthy listeners may incur more serious processing errors in patients with semantic impairment.

The progressive course of SD typically spares superior temporal and inferior parietal structures critical for phonological storage and phonetic perception. Consequently, patients with SD experience clinically preserved phonological perception until the late stages of the disease. Phonology is a residual strength in SD that should be capitalised upon in the selection of target stimuli. Patients here showed evidence of using phonological regularities to solve semantic problems in their single-word judgements. Thus, careful attention to both the phonological and semantic attributes of a therapeutic set may be warranted. Patients with SD may have the greatest success in relearning a small, closed set of words with careful attention to an optimal fit between phonological form, grammatical class, and meaning.

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