



Published in final edited form as:

Neurocase. 2008 ; 14(2): 131–140. doi:10.1080/13554790802032218.

Refractory Access Disorders and the Organization of Concrete and Abstract Semantics: Do they Differ?

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Abstract

Patients with “refractory semantic access deficits” demonstrate several unique features that make them important sources of insight into the organization of semantic representations. Here we attempt to replicate several novel findings from single-case studies reported in the literature. Patient UM-103 displays the cardinal features of a “refractory semantic access deficit” and showed many of the same effects of semantic relatedness reported in the literature. However, when probing concrete and abstract words, this patient revealed very different patterns of performance compared to two previously reported patients. We discuss the implications of our data for models of semantic organization of abstract and concrete words.

Cognitive neuropsychology has provided remarkable insight into the organization of human memory. For example, soon after Tulving (1972) first proposed a distinction between episodic and semantic memory, Warrington (1975) reported patients with cerebral atrophy that provided strong evidence of a semantic memory system that is dissociable from episodic memory and short-term memory. These patients, despite their generally preserved cognitive function, were very impaired on tasks requiring use of conceptual knowledge.

These seminal studies of semantic memory described patients with what are now considered “degraded stores” of semantic representation. That is, the long-term representations that support semantic knowledge are presumed damaged. The fact that such patients are relatively consistent in their performance on particular items over multiple administrations suggested that they no longer possess the long-term semantic representations necessary to perform a particular task. Today, patients with a similar constellation of deficits would likely be considered cases of “semantic dementia” (Hodges, Patterson, Oxbury & Funnell, 1992).

However, from the outset, it was clear that some patients identified as having deficits of semantic processing were qualitatively different from those patients with “degraded stores”. For example, Warrington and McCarthy (1983) reported patient VER, who, while showing semantic impairment, revealed very different patterns of performance. VER was inconsistent across multiple presentations of the same stimuli and also sensitive to rate of presentation (i.e., her performance was worse when trials were presented every 2 seconds as compared to every 10 seconds). This inconsistency and sensitivity to rate of presentation was thought to be attributable to impaired *access* to stored semantic representations. In VER's case, stored semantic representations were thought to be relatively intact, but the mechanisms used to access these representations were damaged. On the basis of these and other observations, it has been argued that at least two types of semantic impairment may be identified: damage to stored semantic representations and damage to mechanisms needed to access those stored representations (see Rapp & Caramazza, 1993 for objections to this view). The term

“refractory semantic access disorders” has been used to describe patients who demonstrate inconsistent performance that is sensitive to repetition and rate of presentation.

Subsequent research has outlined several unique features that characterize refractory semantic access disorders (Forde & Humphreys, 1997; Crutch & Warrington, 2005). These studies have often used spoken-word/written-word matching tasks in which patients are presented arrays comprised of 3–6 words. Each word in the array is then probed in a random order for multiple repetition cycles before a new array of words is presented. Most conspicuously, patients with refractory semantic access disorders demonstrate inconsistent performance with repeated presentation of the same items. For example, these patients might successfully match a spoken word to the correct written word upon initial presentation but then incorrectly match the same spoken word only seconds later. Thus, these patients demonstrate a decline in accuracy as a function of repetition.

The sensitivity to item repetition and rate of presentation has been attributed to the semantic system entering a state of refractoriness following initial activation. Thus, allowing more time between successive presentations of items allows “noise” in the semantic system to dissipate with a resulting improvement in performance. The exaggerated refractory state has also been proposed to explain another unique feature of these patients – they show no effect of lexical frequency. Presumably, higher frequency items produce greater initial semantic activation and larger refractory states, making subsequent items more difficult to process (Crutch & Warrington, 2005).

How to best conceptualize the refractory pattern of performance is still a matter of some debate. One possibility is that semantic representations temporarily enter an inhibited state following initial activation and that this inhibition spreads among representations that share semantic space. A similar account was instantiated in a computational model (Gotts & Plaut, 2002) by introducing damage to neuromodulatory mechanisms that serve to manage normal synaptic depression of semantic representations during semantic processing. However, Forde and Humphreys (2007) have presented data indicating that the refractory pattern might be better characterized by excessive or persistent activation of semantic representations. By this account, excessive activation of semantic representations spreads among items sharing semantic space, making it more difficult to select a target from among the semantically related items. Yet another hypothesis is that at least some of the features of refractory disorders are attributable to an impairment of executive processes that interact with the semantic system (Jefferies & Lambon Ralph, 2006). Obviously, these accounts are not mutually exclusive. Moreover, it is very possible that the large lesions typically reported to be associated with refractory patterns might produce multiple functional deficits that interact to produce the features of refractory deficits.

Probing the Organization of Semantic Knowledge

Perhaps the most interesting feature of refractory semantic access patients is their extreme sensitivity to semantic relatedness. These semantic relatedness effects are thought to result from activation of semantic representations that presumably share both semantic and “neural” space (Crutch & Warrington, 2003a). Thus, the presence and size of semantic relatedness effects might be used to make inferences about the organization of semantic knowledge (Crutch & Warrington, 2003a).

For example, Crutch and Warrington (2004) used this logic to explore the organization of proper nouns such as famous people. Using a spoken-word/written-word matching task, they varied the semantic relatedness of four-word arrays presented to patient AZ. The related arrays were four famous people from the same occupation (i.e., British politicians, foreign politicians, television presenters and sportsmen) or from different occupations. Crutch and

Warrington found that patient AZ was worse when proper names were presented in the related arrays (four names with same occupation) compared to unrelated arrays (four names with different occupations). These data suggest that representations of famous people with common occupations share semantic and neural space and that occupation is one dimension used by the semantic system in organizing proper names. Similar paradigms have been used to probe the organization of semantic domains such as living things (Crutch & Warrington, 2003a), geography (Crutch & Warrington, 2003b) and concrete and abstract words (Crutch & Warrington, 2005).

Organization of Concrete and Abstract Semantics

Differences in the processing of concrete and abstract words have long been reported in numerous paradigms with normal subjects. For example, when compared to abstract words, subjects are faster to make lexical decisions for concrete words (James, 1975) and have better short-term recall of concrete words (Walker & Hulme, 1999). Concrete words are also acquired at an earlier age than abstract words during language acquisition (Brown, 1957). The cognitive neuropsychological literature contains many examples of exaggerated forms of the basic concreteness effect (i.e., much better processing of concrete relative to abstract words). Reversals of this general effect have also been reported in which patients demonstrate an advantage for abstract words compared to concrete words (Warrington, 1975; McCarthy and Warrington, 1985; Breedin, Saffran & Coslett, 1994). In fact, the possibility that the representation of abstract and concrete concepts might be fundamentally different was first proposed in the original studies of category specific semantic deficits (Warrington, 1975). However, the vast majority of subsequent research on semantic organization has been limited to concrete words (Crutch & Warrington, 2005; Vigliocco & Vinson, 2007).

Most theories of semantic organization have suggested that the difference between concrete and abstract words is primarily attributable to the greater number of representations associated with concrete concepts, which makes concrete concepts easier to access and maintain (Breedin, Saffran & Coslett, 1994). For example, Dual Coding Theory (Paivio, 1986) proposed that concrete concepts are coded in two ways, a verbal code and a nonverbal sensorimotor code, whereas abstract words are represented only by a verbal code.

More recently, Crutch and Warrington (2005) have addressed the distinction between concrete and abstract concepts in their study of refractory semantic access disorders. Crutch and Warrington (2005) reported patient AZ who showed the typical effect of semantic relatedness with concrete words. That is, she was worse with arrays that included exemplars from the same semantic category compared to those drawn from different semantic categories. However, when examining abstract words, AZ demonstrated no difference between abstract words drawn from the same semantic “categories” (in the case of abstract words, the categories consisted of synonyms) and those drawn from different categories. When presented arrays of associatively related abstract words (i.e. non-synonymous words that are often bound in real world and sentential contexts), patient AZ was worse with associatively related arrays compared to unrelated arrays. The reverse pattern was found for concrete words – the typical effect of semantic relatedness, but no difference between concrete words in associatively related arrays compared to unrelated arrays. Crutch and Warrington proposed that these data suggest that abstract words are organized primarily by associative relatedness, while concrete words are organized by semantic category. This model differs from other models of concrete and abstract organization because, as Crutch and Warrington (2005) state, “One common theme in these theories is that a quantitative distinction is drawn between concrete and abstract concepts, with concrete items more

strongly represented. By contrast we argue here that the fundamental distinction is rooted in qualitatively different principles of organization.” (p. 616).

Here we report our attempts to replicate the Crutch and Warrington (2005) results with a patient who demonstrates the cardinal features of a refractory semantic access deficit – he demonstrates no effect of word frequency, his performance is marked by inconsistency with repetition, and he is extremely sensitive to semantic relatedness. Having established patient UM-103's refractory deficit, we then attempt to replicate the dissociations of associative and semantic relatedness for concrete and abstract words reported by Crutch and Warrington (2005).

Patient Description

UM-103 is a right-handed 49-year old man with a high school education who in 1999 suffered a large infarction involving the left frontal, parietal and temporal lobes, as well as the basal ganglion (Figure 1). His aphasia is characterized by both expressive and receptive difficulties.

Despite his aphasia, he performed relatively well on a number of semantic tasks. For example, he was correct on 79% of trials on the picture version of the Pyramids and Palm Trees Test (Howard & Patterson, 1992). His performance was quite similar to patient AZ (73% correct) from Crutch and Warrington (2005).

UM-103's reading was assessed using subtests of the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart, 1992). On the PALPA stimuli assessing the effects of imageability and frequency on reading, he read significantly more high as compared to low imageability words (High Imageability = 80%, Low Imageability = 35%, $X^2 = 16.57$, $p < .001$). He demonstrated no effects of frequency, reading 60% of high frequency words correctly and 55% of low frequency words correctly. He demonstrated no effect of grammatical class when words were controlled for imageability and no effects of spelling sound regularity (regular = 63%; exception = 73%). UM-103 was unable to read even a single 3-letter nonword from the PALPA Subtest 36, making lexicalization errors or refusing to provide a response.

Finally, UM-103's reading errors were primarily visual (e.g. gravity → grave, plane → planet); he made a very small number of errors (< 5 in the 270 reading opportunities from the PALPA materials reported above) that were considered unambiguously semantic (student → school; pupil → principal). He also produced a number of perseverations during reading.

UM-103's presentation appears typical of other patients with refractory patterns previously reported in the literature. For example, patient AZ (Crutch & Warrington, 2003, 2005) was described as “globally aphasic” with a lesion involving left frontal, parietal and temporal areas. Although reading data have not been reported for patient AZ, a review of the refractory access patients for whom reading data have been reported indicates that these patients have typically demonstrated a deep dyslexic pattern of acquired dyslexia. Presumably, deep/phonological dyslexia is necessary to reveal refractory patterns, which necessitates reading via a lexical/semantic route and results in the types of semantic interference seen in these patients.

Experiment 1: Demonstration of Refractory Access Deficit

Before addressing Patient UM-103's performance on abstract and concrete stimuli we first determined whether he demonstrated the cardinal features of refractory access deficits – that

is, whether he was sensitive to semantic relatedness, showed increased errors as a function of repetition and was sensitive to rate of presentation. Experiment 1 also serves as a replication of Crutch and Warrington (2004) and their demonstration that patient AZ showed greater interference for famous people organized by occupation, suggesting that occupation is one of the organizing principles for famous people in the semantic system.

Method—A stimuli set consisting of four “categories” of famous people was constructed (see Appendix 1). Four exemplars were presented from each of the following four occupations: US Presidents (*George Bush, Ronald Reagan, Bill Clinton, John Kennedy*), NBA Basketball Players (*Michael Jordan, Shaquille O’Neal, Allen Iverson, Kobe Bryant*), NASCAR Drivers (*Tony Stewart, Dale Earnhardt, Jeff Gordon, Jimmie Johnson*) and Hollywood Actors (*Tom Cruise, Brad Pitt, Russell Crowe, Bruce Willis*). These “categories” were judged to be familiar to the patient based on previous discussion with the patient and his wife.

Each array consisted of four words with each word being printed in a corner of an 8.5” × 11” sheet of paper. The patient was instructed that “he would hear a word and he should point to the word on the page that corresponds to the word he just heard”. Each item in each array was then sampled 4 times. For each “repetition cycle”, each item was sampled one time in pseudo-randomized order. After all four items were sampled, the patient was presented with three more “repetition cycles” in which the same words were sampled again in a different pseudorandomized order. The 4 “repetition cycles” for each array resulted in 16 matching trials per array. Four “related” arrays were constructed and the same items were rearranged by drawing one word from each “related” category and combining those four words into “unrelated” arrays. This provided 64 related trials and 64 unrelated trials with 16 trials at each “repetition cycle” for each condition.

Stimuli were administered using a 1 second and 10 second response stimulus interval (RSI) on separate days. For the 1 second RSI a new trial (i.e., spoken word) was presented immediately following the patient's pointing response to the previous trial. For the 10 second RSI, the experimenter waited 10 seconds before presenting the next trial.

Results—Data from Experiment 1 appear in Figure 2. UM-103 was much worse when famous people were grouped by occupation (73%) compared to “unrelated” arrays (47%), $X^2 = 9.4$, $p = .01$. Moreover, UM-103 also showed an increase in errors between the first presentation cycle and fourth presentation cycle for related ($X^2 = 6.15$, $p = .025$) but not unrelated arrays ($X^2 = 1.65$, $p = .20$).

With regard to rate of presentation, UM-103's overall accuracy (collapsed over all presentation cycles) improved significantly when stimuli were presented with a 10 second RSI (84%) compared to a 1 second RSI (60%), ($X^2 = 18.730$, $p = .0001$).

Discussion: Experiment 1—Based on the data from Experiment 1, it appears that UM-103 demonstrates three of the principle features of a refractory semantic access disorder – he is sensitive to semantic relatedness, shows a variable performance with an increase in errors as a function of repetition and is sensitive to rate of presentation. Having established that UM-103 shows the most typical features of a refractory access disorders, we now examine his performance on abstract and concrete words using stimuli published by Crutch and Warrington (2005).

Experiment 2: Abstractness and Frequency

Method—We administered a spoken-word/written-word matching task using the stimuli provided by Crutch and Warrington (2005). The experimenter (ACH) spoke a word and

UM-103 was asked to point to the corresponding word among an array of four words printed on a sheet of paper. Stimuli consisted of 288 words formed on the basis of frequency (low, middle, high) and abstractness (very low, low, medium). Items were presented with a RSI of 1 second.

Results—UM-103's performance was again typical of refractory access patients in that his performance on spoken-word/written-word matching was not influenced by frequency. Moreover, there was no differences among words of very low, low and mildly low abstractness (see Table 1). Collapsed across abstractness, UM-103's accuracy was 62.5% for low frequency, 65.6% for medium frequency, and 57.3% correct for high frequency. Collapsed across frequencies, UM-103 was 60% correct on words of very low abstractness, 66% correct on words of low abstractness and 59% correct on words of medium abstractness. Although UM-103 performed similarly to other refractory access patients in the literature in that he showed no frequency effect, it is of note that he did not show the reverse frequency effect (i.e., better performance for low frequency words) demonstrated by patient AZ in Crutch and Warrington (2005)¹.

Experiment 3- Associative and Semantic Relatedness of Abstract and Concrete Words

Having established that patient UM-103 demonstrates the principal features of a refractory access disorder, we then attempted to replicate one of the novel findings reported by Crutch and Warrington (2005) – namely, that abstract words are insensitive to semantic relatedness of an array, but are instead sensitive to associative relationships.

Method—Stimuli were borrowed from Experiments 4 and 5 from Crutch and Warrington (2005). Eight semantically related and eight unrelated arrays were formed for both concrete and abstract words. For concrete words, the semantically related arrays were comprised by four exemplars from the same category (e.g., *goose, crow, sparrow, pigeon*). For abstract words, semantically related arrays consisted of four synonymous words (e.g., *boil, heat, cook, fry*). In addition, eight associatively related (but not synonymous) arrays were formed for concrete words (e.g., *farm, cow, tractor, barn*) and abstract words (e.g., *exercise, healthy, fitness, jogging*). The same words were arranged into unrelated arrays. A 1 second RSI was employed for this experiment.

Results—UM-103's data appear in Figure 3. Unlike patient AZ, patient UM-103 demonstrated effects of both semantic and associative relatedness for both concrete and abstract words. For concrete words, he was worse with semantically blocked arrays (63%) compared to the same words presented in unblocked arrays (78%), $X^2 = 6.80, p < .01$. UM-103 was also worse when concrete words were presented in arrays blocked by associative relatedness (48%) compared to the same words presented in unrelated arrays (63%), $X^2 = 6.98, p < .01$. A similar pattern was found for abstract words. UM-103 was worse when abstract words were blocked semantically (27%) compared to unrelated arrays (47%), $X^2 = 12.50, p < .01$. When abstract words were arranged by associative relatedness, he was worse with the related arrays (39%) compared to unrelated arrays (65%), $X^2 = 15.02, p < .001$.

Thus, accuracy was worse for blocked conditions compared to unblocked conditions, regardless of whether the arrays were blocked according to semantic or associative relatedness. Moreover, this same pattern emerged for both concrete and abstract words.

¹While patients with “refractory access” patterns of performance typically demonstrate no effect of frequency in spoken-word/written-word matching tasks, some patients demonstrate reverse frequency effects (Crutch & Warrington, 2005). Moreover, Jefferies and Lambon Ralph (2006) have reported that patterns of frequency effects vary between tasks (i.e., spoken-word/written word matching vs. naming) and among patients.

Discussion

Patient UM-103 exhibits all the features of a “refractory semantic access deficit”. His performance is influenced by rate of presentation and repetition (Experiment 1), he is sensitive to semantic relatedness (Experiment 1 & 3) and he is insensitive to frequency (Experiment 2).

Having established UM-103 as representative of a “refractory semantic access deficit”, we then attempted to replicate data reported by Crutch and Warrington (2005), which revealed a possible distinction between the principles of organization for concrete and abstract words. This inference was based on a dissociation of patient AZ's performance on concrete and abstract words that were grouped according to associative and semantic relatedness. Patient AZ showed the typical effects of relatedness for arrays of concrete words grouped for semantic relatedness, but not associative relatedness. Moreover, patient AZ demonstrated the reverse pattern for abstract words – her performance was much worse for arrays of abstract words grouped by associative relatedness compared to unrelated arrays, while no such difference was reported for abstract words in semantically related vs. unrelated arrays. The patient presented here, UM-103, using the concrete and abstract stimuli provided by Crutch and Warrington (2005), revealed a very different pattern of results. He exhibited similar effects of both semantic and associative relatedness for both concrete and abstract words.

Data from Experiment 3 are problematic for a strong version of the Crutch & Warrington (2005) account. A key component of their reported dissociation between concrete and abstract words were two null results, whereby patient AZ failed to show significant differences in performance between associatively related compared to associatively unrelated arrays of concrete words. Similarly, AZ showed no differences in arrays comprised of semantically related arrays of abstract words compared to arrays of semantically unrelated abstract words. Data reported here show significant differences between related and unrelated stimulus arrays regardless of whether these arrays were comprised of concrete or abstract words and regardless of whether the arrays were organized by associative or semantic relatedness.

Reassessing the Evidence for Crutch & Warrington (2005)

In retrospect, given that refractory access disorders have been conceptualized as resulting from spreading activation among related semantic representations, it is surprising that patients with such deficits would not show interference effects for associated stimuli. For example, in the priming literature, which has been similarly explained from a “spreading activation framework” perspective (Collins and Loftus, 1975), priming is often reported for associated words (e.g., *bread* primes *butter*) (Fishchler, 1977). In fact, some have proposed that much of automatic “semantic priming” is driven primarily by associative relationships (Shelton & Martin, 1992).

Our failure to replicate the original demonstration of the concrete vs. abstract dissociation necessitates a brief review of two subsequent studies reported as corroborative support for the Crutch and Warrington (2005) proposal. Most importantly, Crutch, Ridha and Warrington (2006) reported bilingual patient IRQ as representing a replication of the abstract vs. concrete dissociation reported in Crutch and Warrington (2005). That is, IRQ showed no effect of associative relatedness for concrete words and no effect of semantic synonymy for abstract words.

However, further examination of these data reveals several potential problems with these conclusions. For example, in the crucial abstract vs. concrete comparison in Experiment 4

(Figure 4 in Crutch et al., 2006), patient IRQ's accuracy on abstract words blocked by semantic similarity (65%) is as poor as her performance on abstract words blocked by association (70%). If patient IRQ truly experienced no “interference” from abstract words blocked by “semantic similarity”, then one might expect her accuracy on semantically blocked abstract words to be comparable to the other arrays of unrelated words presented in this experiment. Similarly, the “dissociation” of abstract and concrete words is at least partly attributable to the anomalous performance of patient IRQ on the abstract words chosen for the “semantic similarity” condition (Figure 4A; Crutch et al., 2006). More specifically, while IRQ's performance on the other three unrelated conditions is > 90%, her performance on the abstract words chosen for semantic similarity is 65%, even when these words were arranged in unrelated arrays, thus giving the spurious impression of no effect for abstract words blocked for semantic synonymy. This point is further illustrated by comparing the unrelated conditions of Figure 4A and Figure 4C in Crutch et al. (2006).

One other study (Crutch, 2006) has been offered as support for the Crutch and Warrington (2005) proposal. Crutch (2006) reported a post-hoc re-analysis of the semantic reading errors of four deep dyslexic patients (originally reported by Coltheart, Patterson and Marshall, 1980). This analysis revealed a greater proportion of associatively related errors compared to semantically related errors when patients attempted to read abstract words. Moreover, concrete words showed the reverse pattern, with fewer associative errors and more semantically related errors. While these data are suggestive, it is of note that fully half of the reading errors to abstract words were judged as “semantically similar” rather than “semantically associated” in the Crutch (2006) re-analysis. Thus, one could argue that the Crutch (2006) data might better be characterized as supporting a model in which abstract words are organized to some extent by both semantic similarity and associative relatedness (although perhaps relying more heavily on associations), which would be more consistent with the data presented here.

Implications of Present Data

What are the implications of the present data? First, we do not intend to discount the potential utility of patients with “refractory semantic access disorders” in making inferences about the organization of semantic knowledge. Such patients have provided many novel insights into the organization of semantic knowledge, one of which we replicate here (the organization of proper nouns such as famous people).

Moreover, it is important to note that we do not wish to suggest that there exist no qualitative differences in the processing or representation of concrete and abstract words. Indeed, as detailed in the Introduction, there is overwhelming evidence that concrete and abstract words differ in processing demands to some degree. Instead, the data reported here question the generalizability of Crutch and Warrington's proposal that the fundamental difference between abstract and abstract words is attributable to abstract concepts being organized in associative networks while concrete concepts are organized categorically.

Importantly, our data are more consistent with models of semantic representation that accommodate meaning in a single system. For example, Vigliocco, Vinson, Lewis and Garrett (2004) proposed the Featural and Unitary Semantic Space (FUSS) hypothesis which models meaning in a single semantic space, while constraining the model with neuropsychological and neuroanatomical evidence. Of particular relevance to the present data, this model accommodates not only object words, but also action words, which are typically much more abstract (Breedin, Saffran & Coslett, 1994) and represents both types of words in a single semantic space using the same principles of organization. FUSS equates the meanings of words as lexico-semantic representations that bind conceptual features that

can be further decomposed into distributed and modality-specific featural representations. Importantly, the FUSS model provides a measure of semantic distance that predicts semantic effects in naming, word-picture interference and priming paradigms. Moreover, FUSS predicts both semantic interference effects and semantic facilitation effects in both speech production and, importantly for our purposes, comprehension (lexical decision task in the priming paradigm).

Conclusions

In conclusion, we report a patient that demonstrates all the features of a refractory semantic access disorder. However, his data do not corroborate the pattern of performance on abstract and concrete words blocked by associative and semantic relatedness originally reported by Crutch and Warrington (2005). Further, we note shortcomings with the additional data reported to support such a proposal. While these data question the abstract-associative/concrete-categorical organization proposed by Crutch and Warrington, the present data are more consistent with models of semantics in which meaning can be represented in the same semantic space using the same principles of organization.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was funded by a grant from the National Institutes of Health's National Institute for Deafness and Other Communication Disorders: R01 DC000191-26 (M.F. Schwartz).

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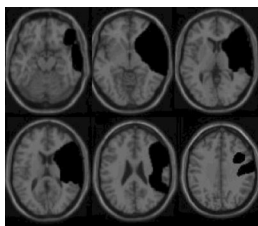


Figure 1.
Tracing of UM's lesion on standardized brain

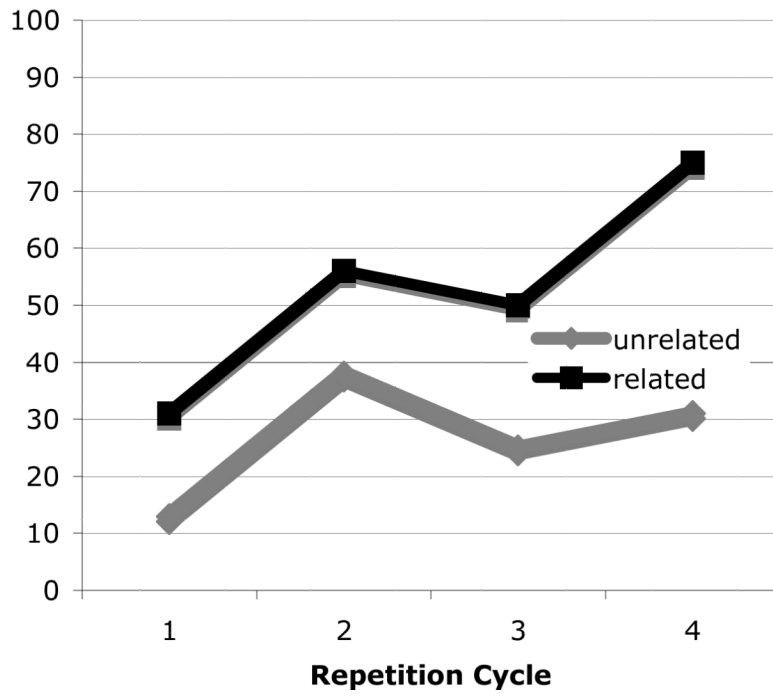


Figure 2. Accuracy as function of repetition for famous people – Patient UM-103

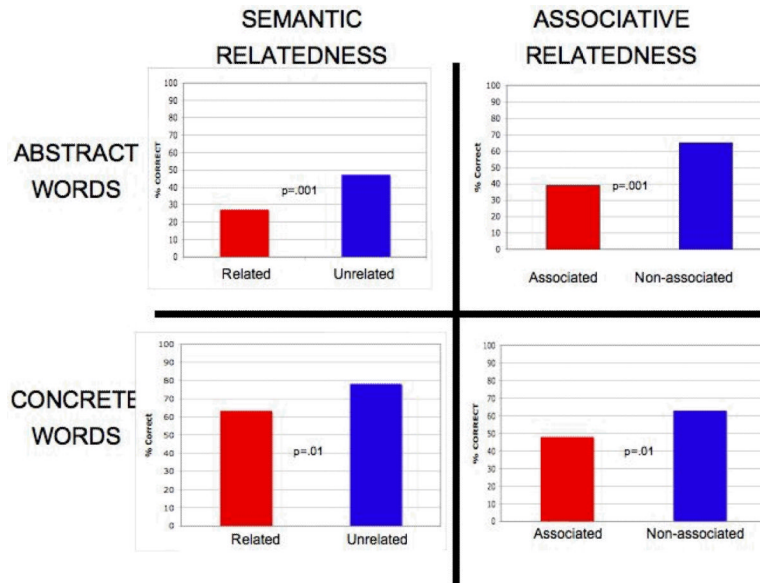


Figure 3. Accuracy for Concrete & Abstract Words in Associatively and Semantically Blocked vs. Unblocked Arrays

Table 1

Percentage correct responses on spoken word-written word matching manipulated for frequency (LF=Low Frequency, MF = Medium Frequency, HF = High Frequency) and abstractness (VLA = Very Low Abstractness, LA = Low Abstractness, MA = Medium Abstractness).

	Frequency			Overall
	LF	MF	HF	
VLA	56.3	71.9	53.1	60.4
LA	65.6	62.5	68.8	65.6
MA	65.6	62.5	50.0	59.4
Overall	62.5	65.6	57.3	