Semantic dementia (SD) is a neurodegenerative disease characterized by progressive atrophy of the anterior temporal neocortex (Boxer, Rankin, & Miller 2003; Grossman, 2002; Mummery et al, 2000). Patients with SD experience language deficits that include anomia, poor auditory comprehension, and surface dyslexia with concurrent loss of conceptual knowledge (Fushimi, Kenjiro, & Ikeda, 2003; Graham, Patterson, Pratt, & Hodges, 2001; Hodges, 2003). One example of semantic degradation in SD comes from "reversal of the concreteness effect." This has been shown for confrontation naming and reading (Breedin et al, 1994; Cipolotti and Warrington, 1995; Warrington, 1975). We consistently observed "reversal of the concreteness effect" on a procedure involving recognition naming to a verbal description in a large group of SD patients (Yi et al, in preparation). This effect is attributed to disease in inferior portions of the left temporal lobe. Although communication impairment is pervasive in SD, little is known about linguistic processes supporting language such as phonology in this population.

We argue that the development of an informed language intervention for SD must be built upon a deeper theoretical understanding of how phonological and lexical levels of processing interact with a degraded semantic system over time. With this goal in mind, we propose an anatomically constrained model of the cognitive-linguistic loss incurred by patients during the course of SD. This model reflects progressive degradation of lexical-semantic support that is marked by distinctive behavioral and physiological changes that occur in the following overlapping stages during disease progression in SD: semantic → lexical → phonological (see figure 1).

--Figure 1—

As semantic memory degrades, patients with SD would be predicted to rely increasingly on residual abilities linked to phonology that support language comprehension and production. Under this model, the potential for language relearning is modulated by residual lexical-semantic support mediated by a relatively preserved phonological system.

Performance on variables associated with different aspects of language can provide converging evidence in support of an interactive model where "top-down" semantic support for language gradually fades and "bottom-up" contributions from phonology and the lexicon are relatively preserved. Reilly, Martin, & Grossman (2005) investigated the contribution of one such semantic variable (i.e., noun imageability) to verbal recall performance in a sample of SD patients. Despite a negligible influence of word imageability on word recall, patients did show mixed effects of lexicality (i.e., an advantage for highly frequent nouns) and preserved phonology (excellent single word repetition). Moreover, measures of naming and semantic memory strongly correlated with patterns of word recall and were also predictive of whether these patients showed learning effects via repetition priming. These results provided preliminary support for our model of language degradation in SD. In the current study, we examine the integrity of lexical-semantic processing to a phonologic stimulus in patients with SD. We expected patients with advanced semantic impairment would have difficulty distinguishing words from non-words, extending their deficit to lexical-phonological processing. In contrast, mildly impaired patients with SD were expected to show relatively preserved lexical decision, but to have difficulty with semantic representations such as demonstrating reversal of the concreteness effect.

Auditory Lexical Decision - Method

Lexical decision is a widely used paradigm in psycholinguistic research. The logic of this task is that if phonological factors such as word length or neighborhood density are held constant, reaction time differences that emerge reflect lexical or semantic processing differences. Neurologically intact adults can discriminate words from nonwords with very high accuracy. Furthermore, adults typically identify concrete words (e.g., *dog*) more rapidly than abstract words (e.g., *truth*) in auditory lexical decision (Kroll & Merves, 1986). We hypothesize that patients with SD will show either a reduction or elimination of this effect. Furthermore, patients with more advanced lexical-semantic impairment should show both loss of an imageability effect *and* difficulty in distinguishing real words from nonwords.

Participants

Participants included three males (mean age = 71.4) diagnosed with SD as part of a consensus review mechanism at the Hospital of the University of Pennsylvania. Diagnoses were derived from a combination of neuroimaging, neuropsychological and linguistic testing, and tau-protein levels in accord with published criteria for SD (Snowden, Goulding, & Neary, 1989). Relevant background testing data are summarized in table 1. Patients successfully passed a hearing screening with tones presented at 30dB HL, 1000, 2000, & 4000 Hz.

-- Table 1--

Materials

Stimuli included nouns (N=60) obtained from the MRC Psycholinguistic database (Coltheart, 1981) and an equal number of phonologically legal nonwords obtained from the ARC nonword database (Rastle, Coltheart, & Harrington, 2001). Thirty high- and 30 low-imageability nouns (average imageability ratings of 579 and 355, respectively, on a 100-700 scale) were matched for word frequency (Kucera & Frances, 1967) and word length in total syllables. Audio stimuli were recorded by a female, native English speaker, then digitized and spliced into individual wavefiles using an acoustic waveform editor.

Method

Stimuli were presented via Eprime software using a laptop computer. Participants heard single words and nonwords presented in completely randomized order. Participants were instructed to indicate their choice (word or nonword) with a keyboard press (color coded green or red). The program presented each stimulus along with a simultaneous text cue that asked, "Was this a word?". Participants were encouraged to respond "as quickly and accurately as possible".

Results:

As a group, participants discriminated words from nonwords with 84.3% accuracy and failed to show a significant difference in response latency between abstract and concrete nouns, $t(349)=1.53$, $p=.13$. Individual lexical decision performance illustrated considerable variability both in latency and accuracy of discrimination as reflected in Table 2.

- Table 2 -

The most impaired patient on measures of semantic categorization, global cognition, and naming was patient, JR. In lexical decision, JR, showed the predicted elimination of imageability when he identified concrete and abstract nouns with similar latencies ($p>.05$). For the contrast of word-nonword, JR showed faster average latencies to identify words, $t(109)=2.57$, $p=.01$.

Patient, RZ, also identified concrete and abstract nouns with similar average latencies ($p>.05$) and he was faster to identify words over nonwords, $t(117)=4.57$, $p<.001$.

LL, the patient with the most intact naming and semantic categorization, also showed high discrimination accuracy (92.5%). However, latencies to identify abstract nouns were significantly shorter than for concrete nouns, $t(117)=2.50$, $p=.02$. Therefore, not only did LL show an elimination of an imageability effect, he showed a complete reversal of the typical pattern among adults.

General Discussion

Crucial to development of a theoretically-sound language intervention is an understanding of the foundation upon which the approach is constructed. Our findings suggest that SD language loss is systematic, and that conceptual damage spares certain lexical and phonological properties. Thus, "reversal of the concreteness effect" is found in a patient who continues to make accurate lexical decisions.

"Reversal of the concreteness effect" is thought to reflect loss of visual-perceptual features that contribute to word meaning. Despite this impairment, lexical decisions can proceed accurately on the basis of phonology. Greater disease, however, appears to obscure the subtle semantic effect for reversed concreteness, although lexical decisions continue to be performed with reasonable accuracy. We argue that the phonology is relatively preserved even in patients with advanced SD. From this perspective, language therapy may augment SD patients' comprehension by focusing on meaning derived from phonology.

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Table 1. Participant profiles and neuropsychological testing results

Patient	JR	LL	LZ
Age	79	61	74
Years of education	n/a	16	12
Duration from Symptom Onset (months)	38	56	34
MMSE (of 30)	6	26	25
Digit Span forward	3	8	3
FAS/Min	16	7.33	14
Boston Naming Test Total of 60	3	8	15
Pyramids & Palm Trees Words (of 52)[a]	n/a	42	n/a
Pyramids & Palm Trees Pictures (of 52)	41	40	n/a

Table 2. Lexical decision results

Patient	Abstract Noun Latency	Concrete Noun Latency	Nonword Latency	% Correct
JR	2658.10 ms	2828.32 ms	3527.21ms	78.3%
RZ	2175.57 ms	2266.40 ms	2967.43 ms	83.3%
LL	1711.46 ms	2357.07 ms	1986.42 ms	92.5%

Figure 1. Erosion of lexical-semantic-phonological support associated with FTD-SD