THE ORGANIZATION OF SEMANTIC MEMORY: EVIDENCE FROM AN INVESTIGATION OF VERB SEMANTIC DEFICITS IN DEMENTIA OF THE ALZHEIMER TYPE

Forouzan Mobayyen

A Thesis

In

The Department

Of

Psychology

Presented in Partial Fulfillment of the Requirements
for the degree of Doctor of Philosophy at
Concordia Unviersity
Montréal, Québec, Canada

Your file Votre référence
ISBN: 978-0-494-31127-1
Our file Notre référence
ISBN: 978-0-494-31127-1

Abstract

The Organization of Semantic Memory: Evidence from an Investigation of Verb Semantic Deficits in Dementia of the Alzheimer Type

Forouzan Mobayyen, Ph.D.
Concordia University, 2007

The feature and domain-specific models of semantic memory were explored in three experiments involving ten patients with mild to moderate dementia of the Alzheimer type (DAT), and eleven age- and education-matched normal elderly controls. In Experiment 1, the living/nonliving things dissociation was examined using a confrontation-naming task comprising Snodgrass and Vanderwarts' (1980) line drawings of living (e.g., animals), and nonliving (e.g., tools) things. In Experiment 2, verb deficits in general, object/action naming dissociation, and past and present-progressive verb dissociation were explored using data from Experiment 1, and Fiez and Tranel's (1997) standardized Action Naming Test. This test comprised single and paired color pictures of actions, eliciting gerundial (e.g., *baking*) and regularly inflected past-tense verbs (e.g., *baked*), respectively. In Experiment 3, verb category-specific deficits were explored in a confrontation-naming task that consisted of short-movies of actions that depicted two verb categories: verbs similar in semantic and argument structure (lexical causatives; e.g., *peeling*), and verbs similar in semantic content (movement verbs; e.g., *crawling*, and perception verbs; e.g., *watching*). Four main hypotheses were examined: (1) The patients would exhibit a living/nonliving things dissociation with a selective living things deficit; (2) If the patients did exhibit an object/action naming dissociation with a selective *verb* deficit (e.g., Cappa et al., 1998), this dissociation would hold across two different sets of verb stimuli depicting actions: static (e.g., pictures), and dynamic (e.g., short-movies); (3) Similar to putative category specificity involving noun-labeled categories (e.g., the living/nonliving things dissociation), patients' verb deficits would also be characterized by category specificity; and (4) Following the domain-specific model, the patients' verb deficits would be characterized by a category dissociation specifically affecting the classes of movement and perception verbs; and following the feature-specific models, the patients' verb deficits would be characterized by a category dissociation, specifically affecting the class of lexical causatives. The results revealed that the patients showed a living/nonliving things dissociation with a selective living things deficit substantiating the localization assumption inherent in both domain and feature specific models. Further, when static images were used to depict verbs, both the patients and the controls had significantly more errors naming actions than objects. In contrast, when short-movies were used to depict verbs, no object/action naming dissociation was observed. These results suggested that the object/action naming dissociation observed in both the patient and control groups could have been a function of the verb stimuli (e.g., static images) used. The results further revealed that similar to their noun deficits, patients' verb deficits were also characterized by category dissociation, specifically affecting perception verbs. Patients had significantly more errors naming perception verbs than movement verbs. This dissociation was to some extent attributed to the abstract and context-dependent semantic underpinnings of perception verbs used in a referential processing task and presented to patients with global cognitive deficits. The pattern of verb category-specificity observed suggested that both *semantic feature* and *semantic content* are reflected in the organization of semantic memory with the implication that domain and feature specific models are fundamentally similar.

Acknowledgments

With the most profound gratitude, I wish to thank my research supervisor, Professor Roberto G. de Almeida. Many thanks for your intellectual and financial support, and for your humility and humor. I feel indebted to you for helping me fulfill a goal that is quite meaningful to me. I admit that this project could not have been possible without your original insights.

I would also like to express my heartfelt appreciation to Professor Eva Kehayia, my co-supervisor, and George Schwartz: A debt of gratitude to Eva who made the recruitment of patients possible, a pivotal step in the completion of this project. Your valuable comments significantly contributed to the refinement of this study. A debt of gratitude to George, also for attending meetings related to this study and providing insightful comments. Your impressive and meticulous effort during the process of patient recruitment, ethical approval and testing was instrumental and very crucial to the completion of this project.

A special thank you to Julie Turbide for her help in the production of PsyScope scripts for experiment 1, and picture-pairs for Experiment 2. A special thank you also to Martha Ivanovna for her assistance in the process of devising movies. For her emotional support during some difficult times, and for being quite resourceful and generous, I would like to express my heartfelt appreciation to Julia de Nardo. I wish to also contribute when you are close to the completion of your dissertation.

My thankful regards to Dr. Katherine Buell, the director of the Pre-doctoral Internship Program in Clinical Psychology at the Kingston Internship Consortium, Dr. Jesscia Jones of the Division of Developmental Disabilities at Ongwanada, Kingston, and Dr. Patricia Davis of the St. Mary's of the Lake Hospital in Kingston, for being supportive and understanding of my efforts to complete this project. Katherine and Jessica, I am grateful of the research day that you helped incorporate into the second half of my pre-doctoral clinical internship year in Kingston. I am also thankful to Professor Angeles Garcia, the Director of the Memory Clinic at the St. Mary's of the Lake Hospital in Kingston, for connecting me to a number of elderly individuals willing to participate in my study.

A very special thank you to the members of my defense committee, Professor Eva Kehayia, Professor Norman Segalowitz, Professor Howard Chertkow, Professor Diane Pouline-Dubois, and Professor Laura Collins. Your valuable comments contributed to the further refinement of the study.

Lasting and profound gratitude to a precious friend, my wonderful husband, Hooman for being "consistently" supportive and loving. You helped me a great deal during the process of the production of the short-movies and testing. You incredibly facilitated the testing process by driving from Toronto to Kingston, where I was working as a pre-doc intern, to give me rides to patients' houses located in quite disparate parts of Québec. I am flattered and moved by your generosity. Your reliable love and devotion have sustained me, always.

Thanks to my loving parents, Maryam and Ali for mirroring the notion that when it comes to me, life difficulties are surmountable challenges, and thus influencing me in myriad ways. Thanks to my grandmother, Sedighe, whose memory I will forever carry. Her consistent and reliable love provided me with a secure base from which to explore. I also appreciate my sisters Farzaneh, Farnaz, and Faraz, for their most sincere care. You have always been there for me to lean on. Your support during difficult times helped me hang on to my compass and concentrate on what is important.

Finally, I would like to thank the participants of this study, patients and their caregivers in particular, who cooperated in spite of their overwhelming difficulties. Without them generously welcoming me into their houses on the weekends, and devoting a considerable amount of their time to my project, the process of testing would have taken quite longer than it did.

Thanks once again to all.

Table of Contents

The structure of semantic memory has been brought under scrutiny through studies of category-specific semantic deficit, or selective impairments confined to specific categories of semantic knowledge (Warrington & Shallice, 1984). There have been reports of brain-damaged patients of various etiologies (e.g., Herpes Simplex Encephalitis) with selective deficits for a variety of semantic categories such as fruit, vegetables and animals (Basso, Capitani, & Laiacona, 1988), abstract versus concrete words (Breedin, Saffran, & Coslett, 1994), and nouns versus verbs (Caramazza & Hillis, 1991). The deficit that is most frequently documented, however, is the impaired knowledge of living things (e.g., animals) in the presence of relatively preserved knowledge of nonliving things (e.g., human-made objects or artifacts), also known as the living/nonliving things dissociation.

More recently, impairments of semantic memory in patients with mild-to-moderate dementia of the Alzheimer type (DAT) have become the focus of attention. According to a number of studies, semantic impairments in DAT are characterized by relatively intact knowledge of the category of nonliving things in the presence of impaired knowledge of the category of living things (e.g., Zannino et al., 2002). There are also studies that indicate no such category dissociation in this population (e.g., Tippett, Grossman, & Farah, 1996). In addition to the living/nonliving things dissociation, studies of naming impairments in DAT patients have documented object/action naming dissociations in that relative to the knowledge of nouns (names of objects), DAT patients' knowledge of verbs is impaired (e.g., Cappa et al., 1998). These reported patterns of dissociation, similar to the living/nonliving things dissociation, remain inconclusive. There are studies indicating more impaired knowledge of nouns than verbs (e.g., Williamson, Adair, Raymer, Kenneth, & Heilman, 1998), more impaired knowledge of verbs than nouns (e.g., Cappa et al., 1998; Robinson, Grossman, White-Devin, & D'Esposito, 1996), or no such dissociation whatsoever (e.g., Fung et al., 2001).

Memory research on impaired populations has led to the development of a number of proposals that could be subsumed under two main models of semantic memory organization – the domain specific (categorical), and the feature specific (e.g., the modality-specific, and the connectionist proposals). From the perspective of the domain specific model, articulated by Caramazza and Shelton (1998), semantic memory is organized in terms of major taxonomic categories (e.g., fruits or vegetables) with the living/nonliving distinction representing the pinnacle of the hierarchy of conceptual knowledge. Semantic deficits, according to this view, occur due to lesions affecting major categories of knowledge, presumably processed by distinct brain regions, and category is posited to be the primary organizing principle of semantic knowledge. From the perspective of feature specific models (e.g., the modality specific models such as the sensory functional theory-the SFT), semantic memory is organized in terms of semantic features or attributes (e.g., perceptual/visual features such as HAVE STRIPES in the meaning representation of tiger or functional/associative features such as CUTS in the meaning representation of knife), feature being the primary organizing principle of knowledge. Semantic deficits, according to this view, arise from lesions affecting sets of features that are shared by clusters of concepts (for a review, see Marques, 2000; de Almeida & Mobayyen, in press). Similar to the domain specific model, feature-specific models, mainly the modality specific ones, assume that the processing of different features might be differentially localized in specific brain regions. The connectionist proposals are also inherently feature-specific but unlike the domain specific and modality specific proposals, they view semantic knowledge as represented in a distributed system that is not differentiated by categories or features of knowledge (Tyler & Moss, 2001). Semantic deficits, according to these proposals, emanate from “differences in the structure and content of concepts across categories” rather than “explicit divisions of conceptual knowledge in independent stores” (Tyler & Moss, 2001, p. 247). More specifically, unlike the domain-specific model and the modality specific proposal, connectionist proposals do not postulate that any specific region of the brain stores or processes any particular information, whether it be *feature* or *category*, and are thus consonant with neuroanatomical findings that indicate the involvement of a network of brain areas in semantic processing (e.g., Devlin et al., 2002).

Whether the domain-specific and the feature specific models are essentially distinct or complementary has not been well established (e.g., Marques, 2000; Kolinsky et al., 2002). The uncertainty with regard to the nature of the organizing principle of semantic knowledge is partially responsible for disagreements about the implications patterns of semantic dissociations may have for semantic memory organization. This uncertainty may partly derive from the fact that a remarkably large body of studies on semantic dissociations have focused on dissociations within conceptual categories labeled by noun words (e.g., living/nonliving things dissociations). There are only a few studies on verb specific semantic impairments (e.g., Breedin, Saffran, Myrna & Schwartz, 1998; Grossman, Mickanin, Onishi, & Hughes, 1996; Kemmerer, Tranel, & Barrash, 2001), and even fewer on verb specific semantic dissociations cutting across different categories of verbs (e.g., Grossman et al., 1996). Since verbs also label various domains of semantic knowledge (e.g., actions), it is only reasonable to suggest that a comprehensive explanation of the nature of semantic memory must incorporate the representation of verb concepts. There are proposals suggesting that verb concepts are represented in terms of semantic features (e.g., Jackendoff, 1990) or a combination of features constituting verb semantic categories (e.g., Jackendoff, 1983, Levin, 1994). Thus, an exploration of the representation of verb concepts is suitable for an examination of the proposed models of semantic memory organization and of the nature of the organizing principle of semantic knowledge.

The present study was devised to investigate the validity of the main assumptions of the current models of semantic memory organization through an investigation of semantic dissociations in mild-to-moderate DAT patients. The main semantic dissociations explored included the living/nonliving things dissociation, object/action naming dissociation, and verb specific semantic dissociations cutting across different categories of verbs. As discussed before, studies on living/nonliving things and object/action naming dissociations in mild-to-moderate DAT remain inconclusive, with few documented studies on verb category specific semantic dissociations.

The present study is organized as follows: First, I review the nature of naming impairment in mild to moderate DAT followed by a review of semantic deficits involving category specificity (e.g., living/nonliving things dissociations; object/action naming dissociations). Next, I present a review on the nature of verb-semantic deficits in individuals with neurological conditions. Then, I turn to a discussion of the main models of semantic memory organization-domain specific and feature specific. This discussion sets the stage for the specific nature of the present study in which semantic dissociations in DAT patients including verb category-specific impairments are explored.

I. Dementia of the Alzheimer's type (DAT) and naming impairment

The dementia syndrome resulting from Alzheimer's disease is characterized by a general cognitive deterioration involving deficits in memory, language, attention, executive functions and visuspatial abilities. Despite the overarching nature of cognitive impairment, memory impairment is the most prevalent and salient feature of the early stages of DAT. While episodic memory deficits, in particular, have been shown to be an initial marker of DAT, an impaired ability to recall or retrieve previously learned knowledge, or semantic memory deficits, also occur in the early stages of the disease (Salmon, Butters, & Chan, 1999).

Naming impairments or anomia in early DAT have been linked to deficits of semantic memory. There are studies that underline not semantic deficits, but visuoperceptual (e.g., Cormier, Margison, & Fisk, 1991) or lexical-phonological retrieval deficits (e.g., Astell & Harley, 1998) as contributing factors to DAT patients' naming impairments. The preponderance of evidence, however, points to a semantic deficit as the major contributor to patients' naming impairments (e.g., Chertkow, Bub, & Seidenberg 1989; Hodges, Patterson, Graham, & Dawson, 1996, Huff, Corkin, & Growdon, 1986; Warrington, 1975). Several factors documented in DAT patients' naming performance have been highlighted as supporting a fundamental semantic deficit. These factors include impaired performance on category fluency tasks (e.g., naming tasks requiring participants to list as many members as possible of a particular semantic category such as animals), associate or attribute listing tasks (tasks requiring participants to list as many associations to a particular semantic category as possible), picture naming deficits with errors that are semantic in nature, category-specific semantic deficits, imageability effects in naming performance, and the finding that the association areas of the lateral and inferior temporal lobe cortex, being associated with semantic memory, are prominent sites of neuropathological alterations in DAT (Salmon et al., 1999). Below, I present a review of DAT studies on semantic impairments that are characterized by category specificity, or category-specific semantic dissociations.

I. 1 Category Specific Semantic Dissociations

Recent studies have demonstrated that DAT patients, similar to patients with focal brain damage (e.g., patients with Herpes Simplex Encephalitis), have naming deficits that affect the category of living things to a significantly larger extent than the category of nonliving things (e.g., Zannino et el., 2002, Zannino, Perri, Carlesimo, Pasqualetti, & Catagirone, 2006). Prevalent in these studies is the use of semantic tasks that involve conceptual and lexical-phonological retrieval such as picture naming and word picture naming tasks. Silveri, Daniele, Giostolisi, and Gainotti (1991), for example, used picture naming (conceptual retrieval) and verbal associate recognition tasks (lexical-phonological retrieval) to examine the living/nonliving things dissociation in fifteen mild-to-moderate DAT patients and ten normal controls. In both tasks, colour pictures of living and nonliving things matched for word frequency and prototypicality were used. In the picture-naming task, participants were required to name the pictures of living and nonliving things and, in the verbal associate recognition task, they were required to identify whether a presented picture was related to a semantic associate or a distractor word pronounced aloud by the examiner. In both tasks, DAT patients exhibited significantly greater difficulty naming and recognizing living in contrast to nonliving things. According to Silveri et al. (1991), the observed living things deficit in early DAT could be explained by the finding that early DAT is characterized by lesions in the temporolimbic structures of both hemispheres presumably involved in the encoding and processing of the knowledge of living things (Gainotti, 1990). More specifically, according to Silveri et al. (1991), a living things deficit in early DAT connotes the salience of temporal lobe pathology in this patient population.

Gonnerman, Anderson, Devlin, Kempler, and Seidenberg (1997) further examined the living/nonliving things dissociation in two experiments with fifteen mild to moderate DAT patients and fifteen normal controls. In the first experiment, two examinations were undertaken, one involving an evaluation of the DAT patients as a group, intended to replicate Silveri et al.'s (1991) findings, and the other involving an examination of the performance of two patients only. Three tasks were employed: a confrontation naming, a superordinate comprehension, and a word-picture matching. In all tasks, black and white line drawings of objects were used. In the superordinate comprehension task, patients were presented with sets of line drawings including items belonging to the categories of living and nonliving things (e.g., fruit, furniture). The task involved selecting the item that belonged to the category named by the experimenter (e.g., point to the fruit). In the word-picture matching task, patients were presented with line drawings of the members of the same semantic category (e.g., fruit) and were asked to point to each member, when it was named by the experimenter (e.g., "point to the apple"). The findings revealed that as a group, DAT patients' semantic impairments were not characterized by a living/nonliving things dissociation. In the second examination, Gonnerman et al. (1997) closely evaluated the performance of two of the previously tested DAT patients, GB and NB, using the same three tasks. GB showed significantly more impaired performance on the category of living things in contrast to nonliving things; whereas, NB revealed the opposite pattern, namely a significantly better performance on the category of nonliving things in contrast to the category of living things. As discussed previously, a selective living things deficit in early DAT has been attributed to lesions in the temporolimbic structures of both hemispheres presumably involved in the processing of living things (Gainotti, 1990). On the basis of the naming performance of NB and GB, Gonnerman et al. (1997) argued against this postulation suggesting a larger heterogeneity in the neuropathological alterations of early DAT.

In their second experiment, Gonnerman et al. (1997) examined the living/nonliving dissociation in another group of probable DAT patients (n=15) and normal controls (n=15) using a confrontation naming task. As in their experiment 1, the group results did not reveal any living/nonliving things dissociation. This finding was attributed to the presence of two subgroups of patients, one showing a nonliving things deficit and the other showing a living things deficit removing any overall category specificity. A close examination of individual cases, involving rank ordering patients according to their naming performance on living things, showed that three of the five patients with the least naming impairment had a nonliving things deficit, with the other two performing equally on both living and nonliving items. The remaining patients with most severe naming impairment appeared to have a living things deficit. Gonnerman et al. (1997) suggested that there is a possible relation between the direction of category dissociation and disease severity. More specifically, at the initial stages of DAT, there appears to be a selective impairment for nonliving things, but as the disease progresses and the neuropathology becomes more dispersed, there is a "cross over" from a nonliving things deficit to a living things deficit. Gonnerman et al. (1997), thus interpret their findings, specifically the direction of category dissociation, as evidence for diffuse neuropathological lesions in DAT.

In Garrard, Patterson, Watson, and Hodges' (1998) view, in proposing a relation between the direction of dissociation and disease stage, Gonnerman et al. (1997) posit that the degree of semantic impairment or anomia (expressed in the study by overall accuracy on the living things) reliably indicates disease severity. Specifically, more severely anomic individuals are at a more severe stage of the disease compared to less severely anomic individuals. This postulation, Garrard et al. (1998) maintain, is a contentious notion. They further argue that Gonnerman et al. (1997) rank ordered the patients not on the basis of their overall naming performance, but on the basis of their performance on naming the living things, hence introducing a confounding bias. To overcome these shortcomings, Garrard et al. (1998) suggest the use of the Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) as a more reliable measure of general disease severity to investigate the relation between disease severity and the direction of category dissociation.

It is important to emphasize, however, that despite being a more comprehensive measure of disease severity than the naming ability per se, the MMSE is not considered to be very reliable. Factors such as educational level, and language ability have been shown to adversely affect performance on the MMSE (e.g., Rosseli, Tappen, & Williams, 2006). Thus, using the MMSE as a means of understanding the relationship between disease severity and the direction of category dissociation could also be misleading, albeit possibly to a lesser extent than using naming ability alone.

Garrard et al. (1998) further examined the living/nonliving things dissociation in fifty-eight patients with mild to moderate DAT, and fifty-six normal controls using line drawings (Snodgrass & Vanderwart, 1980) that represented living (e.g., land animals), and nonliving (e.g., household items) things. Four tasks were used: category fluency, confrontation naming, naming in response to verbal description (e.g*., what do we call the small, green animal that leaps around ponds?*), and word-picture matching. The same items were used in all tasks. Consistent with Gonnerman et al.'s (1997) findings, the results showed that although there was a trend for a living things deficit, DAT patients as a group did not reveal significant living/nonliving things dissociation. To examine whether the overall level of disease progression, as measured by the MMSE scores, could explain the absence of living/nonliving things dissociation, Garrard et al. (1998) divided the DAT patients into two groups. The first group had a mean MMSE score of 25.5 (mild disease severity), and the second group had a mean MMSE score of 14.31 (moderate disease severity). The results showed no significant living/nonliving things dissociation. Further, contrary to Gonnerman et al.'s (1997) predication regarding the relation between disease severity and the direction of living/nonliving things dissociation, a nonliving things deficit was not observed in the mild group. In fact, the degree of the living things advantage did not significantly differ between the two patient groups. Garrard et al. (1998) argued that this finding indicates that the degree of semantic impairment may not be a reliable measure of disease severity.

In a second analysis, Garrard et al. (1998) carried out a close examination of the profiles of individual patients. Similar to Gonnerman et al.'s (1997) analysis of individual profiles, Garrard et al. (1998) ranked the patients according to their naming performance on the living things. There were eleven patients who exhibited a living/nonliving things dissociation: Eight patients with most severe naming impairment showed a significant living things deficit, and three patients, two of whom had a moderate naming impairment, showed a significant nonliving things deficit. Thus, similar to Gonnerman et al.'s (1997) findings, the direction of category specificity was largely contingent on the degree of semantic impairment, assuming that naming the living things is a reliable measure of overall naming performance.

In closely examining individual cases, both Gonnerman et al. (1997) and Garrard et al. (1998) found a correlation between the direction of living/nonliving things dissociation and semantic impairment in that patients with most severe naming impairment exhibited a living things deficit; whereas patients with moderately severe naming impairment revealed a nonliving things deficit. This finding, Garrard et al. (1998) point out, could be construed as an indication of widespread pathological involvement in DAT provided that the level of semantic impairment is in fact a reliable measure of disease severity. In another analysis, Garrard et al. (1998) ranked ordered cases according to their scores on the MMSE and examined living/nonliving things dissociation and its direction. The results showed larger living/nonliving things dissociations at the lower ranges of the MMSE, even though the direction of the dissociation was not contingent on the severity of disease as determined by the MMSE scores. In other words, the living things deficit did not differ considerably between mild or more severe patients as determined by their MMSE scores.

The rank ordering of the cases produced by Garrard et al. (1998), using the performance of the patients on the naming task and the MMSE, were rather inconsistent.

In Garrard et al.'s (1998) view, this inconsistency reflects a non-linear relationship between semantic impairment and disease severity indicating that semantic impairment cannot be a consequence of widespread disease progression. This argument, however, would be tenable if the MMSE scores represented a reliable indication of disease progression.

Following Silveri et al. (1991), Garrard et al. (1998) suggest that a living things deficit in DAT may underline a selective pathology of the temporal lobes assumed to be involved in the processing of living things (Gainotti, 1990). However, the large heterogeneity characteristic of DAT may suggest that sometimes the initial temporal lobe pathology that is characteristic of DAT may extend to other areas such as the left frontoparietal area assuming to be involved in the processing of nonliving things (Gainottie, 1990). On the basis of this premise, Garrard et al. (1998) propose that it is not farfetched to observe that some DAT patients or patient groups may exhibit a nonliving things deficit whereas others may exhibit the opposite pattern.

Zannino et al. (2002) also explored living/nonliving things dissociation in fifty-four mild to moderate DAT patients and thirty normal controls. Two tasks were used: a confrontation naming and a multiple-choice format questionnaire. In the confrontation naming task, the participants were asked to name line drawings (Snodgrass & Vanderwart, 1980) of living (e.g., fruit) and nonliving (e.g., vehicles) things. Through the questionnaire, Zannino et al. (2002) explored participants' knowledge of the superordinate category and the subordinate perceptual and functional features of items used in the confrontation-naming task. The questionnaire consisted of six questions for each item (e.g., orange). The first two questions examined general (e.g., *Is it an animal or* *plant or an object*?) and same-category (e.g., *Is it a tree, a vegetable or a fruit*?) superordinate information. The two other questions examined subordinate perceptual features (e.g., *Is it round*, *oblong*, or *conical*?), and the last two evaluated subordinate functional features (e.g., *Do we eat it raw, dried or both ways*?).

The results revealed significant living/nonliving things dissociation among DAT patients with markedly more impaired knowledge of living than nonliving things. This finding remained tenable when the possible influence of a number of factors such as visual complexity, prototypicality, and name agreement were removed, although values corresponding to these factors were derived from Snodgrass and Vanderwart's (1980) normative data collected from undergraduate students, who are considerably younger and more educated than DAT patients. Single-case analyses indicated that six patients on the confrontation naming task and eight patients on the questionnaire had a significant living things deficit. When these patients' data were removed, there still remained a significant trend for living/nonliving things dissociation with a living things deficit.

Examining patients' performance on the items of the questionnaire that explored the knowledge of perceptual and functional features revealed that performance accuracy did not significantly vary as a function of the perceptual and functional nature of the questions, despite the presence of significant living/nonliving things dissociation. This finding does not support the notion that a living things deficit is sustained by an impaired knowledge of perceptual as opposed to functional features. Furthermore, the living things impairment seemed to be sustained by damage to subordinate and distinctive features (e.g., *oblong*), regardless of the specific kind (perceptual/visual or functional/associative), as opposed to superordinate and shared features (e.g., *mammals*).

Exploring the relation between the direction of the living and nonliving things dissociation and performance on the MMSE and the confrontation naming task indicated that the direction of category dissociation was not contingent on the magnitude of semantic impairment, as measured by performance on the confrontation naming task, and global cognitive impairment, as measured by the MMSE scores. Consistent with Garrard et al.'s (1998) findings, however, there was a trend towards larger category dissociation effects as the disease increased in severity, regardless of its direction.

Living/nonliving things dissociation and the possible role of "semantic distance" in the generation of such category effects were investigated by Zannino et al. (2006) in twenty mild to severe DAT patients. Following Cree and McRae (2002), Zannino et al. (2006) postulated that the living things deficit observed in brain-damaged patients, including DAT patients, is accounted for by semantic distance defined as the extent to which concepts are semantically similar in terms of their primitive features. They postulated that differentiating between two concepts becomes increasingly more difficult as the semantic distance between them decreases. On the basis of previously collected feature norms (e.g., Zannino et al., in press), Zannino et al. (2006) computed semantic distance values for the living and nonliving line drawings (Snodgrass & Vanderwart, 1980). The semantic distance values of living things were lower than nonliving things (see Zannino et al., 2006 for details regarding the computation of semantic distance values).

The stimuli consisted of noun words taken from a previous study (Zannino et al., in press) and line drawings of objects. Specifically, for each noun, a corresponding line drawing was drawn either from the Snodgrass and Vanderwart's (1980) or from the Dell'

Acqua, Lotto and Job's (2000) corpora representing the living (e.g., animals and fruits) and nonliving (e.g., vehicles, and furniture) categories. Three semantic tasks were used: confrontation naming, word-picture matching, and similarity judgment. Unlike the stimuli in the first two tasks, the stimuli in the similarity judgment task were matched according to their semantic distance values. This task consisted of a number of trials each containing three words associated with the same semantic category (e.g., furniture) aligned in three different rows. Participants were required to select from the rows two (e.g., wardrobe) and three (e.g., couch), the word that was most semantically similar to the word in the first row (e.g., dresser).

The results of the confrontation naming and word-picture matching tasks indicated that DAT patients' knowledge of living things was significantly more impaired than their knowledge of nonliving things. This category effect remained tenable when the possible role of factors such as visual complexity, and familiarity were taken into account. On the semantic judgment task, DAT patients did not exhibit a living/nonliving things dissociation. In Zannino et al.'s (2006) view, this was due to the matching of items according to their semantic distance values.

The role of semantic distance was taken into account in the confrontation naming and word-picture matching tasks. In the confrontation-naming task, taking semantic distance into account resulted in the previously significant living/nonliving things dissociation approaching significance. In the word-picture matching task, considering semantic distance resulted in the significant living/nonliving things dissociation being no longer significant. Caveats to consider however include the use of normative information (e.g., visual complexity) derived from the Snodgrass and Vanderwart's (1980) corpus obtained from younger and more educated undergraduate students than DAT patients, and a lack of an age- and education-matched control group who could have to some extent compensated for the former limitation.

Fung et al. (2001) further investigated the living/nonliving things dissociation in twenty mild to moderate DAT patients and sixty normal controls. In addition to the living/nonliving things dissociation, Fung et al. (2001) also investigated the object/action naming dissociation previously reported in the DAT population (e.g., Cappa et al., 1998). Two tasks were used: confrontation naming and semantic association judgment. In the confrontation-naming task, line drawings depicting nouns (e.g., Snodgrass and Vanderwart, 1980) and verbs (e.g., the Action Naming Test; Obler & Albert, 1982) and computer animations representing verbs were used. The semantic judgment task involved asking the patients to determine which of the two words presented at the bottom of the computer screen more resembled the target word presented at the top of the screen (e.g., *Sailing: Boating, Driving; Nail: Screw, Derail*). The stimuli were matched according to factors such as name agreement, and familiarity on the basis of normative information derived from age-and education-matched normal elderly individuals. In addition to adequate control for such confounding stimulus factors and the use of animations to depict actions, another novel aspect of Fung et al.'s (2001) study was a pre-selection of stimuli on the basis of the previously collected norms on the elderly individuals. Thus, the performance in the control group was not biased by a ceiling effect.

The results revealed that in both confrontation naming and semantic association judgment tasks, DAT patients as a group were significantly more impaired in their knowledge of living than nonliving things. Further, only when animations were used to represent verb concepts, DAT patients' action naming was significantly better than their object naming; otherwise no object/action naming dissociation was found. A close examination of individual cases indicated that 83% of the patients on the confrontation naming task, and 94% of the patients on the association judgment task had a living things deficit.

Druks et al., (2006) further investigated object/action naming dissociation in nineteen patients with mild to moderate DAT. Line drawings depicting nouns and verbs derived from the Object and Action Naming Battery (Druks & Masterson, 2000) were used in a confrontation naming task. They attempted to match the stimuli on factors such as name agreement, age of acquisition, visual complexity, frequency, and imageability. However, the matching of items on age of acquisition resulted in verbs being more frequent than nouns. Although the normative information used to match the stimuli on such stimulus factors was not derived from elderly individuals, there was a control group consisting of nineteen age-and education-matched normal elderly individuals. Naming accuracy and latency were both used as measures to examine object and action naming. A qualitative analysis of the errors was also undertaken.

The results revealed that in both patient and control groups, action naming was slower and produced more errors than object naming, although naming latency for the verbs and nouns did not differ significantly. The results further indicated that imageability was a significant predictor of both object and action naming accuracy and latency, and visual complexity was a significant predictor of object and action naming latency. In Druks et al.'s (2006) view, the observed object/action naming dissociation in both patient and control groups was to some extent accounted for by the fact that verbs were lower in imageability than nouns. This is expected given the use of line drawings to depict verbs. In other words, unlike nouns, verbs require a more complex drawing involving a scene with a participant(s) carrying out an action. The analysis of errors indicated that nouns and verbs elicited different error types. In contrast to verbs, in both patient and control groups, nouns elicited more visual (e.g., *brain→ hairnet*) and coordinate (*cherry → apple*) error types. Further, the patients and controls made no more omission errors[1] for verbs than nouns. Expectedly, errors of interpretation (e.g., *touching→pointing*; *dreaming→sleeping)* occurred more frequently in response to the verb line drawings in both patient and control groups. From the perspective of Druks et al. (2006), these errors cannot be ascribed to a more pronounced verb-semantic degradation; rather they may be accountable by the characteristic of the verb stimuli employed (e.g., line drawings).

From the perspective of Druks et al. (2006), the observed object/action naming dissociation in both patient and control groups could be an exacerbation of the pattern already present in the controls, and is thus better accounted for "by the differences between the demands of object and action naming than differences between Alzheimer's patients and normal language users" (p. 339)

Following Fung et al (2001), one could further contend that the findings of object/action naming dissociations underscored in past studies (e.g., Cappa et al., 1998) as well as in quite recent ones (e.g., Druks et al., 2006) are to some extent obscured by the fact that static images such as line drawings or coloured pictures are employed to represent verb concepts. Verbs lexicalize events and thus may not be adequately captured

[1] Incorrect responses involving more than one type of error with one of the errors being circumlocution, which refers to "adequate definition" without retrieving the correct word (e.g., saddle →a seat on a horse).

by means of stagnant stimuli (Fung et al., 2001). To better understand the nature of object/action naming dissociations, if any, and their implications for conceptual representation, one could perhaps use animated stimuli, as used by Fung et al. (2001), that are ecologically more valid than static images such as short-movies of actions.

The following represents an overview of studies on verb-semantic deficits in brain-damaged patients of differing etiologies.

II. Verb-Semantic Deficits

There is a great wealth of research on verb deficits involving agrammatic aphasic patients. Agrammatic aphasic patients are mainly patients with the so-called Broca's aphasia. These patients have suffered a frontal lesion as the result of which their speech is characteristically "telegraphic" with function words (e.g., determiners, pronouns, prepositions) being frequently absent. Specifically, they show a selective impairment of function words accompanied by a relative sparing of major content words such as nouns, verbs, and adjectives (Myerson & Goodglass, 1972). Aside from having difficulty producing function words, agrammatic patients have also been shown to have particular problems producing main verbs in their spontaneous speech (e.g., Miceli, Silveri, Villa, & Caramazza, 1984). Such difficulties, usually occurring in conjunction with agrammatism, have been attributed to the syntactic complexity of verbs (e.g., *verb* argument structure) in contrast to nouns (Breedin et al., 1998). However, as Breedin et al. (1998) contend, the notion that verb retrieval deficits are the result of a syntactic processing disorder does not explain verb deficits reported in nonagrammatic populations.

Caramazza and Hillis (1991), for example reported two nonagrammatic patients, HW and SJD, who had suffered injury to their parietal and frontotemporal regions, respectively. Their pattern of performance suggested modality-specific impairments mainly restricted to the class of verbs. In contrast to HW who demonstrated a verb deficit in oral reading, SJD exhibited a verb deficit in written production. In Caramazza and Hillis' (1991) view, this dissociation indicated a lexical processing deficit involving the grammatical class of words that presumably represented a dimension of lexical organization. The grammatical class knowledge, they contend, may be represented redundantly in the phonological and orthographic (output) lexicons and not in the semantic system; although an impairment of the semantic system underlying verb deficits has been documented in a number of studies involving patients with both focal (e.g., Breedin et al., 1998) and diffuse (e.g., Cappa et al., 1998) brain lesions.

A semantic basis underlying verb deficits was suggested in a study by Breedin et al. (1998) involving eights aphasic patients and five normal controls. A verb story completion task was used consisting of a story with verbs (e.g., *Went/Walked*) deleted from the second sentence (e.g., *The bus stopped and let people on. Marty ------- to the back of the bus. There were plenty of seats there. What did Marty do when he got on the bus*?). Breedin et al. (1998) hypothesized that verb semantic complexity may play a role in patients' verb retrieval. According to some theories of verb semantic representation (the featural view; e.g., Rappaport-Hovav & Levin, 1997), verbs such as *to run* could be reduced to primitive semantic features (e.g., GO) in addition to other semantic components and are thus considered "heavy", or semantically complex. Verbs such as *to go*, *to have*, or *to do* however, represent the primitive features of heavy or semantically complex verbs, and are thus considered "light" or semantically simple.

Breedin et al.'s (1998) findings revealed that verb semantic complexity did have a significant effect on patients' verb retrieval such that patients' use of semantically complex verbs (heavy verbs) was significantly better than their use of semantically simple verbs (light verbs). In Breedin et al.'s (1998) view, this finding is consonant with the basic premise of the feature-specific models of conceptual representation-which will be discussed in length later on- according to which verb concepts are decomposable into primitive semantic features (e.g., the meaning of the verb to *run* can be decomposed into the semantic feature GO in addition to other primitive components). Additional semantic features in semantically complex verbs, Breedin et al. (1998) contend, may suggest more connections among them, and more connections among semantic features, may in turn suggest “a stronger ‘memory trace’ ” (p. 21). Thus, in Breedin et al’s (1998) view, the addition of semantic features may facilitate verb retrieval.

On the basis of two assumptions, Breedin et al.’s (1998) findings in fact argue against the decompositional/reductionist or feature-specific models: (1) Retrieval rate is contingent on the number of semantic features (Kintsch, 1974; de Almeida, 1999); and (2) The meaning representation of complex verbs consists of feature sets, included in which are light verbs, leading to the predication that the more features a verb has, the greater the likelihood that some of its subcomponents will be affected (Mobayyen & de Almeida, 2005). On the basis of these two assumptions, if the meaning representation of verbs consists of features, as postulated by Breedin et al. (1998), one should expect patients with verb deficits to have a better recall of semantically simple than semantically complex verbs. Breedin et al.’s (1998) finding of better recall in patients with verb deficits for semantically more complex verbs may suggest that verbs are not represented on the basis of complex sets of features. However, their results could also be explained as a function of a frequency effect, which has been shown to affect verb production in that less frequent verbs are produced better than more frequent verbs (e.g., Kemmerer & Tranel, 2000).

The influence of stimulus factors influencing brain-damaged patients’ verb production was investigated by Kemmerer and Tranel (2000). Specifically, they explored the influence of factors such as visual complexity, familiarity, name agreement, and word frequency on the verb production of fifty-three patients with unilateral left hemisphere brain damage. They administered the Fiez and Tranel's (1997) standardized Action Naming Test that consists of a confrontation-naming task including coloured pictures of actions. These pictures included single and paired pictures, single pictures portraying ongoing actions, and picture pairs portraying two situations: a situation where an agent produced some changes in another entity, and the same situation after the change had occurred. Single pictures elicited verbs in the imperfective aspect, encoded by the regular suffix- *ing (e.g., chopping)*, and picture pairs elicited verbs in the perfective aspect, encoded either by the regular past tense suffix- *ed (e.g., chopped)* or by an irregular past tense form (e.g., *lit*). On the basis of the values derived form the Fiez and Tranel's (1997) original standardization norms, the pictures were classified according to factors such as name agreement, visual complexity and familiarity.

The patients were divided into impaired and normal control groups on the basis of their overall verb production. The results revealed that for both groups, action naming was significantly facilitated by factors such as familiarity, image agreement, name agreement, homophonous noun (whether the root of a verb had a homophonous noun; e.g., *rake*) and "undergoer change of location" (whether the actor carrying out the action had a change of spatial location). Factors such as visual complexity did not facilitate action naming. Less frequent verbs were named significantly better than more frequent verbs, and there also seemed to be a trend for patients to name single pictures eliciting verbs with the tense-morpheme, *ing* better than paired pictures eliciting regularly (*ed*) and irregularly inflected verbs. This trend was not observed in the control group.

As indicated by some of the above-mentioned studies, verb production can be selectively impaired. Although it is possible that classes of events, which may be lexicalized by verbs with different semantic and syntactic (verb argument structure) properties- could generate different types of verb category-specific dissociations within the semantic system, there are very few studies examining such category specificity. In one of the very few documented studies on verb category-specific dissociations, Grossman et al. (1996) investigated verb-semantic deficits employing two tasks - a triadic comparison and a sentence rating tasks- involving twenty-five mild-to-moderate DAT patients and sixteen normal controls. In the triadic comparison task, a task examining semantic similarity between verbs, the DAT patients were presented with triads of verbs, each containing a member from each of the three categories of movement verbs (*crawl, remain, jump*), cognition verbs (*think, suggest, remember*), and perception verbs, which were related to either movement (*gaze, listen*) or cognition (*observe, hear*) according to their classification. The patients were required to identify semantic relations between verbs by clustering them according to their verb semantic categories. In the sentence-rating task, the DAT patients were presented with ten verbs (e.g., *jump, hear*) embedded in four different types of syntactic structures (e.g., noun phrase-verb-propositional phrase) and were required to judge the structural coherence of the sentences (e.g., *the horse jumped over the fence; the horse heard over the fence)*. The findings indicated that DAT patients had difficulty clustering movement verbs according to their semantic relatedness and gave lower ratings for sentence frames that were most appropriate for these verbs. Grossman et al. (1996) argued for a deficit within the verb-semantic category affecting the category of movement verbs, in particular.

In brief, it appears that verb-specific deficit may cut across grammatical and semantic categories (e.g., movement verbs). As previously discussed, models of semantic memory organization have been largely developed on the basis of semantic dissociations involving noun-labeled conceptual categories (e.g., fruits, animals). There is a paucity of studies on verb-labeled conceptual categories. Provided that semantic knowledge also encompasses events lexicalized by verbs, this shortcoming casts doubt on the generalizability of the current models to the organization of semantic knowledge. I now turn to a discussion of these models, mainly the domain-specific and feature-specific models.

III. Models of Semantic Memory Organization: The Domain-Specific and the Feature-Specific

On the basis of impaired and preserved noun-labeled conceptual categories in brain-injured patients, a number of proposals regarding semantic memory organization have been developed. These proposals could be subsumed under two broad models: the domain specific (categorical), and the feature specific.

From the perspective of the domain-specific or the categorical model, articulated by Caramazza and Shelton (1998), semantic memory is organized on the basis of major taxonomic categories (e.g., animals), category representing the primary principle of semantic memory organization. These categories, are presumably processed and stored by "specialized and functionally dissociable neural circuits" that are developed due to evolutionary pressures (p. 9). These "circuits" are explicitly and distinctively represented and processed by different areas of the brain, and selective damage to these brain areas results in domain-specific semantic impairments. The living things deficit, for example, documented in early DAT and Herpes Simplex Encephalitis, is explained by the assumption that knowledge of the living things, organized categorically, is stored in and processed by the temporolimbic areas of the brain, areas that are primarily affected in early DAT and HSE. The nonliving things deficit is similarly explained by the assumption that knowledge of the nonliving things, represented categorically, is stored and processed by the left frontoparietal areas that may also be affected in some DAT patients. Caramazza and Shelton (1998) contend that the categories on the basis of which knowledge is organized are "evolutionarily significant" categories such as fruits, animals, vegetables, and artifacts, but as they acknowledge, it is not quite clear what constitutes an "evolutionarily significant" semantic category, and how concepts constellate within these distinct categories. Caramazza and Shelton (1998) suggest that "evolutionarily significant" categories are those "for which it is plausible to propose that their successful recognition would have fitness value" (p. 20). They also allude to the similarity in the core semantic content as the principle holding the concepts within each category together.

According to Marques (2000), the domain specific model has been supported by several case studies including a study by Hart, Berndt and Caramazza (1985). Hart et al. (1985) reported the case of a brain-damaged patient, MD, who had significant difficulty naming members of fruit and vegetable categories but not food products outside these categories. Kolinsky et al. (2002) also documented the case of a brain-damaged patient, ER, affected with HSE, who had significantly more impaired knowledge of living than nonliving things. Despite showing a clear deficit in semantic tasks involving retrieving and defining living things, ER's knowledge of superordinate biological categories appeared to be preserved. He was able to distinguish animals from plants, fruits and vegetables and had intact knowledge of categorical relations (such as "the owl is a bird"), and attributes (e.g., "the owl has a wing"). In addition, ER's knowledge of perceptual and functional features of living things was equally impaired, thereby refuting an explanation of his living/nonliving things dissociation in terms of the sensory-functional theory of semantic deficits, as proposed by Warrington and Shallice (1984).

Warrington and Shallice (1984) documented the cases of two patients, JBR, and YOT whose deficits could not be accounted for by the living/nonliving categorization of semantic knowledge. JBR exhibited a living things deficit, but he also had difficulties identifying a number of categories within the nonliving domain such as musical instruments and gemstones. YOT exhibited a nonliving things deficit (e.g., artifacts), but he also had difficulties identifying the category of body parts within the living domain. To account for these findings, Warrington and Shallice (1984) posited that musical instruments and gemstones resemble living things in that they are primarily recognizable on the basis of their perceptual/visual attributes or features. Body parts, however resemble nonliving things in that functional properties or features are most crucial to their recognition. On this premise, Warrington and Shallice (1984) posited that a selective impairment of visual semantic knowledge, resulting from brain injury, would affect living things to a larger extent than nonliving things, with the exception of the category of musical instruments, generating the typical category-specific patterns. The organization of semantic knowledge in terms of perceptual and functional features of objects has been coined as the sensory-functional theory of semantic memory organization (The SFT). Unlike the domain specific model, the SFT postulates that semantic memory is subdivided by the modality of knowledge such that one semantic component is dedicated to functional/associative information pertaining to objects; whereas another semantic component is dedicated to visual/perceptual information pertaining to objects. Similar to the domain specific model, however, the SFT posits that visual and functional features of objects are localized in different parts of the cortex namely the temporolimbic and frontoparietal areas, respectively. Thus, both the domain specific and the SFT emphasize the segregation of the semantic system at the anatomical level and are thus referred to as the localization models of semantic memory organization.

The reformulation of the broader domains of living/nonliving categories into sensory/functional features, as stipulated in the SFT, has not been supported by a number of studies. There are documented cases of patients who have living things deficits without the accompanying selective deficits for the perceptual properties, as well as cases of patients with poor knowledge of visual information in the absence of an accompanying disproportionate impairment for living over nonliving things (e.g., Laiacona, Capitani & Barbarotto, 1997). These reports, however, do not alter the fundamental localization claim of the SFT theory, and also the domain specific model, according to which damage to specific stores of knowledge in the brain, whether they have living/nonliving or perceptual/functional structural organization, results in category specific semantic dissociations.

The SFT, a modality specific proposal, is an example of a feature specific model of semantic memory organization. The feature-specific models are based on the premise that semantic memory is primarily organized on the basis of primitive semantic features or attributes. Specifically, semantic feature, not category, is the primary organizing principle of semantic knowledge, and the categorical nature of semantic deficits is the consequence of this more fundamental constituent (Marques, 2002).

Not all feature-based proposals of semantic memory organization contain an assumption of modality specificity. Within the neuropsychological literature, there are a number of different feature-based proposals some of which adhere to a feature type (e.g., perceptual versus functional) organization of semantic memory and assume modality specificity in semantic memory organization (e.g., the SFT) and some others underscore feature properties (such as shared features, distinctiveness of features, and correlation among features) and their differential distribution across categories in the structure of semantic memory without making or opposing the assumption of modality specificity (for a review, see Vinson, Vigliocco, Cappa, & Siri, 2003). The proposals underscoring feature properties are usually referred to as the connectionist proposals of semantic knowledge espousing the view that "distributed featural networks" stand for concepts (Vinson et al., 2003). Unlike the feature-type (e.g., the SFT) proposals and the domain specific model, the feature-property proposals de-emphasize "the anatomical substrate", or regionally specific neural correlates for categories or feature types (e.g., perceptual vs. functional) and postulate that semantic knowledge is represented in "a unitary distributed conceptual system" that is not differentiated by categories of knowledge (e.g., living and nonliving things) (Tyler & Moss, 2001, p. 247). This postulation is consonant with recent neuroimaging studies (Devlin et al., 2002) suggesting a network of brain regions, rather than distinct regions, simultaneously activated in tasks of semantic processing. From the perspective of these accounts, category specific semantic dissociations emanate from "differences in the structure and content of concepts across categories" rather than from explicit organization of conceptual knowledge in distinct brain areas. (Tyler & Moss, 2001, p. 247).

The feature-property or connectionist proposals also differ with respect to their assumptions regarding the structure of concepts within the living and nonliving domains. These assumptions may involve the proportion of perceptual and functional features (e.g., Farah & McClelland, 1991), intercorrelations between features (e.g., Devlin, Gonnerman, Anderson, & Seidenberg, 1998) or the distinctiveness of features (e.g., Tyler, Moss, Durrant-Peatfield, & Levy, 2000) (for a review, see Vinson et al., 2003).

According to Moss, Tyler, Durrant-Peatfield, and Bunn (1998), distinctiveness refers to an identifying feature of a concept within a semantic category that remains largely unshared with other concepts. For example, elephants have the distinctive feature of HAS A TRUNK, which is not shared with other animal concepts. The feature HAS LEGS, however, is not regarded to be a distinctive feature, as it is shared with many other animal concepts. Inter-correlation between features refers to the amount of correlation a feature has with other features manifest in the proportion of times one feature co-occurs with others. The features HAS EYES and HAS EARS, Moss et al. (1998) point out, have a large correlation because entities with eyes and ears co-occur quite frequently; HAS STRIPES and HAS A MANE, however, do not have a large correlation because they more frequently occur separately than together, except for once in the case of *zebra*.

In Devlin et al.'s (1998) connectionist proposal, distinctiveness and intercorrelation between features represent the basic principles of the organization of the semantic system. In Devlin et al's (1998) view, the proportion of non-distinctive, correlated features in concepts of living things is significantly larger than those in concepts of nonliving things. The larger proportion of non-distinctive, correlated features in the meaning representation of living things presumably compensate for the loss of a few features in the system, thus making them less vulnerable to minimal damage than concepts labeling nonliving things. This proposal, thus predicts that at the initial stages of non-focal brain damage (e.g., early DAT), there is a living things advantage (a nonliving things deficit) due to the disruption of some of the distinctive and non-correlated features of nonliving things. Living things are presumably not as vulnerable, having highly correlated features in their meaning representations compensating for "the activation reduction" of the disrupted features. Presumably, at some point, when the disease increases in severity and the amount of damage augments, large clusters of highly intercorrelated features would not be able to compensate for each other any longer. Thus, there will be an activation reduction involving whole sets of the living things that are contingent on those clusters of features. Support for this proposal comes from Gonnerman et al.'s (1997) study, discussed previously, where they found an association between Alzheimer's disease severity and the direction of category dissociation. However, this pattern was not supported in Garrard et al.'s (1998) study, also discussed previously: the direction of category dissociation (a living or nonliving things deficit) was not found to be contingent on the degree of disease severity (e.g., moderate or severe dementia as measured by the MMSE).

Incorporating the notions of feature types (e.g., perceptual vs. functional), intercorrelation between features, and shared/distinctive features in their connectionist proposal, Tyler et al. (2000) emphasize the kind of associations between perceptual and functional features in the meaning representation of both living and nonliving things. Specifically, they argue for the different types of association between perceptual and functional features for living and nonliving concepts. For living concepts, the correlated perceptual features are associated with different biological functions (e.g., eyes for seeing, and legs for moving, etc), but the distinctive perceptual features are not (e.g., HAS STRIPES for tiger; HAS A MANE for lion). For nonliving things, however, the association between perceptual and functional features would involve the distinctive perceptual features (e.g., the perceptual feature HAS A SHARP EDGE and the functional feature CUTS for knife). As Vinson et al. (2003) argue, the above-mentioned postulations should lead to the following predictions: First, category specific semantic dissociations should predominantly involve a living things deficit because there is a weak correlation between the distinctive features of living things and other features; Second, the loss of visual/perceptual knowledge should be variable and in the case of a living things deficit, the distinctive features should be less immune to damage than correlated features; and finally, due to the high correlation between the distinctive perceptual features and functions, a nonliving things deficit should arise only when the damage to the semantic system is severe. Evidence compatible with these predictions comes from Zannino et al.'s (2002) study, discussed earlier, where the living things deficit in DAT seemed to be sustained by damage to the subordinate and distinctive features, regardless of the specific kind, as opposed to the superordinate and shared features. Their findings did not seem to support Devlin et al.'s (1998) model, as no association between the direction of category dissociation and disease severity was found.

Recent studies suggest that domain-specific and feature-specific models may share common grounds regarding the organization of semantic category and the relation between feature and category (e.g., Marques, 2000; Kolinsky et al., 2002; de Almeida & Mobayyen, in press). There are studies suggesting that feature and category are both reflected in the organization of semantic memory (de Almedia & Mobayyen, in press; Marques, 2000), and there are also accounts suggesting that the basic assumptions of domain and feature-specific models, regarding feature and category, may represent assumptions "addressed at a different level in a hierarchy of questions about the organization of semantic knowledge" (Mahon & Caramazza, 2003). According to Kolinsky et al. (2002), the domain-specific model does not provide adequate information regarding the nature of the representation of knowledge within conceptual categories such that the categories of fruits and animals constitute two distinct categories, and thus it is not quite clear how concepts constellate within each category. In addition, the domain-specific model does not appear to have a view regarding how individual concepts may be represented within the semantic system. The feature-specific models, however, provide us with a framework to understand how concepts may constellate within each category and how each individual concept may be represented.

Regarding the representation of individual concepts, a clear assumption of all feature-based proposals is that "most if not all lexical concepts[2]" nouns and verbs, are composites, that is they can be decomposed in terms of primitives" (Jackendoff, 1990, p. 10). The concept labeled by the word *dog*, for example, is assumed to be expressed in terms of sets of features including FURRY, FOUR-LEGGED, BARKS, etc (see de Almeida, 1999). Monomorphemic verbs (e.g., *kill*), representing lexical concepts, are also assumed to have composite representations in semantic memory (Jackendoff, 1990).

A great deal of controversy as well as insight has resulted from the postulation that lexical causative verbs such as *kill* are represented on the basis of a semantic template with the primitive constant feature CAUSE (e.g., Jackendoff, 1990; but see de Almeida, 2001). More specifically, in the class of causative verbs, causation is assumed to be expressed through a semantic template comprising three sub-event predicates such as [CAUSE [x [E]]] in which X is assumed to represent the agent of causation and E is the resultative event or the object of the supposedly primitive feature CAUSE (de Almeida & Mobayyen, in press). However, whether or not causative verbs are decompositional is the subject of a major dispute. For example, the verb *Kill* in the sentence *John Killed Mary* is assumed to be represented as [CAUSE [John [Mary <dead>]]]. CAUSE is presumably

---

[2] Lexical concepts are concepts expressed by monomorphemic words from different categories such as nouns and verbs (e.g., concepts expressed by words such as *kill* or *dog*).

the likely primitive. However, as Jackendoff (1990) points out, there are "descriptive inadequacies oozing out around the edges of decomposition" (p. 113). For example, "a rock being not alive does not qualify it as dead" (p. 113). In fact, Fodor (1990) and de Almeida (1999) assume that concepts cannot be decomposed into other elements or features- a view known as atomism. According to this view, a concept such as *dog* or *kill* does not have "internal components" at the semantic/conceptual level, and it is rather represented by a "metalinguistic translation" in a language of thought (see de Almeida, 1999).

It is not clear which of the main models (e.g., domain or feature specific) better account for the nature of conceptual knowledge. Moreover, the basic assumptions of these models have not been verified in brain-damaged individuals with verb category-specific semantic deficits. The present study aims at compensating for this shortcoming. In the following section, I discuss the purpose of the present study, the specific verb categories implemented, and the hypotheses evaluated.

IV. The Present Study

As discussed before, researchers investigating semantic memory organization have not as yet reached an agreement on the nature of semantic memory organization and the nature of the representation of individual concepts. Some espouse the view that category-specific semantic dissociations suggest a primary organization of semantic memory on the basis of evolutionarily important conceptual categories ignoring the manner in which individual concepts are represented (e.g., Caramazza & Shelton, 1998). Others propose that category-specific semantic dissociations suggest a primary organization of semantic memory in terms of semantic features having the inherent postulation that concepts are decomposable into primitive semantic features (e.g., Warrington & Shallice, 1984). There are other arguments indicating that neither model may accurately represent the nature of semantic memory organization and the nature of the representation of concepts (e.g., de Almeida, 1999, 2001).

As previously discussed, one reason for this uncertainty is that the majority of studies, on the basis of which the main models are developed, have focused attention on investigating semantic dissociations involving noun categories (e.g., the living/nonliving things dissociation) or dissociations between noun and verb categories. If we assume, following feature-specific models, that category-specific semantic dissociations emanate from selective damage to specific features of concepts labeled by noun words, then we are automatically adhering to the view that concepts are decompositional. If so, it is logical that we must expect documented cases of verb category-specific semantic dissociations resulting from selective damage to specific features from which verb concepts are presumably composed (e.g., CAUSE). However, the type of category specific semantic dissociations involving noun-labeled concepts has not been observed in patients with verb-semantic deficits, and to my knowledge there are no documented studies indicating that verb deficits can also be characterized in terms of selective damage to features such as CAUSE, which are assumed to be constitutive of verb semantic templates (Jackendoff, 1990). Although Breedin et al. (1998) and Grossman et al. (1996) have documented verb class dissociations, as discussed previously, they did not find dissociations along the lines of semantic-template internal features. This may indicate that damage to verb concepts may not occur along these lines. Also plausible is that studies on verb semantic deficits have not taken into account verb classification according to coherent semantic, and syntactic categories that may be essential for understanding categories of verb concepts and semantic knowledge representation. Additional possibilities for the present state of uncertainty regarding semantic memory organization include the great variability among different patients that makes developing inferences quite challenging, and also the fact that the majority of studies on verb-semantic deficits mainly utilize line drawings or colour photographs to depict verb concepts (e.g., Druks et al., 2006; Kemmerer & Tranel, 2000; Robinson et al., 1996). As verb stimuli, Fung et al. (2001) used computer animations that resembled human sequences- which may represent a significantly more valid way of conveying actions than pictures. Realistic short-movies of verbs, however, may represent the most ecologically valid way of conveying actions. Studies on verb processing deficits employing such stimuli to represent different classes of verb concepts (e.g., movement verbs; *walk*) have not yet been reported.

The main purpose of this study was to investigate the validity of the assumptions of the proposed models of semantic memory organization. Since the basic assumptions of these models are, to a large extent, founded on semantic dissociations involving living/nonliving things categories, this dissociation was initially explored. Mild-to-moderate DAT patients were selected for this study because the nature of semantic dissociations in this patient population remains inconclusive. Whereas there are studies indicating significantly more impaired knowledge of living than nonliving things (e.g., Fung et al., 2001; Zannino et al., 2002, 2006); there are also studies indicating no such dissociation (e.g., Garrard et al., 1998; Gonnerman et al., 1997; Tippett et al., 1996). These conflicting findings suggest the need for further research.

The investigation of living/nonliving things dissociation was followed by an examination of verb-semantic deficits in the same DAT patients. Again, further examination of verb-semantic deficits in mild to moderate DAT is important because object/action naming dissociations in this population also remain inconclusive. More specifically, there are studies suggesting object/action naming dissociations with a selective verb deficit (e.g., Cappa et al., 1998; Durks et al., 2006; Robinson et al., 1996;), object/action naming dissociations with a selective noun deficit (e.g., Williamson et al., 1998), or no such dissociations (e.g., Fung et al., 2002).

This study was motivated to a large extent by the claim made in linguistics that the behavior of a verb is in part determined by its meaning or semantics (Jackendoff, 1990; Levin, 1994). From this perspective, verb classes or categories are defined on the basis of features (semantic template constituents) that compose verb meanings, thus making them appropriate for an investigation of semantic memory organization. A brief discussion of the nature of the verbs used in this study will follow.

IV.I. Verb Classes

Lexical Causative Verbs

Lexical causatives are presumably a semantically coherent class of verbs, for all its members denote causation (Levin, 1994). More explicitly, these verbs supposedly have the semantic feature CAUSE inherent in their meanings, as represented by a semantic template such as [CAUSE [x [E]]] in which x is the agent of the main causative event and E represents a resultative event whose agent is not x but syntactically expressed by the direct object of the sentence. Thus, to use a well-known example, for the verb *Kill* in *John Killed Mary*, *John* is the agent of the main causative event while *Mary* is the agent of the resultative change-of-state DIE. Despite sharing semantic features or structure, in general, lexical causatives denote events that do not share semantic content in terms of denoting similar events. For instance, the lexical causative verbs *bounce* and *stop* denote different events such that *John bounced the ball* and *John stopped the ball* denote different activities that John performed with the ball. In both cases, however, the verbs denote that John is an agent of causation of the event of which the ball is the object that underwent a change of state or position in space. In general, these statements can be interpreted a meaning John CAUSE the ball to bounce and John CAUSE the ball to stop.

Additionally, causative verbs display a set of syntactic properties that presumably reflect the meaning components of this class (Rappaport Hovav & Levin, 1998). For example, in terms of their argument-taking properties, they assume two arguments expressed as the subject and the object (e.g., *John* and *the ball*). In summary, essentially, lexical causatives are assumed to share semantic feature or structure not content (de Almeida & Mobayyen, in press).

Movement Verbs

All verbs of motion denote bodily movement through space (e.g., *walk, jump*). Assuming a decompositional view of semantic representation, the meaning of movement verbs presumably includes the semantic feature GO. However, although all these verbs share, by assumption, the feature GO, none shares the manner of movement. In other words, they differ in their semantic representation with respect to how the movement is carried out (Levin, 1994). Thus, as a class, movement verbs are presumably less semantically coherent than lexical causative verbs. Additionally, movement is a component of many verb meanings (contact verbs; e.g., *touch, pound*). In fact, in Jackendoff's (1990) view, even verbs such as *sell* or *buy* may have the feature GO in their semantic structures in the sense that to sell or to buy something involves the movement of an object from A to B (except of course for pragmatically immovable objects such as in *John bought a castle from Mary*). In any case, sharing the feature GO does not entail similar features or a similar structure, as discussed in the case of lexical causative verbs. Rather, the meaning of movement verbs seem to be represented more on the basis of the semantic content of motion than on the primitive feature GO. For example, the verbs *walk* and *run* in *John walked home* and *John ran home* denote similar events that John performed in the sense that they both involve bodily motions and as such share semantic content. Syntactically, however, these verbs are not similar: While *walk* is considered intransitive, *run* is "preferred" intransitively (de Almeida & Mobayyen, in press).

Verbs of Perception

According to Levin's (1994) classification of verbs, the perception verbs used in this study fall under the categories of sight (e.g., *watch*) and see (e.g., *feel*) verbs. Both *sight* and *see* verbs usually take two arguments (e.g., *I saw the Mona Lisa*; *the crew observed the island*). Specifically, they take the perceiver as the subject and what is perceived as the direct object. They can, however, be used as both transitives and intransitives. As the label "perception" suggests, these verbs are tied to the actual perception of an entity, and in this sense they are semantically coherent. However, unlike lexical causatives, it is not clear whether a primitive feature is shared by all class members. One can postulate that these verbs may all share the feature PERCEIVE (Segalowitz & de Almeida, 2002). But, similar to the case of movement verbs and the feature GO, in this case also the feature PERCEIVE could be the component of some other verbs belonging to a different verb class (e.g., psychological verbs such as *fear*). Thus, it is safe to assume that perception verbs may be semantically similar in that they all share the semantic content of perception. Also, as in the case of movement verbs, perception verbs denote similar events and thus share semantic content beyond the sharing of the semantic feature PERCEIVE (de Almeida & Mobayyen, in press).

As discussed previously, the verb classes described above will be used to examine the validity of the assumptions of the main models of semantic memory organization. Since these verb classes are assumed to be semantically coherent (shared feature or content), they would be suitable candidates for investigating verb semantic/conceptual representation. Stated explicitly, by using semantically coherent verb classes, one could better identify the mechanism underlying the breakdown of verb concepts and its implications for the organization of conceptual knowledge.

IV. II. Hypotheses

Following past research (Fung et al., 2001), it was expected that DAT patients would have an overall noun (e.g., living and nonliving things) deficit characterized by a disproportionate impairment of the knowledge of living than nonliving things. More explicitly, it was expected that DAT patients would exhibit a living/nonliving things dissociation with a selective living things deficit. In addition, in keeping with past research (Warrington & Shallice, 1984), it was hypothesized that in contrast to other living items (e.g., fruits), DAT patients would be less impaired in naming *body parts* (e.g., legs), and in contrast to other non-living items (e.g., vehicles), they would be more impaired in naming *musical instruments* (e.g., piano). This hypothesis is based on the SFT proposal according to which the living things deficit is the result of damage to visual features, crucial for the recognition of living things, and the nonliving things deficit is the result of damage to functional features, crucial for the recognition of nonliving things (Warrington & Shallice, 1984).

In addition, in keeping with past research (Cappa et al., 1998), it was hypothesized that DAT patients would exhibit an overall verb-semantic deficit. On the basis of the literature, it is not clear how to hypothesize the presence and the direction of an object/action naming dissociation in DAT. As discussed before, there are studies indicating an object/action naming dissociation with a selective *noun* deficit (e.g., Williamson et al., 1996), an object/action naming dissociation with a selective *verb* deficit (e.g., Cappa et al., 1998), or no such dissociation (e.g., Fung et al., 2001). Fung et al. (2001) argue that the use of static images to convey dynamic actions may account for these conflicting findings. More specifically, they contend that actions conceptualized as "process of doing" could be best conveyed by dynamic rather than static stimuli. If dynamic stimuli indeed represented a more valid way of capturing actions than static images, it was hypothesized that patients' action naming in response to dynamic stimuli would be significantly better than their action naming in response to static pictures. Furthermore, if DAT patients did in fact exhibit an object/action naming dissociation with a selective *verb* deficit (e.g., Robinson et al., 1996), it was expected that this pattern of dissociation should hold across two different sets of stimuli, namely dynamic (e.g., short-movies) and static (e.g., pictures) stimuli.

Moreover, similar to putative category specificity involving noun-labeled concepts (e.g., living/nonliving things deficit), it was hypothesized that patients' verb-semantic deficits would also be characterized by category specificity. Following the domain-specific model, it was hypothesized that patients would have significantly more errors naming movement and perception verbs than lexical causatives. This hypothesis was based on the premise that movement and perception verbs are represented categorically on the basis of shared semantic content (de Almeida & Mobayyen, in press). If category specific semantic deficits were caused by damage to conceptual categories sharing semantic content, it was expected that patients' verb category specificity would *mainly* affect the verb categories of movement and perception verbs. Following the feature-based models, it was hypothesized that patients would have significantly more errors naming lexical causatives than movement and perception verbs. This hypothesis was based on the premise that lexical causatives are represented by a semantic template with the constant feature CAUSE (Jackendoff, 1990; Rappaprt-Hovav & Levin, 1998). If category specific deficits were caused by a selective damage to the primitive semantic features (e.g., Warrington & Shallice, 1984), it was hypothesized that this category specificity would *mainly* affect the retrieval of lexical causatives. Realistic short-movies of actions were devised to depict semantically coherent verb categories (e.g., lexical causative, movement and perception verbs).

Finally, following past research (e.g., Kemmerer & Tranel, 2000), it was expected that patients would have significantly more errors naming pictures eliciting verbs in the regularly inflected past-tense form (e.g., *chopped*) than pictures eliciting verbs in the regularly inflected present-progressive tense form (e.g., *chopping*).

Experiment 1

The goal of this experiment was to investigate whether or not mild to moderate DAT patients had a semantic deficit characterized by category dissociations along the lines of the living and nonliving things. Past research on DAT patients involving living/nonliving things dissociation remains inconclusive. In contrast to studies underlining living/nonliving things dissociation in DAT patients (e.g., Fung et al., 2001), there are studies that indicate no such dissociation in this population (e.g., Tippett et al., 1996). Some factors possibly contributing to the variability in findings are considered to be methodological limitations (e.g., a ceiling effect in the performance of the control group) and the heterogeneity characteristic of DAT patients.

On the basis of more recent studies (e.g., Fung et al., 2001; Zannino et al., 2002; 2006), where potential confounding factors were well controlled, it was expected that DAT patients would have an overall semantic deficit characterized by a living/nonliving things dissociation. More specifically, it was expected that DAT patients would be significantly more impaired in naming living than nonliving things. Moreover, in keeping with past research (e.g., Warrington & Shallice, 1984), it was expected that in contrast to other living items (e.g., fruits), DAT patients would be less impaired in naming *body parts* (e.g., *legs*), and in contrast to other non-living items (e.g., vehicles), they would be more impaired in naming *musical instruments* (e.g., *piano*).

Method

Participants

The participants were 10 DAT patients (3 males and 7 females) and 11 normal elderly controls (4 males and 7 females). All participants were native speakers of English. The DAT patients had no clinical evidence of auditory and visual impairments. They were diagnosed with Alzheimer's disease on the basis of the criteria established by the National Institute of Neurological and Communicative Disorders and Stroke, Alzheimer's disease and Related Disorders Association (McKhann et al., 1984). The patients' medical history, brain imaging (e.g., Computed Tomography), laboratory tests (e.g., blood work) and neuropsychological assessment indicated that their dementia symptoms could not be better accounted for by an illness other than Alzheimer's disease. On the basis of clinical evaluation and the Mini Mental State Examination (MMSE) scores (Folstein, Folstein, & McHugh, 1975) the patients were mildly to moderately impaired with a mean MMSE of 22.4 (S.D. = 2.45). The patients ranged in age from 67 to 92 years (mean = 77; S.D. = 8.4). Their years of education ranged from 6 to 15 years (mean = 10.7; S.D. = 2.26). Their average score on the Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 1983) was 30.2 (Table 1).

The control participants were 11 normal elderly individuals matched to the patients in terms of age (mean = 73.27; S.D. = 9.46; t (9) = 1.009, p = 0.33), ranging from 60 to 86 years, and of education (mean = 12.54; S.D. = 2.46; t (9) = -1.62, p = 0.13) ranging from 10 to 15 years. They had no clinical evidence of visual or auditory impairment, psychiatric disorders, or brain damage. Their average score on the BNT and

The MMSE tests were 55 and 28.63, respectively (Table 2). The patient and control

Table 1

Demographic information and Boston Naming Test and Mini Mental State Examination scores for 10 Alzheimer patients.

Patient	Gender	Age	Years of Education	BNT	MMSE
WAJ	F	70	10	29	26
SP	F	67	11	33	20
RH	M	74	11	38	24
JH	M	76	15	41	22
PF	F	89	11	17	25
JL	F	82	11	41	24
LMH	F	68	11	37	19
KH	F	92	6	17	19
CM	F	76	12	28	23
EH	M	76	9	21	22

Table 2

Demographic information and Boston Naming Test and Mini Mental State Examination scores for 11 control participants.

Control	Gender	Age	Years of Education	BNT	MMSE
PM	F	82	11	49	26
PT	F	63	15	56	30
HP	F	69	11	56	28
DL	F	60	11	53	28
RL	M	64	11	59	29
JB	F	71	10	53	30
LS	F	81	14	53	28
WW	M	66	17	60	30
RC	M	86	11	59	30
KM	F	81	11	55	30
JL	M	83	16	52	26

groups showed significant differences in their MMSE scores, $F(1, 19) = 49.03$, $p < .0001$, and BNT scores, $F(1, 19) = 67.74$, $p < .0001$. Informed consent was obtained from all participants and patients' caregivers prior to the study (Appendix A).

Apparatus

Stimulus presentation was controlled by a Macintosh G3 computer (laptop) running PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993). The data were collected in the computer. The experimenter also recorded the data in booklets.

Stimuli

The stimuli were derived from the Snodgrass and Vanderwart's (1980) corpus consisting of 118 line drawings of objects belonging to both living (Figure 1) and nonliving (Figure 2) categories. The set of practice trial stimuli consisted of 10 line drawings (*flower*, *cat*, *ostrich*, *sea horse*, *donkey*, *chicken*, *tree*, *leaf*, *canon*, *car*), and the set of experimental trial ctimuli consisted of 108 line drawings. In the experimental trials, the living categories (n=6) included aquatic/amphibiotic animals, insects, fruits, vegetables, terrestrial animals, and body parts. The nonliving categories (n=6) included tools, vehicles, household items, musical instruments, kitchen items, and clothing items. On the basis of the normative values (Appendix B) provided in the Snodgrass and Vanderwart's (1980) corpus, the stimuli within the semantic categories of living and nonliving things were matched according to name agreement, image agreement, familiarity, visual complexity, and lexical frequency (Francis & Kucera, 1982). Regarding the stimuli within the living subcategories (e.g., fruits), there was a significant effect of familiarity, $F(5, 47) = 30.06$, $p < .0001$, with significant mean differences

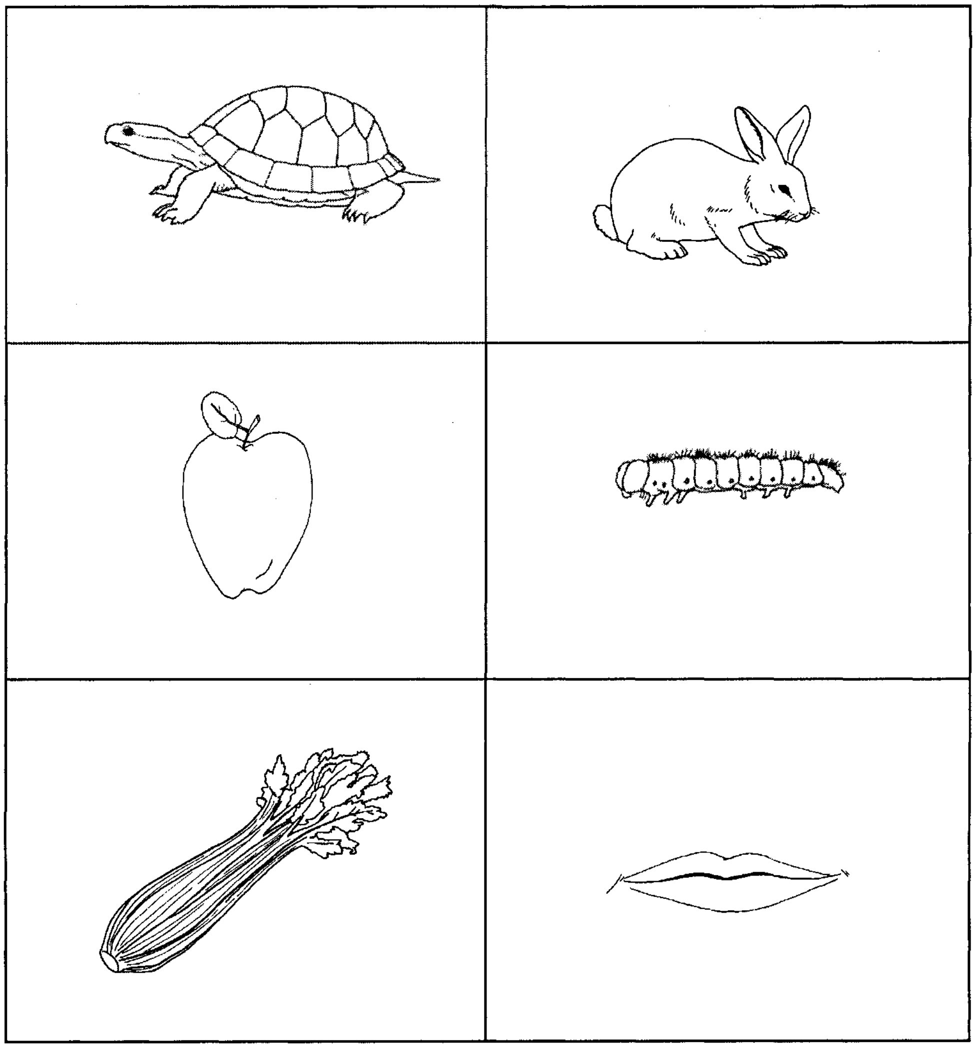


Figure 1. Snodgrass and Vanderwart's (1980) line drawings representing six subcategories of Living Things used in the study: Aquatic/Amphibiotic Animals (e.g., turtle); Insects (e.g., caterpillar); Fruits, (e.g., apple); Vegetables (e.g., celery), Terrestrial Animals (e.g., rabbit); and Body Parts (e.g., lips).

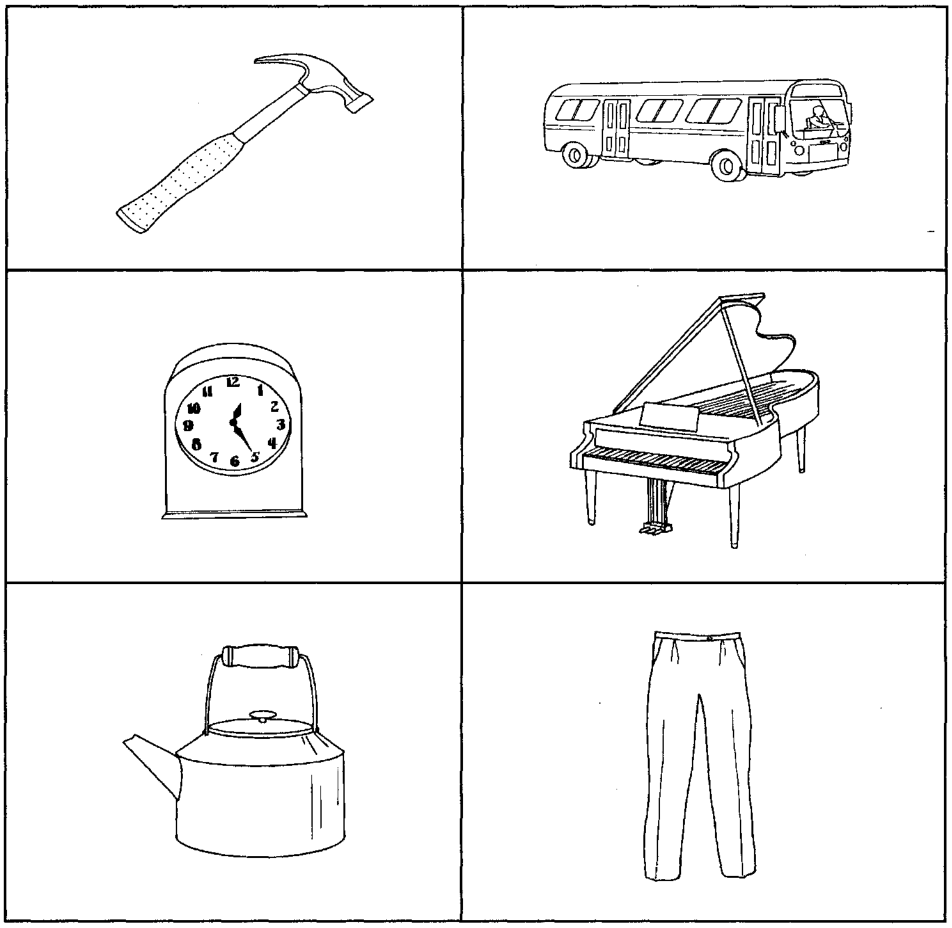


Figure 2. Snodgrass and Vanderwart's (1980) line drawings representing six subcategories of Nonliving Things used in the study: Tools (e.g., hammer); Vehicles (e.g., bus); Household Items (e.g., clock); Musical Instrument (e.g., piano); Kitchen Items (e.g., kettle); and Clothing Items (e.g., pants).

between the subcategories of aquatic/amphibiotic animals (*M* = 2.23, *SD* = 0.6) and vegetables (*M* = 3.28, *SD* = 0.3) aquatic/amphibiotic animals and fruits (*M* = 3.4; *SD* = 0.3); aquatic/amphibiotic animals and bodyparts (*M* = 4.6, *SD* = 0.1); insects (*M* = 2.35; *SD* = 0.47) and vegetables (*M* = 3.28, *SD* = 0.3); insects and fruits; insects and bodyparts; vegetables and terrestrial animals (*M* = 2.64; *SD* = 0.7); vegetables and bodyparts; fruits and terrestrial animals; fruits and bodyparts, and terrestrial animals and bodyparts. There was also a significant effect of image agreement, F (5, 47) = 9.68, $p < .0001$, with significant mean differences between the subcategories of insects (*M* = 2.83, *SD* = 0.6) and aquatic/amphibiotic animals (*M* = 3.65, *SD* = 0.3); aquatic/amphibiotic animals and fruits (*M* = 4.17, *SD* = 0.5); aquatic/amphibiotic animals and bodyparts (*M* = 4.16, *SD* = 0.3); insects and vegetables (*M* = 3.93, *SD* = 0.2); insects and fruits; insects and terrestrial animals (*M* = 3.98, *SD* = 0.4); and insects and bodyparts. A significant effect of lexical frequency was further observed, F (5, 47) = 8.38, $p < .0001$, with significant mean differences between the subcategories of aquatic/amphibiotic animals (*M* = 9.6, *SD* = 11.61) and bodyparts (*M* = 49, *SD* = 33.94); insects (*M* = 3.66, *SD* = 4.13) and bodyparts; vegetables (*M* = 9.1, *SD* = 10.48) and bodyparts; fruits (*M* = 8.3, *SD* = 7.18) and bodyparts; and terrestrial animals (*M* = 12.80, *SD* = 17.68) and bodyparts. There was no significant main effect of name agreement and visual complexity.

With regard to the stimuli within the subcategories of nonliving things (n = 6), there was a significant effect of familiarity, F (5, 49) = 9.11, $p < .0001$, with significant mean differences between the subcategories of tools (*M* = 3, *SD* = 3.20) and kitchen items (*M* = 4.28, *SD* = 0.4); tools and clothing items (*M* = 3.97, *SD* = 0.5); vehicles (*M* = 3.44, *SD* = 0.6) and kitchen items; musical instruments (*M* = 2.6, *SD* = 0.5) and household items (*M*

= 3.8, *SD* = 0.7); musical instruments and kitchen items; musical instruments and clothing items; and musical instruments and vehicles. There was also a significant effect of visual complexity, F (5, 49) = 12.01, $p < .0001$, with significant mean differences between the subcategories of tools (*M* = 2.36, *SD* = 0.4) and vehicles (*M* = 3.65, *SD* = 0.5); tools and musical instruments (*M* = 4, *SD* = 0.5); vehicles and household items (*M* = 2.5, *SD* = 0.6); vehicles and kitchen items (*M* = 2.4, *SD* = 0.6); vehicles and clothing items (*M* = 2.44, *SD* = 0.7); household items and musical instruments; musical instruments and kitchen items; and musical instruments and clothing items. The main effect of image agreement approached significance at F (5, 49) = 2.1, $p = .07$, with significant mean differences between the subcategories of tools (*M* = 3.86, *SD* = 0.6) and household items (*M* = 3.24, *SD* = 0.7); tools and clothing items (*M* = 3.34, *SD* = 0.5); household items and kitchen items (*M* = 3.82, *SD* = 0.5); and kitchen items and clothing items. There were no significant effects of name agreement, and lexical frequency.

Living Items

The items within the categories of living things were: *duck, turtle, seal, alligator, frog, fish, swan, penguin* (Aquatic/Amphibiotic Animals); *ant, bee, beetle, caterpillar, butterfly, spider* (Insects); *pineapple, banana, watermelon, cherry, pear, apple, grapes, lemon, orange, strawberry* (Fruits); *celery, carrot, potato, pumpkin, corn, mushroom, pepper, tomato, asparagus, onion* (Vegetables); *giraffe, elephant, rabbit, camel, cow, monkey, squirrel, bear, rooster, mouse* (Terrestrial Animals); *ear, eye, finger, foot, leg, lips, nose, toe, thumb* (Body Parts).

Nonliving Items

The items within the categories of nonliving things were: *pliers, nail, hammer,* *chisel, scissors, screw, screwdriver, wrench, nut, ruler* (Tools); *motorcycle, sailboat, bus, train, truck, sled, wagon, bicycle, airplane, babycarriage* (Vehicles); *lamp, couch, clock, chair, vase, stool, rocking chair* (Household Items); *flute, guitar, harp, piano, trumpet, violin, accordion, drum* (Musical Instruments); *pitcher, kettle, spoon, fork, pot, cup, saltshaker, frying pan, refrigerator, stove* (Kitchen Items); *jacket, tie, sweater, mitten, sock, skirt, shoe, shirt, pants, glove* (Clothing Items).

Procedure

Two of the patients were tested at the memory clinic of the Douglas Hospital in Montreal and the others were tested at their houses. Six of the control participants were tested in their houses in Montreal, and the other five were tested at the Hotel Dieu Hospital in Kingston. They were all tested individually in a quiet room seated in front of the computer.

The line drawings of living and nonliving things were presented one at a time. The presentation of the stimuli within each category was randomized. The participants were required to name the line drawings upon presentation with no time pressure. Their responses were recorded by both the computer and the experimenter. There was no time pressure. As there were a number of tasks in this study (e.g., object naming in this experiment, and several action naming tasks in Experiment 2 and 3), the presentation of the tasks across the participants was counterbalanced.

Scoring

Based on the predetermined target nouns provided in the Snodgrass and Vanderwart's (1980) normative data, participants' responses were scored as correct or incorrect. For each line drawing correctly named, the participants received one point. Apart from the target responses, responses considered as correct included “sofa” for “*couch*”, “trousers” for “*pants*”, “pram” for “*babycarriage*”, “sleigh” for “*sled*”, and “rat” for “*mouse*”. The scores for each participant were converted into percentages.

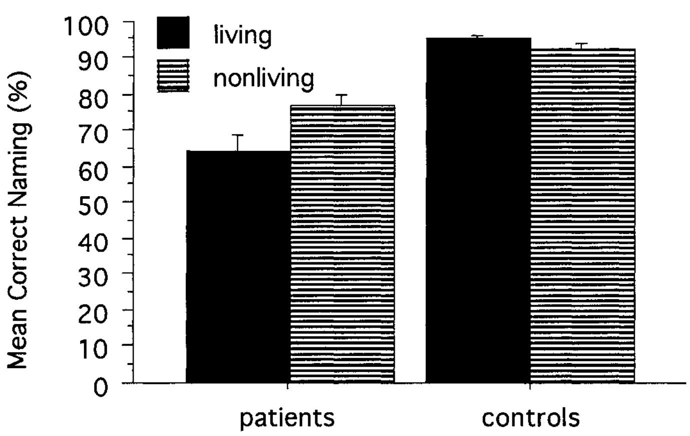
Results

The raw data comprised the participants' percentage correct naming. The statistical methods included mixed two-way and one-way ANOVAs, and post-hoc Tukey tests at the alpha level of 0.05.

To determine whether or not participants' overall naming performance significantly varied as a function of semantic category, a 2 (participants: patients, controls) by 2 (semantic category: living, nonliving) mixed ANOVA was conducted on the participants' percentage correct naming (Appendix C, Table 1). The analysis revealed a significant main effect of participants (the between factor), F (1, 9) = 50.43, p < .0001, and a significant interaction between participants and semantic category (the within factor), F (1, 9) = 13.33, p = .0053 (Figure 3). The effect of semantic category approached significance at F (1, 9) = 3.64, p = .08. To pinpoint the locus of the significant interaction, two one-way within-subjects ANOVAs were conducted (Appendix C, Table 2). The results revealed a significant effect of semantic category for the patients, F (1, 9) = 7.83, p = .021. The same analysis conducted for the controls approached significance at F (1, 10) = 4.62, p = .07.

An examination of the relative accuracy of the individual patients on the living and nonliving categories revealed that 2 out of 10 (20%) patients had living things advantage; whereas 8 out of 10 (80%) patients had a nonliving things advantage (Table 3).

To ascertain whether participants' overall naming performance within the category of living things varied as a function of the different semantic subcategories of the living category, a 2 (participants: patients and controls) by 6 (living category: aquatic/amphibiotic animals, insects, vegetables, fruits, terrestrial animals, body parts)



Participants

Figure 3. Mean percentage correct naming as a function of semantic category (living and nonliving) and participants.

Table 3

Patients' Percentage Correct Naming on Living and Nonliving Things.

Patients (n=10)	Living Things	Nonliving Things
WAJ *	79.24	76.36
SP *	71.69	65.45
RH	71.69	80.00
JH	66.03	83.63
PF	30.18	74.54
JL	84.91	89.09
LMH	69.81	90.91
KH	52.83	61.81
CM	58.49	74.54
EH	56.60	70.91

Note. " * " represents patients with a living things advantage mixed ANOVA was carried out (Appendix C, Table 3). The analysis revealed a significant main effect of the living things category (the within factor), F (5, 9) = 22.37, p < .0001, a significant main effect of participants (the between factor), F (1, 9) = 75.51, p < .0001, and a significant interaction, F (5, 45) = 5.739, p = .0004 (Figure 4). To determine the locus of the significant interaction, two one-way within-subjects ANOVAs, and subsequent post-hoc Tukey tests were carried out (Appendix C, Table 4). The results of the analyses revealed significant effects of naming for both patients, F (5, 45) = 15.30, p < .0001 and controls, F (5, 50)= 8.65, p < .0001.

Post-hoc Tukey tests carried out on the patients' data revealed significant mean differences between the subcategories of aquatic/amphibiotic animals (*M* = 57.50, *SD* = 21.40) and insects (*M* = 34.99, *SD* = 14.59); aquatic/amphibiotic animals and body parts (*M* = 88.89, *SD* = 13.85); insects and vegetables (*M* = 68, *SD* = 18.13); insects and fruits (*M* = 56, *SD* = 19.55); insects and terrestrial animals (*M* = 76, *SD* = 22.70), insects and body parts; fruits (*M* = 56, *SD* = 19.55) and body parts, and vegetables and body parts. Post hoc Tukey tests carried on the controls' data revealed significant mean differences between the subcategories of aquatic/amphibiotic animals (*M* = 96.59, *SD* = 5.83) and insects (*M* = 80.30, *SD* = 14.56), insects and vegetables (*M* = 100), insects and fruits (*M* = 96.36, *SD* = 8.09), insects and terrestrial animals (*M* = 92.27, *SD* = 4.67), and insects and body parts (*M* = 95.96, *SD* = 7.49).

Planned t-tests revealed significant mean differences between patients' and controls' naming performance on the subcategories of aquatic/amphibiotic animals, t (9) = -5.67, p = .0003; insects, t (9) = -6.37, p = .0001; vegetables, t (9) = 5.58, p = .0003; fruits, t (9) = -6.33, p = .0001; and terrestrial animals, t (9) = -3.09, p = .01. No significant mean

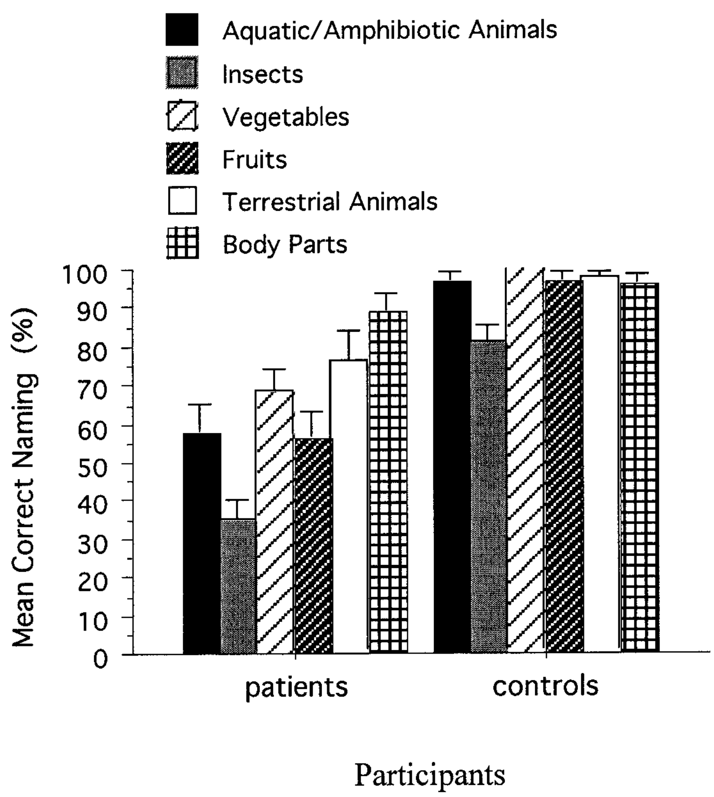


Figure 4. Mean percentage correct naming as a function of participants and living category.

differences between patients' and controls' performance on the subcategory of body parts were found.

To ascertain whether the participants' overall naming performance within the category of nonliving things varied as a function of the different semantic subcategories of the nonliving category, a 2 (participants: patients and controls) by 6 (nonliving category: tools, vehicles, household items, musical instruments, kitchen items, clothing items) mixed ANOVA was carried out (Appendix C, Table 5). The analysis revealed a significant main effect of the nonliving category (the within factor), F (5, 9) = 9.91, $p <$ .0001, a significant main effect of participants (the between factor), F (1, 9) = 36.02, p = .0002, and a significant interaction, F (5, 45) = 5.99, p = .0002 (Figure 5). To determine the locus of interaction, two one-way ANOVAs and subsequent post-hoc Tukey tests were conducted (Appendix C, Tables 6). The analyses revealed a significant effect of naming for the patients, F (5, 45)= 10.12, $p <$ .0001, but not for the controls. Post-hoc Tukey tests on the patients' data revealed significant mean differences between the subcategories of tools (M = 66, SD = 18.37) and clothing items (M = 92, SD = 10.32); vehicles (M = 85, SD = 11.78) and musical instruments (M = 55, SD = 18.81); household items (M = 85.71, SD = 20.20) and musical instruments; kitchen items (M = 85, SD = 8.49) and musical instruments; and clothing items and musical instruments; and kitchen items (M = 85, SD = 8.49), and clothing items. No significant mean differences between the subcategories of tools and musical instruments was found. Planned t-tests between patients' and controls' performance on the subcategories of nonliving things revealed significant mean differences between patients' and controls' performance on the

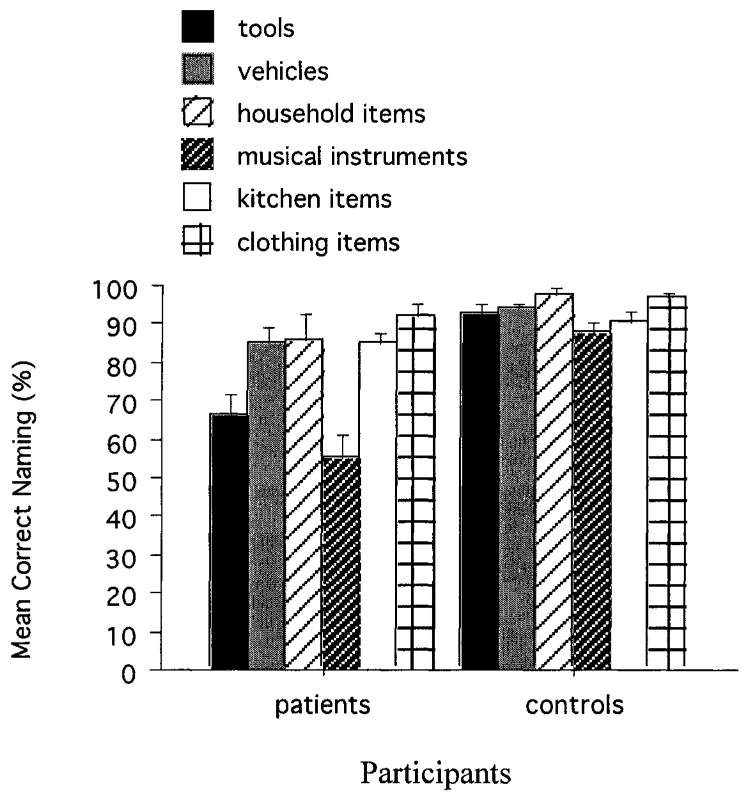


Figure 5. Mean percentage correct naming as a function of participants and nonliving category.

subcategories of musical instruments, $t(9) = -5.45$, $p = .0004$, and tools, $t(9) = -3.881$, $p = .0037$, but not other subcategories of nonliving things.

Discussion

The main objective of this experiment was to determine whether or not DAT patients' semantic deficits are characterized by living/nonliving things dissociation. It was hypothesized that patients would exhibit an overall noun-semantic deficit characterized by living/nonliving things dissociation with a selective living things deficit. Following Warrington and Shallice's (1984) SFT proposal, it was further hypothesized that patients would show narrower category-specific semantic dissociations characterized by more preserved knowledge of the subcategory of *body parts* compared to other living subcategories, and more impaired knowledge of the subcategory of *musical instruments* compared to other nonliving subcategories.

The findings revealed that DAT patients' impaired knowledge of nouns was in fact characterized by a disproportionate impairment of the knowledge of living than nonliving things. These results are consistent with those of well-controlled DAT studies (e.g., Fung et al., 2001), where line drawings (e.g., Snodgrass & Vanderwart, 1980) were also employed to depict objects.

As discussed before, both the domain and feature-specific models view the living things deficit as arising from damage to specific neural mechanisms, mainly the temporolimbic structures- presumed to be involved in storing and processing of the living things (Gainotti, 1990, Gainotti, Silveri, Daniele, & Giustolisi, 1995). In light of the finding that the neuropathological alterations in early DAT mainly concern the temporolimbic structures (Salmon et al., 1999), the observed living things deficit may corroborate the localization assumption inherent in both models, and in this sense supports both models of semantic memory organization. The present data do not specifically speak to the fine-grained disagreements between the two models mainly which element of knowledge, *category* or *feature*, constitutes the organizing principle of semantic knowledge. However, narrower category-specific deficits, specifically, the findings of significantly better performance on the subcategory of *body parts* compared to the majority of other living subcategories and significantly impaired performance on the subcategory of *musical instruments* compared to the majority of other nonliving subcategories, may be taken as support for the feature-specific models (e.g., the SFT) of semantic memory organization.

The findings indicated that although on all subcategories of living things, patients' pattern of response was similar to that of the controls, albeit marked with significant decline, patients' performance on the subcategory of *body parts* approached that of the controls in that on this subcategory, there were no significant mean differences between patients' and controls' naming performance. Also, within the patient group, the knowledge of *body parts* was significantly more preserved compared to the majority of other living subcategories (e.g., fruits, aquatic-amphibiotic animals, vegetables). This finding may be taken as support for the SFT proposal, according to which in brain-injured patients with a living things deficit, the knowledge of *body parts* remains more preserved than the knowledge of other living subcategories. This is assumed to be due to a disproportionately less impaired functional/associative features, presumed to be crucial for the recognition of *body parts*, than visual/perceptual features, presumed to be crucial for the recognition of other living subcategories such as fruits, vegetables, etc (Warrington & Shallice, 1984).

However, it is important to note that the stimuli depicting *body parts* were found to be significantly more familiar than the stimuli depicting the majority of other living subcategories (e.g., aquatic/amphibiotic animals, fruits, vegetables, and terrestrial animals). The *body parts* were also found to be significantly higher in lexical frequency than all other living subcategories. These factors, namely lexical frequency and familiarity, may have contributed to the patients' significantly better naming performance on the subcategory of *body parts* compared to other living subcategories.

Moreover, patients' naming performance on the subcategory of *musical instruments*, presumed to be contingent on visual/perceptual features, was significantly more impaired than their naming performance on the majority of other nonliving subcategories (e.g., vehicles, household items, kitchen items and clothing items), presumed to be contingent on functional/associative features. However, there was no dissociation between the subcategories of tools and musical instruments; in other words, there were no significant mean differences within the patients between the subcategories of *tools,* assumed to be recognized on the basis of functional features, and *musical instruments*, assumed to be recognized on the basis of perceptual features. This is at odds with the SFT assumptions. Also, when comparing patients' performance to the controls, patients had significantly more errors naming *musical instruments*, presumed to be contingent on visual/perceptual features, than controls. Again, patients were also significantly more impaired in naming tools, also presumed to be contingent on functional features, compared to the controls. This pattern is also at odds with the predictions of the SFT proposal.

One way to account for patients' significantly more impaired performance on the subcategory of *musical instruments* is to draw on the familiarity ratings of the stimuli depicting *musical instruments*: These stimuli were found to be significantly less familiar than the stimuli depicting all other nonliving subcategories.

According to Whatmough and Chertkow (2002), considering that stimulus factors such as familiarity and word frequency are highly correlated, they may be only pertinent depending on the experimental task at hand. For example, lexical frequency is a relevant stimulus factor in semantic tasks where printed words are used because it facilitates the reading of a word. In picture naming tasks, however familiarity ratings may be of relevance as they correlate highly with DAT patients' correct naming scores. Whatmough and Chertkow (2002) further point out that a clear understanding of the stimulus factors on the basis of which the stimuli are to be matched is also essential: "experiments that equate categories on the basis of factors that are not clearly understood could either remove effects that point to the basis of category effects or produce results that imply a superficial perceptual basis for category effects when a deeper level of explanation should be considered" (p. 193). The visual complexity factor, they point out, remains equivocal, as it is not known what the visual complexity ratings are based on.

In brief, the finding of a living things deficit in early DAT, characterized by neuropathological changes in the temporolimbic structures, presumably involved in the processing of living things, supports the localization assumption inherent in both domain and feature specific models of semantic memory. Patients' patterns of relatively intact and impaired knowledge of subcategories of living (e.g., *body parts*), and nonliving (e.g., *musical instruments*) things, respectively may be taken as support for the SFT proposal. However, it is essential to note that frequency and familiarity effects may have contributed to the patients' better naming of *body parts* in contrast to other living subcategories. Similarly, a familiarity effect may have contributed to the patients' more impaired naming of *musical instruments* in contrast to other nonliving subcategories.

One limitation of this study is the use of black and white line drawings to depict objects. Montanes, Goldblum, and Boller (1995) found that when colour pictures were used to represent living and nonliving things, DAT patients did not show any category effect. Thus, in future studies, the use of such ecologically valid stimuli is of importance. Another limitation of this experiment is the fact that the values used to match the stimuli on factors such as familiarity were taken from the Snodgrass and Vanderwarts' (1980) standardized norms. These norms are derived from undergraduate students, who are considerably younger and more educated than DAT patients. However, the inclusion of age- and education-matched control participants, whose performance on the majority of the stimuli did not approach ceiling, to some extent compensated for this shortcoming.

In the following experiments, data from this experiment are used to evaluate other dissociations, documented in early DAT, namely object/action naming dissociation-whose nature in the DAT population remains unclear. Similar to Fung et al.'s (2001) study, the percentage accuracy scores of the living and nonliving things would be used to examine patients' naming of objects as opposed to actions.

Experiment 2

The main purpose of this experiment was to determine if patients had an overall verb-semantic deficit. An additional goal was to investigate whether or not patients exhibited an object/action naming dissociation, using patients' object-naming data obtained in Experiment 1. As discussed previously, past research involving an object/action naming dissociation in DAT remains inconclusive. There are DAT studies that indicate more preserved knowledge of nouns relative to verbs (e.g., Robinson et al., 1996), more preserved knowledge of verbs relative to nouns (e.g., Williamson et al., 1998), or no such dissociation (e.g., Fung et al., 2001). DAT studies demonstrating more preserved knowledge of verbs than nouns (e.g., Williamson et al., 1996) explain their findings by suggesting that similar to the knowledge of nonliving things, the knowledge of verbs is predominantly processed by the frontoparietal structures that may remain better preserved in early DAT. Similar to living things, however, objects/nouns in general are mediated by the temporolimbic structures that are affected early in the course of the disease (e.g., Williamson et al., 1998). DAT studies indicating more preserved knowledge of nouns than verbs explain their findings by suggesting that the meaning representation of verbs makes them more susceptible to damage than nouns (e.g., Robinson et al., 1996). More specifically, the semantic representation of nouns is taken to be hierarchical consisting of several levels with members of the same semantic category sharing many common features. This allows for more redundancy making noun concepts easier to retrieve, and more resistant to damage. The semantic representation of verb concepts, however, is assumed to be "matrix-like" with fewer levels and fewer shared features. This makes them more difficult to retrieve and more vulnerable to damage (Robinson et al., 1996).

Aside from the above-mentioned explanations, it is not unlikely that the conflicting findings pertaining to object/action naming dissociation could be to some extent a function of the variable stimuli employed to depict verbs (Fung et al., 2001). For example, Cappa et al. (1998), Williamson et al. (1996) and Druks et al. (2006) used line drawings of actions (e.g., The Action Naming Test, Nicholas et al., 1985; An Object and Action Naming Battery, Druks & Masterson, 2000), and Fung et al. (2001) used both line drawings (the Action Naming Test; Olber & Albert, 1982), and computer animations resembling human action sequences. As Fung et al. (2001) cogently argue, actions conceptualized as "process of doing" could be best conveyed by dynamic (e.g., computer animations) rather than static (e.g., line drawings) images.

In this experiment, object/action naming dissociation was investigated using colour photographs of actions derived from Fiez and Tranel's (1997) standardized Action Naming Test Battery and the object naming data obtained in Experiment 1. The Fiez and Tranel's (1997) Action Naming Test consists of a large set of colour photographs that are matched according to factors such as visual complexity, familiarity, lexical frequency (Francis & Kucera, 1986), and image agreement. It also includes standardized administration and scoring procedures.

An additional objective of this experiment was to explore whether or not there are subtypes of dissociation within verbs involving inflectional-tense morphemes (regular past-tense; e.g., *-ed* vs. present progressive tense; e.g., *-ing*). Double dissociations between regularly and irregularly inflected verbs have been documented in patients with focal brain damage such as aphasic patients (Marslen-Wilson & Tyler, 1997), and in patients with widespread brain lesions such as patients with DAT and Parkinson's disease

(Ullman et al., 1997). Ulman et al. (1997), for example, reported that anterior-lesion aphasic patients and patients with Parkinson's disease had greater difficulty producing past-tense forms for nonwords than for irregular verbs. The posterior lesion aphasic patients and patients with DAT, however, had more difficulty generating past tense forms for irregular verbs than for nonwords. Fiez and Tranel's (1997) Action Naming Test provided the opportunity to explore double dissociations between past (*-ed*) and present progressive (*-ing*) tense verbs in DAT- an examination that to my knowledge has not been reported to date. In keeping with previous research (e.g., Kemmerer & Tranel, 2000), it was expected that patients would have significantly more errors naming regularly inflected past-tense verbs (*-ed*) as compared to verbs in present progressive (-*ing*).

Method

Participants

The same DAT patients and normal elderly controls participating in Experiment 1 comprised the participants.

Apparatus

The apparatus was the same as the one used in Experiment 1. As in Experiment 1, the data were collected in the computer. The experimenter also recorded the data in booklets.

Stimuli

The stimuli consisted of 103 single (Figure 6) and paired (Figure 7) colour photographs of actions that constituted the standardized Action Naming Test developed by Fiez and Tranel (1997) (Appendix D). The practice trials consisted of 8 colour photographs (4 single and 4 paired), and the experimental trials consisted of 95 colour photographs (75 single and 20 paired). A few modifications to Fiez and Tranel's (1997) standardized Action Naming Test were made (see Appendix D for the version used in the study). These modifications included removing five paired colour photographs eliciting irregular past-tense action responses including *Lit*, *Broken*, *Torn*, *Sprouted*, *Closed/Shut*, and removing ten single colour photographs (and replacing them with ten other colour single photographs from the original Fiez and Tranel's Test Battery) eliciting gerundial action responses including *bouncing/dribbling*, *peeking*, *squeezing*, *bending*, *looking*, *spilling/spilled*, *twisting/winging*, *tiptoeing*, *skating*, *walking/strolling*. The pictures eliciting these gerundial forms were instead used in the development of movie stimuli in Experiment 3.

On the basis of the values provided in the Fiez and Tranel's (1997) normative data

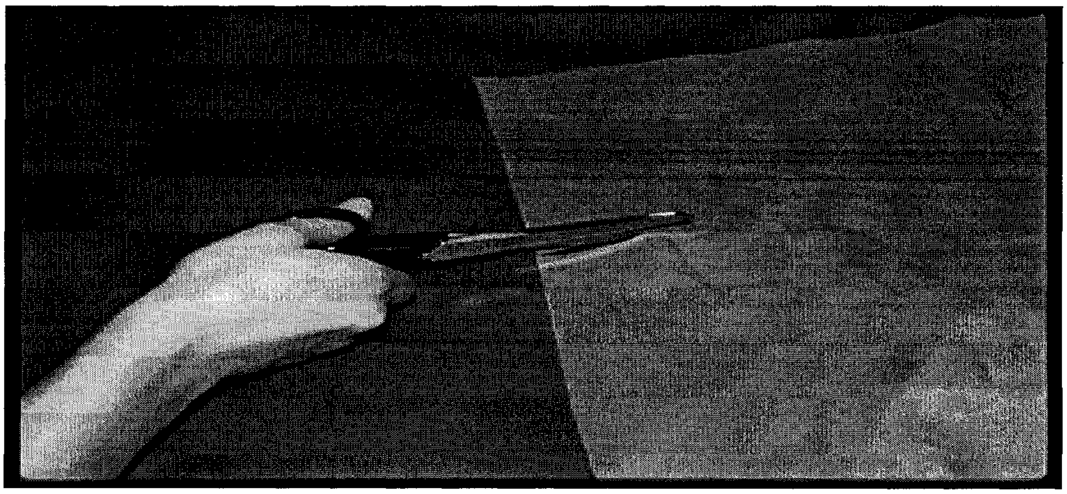


Figure 6. Single colour photograph of action derived from Fiez and Tranel's (1997) Action Naming Test depicting the action "*Cutting*".

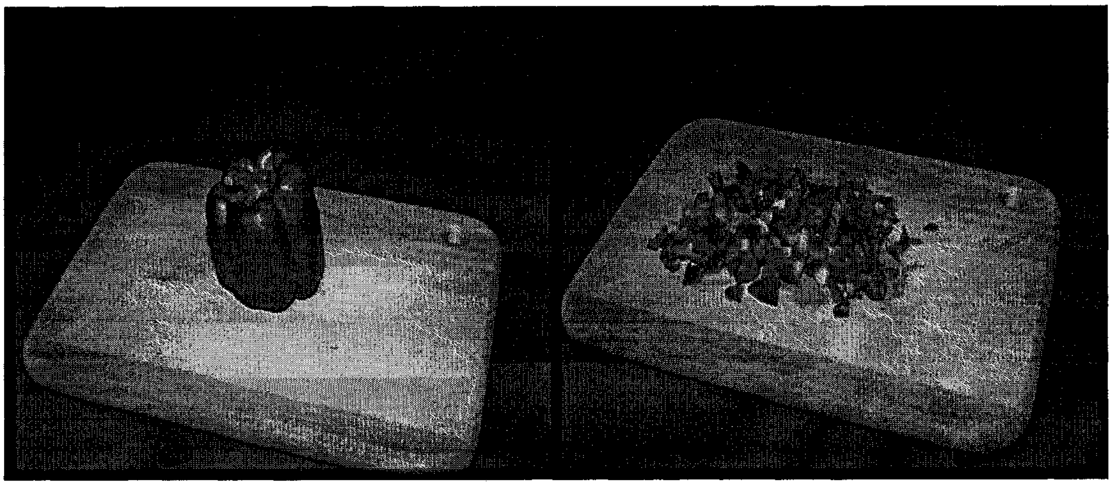


Figure 7. Paired colour photograph of action derived from Fiez and Tranel (1997) Action Naming Test depicting the action *"Chopped"*.

(Appendix E), the single and paired photographs were matched according to image agreement, name agreement, visual complexity, familiarity, and lexical frequency (Francis & Kucera, 1982). The object-naming data obtained in Experiment 1 (the accuracy scores for living and nonliving things), and the single colour photographs of actions were used to examine object/action naming dissociation. Analyses- using values provided in the Snodgrass and Vanderwart's (1980) and Fiez and Tranel's (1997) corpora- revealed significant mean differences between the two sets of stimuli (line drawings of objects and pictures of actions) in terms of name agreement, F (1, 181) = 11.75, $p = .0008$, image agreement, F (1, 181) = 9.67, $p = .002$, familiarity, F (1, 181) = 6.57, $p = .01$, and lexical frequency, F (1, 181) = 17.76. $p < .0001$. The mean difference in visual complexity between the two sets of stimuli approached significance at $p = .05$.

Single photographs depicting ongoing actions

There were 75 single photographs depicting agents engaged in ongoing action, and thus eliciting present progressive forms of verbs (e.g., *cutting*).

Photograph-pairs depicting a change of state or event

There were 20 pairs of photographs depicting a change of state or event. One picture item in the pair depicted a person/object before something happened, and the other item depicted the same person/object after something happened. The stimuli thus elicited regularly inflected past-tense forms of verbs (e.g., *chopped*). The Adobe Photoshop program was used to attach two single colour photographs that together represented an action occurring in the past.

Procedure

There were two tasks, one consisting of single photographs and the other consisting of paired photographs of action. The presentation of the stimuli within each task was randomized. As mentioned earlier, the presentation of the tasks devised for this study was counterbalanced across the participants. The participants were instructed to name each picture or picture pair with a single-word answer (e.g., *running, chopped*) that best characterized the action. They were told that only verbs should be used and that other kinds of words and phrases should be avoided. They were also told to include the proper inflection on all verbs (e.g., -*ing*). The experimenter closely followed the administration procedure provided in the Fiez and Tranel's (1997) Action Naming Test. There was no time pressure.

Scoring

On the basis of predetermined target verbs provided in the Fiez and Tranel's (1997) Action Naming Test, participants' responses were scored as correct or incorrect. For each photograph correctly named, the participants received one point. The scores for each participant were converted into percentages.

Results

The raw data comprised the participants' percentage correct naming. The statistical methods included mixed and between- and within-subjects ANOVAs, and post-hoc Tukey tests at the alpha level of 0.05.

Patients' overall verb-semantic deficit was examined by conducting a one-way between-subjects ANOVA (Appendix F, Table 7). The analysis revealed a significant effect of participants, F (1, 19) = 66.54, $p < .0001$ (Figure 8).

To examine if patients' knowledge of verbs significantly differed from their knowledge of nouns, a 2 (participants: patients, controls) by 2 (semantic category: objects/nouns and actions/verbs) mixed ANOVA was carried out (Appendix F, Table 8). The analysis revealed a significant main effect of semantic category (the within factor), F (1, 9) = 38.92, $p = .0002$, a significant main effect of participants (the between factor), F (1, 9) = 112.01, $p < .0001$, and a significant interaction, F (1, 9) = 34.20, $p = .0002$ (Figure 9). To pinpoint the locus of the significant interaction, two one-way within-subjects ANOVAs were conducted on patients' and controls' data (Appendix F, Table 9). The analyses resulted in a significant effect of semantic category for *both* patients, F (1, 9) = 41.008, $p = .0001$, and controls F (1, 10) = 25.494, $p = .0005$.

To determine whether participants' action naming differed as a function of the single and paired pictures eliciting verbs in the present (*-ing*) and past-tense (regular past tense) forms, respectively, a 2 (verb inflection: regular past-tense, present progressive) by 2 (participants: patients, controls) mixed ANOVA was carried out (Appendix F, Table 10). The analysis revealed a significant main effect of verb inflection (the within factor), F (1, 9) = 17.451, $p = .0024$, a significant main effect of participants (the between factor), F (1,

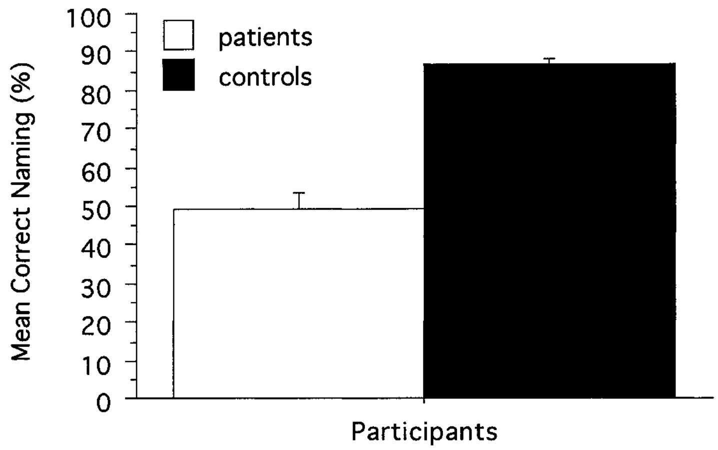
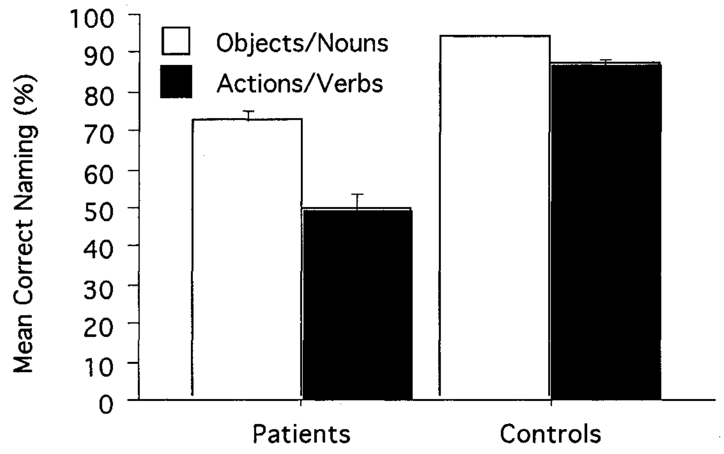


Figure 8. Participants' mean percentage correct action naming.



Participants

Figure 9. Mean percentage correct action naming as a function of semantic category (nouns and verbs) and participants.

9) = 122.348, $p < .0001$, and a significant interaction, F (1, 9) = 66.56, $p < .0001$ (Figure 10).

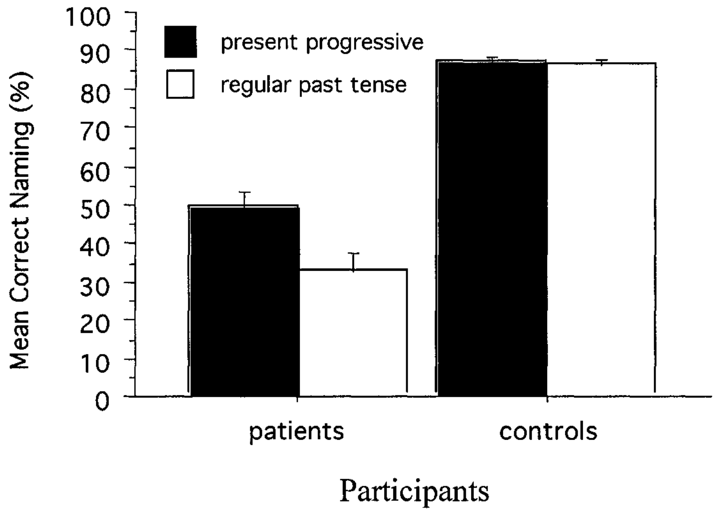


Figure 10. Mean percentage correct naming as a function of verb inflection (present progressive and regular past tense) and participants.

Discussion

The main objective of Experiment 2 was to investigate the hypothesized verb-semantic deficit in DAT patients. Investigating the presence of an object/action naming dissociation and dissociations within verbs (present-progressive vs. past-tense) constituted additional goals. It was hypothesized that patients would have significantly more errors naming picture-pairs eliciting regularly inflected past-tense verbs (e.g., *chopped*) than single pictures eliciting verbs in the present-progressive (e.g., *chopping*).

As hypothesized, the findings suggested that patients had a verb-semantic deficit and an object/action naming dissociation with significantly more errors naming actions than objects. However, similar to Druks et al.'s (2006) findings, the pattern of object/action naming dissociation observed in the patients was also observed in the controls. Studies linking cognitive function to neuroanatomy indicate that an object/action naming dissociation with a selective *verb* deficit is associated with lesions in the inferior frontal gyrus (frontoparietal structures). An object/action naming dissociation with a selective *noun* deficit, however is associated with lesions extending to the inferior temporal gyrus (temporolimbic structures) (Druks et al., 2006). The finding of an object/action naming dissociation with a selective action-naming difficulty not only in the patients but also in neurologically intact control groups may challenge such explanations.

A more plausible explanation is to suggest that the observed object/action naming dissociation in both patient and control groups is to some extent a function of the stimuli employed to depict verbs. The verb stimuli used consisted of static colour pictures that may not be suitable (or ecologically valid) for depicting dynamic actions. As Fung et al. (2001) point out, static images such as pictures do not capture the time dimension that is pivotal to a complete representation of concepts lexicalized by verbs. One could further contend that the use of static images to convey actions may have contributed to the significant mean differences between the noun and verb stimuli in terms of factors such as name agreement, image agreement, and familiarity, factors found to represent distinct characteristics of pictured stimuli (Snodgrass & Vanderwart, 1980). In Kemmerer and Tranel's (2000) study, where the same single, colour pictures were used as verb stimuli, stimulus factors such as familiarity, image agreement, and name agreement were found to facilitate verb retrieval. In brief, it is not farfetched to suggest that the specific properties of the verb stimuli (e.g., stimulus factors such as familiarity, and their ecological validity) could have partially contributed to the observed object/action naming dissociation in both the patient and control groups.

Furthermore, the verbs elicited by static pictures were found to be significantly more frequent than the nouns elicited by the line drawings (the data for the nouns was obtained in Experiment 1). There are studies indicating that lexical frequency is not a significant predictor of word retrieval (e.g., Druks et al., 2006; Morrison, Ellis, & Quinlan, 1992). Name agreement, on the other hand, has been underscored as a prominent predictor of object and action naming accuracy (e.g., Kan & Thompson-Schill, 2004). In the present experiment, the verb stimuli were found to have significantly less name agreement compared to the noun stimuli. Clearly, the use of ecologically valid stimuli to depict actions could facilitate a matching of noun and verb stimuli on the basis of name agreement.

An insightful extension of this study would be a further investigation of object/action naming dissociation employing ecologically valid verb stimuli such as short-movies of actions. This would allow for the opportunity to build on the present findings by examining verb-semantic knowledge, and object/action naming dissociation, if any, in response to two different sets of verb stimuli, namely static pictures, using data from this experiment, and short-movies of actions. The use of short-movies of actions would be reported in Experiment 3.

Moreover, unlike the controls, the patients had significantly more errors naming picture-pairs eliciting regularly inflected verbs in the past-tense than single pictures eliciting verbs in the present-progressive. In other words, in DAT patients, present progressive and regular past-tense verbs dissociated from one another. It is important to note that the patients did not seem to have difficulty generating the tense-morpheme, *ed*, per se, rather they had difficulty generating the regularly-inflected past-tense verb in its entirety.

One could postulate that perhaps the syntactic properties (the number of associated arguments) of past and present-progressive verbs contributed to DAT patients' present-progressive/past-tense dissociation. According to the Argument Structure Complexity (ASC) proposal expounded by Thompson (2003), verbs with additional arguments, being syntactically more complex, generate more retrieval errors than verbs with less associated arguments. This is explained by suggesting that, as verbs become syntactically more complex, they may require more processing resources rendering their retrieval more difficult. Support for the ASC proposal is derived from studies on agrammatic patients indicating that verbs' syntactic properties (the number of associated arguments) largely affect their verb retrieval (e.g., Kim & Thompson, 2004): for example, agrammatic patients exhibit significantly more errors retrieving "three-place" verbs (e.g., *the boy is* *leaning the ladder against the wall*) than "two-place" verbs (e.g., *the girl is drying the dishes*), and significantly more errors retrieving two-place verbs than "one-place" verbs (e.g., *the dog is barking*).

A close examination of the verbs used in this experiment indicated that among past-tense verbs, 85% included one-place (e.g., *she turned*) and 15% included two-place (e.g., *she framed the picture*) verbs. Among the verbs in the present-progressive, 42.7% included two-place (e.g., *she is kicking the ball*) and 57.3% included one-place (e.g., *she is smiling*) structures. Thus, it appears that the number of two-place verbs associated with more errors, is in fact markedly less among verbs in the past tense (15%) than among those in the present-progressive (42.7%). Nonetheless, patients exhibited more difficulty retrieving verbs in the past than present-progressive. This may suggest that a greater number of arguments may not have contributed to the greater number of errors associated with past-tense verbs. Support for this assumption is derived from studies indicating that unlike agrammatic patients, DAT patients' verb deficits are not associated with verb syntactic complexity involving the number of associated arguments. (e.g., Kim & Thompson, 2004). In fact, a selective semantic deficit, as opposed to a syntactic deficit has been shown to underlie DAT patients' verb processing deficits (e.g., Kim & Thompson, 2004).

On the basis of the above, one may conclude that a selective semantic deficit may be a likely contributor to the patients' present-progressive/ past-tense verb dissociation with a selective past-tense verb deficit. This conclusion is also based on the premise that semantic information may be instrumental to understanding verb morphology involving tense (past and present). In other words, semantic information may be essential in disambiguating the inflectional morphology of verbs (*drop→ dropped; ring →rang/wrung*) (Plunkett & Bandelow, 2006).

Another way to explain the observed pattern of present-progressive/past-tense verb dissociation is to consider the demands of the employed task in which paired static images were used to convey actions containing an explicit time dimension (e.g., *chopped)*. It may be quite demanding for DAT patients to *infer* a change of state or event occurring within a time dimension on the basis of paired static images (e.g., before something happened, and after something happened). Even more demanding is the use of these stimuli in a production task that requires the DAT patients to activate a pool of plausible candidate concepts, and from among those, *select* only one appropriate concept that best maps onto the presented picture (Kemmerer et al., 2001). The observed pattern of dissociation thus may also reflect task demands in patients who have a fundamental semantic deficit. In future studies, the use of a comprehension task, in addition to a production task, may shed more light on the nature of the observed present-progressive/past-tense verb dissociation.

In brief, the results of this experiment indicated that DAT patients have a significant verb-semantic deficit. Object/action naming dissociation was observed in both the patient and control groups. The findings further showed that the patients exhibited a present-progressive/past-tense verb dissociation with a selective deficit involving regularly inflected past-tense verbs.

One objective of the following experiment is to further build on the object/action naming dissociation observed in this experiment, this time employing short movies of actions. As discussed before, this would allow for an investigation of patients' verb knowledge in response to two sets of verb stimuli, static (pictures), and dynamic (short-movies).

Experiment 3

The main purpose of Experiment 3 was to investigate whether DAT patients' verb-semantic deficit was characterized by category-specificity. As discussed previously, the main models of semantic memory organization have been developed on the basis of impaired and spared conceptual categories involving noun-labeled concepts (e.g., the living/nonliving things dissociation). Although it is likely that classes of events, lexicalized by verbs with different semantic properties, could engender different types of verb category-specific dissociations, there are very few studies examining such category dissociation (e.g., Grossman et al., 1996, Breedin et al., 1998). As discussed previously, Breedin et al. (1998), and Grossman et al. (1996) have documented verb-semantic dissociations in brain-injured patients. But, they did not find verb-semantic dissociations along the lines of semantic content or semantic-template internal features. It is possible that such studies did not consider classifications according to semantically coherent verb categories that may be instrumental for an understanding of the mechanism (e.g., feature or content) underlying the break down of verb concepts. The identification of such a mechanism would allow for a better understanding of the implications patterns of verb-semantic impairments may have for the models of semantic memory organization.

Additionally, studies on verb-production deficits mainly use static images such as colour pictures (e.g., Kemmerer & Tranel, 2000) to depict verb concepts. However, as Fung et al. (2001) argue, dynamic actions and events lexicalized by verbs are best conveyed by dynamic stimuli such as realistic short-movies of actions. To date, there are no documented studies in which realistic short-movies of actions have been used to investigate verb category specific semantic dissociations.

An objective of Experiment 3 was to examine verb category-specific semantic deficits using realistic, short-movies of actions that depicted semantically and syntactically coherent verb classes. An action-naming test comprising realistic short-movies was specifically developed for this experiment. The development of this test allowed for an investigation of patients' action naming across two different sets of verb stimuli: the newly developed short-movies, and the single colour pictures of actions (using data obtained in Experiment 2). Experiment 3 was also intended for a further exploration of patients' noun knowledge relative to their verb knowledge using patients' object-naming (Experiment 1) and action-naming (short-movies) data.

If dynamic stimuli indeed represented a more valid way of depicting actions than static pictures (Fung et al., 2001), it was hypothesized that patients' action naming in response to the short-movies (dynamic stimuli) would be significantly better than their action naming in response to the single colour pictures (static stimuli). Further, if patients did in fact have an object/action naming dissociation with a selective *verb* deficit (e.g., Cappa et al., 1998; Robinson et al., 1996), it was hypothesized that this dissociation should hold across the two different sets of stimuli used to depict verbs: static pictures and dynamic short-movies.

Moreover, following the domain-specific models, it was hypothesized that patients would have category-specific verb-semantic impairments, specifically affecting the class of movement and perception verbs. In other words, it was expected that patients would have significantly more errors retrieving movement and perception verbs, presumed to share *semantic content*, than lexical causatives, presumed to share *semantic feature*, CAUSE. This hypothesis was based on the assumption of domain-specific models according to which category-specific semantic deficits arise from a selective damage to conceptual categories that may comprise concepts that share *semantic content* (Caramazza & Shelton, 1998). Concepts are assumed to be organized categorically on the basis of shared *semantic content*, and damage at the level of *semantic content* would result in category-specific semantic impairments.

Following the feature-specific models, it was hypothesized that patients would have category-specific verb semantic impairments specifically affecting the class of lexical causatives. The expectation was that patients would have significantly more errors retrieving lexical causatives, presumed to share *semantic feature* CAUSE, than movement and perception verbs, presumed to share *semantic content*. As discussed before, this prediction was based on two fundamental assumptions of the feature-specific models: (1) The class of lexical causative verbs is represented on the basis of a semantic template whose main constant is the semantic feature CAUSE (e.g., Jackendoff, 1990); (2) Semantic dissociations arise from selective damage to specific semantic features from which concepts are composed (e.g., Warrington & Shallice, 1984).

Finally, an error analysis was conducted to better understand the nature of patients' action-naming errors and its implications for the representation of verb concepts.

The investigation of verb category specific semantic impairments involved two analyses: one analysis with participants' performance on the whole set of movies and another on a subset of movies, which were normalized for naming agreement.

Method

Participants

The same DAT patients and normal elderly individuals participating in the previous experiments comprised the participants.

Apparatus

The apparatus was the same as the one used in Experiment 1 and 2.

Stimuli

Twenty-nine realistic movies of action were shot by Nite Vision productions. In order to maintain visual similarity, a small number of actors (n = 3) were employed, and the same filming background was used. To reduce visual complexity, an attempt was made to restrict the focus of the movie to the part of the scene necessary to portray the action. The raw video was transferred to a Macintosh computer equipped with the iMovie program. Using the iMovie program, the unwanted movie frames were cropped and the length of movies was made consistent.

The movies belonged to three different verb categories consisting of lexical causative verbs (Figure 11), movement verbs (Figure 12) and perception verbs (Figure 13).

<u>Lexical Causatives</u>

The lexical causative verbs included *peeling, bending, twisting, crumpling, flipping, squeezing, crushing, spilling, folding,* and *bouncing*. During the filming of these verbs, one agent was present in the scene interacting with an object (e.g., *squeezing* an orange). Some of Fiez and Tranel's (1997) colour pictures (e.g., *bouncing/dribbling*, *squeezing*, *bending*, *spilling/spilled*, and *twisting/wringing*) were used as models.

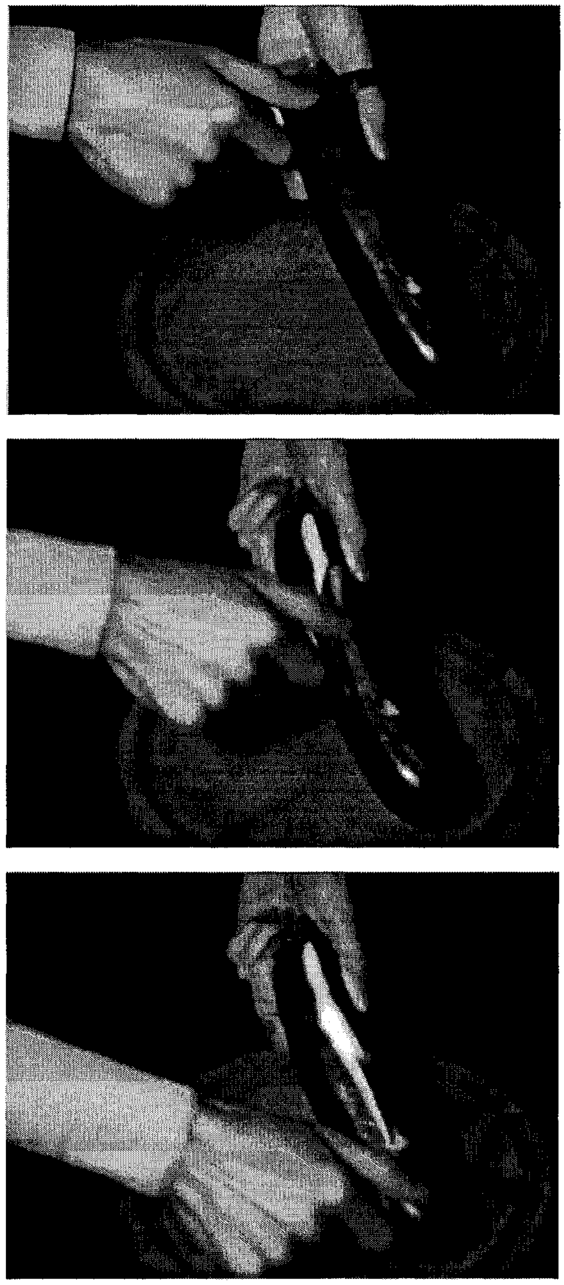


Figure 11. Movie frames depicting "*Peeling*" belonging to the category of Lexical Causatives.

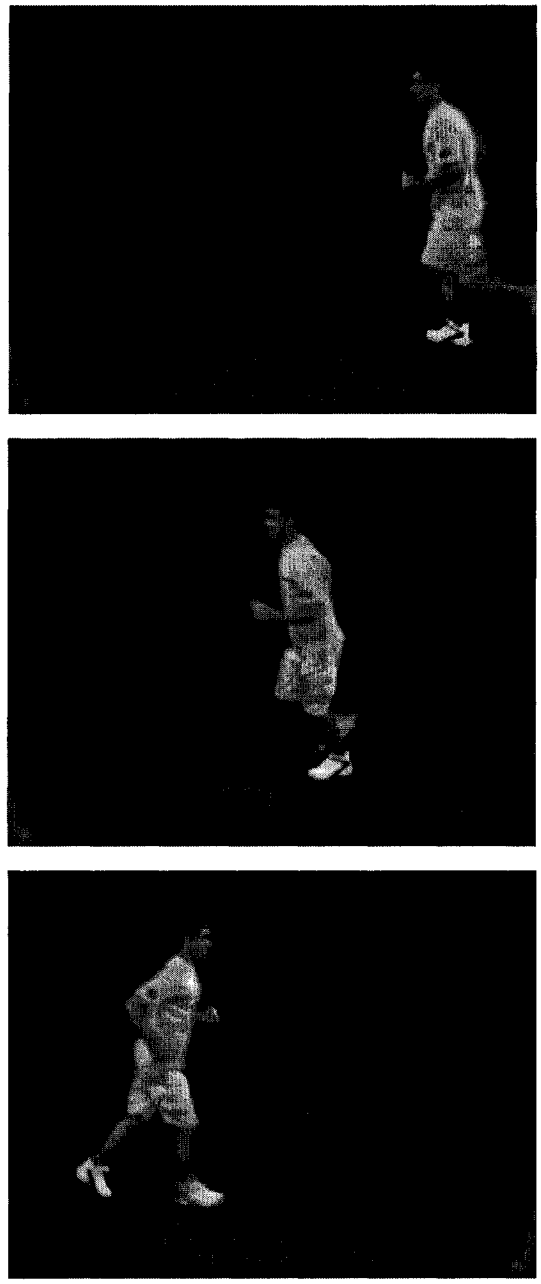


Figure 12. Movie frames depicting "*Running*" belonging to the category of Movement verbs.

Figure 13. Movie frames depicting "*Listening*" belonging to the category of Perception verbs.

Movement Verbs

The movement verbs consisted of *tiptoeing, skating, walking, running, climbing, hopping, leaping, swinging, rolling,* and *crawling*. In the movie scenes, there was one agent who either interacted with an object (e.g., *climbing* a ladder, *swinging* in a swing) or moved (e.g., *tiptoeing, skating, walking, running, hopping, leaping, rolling and crawling*).

Perception Verbs

The perception verbs were *scanning, looking, smelling, peeking, glaring, staring, listening, tasting,* and *watching.* The movie scenes involved one agent, except for the depiction of *staring*, where two agents were required. The agent either interacted with an object (e.g., *smelling* a flower, *watching* TV, *scanning* a paper, *tasting* yogurt), or simply appeared to perceive (e.g., *looking, peeking, glaring, listening, staring*) using hands and facial expressions (e.g., *listening, looking, peeking*), or facial expressions, only (e.g., *glaring, staring*).

Fiez and Tranel's (1997) colour pictures of *looking*, *smelling*, *peeking*, *glaring*, *listening*, and *watching* were used in the development of the short movies depicting these actions.

Procedure

The procedure in terms of the location of testing and the number of patients and controls tested in different locations was the same as the one adopted in Experiment 1 and 2. The movie stimuli were presented randomly and one at the time. The participants were required to tell the experimenter, in response to her question, what the person in the movie was doing, under no time pressure. The participants were instructed not to provide a response until after the experimenter had presented them with a question (e.g., what is the person doing?). In response to the question, the participants were instructed to provide one-word responses (gerundial verbs; e.g., *bouncing*), and to avoid definitions and descriptions. The participants' responses were recorded by both the computer and the experimenter.

Following Fiez and Tranel's (1997) standardized instruction included in their Action Naming Test, for the movie stimuli depicting *hopping*, *tasting*, and *peeling* the participants were prompted to provide a second response (e.g., what kind of jumping? what would be a more specific word describing the action besides eating? what kind of cutting), if their first responses included *jumping*, *eating,* and *cutting* respectively.

Scoring

For each movie correctly named, the participants received one point (see Table 4 for a list of responses - other than target responses - that were also scored as correct). Responses that were provided in the context of a sentence (e.g., she is *climbing up* the ladder), despite instructions and prompting, were scored as correct. The scores for each participant were converted into percentages. To view responses scored as incorrect see Appendix I.

Table 4

Participants' responses to the short-movies of actions that were also scored as correct.

Action/Target response	Responses Also Scored as Correct
Folding	Folding up
Twisting	Wringing
Spilling	Spilled; Spilt
Bouncing	dribbling; Bouncing a ball
Glaring	Squinting
Running	Jogging; Slow jog
Rolling	Rolling over, Rolling around
Skating	Rollerblading; Rollerskating
Leaping	Leapfrog; Leapfrogging
Climbing	Climbing up
Peeling	Cutting
Flipping	Tossing
Scanning	Searching; Checking
Watching	Watching TV; Watching a computer screen
Crawling	Crawling on the floor
Hopping	Jumping
Walking	Strolling
Crushing	Breaking; Destroying
Crumpling	Crushing; Scrunching

Results and Discussion

The main purpose of Experiment 3 was to determine if patients' verb-semantic deficits were characterized by category specificity. If so, the goal was to examine the implications of the pattern of category-specificity for the main models of semantic memory organization. Following feature-specific models, it was hypothesized that patients would exhibit significantly more errors retrieving lexical causatives than movement and perception verbs. Following domain-specific models, it was hypothesized that patients would exhibit significantly more errors naming movement and perception verbs than lexical causatives. Additional goals included a further examination of object/action naming dissociation, as well as an examination of patients' action naming in response to two different sets of stimuli: static (e.g., colour pictures) and dynamic (e.g., realistic short-movies). If dynamic stimuli depicted actions significantly better than did static images (Fung et al., 2001), it was hypothesized that patients' action naming in response to the short movies (dynamic stimuli) would be significantly better than their action naming in response to the colour pictures (static pictures). Further, if patients did in fact exhibit an object/action naming dissociation with a selective *verb* deficit (e.g., Cappa et al., 1998; Robinson et al., 1996), it was hypothesized that this pattern of dissociation should hold across the two sets of verb stimuli used: short-movies and static pictures.

The raw data consisted of participants' percentage correct naming. The statistical methods employed included two-way and one-way between-subjects and within-subjects ANOVAs, and post-hoc Tukey tests at the alpha level of 0.05.

Dynamic Action Naming

Data derived from all the short-movies (n=29) devised for Experiment 3 were used to investigate whether the patients exhibited an overall verb-semantic deficit characterized by category specificity.

In order to establish whether patients had an overall verb-semantic deficit, a one-way between-subjects ANOVA was conducted (Appendix H, Table 11). The analysis revealed a significant effect of participants, F (1, 19) = 31.78, $p < .0001$ (Figure 14). Similar to the findings of Experiment 2, this finding indicates that DAT patients may have a significant verb-semantic deficit.

Verb category specificity was examined by conducting a 2 (participants: patients, controls) by 3 (verb semantic category: lexical causative, movement, and perception verbs) mixed ANOVA (Appendix H, Table 12). The analysis revealed a significant main effect of participants (the between factor), F (1, 9) = 29.339, $p = .0004$, a significant main effect of verb- semantic category (the within factor), F (2, 18) = 28.71, $p < .0001$, and no significant interaction (Figure 15).

Two one-way within-subjects ANOVA and subsequent post-hoc Tukey tests were conducted on the patients' and controls' data (Appendix H, Table 13). The analyses resulted in a significant effect of verb category for both patients, F (2, 18) = 16.225, $p < .0001$, and controls, F (2, 20) = 11.348, $p = .0005$. Post-hoc Tukey tests of the patients' data revealed a significant mean difference between movement verbs (M = 69, SD = 12.87) and perception verbs (M = 39, SD = 25.42), and perception verbs and lexical causative verbs (M = 61, SD = 12.87). The same analyses for the controls also resulted in

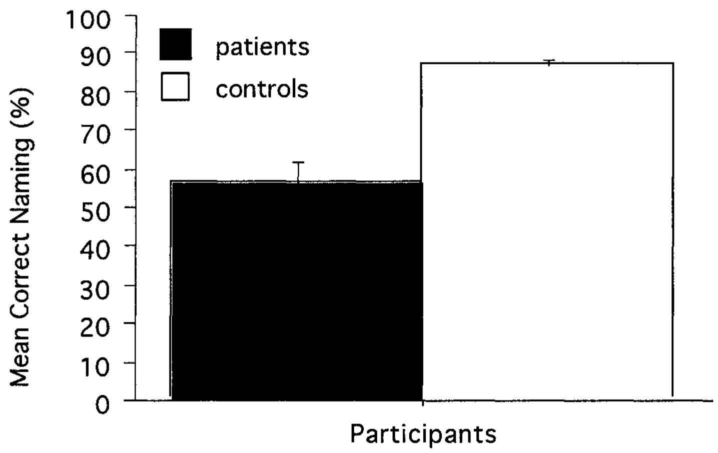
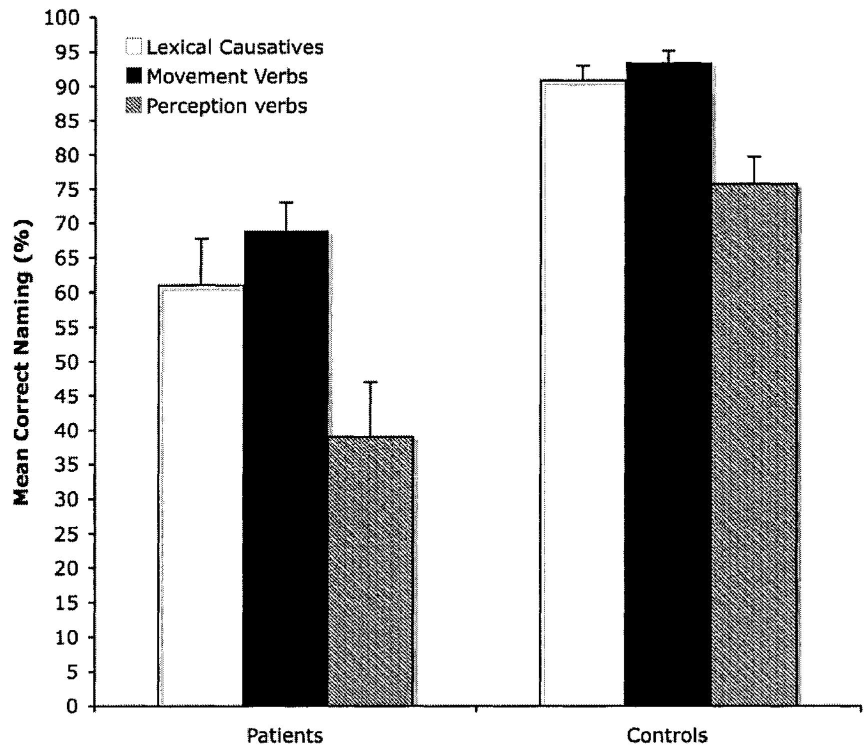


Figure 14. Participants' mean percentage correct action naming.



Participants

Figure 15. Mean percentage correct action naming as a function of verb semantic category (lexical causatives, movement verbs and perception verbs) and participants (patients and controls).

significant mean differences between movement verbs (*M* = 93.63, *SD* = 5.04), and perception verbs (*M* = 75.76; *SD* = 12.98), and perception verbs and lexical causative verbs (*M* = 90.91, *SD* = 7.01). To examine differences in responding to the three verb categories across participants, item analyses involving one-way between-subjects ANOVA, with verb category as the independent variable, were carried out (Appendix H, Table 14). The analysis on the patients' data approached significance, $F2\ (2, 26) = 2.75$, $p = .08$. Subsequent post-hoc Tukey tests showed significant mean difference between movement verbs (*M* = 70, *SD* = 38.29) and perception verbs (*M* = 37.78, *SD* = 21.08), $p = .02$. The analysis on the controls' data was nonsignificant.

Although the findings may indicate that patients' verb deficit is category specific, this category-specificity cannot be attributed to any selective impairment at the level of verb-*semantic feature* or *content*. The reason is that not only the patients' verb knowledge but also that of the controls was characterized by category specificity. One possible reason is that actions lexicalized by perception verbs are more difficult to depict than those lexicalized by lexical causative and movement verbs leading to more errors for perception than lexical causative and movement verbs in both patient and control groups.

The main purpose of this analysis was to determine whether or not there was an overall verb class distinction independent of verb agreement and thus took into account all the short-movies devised for the experiment. In the analysis described below, data derived from a subset of movies that were matched according to name agreement were re-scored and re-analyzed. As discussed before, name agreement has been considered to be a prominent predictor of object and action naming accuracy (e.g., Kan & Thompson-Schill, 2004).

Re-Analyses of High Naming Agreement Stimuli

In order to determine whether or not the dynamic action naming results presented earlier were a function of discrepancies in action naming agreement, a normative naming task was presented to 15 normal elderly controls. These normal elderly individuals ranged in age from 58 to 82 years (mean = 71.6; S.D. = 7.83). They were native speakers of English, and their years of education ranged from 11 to 15 years (mean = 12.67; S.D. = 1.44). Their mean MMSE (Folstein et al., 1975) and BNT (Kaplan et al., 1983) scores were 28, and 56 respectively. Five of the normal elderly individuals were tested at the Psycholinguistics and Cognition lab of Concordia University and the other 10 were tested at their houses in the Kingston, Ontario area. On the basis of the normative information (Appendix G), 15 movies of actions belonging to the verb categories of lexical causatives, movement verbs, and perception verbs were selected (Table 5). The movies within each verb category were closely matched with those belonging to other verb categories on the basis of name agreement (Table 6).

On the basis of the data derived from the subset of short-movies, patients' verb-semantic deficits were further examined. A one-way between-subjects ANOVA (Appendix H, Table 15) revealed a significant effect of participants, $F\,(1, 19) = 19.92$, $p = .0003$ (Figure 16).

A 2 (participants: patients, controls) by 3 (verb semantic category: lexical causative, movement and perception verbs) ANOVA was carried out to examine verb category specificity (Appendix H, Table 16). The analysis resulted in a significant main effect of participants, $F\,(1, 9) = 21.81$, $p = .0012$, and a significant main effect of verb

Table 5

The verbs depicted by the high-naming agreement short movies of actions (n=15).

Lexical Causatives (n = 5)	Movement Verbs (n = 6)	Perception Verbs (n = 4)
Peeling	Crawling	Listening
Bending	Swinging	Tasting
Squeezing	Rolling/Rolling over	Watching
Folding	Hopping	Smelling
Bouncing	Climbing	
	Walking	

Table 6

The mean name agreement values of the short-movies depicting lexical causatives, movement and perception verbs (standard deviations are in brackets).

Lexical Causatives (n = 5)	Movement verbs (n = 6)	Perception verbs (n = 4)
93.31 (5.44)	93.33 (9.42)	93.33 (8.43)

Note. Name agreement was defined as the percentage of individuals arriving at the same label for the action conveyed in the short-movie. The cut-off point was set at 80% (13 out of 15 individuals arriving at the same label for the action depicted in the short-movie).

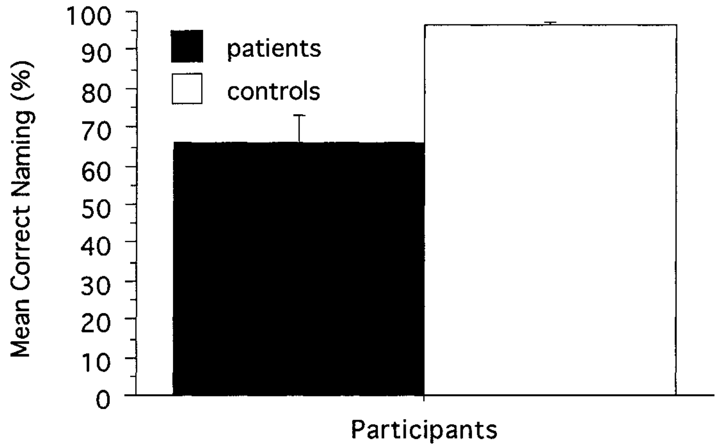
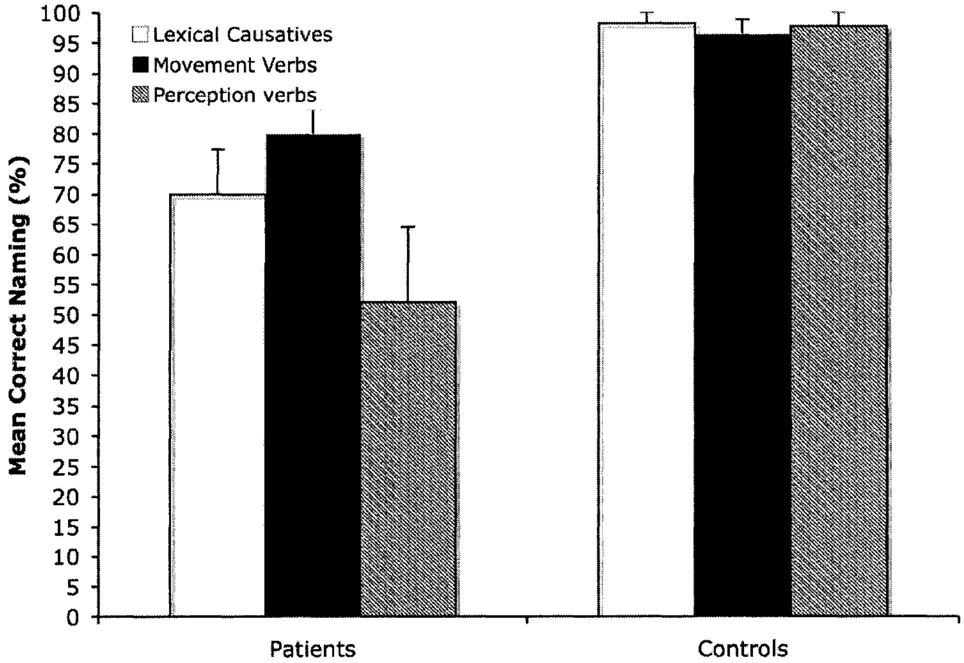


Figure 16. Participants' (patients and controls) mean percentage correct action naming for high-naming agreement stimuli.

semantic category, $F(2, 18) = 3.71$, $p = .04$. The interaction approached significance at $p = .08$ (Figure 17).



Participants

Figure 17. Mean percentage correct action naming for high-naming agreement stimuli.

One-way within-subjects ANOVAs for both patients and controls (Appendix H, Table 17) showed a significant effect of verb semantic category for the patients, F (2, 18) = 3.90, p = .04, but not for the controls. Subsequent post-hoc Tukey tests for the patients showed a significant mean difference between movement verbs (M = 80, SD =13.13), and perception verbs (M = 52.50, SD = 39.87), p = .03.

In order to examine the differences in responses to the three verb categories across the participants, item analyses involving one-way between-subjects ANOVA, with verb category as the independent variable, were carried out (Appendix H, Table 19). The analyses, on both patients' and controls' data, were nonsignificant.

The results indicate that the DAT patients' verb-semantic representation may be characterized by a disproportionate impairment of the knowledge of perception verbs. In principle, these findings do not substantiate the hypothesis of a lexical-causative specific verb deficit: patients' naming of lexical causatives, presumably represented by the semantic *feature* CAUSE, does not significantly differ from their naming of movement verbs, presumably represented by the *semantic content* of motion. The results also indicate that similar to movement verbs, patients' naming of perception verbs, also assumed to be represented on the basis of *semantic content*, does not significantly differ from their naming of lexical causatives.

One way to interpret these findings is to suggest that *both* semantic feature and semantic content represent organizational principles of semantic knowledge. This postulation is supported by previous research (de Almeida & Mobayyen, in press) that indicated similar patterns of retrieval for these verb categories also suggesting that *semantic feature* and *content* may *both* represent encoding elements of concepts.

More specifically, in a previous study (de Almeida & Mobayyen, in press) on normal individuals, a proactive interference (PI) paradigm[3] was used to investigate which element, *feature* or *content*, is involved in conceptual representation. The feature-specific models were substantiated if lexical causatives, presumed to be encoded on the basis of the *semantic feature* CAUSE, produced the most significant amount of PI build-up[4] suggesting that concepts are encoded on the basis of *semantic feature*. The domain-specific model, in turn was supported if movement verbs, presumably represented on the basis of the *semantic content* of motion, were found to engender the most significant amount of PI build up suggesting that concepts are encoded on the basis of *semantic content*. These hypotheses were based on the premise that *verb* retrieval is a "reflection of how the materials were encoded in the first place" (Wickens et al., 1976, p. 307).

The findings of the above-mentioned research revealed that the participants' pattern of recall (PI build-up) was in fact similar for lexical causative, movement and perception verbs. This suggested that *feature* and *content* are both implicated in the structure of semantic memory with the implication that feature and domain-specific models are fundamentally similar in their assumptions regarding semantic memory organization.

The present findings, along with those of previous research (de Almeida & Mobayyen, in press), further suggest that *semantic feature*, assumed to be the building

---

[3] In a PI paradigm, participants are presented with four trials, the first three (the PI build-up trials) comprising items from the same semantic category and the last trial (the PI-release trial) consisting of items from a different semantic category. The premise is that items encoded similarly would produce the most significant amount of PI build up leading to a significant PI release on the fourth trial (for a review see Wickens et al., 1976; and Marques, 2000).

[4] PI build-up refers to a continuous decrease in the amount of recall across the first three trials of a PI paradigm that is assumed to be caused by the similarity in the inferred encoding characteristics of the to-be called concepts.

block of semantic memory, and *semantic content*, assumed to be the principle constellating concepts within conceptual categories, are *both* reflected in the organization of semantic knowledge. Verb dissolutions, then may occur along the lines of *semantic feature* and *semantic content.*

In spite of the above-mentioned postulation according to which movement and perception verbs are similarly represented, the findings indicate that patients' naming performance in these two respective verb categories differ significantly. One way to explain this finding is to draw on the nature of the naming errors in response to these verbs because the pattern of errors may be indicative of the semantic properties affecting particular verbs or verb classes.

Following on the error classification systems developed by Bayles, Tomoeda, and Trosset (1990), and Druks et al. (2006), a qualitative analysis of errors in response to the movie stimuli was undertaken. Patients' action naming errors were classified as "semantically unrelated" (e.g., *Hopping* → *Watching)*, "don't know", "semantically related" (e.g., *Peeling* → *Shredding)*, and "others" (e.g., *Squeezing* → *Juicing*). The semantically related errors in turn were categorized as "co-ordinate" (e.g., *Tasting* → *Sipping)*, "subordinate" (e.g., *Climbing* → *Going up*), "superordinate" (e.g., *Hopping* → *Jumping)*, and "same-category" (e.g., *Tasting* → *Looking*) errors. The semantically unrelated errors included errors of misinterpretation (see Druks et al., 2006) such as *sitting* for *watching*, and *holding* for *squeezing*, as well as associative or definitional errors such as *playing* or *putting up and down* for *bouncing*. These error responses were presumed semantically unrelated because they shared neither semantic feature (e.g., CAUSE) nor content with other members of their respective categories. The "same-category" errors referred to error responses (e.g., *Looking*) that represented items belonging to the same semantic category (e.g., perception verbs) as the target response (e.g., *Tasting*).

On the basis of this categorization, a qualitative analysis of patients' errors showed that across the verbs constituting the category of lexical causative verbs, 43.75% of the errors were "semantically unrelated", 18.75% were "super-ordinate", 12.5% were "co-ordinate", 18.75% were "same-category", and 6.25% were "others" (Table 7).

Across the movement verbs, 8.33% of the patients had "semantically unrelated' errors, 50% had "superordinate" errors, 16.67% had "coordinate" errors, 16.67% had "subordinate" errors, 8.33% had "same-category" errors, and 0% had "others", and "don't know" errors (Table 8). Across the perception verbs, 15.78% of the errors were "semantically unrelated", 15.78% were "superordinate", 36.84% were "co-ordinate", 21.05% were "same-category", 10.53% were "don't know", and 0% were "others" (Table 9).

For the control group, across the lexical causative verbs, there were two "co-ordinate" errors (e.g., Peeling → *Paring; Peeling* → *Scraping)*, and across the movement and perception verbs, there were one "co-ordinate" error (e.g., *Climbing* → *Mounting)*, and one "semantically unrelated" error (e.g., *Listening* → *Bending*), respectively.

Table 7

Errors in response to short-movies depicting lexical causatives followed by the number and percentage of errors according to error type for patients.

	Errors	Number	Percentage
Lexical Causatives			
Semantically related			
Super-ordinate	*(Peeling → Cutting)* *(Peeling → Cutting)* *(Peeling → Cutting)*	3	18.75
Co-ordinate	*(Peeling → Shredding)* *(Peeling → Scraping)*	2	12.5
Sub-ordinate		0	
Same-category	*(Bending → Flipping)* *(Bending → Breaking)* *(Bending → Break)*	3	18.75
Semantically Unrelated	*(Bending → Lifting)* *(Bending → Pulling)* *(Bending → Scraping)* *(Bending → Holding)* *(Bouncing → Playing)* *(Bouncing → Playing)* *(Bouncing → Putting up and down)*	7	43.75
Others	*(Squeezing → Juicing)*	1	6.25
Don't Know		0	0

Note. The verb error is the second verb from left to right.

Table 8

Errors in response to short-movies depicting movement verbs followed by the number and percentage of errors according to error type for the patients.

	Error	Number	Percentage
Movement Verbs			
Semantically related			
Super-ordinate	*(Hopping → Jumping)* *(Hopping → Jumping)* *(Hopping → Jumping)* *(Hopping → Jumping)* *(Hopping → Jumping)*	5	50
Co-ordinate	*(Rolling → Turning over)* *(Rolling → Turning over)*	2	16.67
Sub-ordinate	*(Climbing → Going up)* *(Climbing → Going up)*	2	16.67
Same-category	*(Hopping → Walking)*	1	8.33
Semantically Unrelated	*(Hopping → Watching)*	1	8.33
Others		0	0
Don't Know		0	0

Note. The verb error is the second verb from left to right.

Table 9

Errors in response to short-movies depicting perception verbs followed by the number and percentage of errors according to error type for the patients.

	Error	Number	Percentage
Perception Verbs			
Semantically related			
Super-ordinate	*(Tasting → Eating)* *(Tasting → Eating)* *(Tasting → Eating)*	3	15.78
Co-ordinate	*(Smelling → Sniffing)* *(Tasting → Sipping)* *(Watching → Looking)* *(Watching → Looking)* *(Watching → Looking)* *(Watching → Looking)* *(Watching → Looking)*	7	36.84
Sob-ordinate		0	0
Same category	*(Smelling → Looking)* *(Tasting → Looking)* *(Listening → Looking)* *(Smelling → Licking)*	4	21.05
Semantically unrelated	*(Tasting → Enjoying)* *(Listening → Sitting)* *(Watching → Sitting)*	3	15.78
Others		0	0
Don't Know		2	10.52

Note. The verb error is the second verb from left to right.

The results of the qualitative analysis of the patients' naming errors indicate that perception verbs elicit a greater amount of "co-ordinate" errors (e.g., *looking* instead of *watching*), as well as "don't know" responses compared to movement verbs. Such "co-ordinate" errors may be indicative of errors of perspective. Perception verbs may not easily incorporate manner of perceiving into their lexical meaning. The manner of perceiving involves the element of perspectivity (*listening* instead of *watching*), which is subjective and ambiguous requiring the participant to take the perspective of the perceiver into account by drawing on the information represented in the context. This perspective-taking element extends the meaning of perception verbs into the cognitive domain thus making them more abstract, mental and context dependent. Semantically, then experiencer-based perception verbs extend into an abstract cognitive domain (Viberg, 1984). In contrast to perception verbs, movement verbs (e.g., *crawling,*) may to a large extent incorporate manner of motion into their lexical meaning, thus expressing motion and manner simultaneously (Slobin, 1996). This makes them more concrete and less ambiguous. In fact, they provide rich contextual information.

In brief, unlike perception verbs, that do not easily incorporate manner of perceiving into their lexical meaning, movement verbs express manner and motion simultaneously. Movement verbs are thus *concrete* providing rich contextual information; whereas perception verbs are *abstract* and context-dependant. These qualities of these verb categories, particularly the concreteness of movement verbs as opposed to the abstractness of perception verbs, may account for patients' significant difficulty naming perception verbs in contrast to movement verbs.

Comparison between dynamic and static pictures

One of the main hypotheses of Experiment 3 was that patients' naming performance in response to the short-movies would be significantly better than their naming performance in response to static picture (single, colour pictures of Experiment 2). Further, if patients indeed exhibited an object/action naming dissociation with a selective *verb* deficit, it was hypothesized that this dissociation should hold across the two different sets of stimuli depicting verbs: the short-movies, and the static pictures.

In order to examine the above-mentioned hypotheses, a 2 (participants: patients, controls) by 2 (stimuli: colour single photographs, movies) mixed ANOVA was carried out (Appendix H, Table 20). The analysis revealed a significant main effect of participants (the between factor), $F\ (1, 9) = 43.27, p = .0001$, a significant main effect of stimuli (the within factor), $F\ (1, 9) = 31.26, p = .0003$, and no significant interaction (Figure 18). To determine whether or not patients' action naming was significantly more impaired than their object naming, a 2 (participants: patients and controls) by 2 (semantic category: object and action) mixed ANOVA was carried out (Appendix H, Table 18). The analysis resulted in a significant main effect of participants (the between factor), $F\ (1, 9) = 51.25, p = .0001$, but no significant main effect of semantic category (the within factor), and no significant interaction (Figure 19).

As hypothesized, the above-mentioned results indicate that patients' action naming in response to short-movies is significantly better than their action naming in response to static pictures. Further, the findings show that when dynamic stimuli are used to capture dynamic actions, patients do not exhibit an object/action naming dissociation with a

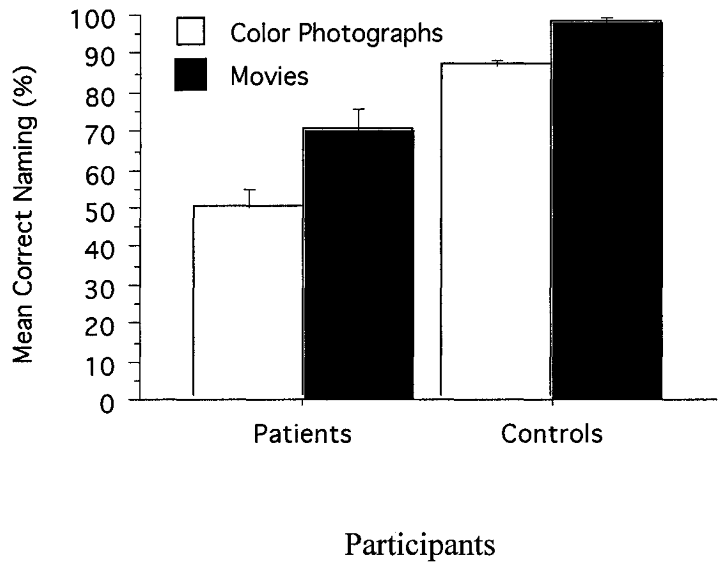
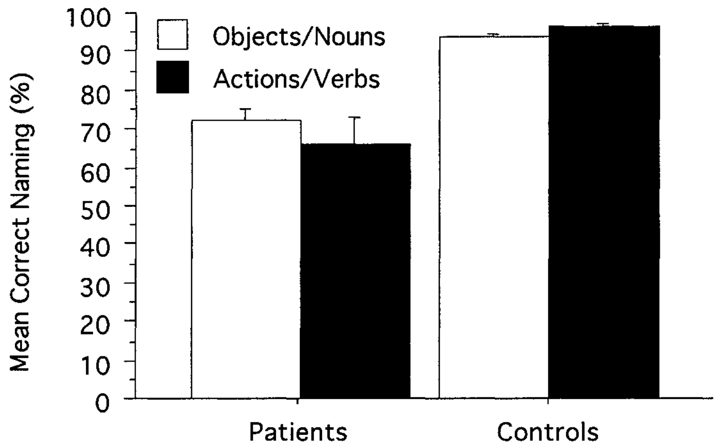


Figure 18. Mean percentage correct action naming as a function of stimuli (colour, single photographs and movies) and participants (patients and controls).



Participants

Figure 19. Mean percentage correct action naming for high-naming agreement stimuli.

selective *verb* deficit. In other words, the object/action naming dissociation with a selective *verb* deficit observed in Experiment 2 does not hold when short-movies, as opposed to static pictures, are used to convey actions. This finding supports the postulation that the object/action naming dissociation observed in Experiment 2 could have been a function of the stimuli used (e.g., depicting dynamic actions in stagnant pictures), particularly in light of the finding that patients action naming was significantly better in response to short-movies as opposed to static pictures.

In summary, the findings of Experiment 3 reveal similar patterns of naming in response to movement and lexical causative verbs, and in response to lexical causative and perception verbs. These findings suggest that both *feature* and *content* are reflected in the organization of semantic memory thus favoring both domain- and feature-specific models of semantic memory organization. The significantly greater number of errors in response to perception than movement verbs is attributed to the abstract and context-dependant nature of perception verbs. Finally, unlike Experiment 2, the present findings do not indicate an object/action naming dissociation with a selective *verb* deficit. This finding may support the postulation that the previously documented object/action naming dissociations (e.g., Experiment 2) with a selective verb deficit could have been a function of the verb stimuli (e.g., static images) used to depict verbs (Fung et al., 2001). Indeed, when dynamic actions are conveyed by dynamic stimuli (e.g., short-movies) as opposed to static images (e.g., colour pictures), patients' knowledge of verbs is not significantly different than their knowledge of nouns.

One limitation of the initial analyses, which were based on the whole set of short-movies (Dynamic Action Naming), was a lack of normative information. Normative information is essential for selecting verb stimuli that do not elicit a range of names and thus adds more precision to the study. Despite compensating for the aforementioned limitation, the re-analysis of the high-naming agreement stimuli was also limited due to the small number of movies depicting verb concepts within each verb category. Regarding error analysis, for example, a larger range of verbs within each verb category would make interpretations regarding verb conceptual representation more generalizable. Developing a range of movies depicting perception verbs however represents a considerable challenge, as many verbs within this category are not easily depictable (e.g., *staring, glaring*). Despite the limitations, a noteworthy strength of Experiment 3 was its implementation of ecologically valid stimuli (e.g., short-movies) to depict semantically coherent verb classes.

In the following section, I would present a general discussion of the experimental results. This discussion is organized as follows: First, I present a review of the overall findings (Experiments 1, 2, and 3). Next, I will discuss the findings of Experiment 3 in light of our current knowledge of verb-semantic representations followed by a discussion on the implications, the findings may have for the main models of semantic memory organization. This section would be followed by concluding remarks.

General Discussion

I. Overview of the Experimental Results

The main objective of the present study was to examine the hypotheses of the current models of semantic memory organization (domain- and feature-specific models) through examining verb category-specific semantic deficits in patients with mild to moderate dementia of the Alzheimer type. Semantic deficits were investigated in patients with early DAT using confrontation-naming tasks. Regarding the use of confrontation-naming tasks, Fung et al. (2001) have pointed out that utilizing static pictures to convey dynamic actions may be responsible for the selective verb deficits documented in past research (e.g., Cappa et al., 1998). Bird, Howard and Franklin (2000) have also argued that selective verb deficits found in action-naming studies are reducible to the imageability factor of the verbs defined as "sensory information" that is needed to engender an image in mind. Aside from this issue, past research involving verb deficits has also been criticized for not taking into account verb classification according to different verb semantic categories that may be necessary for understanding semantic knowledge representation (de Almeida & Mobayyen, in press). To circumvent these issues, for the purpose of this study, realistic short movies of actions, depicting semantically coherent verb classes, were devised.

The main objective of Experiment 1 was to determine whether or not patients' noun-semantic deficits were characterized by living/nonliving things dissociation with a selective living things deficit. This dissociation was initially explored because the living/nonliving things dissociation has been used as a framework for the development of the main assumptions of feature- and domain-specific models. In addition, the presence of the living/nonliving things dissociation in early DAT remains inconclusive.

As hypothesized, the findings indicated that DAT patients' noun-semantic deficits were characterized by living/nonliving things dissociation with a selective living things deficit. This finding in individuals with mild-to-moderate DAT substantiated the localization assumption inherent in both domain and feature-specific models. More importantly, the observed category specificity set the stage for an exploration of verb-semantic deficits (Experiment 2) and verb category specific semantic deficits (Experiment 3).

The results of Experiment 1 also indicated that patients had significantly better naming performance on the subcategory of *body parts* compared to the majority of other living subcategories, and significantly more impaired naming performance on the subcategory of *musical instruments* compared to the majority of other nonliving subcategories. Although these findings may be taken as support for the SFT proposal, one needs to consider that the stimuli depicting *body parts* were significantly more familiar and more frequent than the stimuli depicting other living subcategories. These factors, namely familiarity and frequency, could have accounted for the finding of better naming performance for *body parts* than other living stimuli. Similarly, the stimuli depicting *musical instruments* were found to be significantly less familiar than the stimuli depicting other nonliving subcategories. The familiarity factor could have also accounted for the finding of more impaired naming for *musical instruments* than other nonliving stimuli. As Whatmough and Chertkow (2002) point out, in DAT patients, accuracy scores are highly correlated with the familiarity ratings of the stimuli.

Experiment 2 involved an investigation of verb-semantic deficits using static images of actions (e.g., colour single and paired pictures). The presence of object/action naming dissociation, if any, and possible dissociations involving verb morphology were also examined. The findings revealed that patients exhibited an object/action naming dissociation with significantly more errors naming verbs than nouns. Similar to Druks et al.'s (2006) study, however, this dissociation was observed in both the patient and control groups. Druks et al. (2006) observed that participants made a significantly greater number of interpretation errors for the verb (e.g., static pictures) than noun stimuli. They explained this finding by pointing out that the imageability ratings for the verb stimuli are lower than those for the nouns, and this may account for the greater number of interpretation errors for the verb stimuli leading to an object/action naming dissociation. In Experiment 2, also the verb stimuli were found to have significantly less image agreement ratings than did the noun stimuli. The lower image agreement or imageability ratings for the verb than the noun stimuli is expected given the difficulty depicting actions, being "processes of doing", through static pictures (Fung et al., 2001). If the documented object/action naming dissociation with a selective *verb* deficit (e.g., Cappa et al., 1998) is not indeed a function of the stimuli (e.g., static images) used to depict verbs, it is expected that the object/action naming dissociation with a selective verb deficit should hold across two different sets of verb stimuli: static (e.g., colour pictures), and dynamic (e.g., realistic short-movies). The results of Experiment 3 indicated that the object/action naming dissociation pattern observed in Experiment 2 did not hold when short-movies were used to depict actions: Patients did not exhibit an object/action naming dissociation when realistic short-movies were used to depict verbs. In addition, patients' naming performance in response to short-movies was significantly better than their naming performance in response to colour pictures. These findings suggested that it is possible that the object/action naming dissociation with a selective *verb* deficit found in Experiment 2, and perhaps in previous studies (e.g., Robinson et al., 1996) is partially accounted for by the fact that in these studies dynamic actions were conveyed by static images.

The patients also exhibited significant difficulty naming picture-pairs that elicited verbs in the regular past-tense (e.g., *chopped*) than single pictures that elicited verbs in the present progressive (e.g., *chopping*). Following the Argument Structure Complexity (ASC) proposal, one may suggest that the present-progressive/past-tense verb dissociation is a function of the syntactic properties (the number of associated arguments) of the verbs. According to the Argument Structure Complexity (ASC) proposal (Thompson, 2003), verbs with a greater number of associated arguments (e.g., two-place verbs) are syntactically more complex than verbs with fewer associated arguments (e.g., one-place verbs). On the basis of the assumption that a greater syntactic complexity leads to a greater number of retrieval errors, it is expected that verbs with a greater number of associated arguments are more prone to retrieval errors than verbs with fewer associated arguments (Thompson, 2003). This is explained by the claim that as verbs become syntactically more complex (e.g., two-place as opposed to one-place verbs), they may require more processing resources rendering their retrieval more difficult. An examination of the verbs used in Experiment 2 revealed that among the past-tense verbs, 85% included one-place (e.g., *she turned*) and 15% included two-place (e.g., *she framed the picture*) structures. Among the verbs in the present-progressive, 42.7% included two-place (e.g., *she is kicking the ball*) and 57.3% included one-place (e.g., *she is smiling*) structures. This analysis suggested that a greater number of associated arguments – and by assumption syntactic complexity – may not be a likely explanation for the greater number of errors associated with the past-tense verbs. Also, there are studies suggesting that unlike agrammatic patients, DAT patients' verb deficits are not associated with verb syntactic complexity involving the number of associated arguments. (e.g., Kim & Thompson, 2004). Instead, a selective semantic deficit, as opposed to a syntactic deficit, has been shown to underlie DAT patients' verb semantic deficits (e.g., Kim & Thompson, 2004; Ullman et al., 1997). It is important to emphasize that in addition to reflecting a fundamental semantic impairment, the observed dissociation may also reflect task demands. The task used was a referential processing task requiring the patients to map verbs onto the actions conveyed by the picture stimuli onto verbs (Kemmerer et al., 2001). The patients were required to *infer*, on the basis of paired static images, actions that contained an explicit time dimension (i.e., action depicting *chopped*). In future studies, the use of a comprehension task, in addition to a production task, may help shed more light on the nature of the regularly inflected past-tense/present progressive verb dissociation.

The main goal of Experiment 3 was to determine whether or not patients' verb-semantic deficit – similar to their noun-semantic deficit – was characterized by category specificity. The findings of Experiment 3 indicated that the patients' verb-semantic deficits were in fact characterized by category dissociation, specifically affecting the class of perception verbs. The patients' naming performance in response to actions labeled by lexical causatives did not significantly differ from their naming performance in response to actions labeled by movement and perception verbs. However, the patients' naming of perception verbs was significantly more impaired than their naming of movement verbs. In the following section, these findings are interpreted in light of the current knowledge of verb-semantic representations.

II. Verb Deficits and Verb Semantic Representations

As mentioned previously, the feature-specific models maintain that lexical causatives are represented by a semantic template comprising the constant feature CAUSE (Jackendoff, 1990; Rappaport-Hovav & Levin, 1998). For example, as de Almeida (1999) points out, according to Rappaport-Hovav and Levin's (1998) model, (1a) would have a semantic representation as shown in (1b):

(1) a. John Killed Mary

b. [CAUSE [John [Mary <dead>]]].

The representation of (1a) would be a basic semantic template in (1b) that consists of the primitive feature CAUSE, determining the semantic-structure similarity between verbs belonging to the class of lexical causatives. The basic template in (1b) also consists of " 'idiosyncratic information' " (Rappaport Hovav & Levin, 1998; e.g., *dead)* that is presumed to determine the difference between lexical causatives that otherwise by assumption have the same basic template as in the case of *kill* in (1b) and *break* in (2b) (de Almeida, 1999). The " 'idiosyncratic information' " determining the semantic difference between (1a) and (2a) is taken to be *dead* and *broken*, respectively.

(2) a. John broke the vase

b. [CAUSE [John [vase <broken>]]].

Unlike lexical causatives, movement and perception verbs are presumed to be represented on the basis of semantic content (de Almeida & Mobayyen, in press). If we posit, following the feature-specific models, that perception verbs are in fact represented by the semantic feature PERCEIVE, then based on Rappaport-Hovav and Levin's (1998) model, the representation of (3a) would be a basic template as shown in (3b) that consists of the primitive feature PERCEIVE determining the semantic-structure similarity between verbs belonging to the class of perception verbs. The basic template in (3b) also consists of idiosyncratic information (e.g., *see*) that is presumed to determine the difference between perception verbs that otherwise by assumption have the same basic template as in the case of *see* in (3b) and *hear* in (4b). The idiosyncratic information determining the semantic difference between (3a) and (4a) is taken to be *see* and *hear*, respectively. The feature PERCEIVE, then cannot logically be a consistent part of the meaning representation of (3a) and (4a): if the idiosyncratic information (e.g., *see, hear*) is removed, the feature PERCEIVE does not represent the semantic-structure similarity between (3a) and (4a).

(3) a. John saw Mary

b. [PERCEIVE <see> [John, Mary]]

(4) a. John heard Mary

b. [PERCEIVE <hear> [John, Mary]]

Thus, although the feature PERCEIVE may serve as a useful notation for the purpose of verb categorization, it does not serve as a shared semantic-structure feature in the meaning representation of perception verbs. Perception verbs then are assumed to be represented mainly on the basis of the shared *semantic content* of perception (de Almeida & Mobayyen, in press).

By the same token, movement verbs are also assumed to share *semantic content* (de Almeida & Mobayyen, in press). On the basis of Rappaport-Hovav and Levin's (1998) model, (5a) would have a representation as shown in (5b) consisting of the primitive feature GO, determining the semantic structure similarity between verbs belonging to the class of movement verbs. The semantic template in (5b) also comprises idiosyncratic information (e.g., *walk*) presumed to establish the difference between movement verbs that are otherwise posited to have the same basic semantic template as in the case of *walk* in (5b) and *run* in (6b). The idiosyncratic information determining the semantic difference between (5a) and (6a) is assumed to be *walk* and *run*, respectively. Similar to the case of perception verbs, if the idiosyncratic information (e.g., *walk*, *run*) is removed, the feature GO does not represent the semantic-structure similarity between (5a) and (6a). Thus, it is thought that movement verbs do not share the feature GO in their meaning representations (de Almeida & Mobayyen, in press).

(5) a. John walked home

b. [GO <*walk*>[John, home]]

(6) a. John ran home

b. [GO <*run*> [John, home]]

The movement verbs are presumed to be represented on the basis of the shared semantic content of motion (de Almeida & Mobayyen, in press). As in the case of perception verbs and the feature PERCEIVE, the feature GO may also serve as a useful descriptive notation for the purpose of the categorization of movement verbs.

On the basis of the above, lexical causatives are considered semantically complex and movement and perception verbs are considered semantically simplex. The findings of Experiment 3 indicated that patients' naming of lexical causatives (semantically complex verbs) did not significantly differ from their naming of movement and perception verbs (semantically simple verbs). These findings are not consistent with those of Breedin et al. (1998) which indicated better retrieval for semantically complex (heavy verbs) than semantically simple verbs (light verbs). As discussed previously, Breedin et al. (1998) argued that better retrieval for heavy verbs is in line with feature-specific models of conceptual organization. Their argument was based on the premise that being semantically complex, heavy verbs have more inter-feature connections leading to "a stronger " 'memory trace' " (p. 21) facilitating their retrieval.

Mobayyen and de Almeida (2005) contended that Breedin et al.'s (1998) findings of better retrieval for semantically complex verbs might in fact challenge the feature-specific models of conceptual representation. Their contention was based on the premise that the more features a verb has, the greater the likelihood that some of its subcomponents will be affected. This premise invited the hypothesis that patients with verb-semantic deficits would have significantly more errors naming semantically complex than semantically simple verbs. As mentioned earlier, the present findings indicated that semantically complex verbs (e.g., lexical causatives) were not significantly more impaired than semantically simple verbs (perception and movement verbs), challenging the assumption that verb-semantic impairments *mainly* occur along the lines of semantic feature.

Breedin et al.'s (1998) finding of better recall in patients with verb deficits for semantically more complex verbs could also be explained as a function of a frequency effect, which has been shown to affect verb production in that less frequent verbs are produced better than more frequent verbs (e.g., Kemmerer & Tranel, 2000). In the present study, the semantically complex verbs (lexical causatives) were found to have the least frequency followed by the semantically simple verbs, perception and movement verbs, which were found to have similar frequencies. Although lexical causatives were the least frequent, their production did not differ from those of movement and perception verbs. Therefore, in this study, a frequency effect does not appear to explain the pattern of verb production.

The findings of non-significant dissociation between lexical causatives and movement verbs and between lexical causatives and perception verbs are in fact consistent with those of a previous PI study carried out on normal undergraduate students (de Almeida & Mobayyen, in press). In this study, verbs employed also consisted of semantically complex (i.e., verbs sharing semantic-structure features such as lexical causatives; e.g., *burn*, *bend*, *melt*) and semantically simple verbs (i.e., verbs sharing semantic content but not semantic feature such as perception verbs; e.g., *hear, watch*; and movement verbs; e.g., *crawl, walk*). The results showed that verbs sharing semantic feature (causatives) generated significant amounts of PI build-up, but so did verbs that belong to semantic categories that differ in their argument and semantic-structure properties (perception and movement verbs). These findings indicated that *both* content and feature represent semantic encoding mechanisms. If so, then one should predict verb-semantic breakdown, in patients with verb deficits, along the lines of feature and content. The present findings appear to support this prediction.

Despite the assumption that movement and perception verbs are represented on the basis of semantic content (de Almeida & Mobayyen, in press), patients' naming of perception verbs was significantly more impaired than their naming of movement verbs. One way to explain this finding is to draw on the nature of the naming errors made in response to these verb classes: In contrast to movement verbs, perception verbs elicited a greater amount of "co-ordinate" errors (e.g., *looking* instead of *watching, seeing* instead of *watching*) that may be indicative of errors of perspective-taking. Perception verbs may not easily incorporate the manner of perceiving, that involves the element of perspectivity, into their meaning representation. The manner of perceiving is a subjective and ambiguous element (e.g., *watching* vs. *looking*; *listening* vs. *hearing)* extending the meaning of perception verbs into the cognitive domain; thereby making them "mental" and context-dependent (Viberg, 1984). Movement verbs, on the other hand, may incorporate manner of motion into their lexical meaning, thus expressing motion and manner simultaneously (Slobin, 1996). This makes them less abstract and more concrete.

Following Breedin et al.'s (1999), one could further argue that perception verbs, being abstract, and movement verbs, being concrete may differ "in the extent to which their meanings constrain the context in which they can occur" (p. 21). The meaning of perception verbs – similar to those of abstract words in general – may become modified on the basis of the context in which they occur (*watching* vs. *looking*). Movement verbs, in contrast are not quite as flexible as perception verbs with regard to the contexts in which they can appear. This may contribute to movement verbs constituting a more coherent verb class than perception verbs. For example, in response to a stimulus depicting an action such as *hearing*, a number of concepts such as *listening*, *noticing*, *understanding*, *concentrating,* may become available; whereas a stimulus depicting the action *running* may activate two concepts, namely those labeled by *jogging*, and *running*.

As Kemmerer et al. (2001) point out, a verb production or a referential processing task requires "deliberate activation of a pool of candidate verbs and controlled selection of the most appropriate one for the given context" (p. 2). The "deliberate activation" and the "controlled selection" of the most suitable verb concepts are even more taxing and demanding when the concepts to elicit are abstract and context-dependent, and the participants are patients with a dementia syndrome characterized by global cognitive deficits. To further examine the observed pattern of movement/perception verb category dissociation, one may also use a comprehension task, such as a word-picture matching task. Kemmerer et al. (2001) found that brain-damaged participants who had significant difficulty producing verbs in referential processing tasks (e.g., picture naming tasks) had no difficulty with the same items in tasks of comprehension such as word-picture matching tasks. In comprehension tasks, in Kemmerer et al.'s (2001) view, the participants are required to recognize verbs that are provided by the experimenter. This makes such tasks less demanding than referential processing tasks that by nature require "mapping verbs onto actions in the world" (p. 2). de Almeida (1999) also argues that in word-picture matching tasks, patients are presented with "two sources of evidence", namely a word and its pictorial representation, on the basis of which they can determine which one of the activated concepts is more likely to be the appropriate one (p. 246).

In the following section, I discuss the implications of the present findings for the main models of semantic memory organization followed by concluding remarks.

III. The Implications for the Main Models of Semantic Memory Organization: The Feature- and Domain-Specific Models

As mentioned earlier, the domain- and feature-specific models contain apparently conflicting assumptions pertaining to the organizing principle of semantic knowledge. From the perspective of the feature-specific models, semantic feature represents the organizing principle of semantic memory. On this premise, category specific semantic deficits arise from a disruption of primitive features that constitute concepts. From the perspective of the domain-specific model, category represents the organizing principle of semantic knowledge. Category-specific semantic deficits, according to this view, arise from a selective damage at the level of conceptual categories. Although the domain-specific model remains equivocal about the nature of the representation of concepts within conceptual categories, there is the inherent assumption that concepts similar in semantic content are organized categorically (Caramazza & Shelton, 1998). Whether the feature and domain-specific models are in fact complementary or distinct remains inconclusive (Marques, 2000; de Almeida & Mobayyen, in press).

The conflicting views regarding the nature of the representation of concepts may be due to the fact that the main models of semantic memory organization have been developed largely on the basis of impaired and spared conceptual categories lexicalized by noun words (e.g., the living/nonliving things dissociation). Although there is a wealth of research in brain-injured populations indicating noun-deficits characterized by category specificity, studies of verb category specific deficits lag behind considerably. Since verb-labeled concepts constitute a major part of our semantic knowledge, the paucity of such studies may cast doubt on the generalizability of the domain- and feature-specific models to the organization of semantic knowledge. As mentioned earlier, the present study compensated for the above-mentioned shortcomings by investigating verb category-specific semantic deficits using dynamic stimuli (e.g., realistic short movies) that represented semantically coherent verb classes. In the case of the presence of verb category specificity, the goal was to examine its implications for the current assumptions of the main models (domain- and feature-specific) pertaining to the nature of the organizing principle of semantic knowledge.

As mentioned earlier, from the perspective of the feature-specific models, semantic deficits arise from a selective damage at the level of primitive features presumed to be constitutive of concepts (e.g., Jackendoff, 1990; Warrington & Shallice, 1984). On the basis of this premise, in Experiment 3, it was hypothesized that patients' verb category specificity would *mainly* affect the verb class of lexical causatives. From the perspective of domain-specific models, semantic deficits arise from a selective damage at the level of conceptual categories comprising concepts that share semantic content (Caramazza & Shelton, 1998). On this basis, it was hypothesized that patients' verb category specific dissociation would *mainly* affect the verb classes of movement and perception verbs.

The findings indicated that similar to their noun deficits, the DAT patients' verb deficits were also characterized by category dissociation, specifically affecting the class of perception verbs. However, patients did not show significant patterns of dissociation between their naming of lexical causatives and movement verbs and between their naming of lexical causatives and perception verbs. These findings corroborate *both* main models, namely feature-specific and domain specific, with the implication that these models may not be fundamentally apart. Semantic content and semantic feature may *both* represent organizational principles of knowledge, and verb deficits may occur on the basis of a selective disruption at either of these levels, namely *semantic content* and *semantic feature*.

Previous research (de Almeida & Mobayyen, in press) carried out on healthy individuals also suggested that *both* semantic content and semantic feature represent organizational principles of semantic memory. As Vinson et al. (2003) point out, diverse patterns of spared and impaired semantic categories in neurological patients have usually been interpreted as arising from either methodological issues or variability in neurological conditions in terms of how pertinent their implications may be for conceptual organization. However, the diverse patterns of spared and impaired semantic categories, Vinson et al. (2003) argue, may in fact reflect different principles underlying semantic memory organization.

One could further argue that the variability in the patterns of spared and impaired *noun-labeled* categories have led to the development of different models, such as the domain-specific and feature-specific models, and each model by itself is unable to account for the variety of observed semantic deficits. The dichotomy established between these models may begin to blur if the findings of studies on verb category specific dissociations are also incorporated and further developed. After all, as discussed previously, events and states lexicalized by verbs represent a large domain of our conceptual knowledge and a generalizable and comprehensive model of semantic knowledge needs to also incorporate patterns of impaired and spared *verb-labeled* categories.

The pattern of verb category specificity, specially affecting abstract and context-dependent perception verbs – in contrast to concrete and contextually rich movement verbs – has implications for the atomic view of category specific deficits proposed by de Almeida (1999, 2001). According to the atomic view of conceptual representation (Fodor, 1990), lexical concepts are indivisible atomic representations, or symbolic translations of the objects, actions, and events in the world. In a "language of thought", these symbolic representations are the basic vocabulary. de Almeida (1999) proposed that categorization effects found in cases of category-specific deficits, affect the inferences triggered by atomic concepts, or the concepts' "Inferential domains". In this theory, a concept's "inferential domain" is the set of entailments related to the concept. For example, the concept HEARING, activated by the word, *hearing* or an image of *hearing,* may in turn activate or "unleash" a set of inferences, or the concept's "inferential domain" (e.g., that x is perceiving y by hearing), and the concept WATCHING, activated by the word *watching* or an image of an event depicting *watching*, may also activate the concept's "inferential domain". Category specificity, de Almeida (1999) argues, is the result of a selective disruption of the "causal link" between a proximal stimulus (e.g., a word or an image) representing a concept and the concept, not of the concept, per se. For example, the functional deficit characterized as a selective perception verb deficit may in fact be a deficit affecting "the causal link" between the perception concepts and the stimuli (e.g., an image) activating these concepts. Since concepts are assumed to share in their "inferential domains", if the causal link between the concept LOOKING and the proximal stimulus (e.g., the shot movie depicting looking) activating this concept is affected, the short-movie may lead the patient to other alternatives such as *observing*, or *watching*. In this case, the concept LOOKING may be unaffected, but its disrupted relation with its proximal stimulus may lead to errors. On this view, when patients are presented with additional information (i.e., such as the word *looking* and a stimulus depicting *looking*), the concept LOOKING may in fact be accessed. The more information patients have about an action or event, the better their ability to retrieve its label. Perception verbs being more abstract and context dependent may thus require more contextual information to be retrieved.

According to de Almeida (1999, 2001), patterns of category-specific semantic deficits may be better accounted for by the atomic view of conceptual representation where indivisible atomic concepts, and not semantic feature and category, constitute conceptual knowledge. Studies investigating fine-grain distinctions between different classes of concepts (e.g., verb classes such as perceptions verbs and cognition verbs) accompanied by error analyses may be a productive avenue towards a further examination of the atomic view. These investigations may help further blur the previously established dichotomy between domain-specific and feature-specific models of semantic organization by shedding more light on *semantic content* and *semantic feature*, as organizing elements of knowledge.

IV. Conclusions

In conclusion, three experiments, involving mild-to-moderate DAT patients, were conducted to investigate the main assumptions of the feature- and domain-specific models of semantic memory organization. The findings suggested that similar to their noun-semantic deficits characterized by category dissociations (Experiment 1), the DAT patients' verb-semantic deficits (Experiment 2 and Experiment 3) were also characterized by category dissociations, specifically affecting the category of perception verbs (Experiment 3). The findings of Experiment 3 substantiated the feature-specific *and* domain specific models by suggesting that *both* semantic feature and semantic content are organizational principles of semantic knowledge. The perception/movement verb naming dissociation may also be explained in the context of the atomic view proposed by de Almeida (1999, 2001).

The findings require confirmation and extension. One way to confirm these findings would be to employ a larger pool of brain-injured patients exposed to different semantic paradigms (e.g., comprehension as well as production tasks). The development of a larger set of stimuli representing different verb classes normalized on age- and education-matched controls would also be informative. Since developing movies depicting perception or cognition verbs, for example could represent a challenge, the use of comprehension tasks in addition to productions tasks may be more important to understand the nature of deficits presumably affecting these concepts.

The present study's main contributions are (1) fine-grain investigation of verb category-specific semantic deficits in patients with verb-semantic deficits; and (b) an advance in the methodological investigation of verb deficits by presenting patients with ecologically more valid stimuli.

An important methodological contribution of the present study was the development of ecologically valid stimuli such as realistic short movies of actions that depicted semantically coherent verb classes. This in fact allowed for an understanding of the mechanisms underlying verb-semantic deficits and their implications for the main models of semantic memory organization. The use of realistic short-movies of actions also allowed for a better understanding of the previously reported patterns of object/action naming dissociations (e.g., Cappa et al., 1998; Robinson et al., 1996; Williamson et al., 1998).

A logical extension of this study would be a further investigation of verb-semantic deficits and verb category-specific deficits in neurological patients using different verb classes in different semantic paradigms (e.g., comprehension tasks). In the present study, within the perception class, five verbs of vision (e.g., *looking*, *watching*) were used. Different modes of seeing may be difficult to name, as one may also need to interpret the facial expressions of the perceiver (e.g., *glaring*). Adding different modes of perceiving in addition to the use of other verb classes (e.g., verbs of cognition) in brain-injured patients would certainly contribute to a better understanding of the nature of conceptual representation.

References

Astell, A. J., & harley, T. A. (1998). Naming problems in dementia: Semantic or lexical? *Aphasiology, 12,* 357-374.

Basso, A., Capitani, E., & Laiacona, M. (1988). Progressive language impairment without dementia: a case with isolated category specific semantic defect. *Journal of Neurology, Neurosurgery, and Psychiatry, 51*, 1201-1207.

Bayles, K. A., Tomoeda, C. K., & Trosset, M. W. (1990). Naming and categorical knowledge in Alzheimer's disease: the process of semantic memory deterioration. *Brain and Language, 39,* 498-510.

Bird, H., Howard, D., & Franklin, S. (2000). Why is a verb like an inanimate object? Grammatical category and semantic category deficits. *Brain and Language, 72*, 246-309.

Breedin, S. D., Saffran, E. M., & Coslett, H. B. (1994). Reversal of the concreteness effect in a patient with semantic dementia. *Cognitive Neuropsychology, 11*, 617-660.

Breedin, S. D., Saffran, E. M., & Schwartz, M. F. (1998). Semantic factors in verb retrieval: An effect of complexity. *Brain and Language, 63,* 1-31.

Cappa, S. F., Binetti, G., Pezzini, A., Padovani, A., Rozzini, L., & Trabucchi, M. (1998). Object and action naming in Alzheimer's disease and frontotemporal dementia. *Neurology, 50,* 351-355.

Caramazza, A., & Hillis, A. E. Lexical Organization of Nouns and Verbs in the Brain. *Nature, 349*, 788-790.

Caramazza, A., & Shelton, J. R. (1998). Domain specific knowledge systems in the brain: the animate-inanimate distinction. *Journal of Cognitive Neuroscience, 10,* 1-34.

Chertkow, H., Bub, D., & Seidenberg (1989). Priming and semantic memory loss in Alzheimer's disease. *Brain and Language, 36,* 420-446.

Cohen, J., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: An interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments & Computers, 25,* 257-271.

Cormier, P., Margison, J. A., & Fisk, J. D. (1991). Contribution of perceptual and lexical semantic errors to the naming impairments in Alzheimer's disease. *Perceptual and Motor Skills, 73,* 175-183.

Cree, G. S., & McRae, K. (2002). Analyzing the factors underlying the structure and computation of the meaning of chipmunk, cherry, chisel, cheese, and cello (and many other such concrete nouns). *Journal of Experimental Psychology: General*, 132, 163-201.

de Almeida, R. G. (1999). What do category specific deficits tell us about the representation of lexical concepts? *Brain and Language, 68,* 241-248.

de Almeida, R. G. (1999). The representation of lexical concepts: A psycholinguistic inquiry. Unpublished doctoral dissertation, Rutgers University, New Brunswick, New Jersey.

de Almeida, R. G. (2001). Conceptual deficits without features: A view from atomism. *Behavioral and Brain Sciences, 24 (3),* 482-483.

de Almeida, R. G., & Mobayyen, F. (In press). Semantic memory organization for verb concepts: Proactive interference as a function of content and structure.

Dell'Acqua, R., Lotto, L., & Job, R. (2000). Naming times and standardized norms for the Italian PD/DPSS se of 266 pictures: Direct comparisons with American, English, French, and Spanish published databases. *Behavior Research Methods, Instruments, and Computers, 32,* 588-615.

Devlin, J. T., Gonnerman, L. M., Anderson, E. S., Seidenberg, M. S. (1998). Category specific semantic deficits in focal and widespread brain damage: A computational account. *Journal of Cognitive Neuroscience, 10*, 77-94.

Devlin, J. T., Russell, R. P., Davis, M. H., Price, C. J., Moss, H. E., Fadili, M. J., & Tyler, L. K. (2002). Is there an anatomical basis for category-specificity? Semantic memory studies in PET and fMRI, *Neurosychologia, 40*, 54-75.

Druks, J., & Masterson, J. (2003). Ediorial. Special Issues: Objects vs. actions and nouns vs. verbs. *Journal of Neurolinguistics, 16,* 59-65.

Druks, J., Masterson, J., Kopelman, M., Clare, L., Rose, A., & Rai, G. (2006). Is action naming better preserved (than object naming) in Alzheimer's disease and why should we ask? *Brain and Language, 98,* 332-340.

Farah, M. J., & McClelland, J. L. (1991). A computational model of semantic impairment: modality specificity and emergent category specificity. *Journal of Experimental Psychology: General, 120*, 339-357.

Fiez, J. A., & Tranel, D. (1997). Standardized stimuli and procedures for investigating the retrieval of lexical and conceptual knowledge for action. *Memory and Cognition, 25 (4),* 543-569.

Fodor, J. A. (1990). *A Theory of Content and Other Essays.* Cambridge, MA: MIT Press.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-Mental State Examination: A practical method for grading the cognitive state of patients for the clinicians. *Journal of Psychiatric Research, 12,* 189-198.

Francis, W. N., & Kucera, H. (1982). *The frequency analysis of English usage*. Boston, MA: Houghton-Mifflin.

Fung, T. D., Chertkow, H., Whatmough, C., Murtha, S., Peloquin, L., & Whitehead, V. (2001). The spectrum of category effects in object and action knowledge in dementia of the Alzheimer's type. *Neuropsychology, 15.* 371-379.

Gainotti, G. (1990). The categorical organization of semantic and lexical knowledge in the brain. *Behavioural Neurology, 3,* 109-115.

Gainotti, G., Silveri, M. S., Daniele. A., Giustolisi, L. (1995). Neuroanatomic correlates of category-specific semantic disorders: A critical survey. *Memory, 3,* 247-264.

Garrard, P., Patterson, K., Watson, P. C., & Hodges, J. R. (1998). Category specific semantic loss in dementia of Alzheimer's type. Functional-anatomical correlations from cross-sectional analyses. *Brain, 121*, 633-646.

Gonnerman, L. M., Anderson, E. S., Devlin, J. T., Kempler, D., & Seidenberg, M. S. (1997). Double dissociation of semantic categories in Alzheimer's disease. *Brain and Language, 57,* 254-279.

Grossman, M., Mickanin, J., Onishi, K., Hughes, E. (1996). Verb comprehension deficits in probable Alzheimer's disease. *Brain and Language, 53,* 369-389.

Hart, J. Berndt, R. S., & Caramazza, A. (1985). Category specific naming deficit following cerebral infarction. *Nature, 316,* 439-440.

Hodges, J. R., Patterson, K., Graham, N., & Dawson, K. (1996). Naming and knowing in dementia of Alzheimer's type. *Brain and Language, 54,* 302-325.

Huff. F. J., Corkin, S., & Growdon, J. H. (1986). *Brain and Language, 28*, 235-249.

Jackendoff, R. (1983). *Semantics and Cognition.* London: The MIT Press.

Jackendoff, R. (1990). *Semantic Structures*. London: The MIT Press.

Jackendoff, R. (1995). *Languages of the Mind: Essays on Mental Representation.* London: The MIT Press.

Kan, I., & Thompson-Schill, S. L. (2004). Effect of name agreement on pre-frontal activity during overt and covert picture naming. *Cognitive Affective and Behavioral Neuroscience, 4,* 43-57.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test.* Philadelphia: Lea & Febiger.

Kemmerer, D., & Tranel, D. (2000). Verb retrieval in brain-damaged subjects: Analysis of stimulus, lexical, and conceptual factors. *Brain and Language, 73,* 347-392.

Kemmerer, D., Tranel, D., & Barresh, J. (2001). Patterns of dissociations in the processing of verb meanings in brain-damaged subjects. *Language and Cognitive Processes, 16,* 1-34.

Kim, M., & Thompson, C. K. (2000). Patterns of comprehension and production of nouns and verbs in agrammatism: Implications for lexical organization. *Brain and Language, 74,* 1-25.

Kintsch, W. (1974). *The Representation of Meaning in Memory*. Hillsdale, NJ: Lawrance Erlbaum.

Kolinsky, R., Fery, P., Messina, D., Peretz, I., Evinck, S., Ventura, P., & Morais, J. (2002). The fur of the crocodile and the mooing sheep: A study of a patient with a category-specific impairment for biological things. *Cognitive Neuropsychology,* *19 (4)*, 301-342.

Laiacona, M., Capitani, E., & Barborotto, R. (1997). Semantic category dissociations: A longitudinal study of two cases. *Cortex, 33,* 441-461.

Levin, B. (1994). *English Verb Classes and Alternations.* Chicago: University of Chicago Press.

Mahon, B. Z., & Caramazza, A. (2003). Category-specific knowledge, sensory modalities, and features: Clues from neuropsychology and functional neuroimaging. *Cognitive Neuropsychology, 20*, 433-450.

Marques, J. F. (2000). The "living things" impairment and the nature of semantic memory organization: An experimental study using PI-release and semantic cues. *Cognitive Neuropsychology, 17*, 683-707.

Marslen-Wilson, W. D., & Tyler, L. K. (1997). Dissociating types of mental computation. *Nature, 387,* 592-594.

Mckhann, G., Drachman, D.,, Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspicies of Health and Human Services Task Force on Alzheimer's disease. *Neurology, 40,* 439-443.

Miceli, G., Silveri, M. C., Villa, G., & Caramazza, A. (1984). On the basis for the agrammatic's difficulty in producing main verbs. *Cortex, 20,* 207-220.

Mobayyen, F. & de Almeida, R. G. (2005). The influence of semantic and morphological complexity of verbs on sentence recall: Implications for the nature of conceptual representation and category-specific deficits. *Brain and Cognition, 57*, 168-171.

Montanes, P., Goldblum, M. C., & Boller, F. (1995). The naming impairment of living and nonliving items in Alzheimer's disease. *Journal of the International Neuropsychological Society, 1*, 39-48.

Morrison, C. M., Ellis, A. W., & Quinlan, P. T. (1992). Age of acquisition not word frequency affects object naming, not object recognition. *Memory and Cognition, 20,* 705-714.

Moss, H. E., Tyler, L. K., Durrant-Peatfield, M., & Bunn, E. M. (1998). Two eyes of a see-through; Impaired and intact semantic knowledge in a case of selective deficit for living things. *Neurocase, 4,* 291-310.

Myerson, R., & Goodglass, H. (1972). Transformational grammars of three agrammatic patients. *Language and Speech, 15,* 40-51.

Nicholas, M., Olber, L., Albert, M., & Goodglass, H. (1985). Lexcial retrieval in healthy aging. Cortex, 21, 595-606.

Obler, L., & Albert, M. (1982). *Action Naming Test.* Boston: Aphasia Research Centre.

Plunkwtt, K., & Bandelow, S. (2006). Stochastic approaches to understanding dissociations in inflectional morphology. *Brain and Language, 98,* 194-209.

Rappaport Hovav, M., & Levin, B. (1998). Building verb meanings. Unpublished manuscript, Bar-Ilan University and Northwestern University.

Robinson, K. M., Grossman, M., White-Devine, T., & D'Esposito, M. (1996). Category-specific difficulty naming verbs in Alzheimer's disease. *Neurology, 47,* 178-182.

Rosseli, M., Tappen, R., Williams, C., & Salvatierra, J. (2006). The relation of education and gender on the attention items of the Mini-Mental State Examination in Spanish speaking Hispanic elders. *Archives of Clinical Neuropsychology, 21 (7),* 677-686.

Salmon, D. P., Butters, N., & Chan, A. S. (1999). The deterioration of semantic memory in Alzheimer's disease. *Canadian Journal of Experimental Psychology, 53:1,* 108-116.

Segalowitz, N., & de Almeida, R. G. (2002). Conceptual representation of verbs in bilinguals: Semantic field effects and a second language performance paradox. *Brain and Language, 81,* 517-531.

Silveri. M. C., Daniele, A., Giustolisi, L., & Gainotti, G. (1991). Dissociation between knowledge of living and nonliving things in dementia of the Alzheimer type. *Neurology, 41*, 545-546.

Slobin, D. I. (1996). Two ways to travel: verbs of motion in English and Spanish. In M. Shibatani & S. A. Thompson (Ed.), *Grammatical Constructions: Their Form and Meaning* (pp. 195-219). Oxford: Clarendon Press.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8*, 584-598.

Thompson, C. K. (2003). Unaccusative verb production in agrammatic aphasia: The argument structure complexity hypothesis. *Journal of Neurolinguistics, 16,* 151-167.

Tippett, L. J., Grossman, M., & Farah, M. J. (1996). The semantic memory impairment of Alzheimer's disease: Category specific? *Cortex, 32*, 143-153.

Tyler, L., & Moss, H. E. (2001). Towards a distributed account of conceptual knowledge. *Trends in Cognitive Sciences, 5,* 244-252.

Tyler, L. K., Moss, H. E., Durrant-Peatfield, M. R., & Levy, J. P. (2000). Conceptual structure of concepts: A distributed account of category-specific deficits. *Brain and Language, 75,* 195-231.

Ullman. M. T., Corkin, S., Coppola, M., Hickok, G., Growdon, J. H., Koroshetz, W. J., & Pinker, S. (1997). A neural dissociation within language: Evidence that the mental dictionary is part of declarative memory, and that grammatical rules are processed by the procedural system. *Journal of Cognitive Neurscience, 9 (2),* 266-276.

Viberg, A. (1984). The verbs of perception: A typological study. In B. Butterworth, B. Comrie, & Ö. Dahl (Ed.), *Explanations for Language Universals* (pp. 123-162). Berlin: Mouton de Gruyter.

Vinson, D. P., Vigliocco, G., Cappa, S., & Siri, S. (2003). The break down of semantic knowledge: Insights from a statistical model of meaning *representation. Brain and Language, 86,* 347-365.

Warrington, E. K., & Shallice, T. (1984). Category specific semantic impairments. *Brain, 107,* 829-853.

Whatmough, C., & Chertkow, H. (2002). Category-specific recognition impairments in Alzheimer's disease. In E. M. E. Forde, & G. W. Humphreys (Ed.), *Category Specificity in Mind and Brain* (pp. 180-210). New York: Psychological Press.

Wickens, D. D., & Dalezman, R. (1976). Multiple encoding of word attributes in memory. *Memory and Cognition, 4 (3),* 307-310.

Williamson, D. J. G., Adair, J. C., Raymer, A. M., & heilman, K. M. (1998). Object and action naming in Alzheimer's disease. *Cortex, 34,* 601-610.

Zannino, G. D., Perri, R., Carlesimo, G. A., Pasqualetti, P., & Catagirone, C. (2002). Category specific impairment in patients with Alzheimer's disease as a function of disease severity: A cross sectional investigation. *Neuropsychologia, 40,* 2268-2279.

Zannino, G. D., Perri, R., Pasqualetti, P., Caltagirone, C., & Carlesimo, G. A. (2006).

(Category-Specific) semantic deficit in Alzheimer's patients: The role of semantic distance. *Neuropsychologia, 44,* 52-61.

Zannino, G. D., Perri, R., Pasqualetti, P., Di Paola, M., Caltagirone, C., & Carlesimo. (in press). The role of semantic distance in category-specific semantic impairments for living things: Evidence from a case of semantic dementia. *Neuropsychologia.*

Appendix A

The Consent Form

CENTRE DE RECHERCHE Hôpital Douglas Hospital RESEARCH CENTRE

CONSENT TO PARTICIPATE
in a research study on memory

This is to state that I agree to participate in a study titled "The Organization of Semantic Memory: Evidence from Investigation of Category-Specific Verb Deficits in Non-Fluent Aphasia and Dementia of the Alzheimer Type" being conducted by Dr. Roberto de Almeida, Dr. N.P.V. Nair and colleagues.

➢ **Purpose**

I have been informed that the purpose of the research is to study why certain memory problems occur.

➢ **Procedure**

I have been informed that the procedure involves memory tasks presented on a computer screen. In these tasks, words, pictures, and movies of actions will be presented. On some tasks, I will be asked to name the pictures and movies of actions, and on other tasks, I need to point out which of the two presented pictures matches the presented word best. There is no time pressure for responding. The study may last approximately 2 hours.

➢ **Conditions of Participation**

- I understand that I am free to participate or not in this study without this affecting my care in any way.
- I understand that I am free to withdraw my consent and discontinue my participation in this study at any time.
- I understand that my participation in this study is confidential. The results from this study may be published but my identity will not be revealed.
- I will not be paid for participating in this study other than reimbursement for expenses related to participating in the study, such as parking or transportation.
- I understand that I may receive information regarding this study from Dr. Nair (phone: 514 761-6131 ext 4405) or Dr. de Almeida (phone: 514 848-2424 ext 2232) during business hours.
- I understand that I may receive information regarding my rights as a subject participating in a research study from the Ombudsman of the Douglas Hospital, Francine Bourassa (phone: 514 761-6131 ext: 3287) during business hours.

I understand this agreement, any questions I may have had have been answered and I consent to participate in this study.

________________________ ________________________

NAME (please print) Date

________________________ ________________________

Signature Caregiver (Name / Signature)

Appendix B

Normative Information (e.g., name agreement) for the Line Drawings of Living and Nonliving Things Derived from Snodgrass and Vanderwart's (1980) Corpus

Target Response	Name Agreement[1]	Image Agreement[2]	Familiarity[3]	Visual Complexity[4]
1. Celery	76	3.75	3.75	4.25
2. Carrot	100	4.5	3.55	2.95
3. Potato	90	3.97	3.46	2.2
4. Pumpkin	98	4.18	3.08	2.6
5. Corn	81	4.08	3.5	3.58
6. Mushroom	98	3.78	2.88	3.12
7. Pepper	67	3.64	2.92	2.48
8. Tomato	88	4.05	3.78	1.98
9. Asparagus	69	3.5	2.68	3.32
10. Onion	95	3.9	3.22	2.85
11. Duck	95	3.85	2.75	3.32
12. Turtle	95	4.12	2.4	3.62
13. Seal	88	3.18	1.62	2.9
14. Alligator	88	3.98	1.65	4.08
15. Frog	100	3.6	2.48	3.42
16. Fish	100	3.58	3.28	3.75
17. Swan	88	3.69	1.97	3.05
18. Penguin	90	3.22	1.7	2.82
19. Ant	81	2.92	2.62	3.92
20. Bee	60	2.78	2.68	4.75
21. Caterpillar	79	2.38	1.72	3.58

1 Participants were asked to identify each picture by writing the first name that came to mind

2 Participants were asked to rate the agreement between the line drawing and their mental image using a 5-point scale, 1 representing low and 5 representing high agreement

3 Participants were asked to judge the familiarity of the picture using a 5-point scale 1 indicating very unfamiliar and 5 indicating very familiar

4 Participants were asked to rate the complexity of each picture on a 5-point scale, I indicating very simple and 5 indicating very complex

22.Beetle	50	2.05	1.88	3.65
23.Butterfly	100	3.92	2.92	4.25
24.Spider	88	2.95	2.28	3.68
25.Giraffe	95	4.48	1.8	4.65
26.Elephant	100	3.85	2.35	4.12
27.Rabbit	100	4.2	2.95	3.28
28. Camel	95	3.92	3.92	3.75
29. Cow	93	3.92	2.42	3.85
30. Monkey	95	3.12	2.58	3.9
31. Squirrel	93	4.42	3.82	3.75
32. Bear	88	3.62	1.98	3.68
33. Rooster	76	4.08	2.22	4.12
34. Mouse	79	4.22	2.45	3.28
35. Pineapple	100	4.6	2.95	4.35
36. Banana	100	4.42	3.65	1.32
37. Watermelon	86	2.85	3.05	2.28
38. Cherry	83	4.52	3.38	1.6
39. Pear	100	4.62	3.55	1.15
40. Apple	98	4.05	3.98	1.82
41. Grapes	90	4.31	3.65	3
42. Lemon	100	4.35	3.25	1.85
43. Orange	81	4	3.34	2.12
44. Strawberry	90	3.98	3.2	3.38
45. Ear	95	4.26	4.5	2.68
46. Eye	98	4.15	4.88	3.48
47. Finger	71	4.6	4.78	2.3

48. Foot	95	4.42	4.78	2.18
49. Leg	81	3.64	4.65	2.55
50. Lips	93	4.1	4.5	1.85
51. Nose	98	3.62	4.52	1.6
52. Toe	55	4.18	4.48	1.98
53. Thumb	98	4.48	4.72	2.38
54. Pillars	88	4.22	3.38	2.2
55. Nail	98	4.73	3.28	1.8
56. Hammer	100	4.1	3.48	2.6
57. Chisel	33	3.15	2.46	3.12
58. Scissors	98	4.4	3.98	2.15
59. Screw	93	3.67	3.2	3.25
60. Screwdriver	98	4.3	3.42	2.35
61. Wrench	76	2.51	2.72	2.02
62. Nut	64	3.62	2.55	2.3
63. Ruler	98	3.98	3.58	1.85
64. Lamp	93	3.26	4.2	1.85
65. Couch	67	3.05	4.4	2.28
66. Clock	98	2.2	4.38	2.68
67. Chair	100	3.22	4.58	2.05
68. Vase	95	2.72	2.78	3.15
69. Stool	98	4.12	3.08	2.32
70. Rockingchair	90	4.12	3.25	3.58
71. Motorcycle	95	3.64	3.25	4.78
72. Sailboat	93	3.25	2.92	3.58
73. Bus	100	4.08	4.5	3.95

74. Train	86	3.2	4.15	4.32
75. Truck	90	2.8	4.02	2.75
76. Sled	98	4.49	2.8	3.05
77. Wagon	79	3.56	2.5	3.35
78. Bicycle	88	3.4	3.78	3.85
79. Airplane	60	3.23	3.78	3.5
80. Babycarriage	52	3.65	2.72	3.42
81. Jacket	81	2.22	4	3.25
82. Tie	69	4.05	3.8	2.9
83. Sweater	83	2.78	4.48	2.9
84. Mitten	76	3.82	3.1	2.35
85. Sock	100	3.72	4.52	1.62
86. Skirt	98	3.28	3.64	1.4
87. Shoe	95	3.02	4.62	3.38
88. Shirt	98	3.28	3.64	1.4
89. Pants	88	3.6	4.55	2.22
90. Glove	98	3.65	3.38	3.02
91. Flute	88	3.41	2.45	4.15
92. Guitar	98	4.2	3.58	4
93. Harp	93	4.28	1.88	4.05
94. Piano	81	4.02	3.42	4.58
95. Trumpet	79	2.89	2.6	3.58
96. Violin	86	4.18	2.68	4.1
97. Accordion	88	3.4	2.15	4.68
98. Drum	98	3.71	2.6	2.88
99. Stove	76	4.1	4.65	4.02

100. Pitcher	88	3.62	3.5	1.85
101. Kettle	40	3.31	3.8	2.4
102. Spoon	98	4.1	4.5	2.02
103. Fork	100	4.15	4.78	2.62
104. Pot	81	3.56	4.22	2.22
105. Cup	93	3.65	4.4	1.78
106. Saltshaker	83	4	4.18	3
107. Frying pan	60	3.92	4.15	2.05
108. Refrigerator	93	3.85	4.68	2.2

Appendix C

The ANOVA Summary Tables (Experiment 1)

Table 1

ANOVA Summary Table for Percentage Correct Naming as a Function of Semantic Category (living and nonliving things) and Participants (patients and controls).

Source	*df*	*SS*	*MS*	*F*
Semantic Category	1	219.620	219.620	3.643
Participants	1	5668.279	5668.279	50.43*
Interaction	1	622.516	622.516	13.33*
Subject	9	1168.890	129.877	
Error Term	9	420.258	46.695	

* $p < .05$

Table 2.

ANOVA Summary Table for Percentage Correct Naming as a Function of Semantic Category (living and nonliving things) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Semantic category	1	790.82	790.82	7.83*
Subject	9	2075.19	230.577	
Error Term	9	908.81	100.979	
	Controls			
Semantic category	1	35.795	35.795	4.62
Subject	10	110.463	11.046	
Error Term	10	77.477	7.748	

* $p < .05$

Table 3.

ANOVA Summary Table for Percentage Correct Naming as a Function of the Living Category (aquatic/amphibiotic animals, insects, vegetables, fruits, terrestrial animals, body parts) and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Semantic Category	5	14987.422	2997.484	22.372*
Participants	1	29305.626	29305.626	75.51*
Interaction	5	4989.785	997.957	5.739*
Subject	9	4927.723	547.525	
Error Term	45	7825.499	173.900	

* $p <.05$

Table 4.

ANOVA Summary Table for Percentage Correct Naming as a Function of the Living Category (aquatic/amphibiotic animals, insects, vegetables, fruits, terrestrial animals, body parts) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Semantic category	5	17255.818	3451.164	15.30*
Subject	9	7803.954	867.106	
Error Term	45	11006.076	244.579	
	Controls			
Semantic category	5	2743.707	548.741	8.65*
Subject	10	724.657	72.466	
Error Term	50	3171.203	63.424	

* $p < .05$

Table 5.

ANOVA Summary Table for Percentage Correct Naming as a Function of the Nonliving Category (tools, vehicles, household items, musical instruments, kitchen items, clothing items) and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Semantic Category	5	6919.019	1383.804	9.911*
Participants	1	6420.917	6420.917	36.026*
Interaction	5	3945.272	789.054	5.991*
Subject	9	2547.677	283.075	
Error Term	45	5926.803	131.707	

* $p < .05$

Table 6.

ANOVA Summary Table for Percentage Correct Naming as a Function of the Nonliving Category (tools, vehicles, household items, musical instruments, kitchen items, clothing items) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Semantic category	5	10264.239	2052.848	10.129*
Subject	9	3640.394	404.488	
Error Term	45	9120.575	202.679	
	Controls			
Semantic category	5	786.229	157.246	2.320
Subject	10	555.307	55.531	
Error Term	50	3388.886	67.778	

* $p < .05$

Appendix D

Fiez and Tranel's (1997) Action Naming Test

Target Verb	Pointed Object	First Answer	Prompt
Flushing (Practice)			
Landing (Practice)			
Tackling (Practice)	(left person) doing		
Scraping (Practice)			
1. Cutting			
2. Following	(ducklings) doing	Swimming	*Besides Swimming,…*
3. Roping/Lassoing/catching	*To (calf)*		
4. Galloping/Trotting		Running	What kind of Running
5. Sewing/Mending/Darning Stitching			
6. Racing			
7. Bucking	(horse) doing	Jumping	What kind of Jumping
8. Loading/Reloading			
9. Hobbling		Tying	What kind of Tying
10. Marching/Parading			
11. Crashing/Wrecking			
12. Kicking			
13. Skating/Ice-skating			
14. Leading/Guiding	(right person) doing		
15. Slicing		Cutting	What kind of Cutting
16. Sawing		Cutting	What kind of Cutting
17. Weighing			
18. Saluting			

Target Verb	Pointed Object	First Answer	Prompt
19. Dunking/Dipping			
20. Pouring			
21. Melting	(Ice) doing		
22. Sticking/Clinging	(yarn) doing		
23. Reaching			
24. Dialing/Calling			
25. Skiing			
26. Yawning		Roaring	Besides Roaring…
27. Sneezing			
28. Receiving/Accepting Taking	(right person) doing		
29. Refusing/Rejecting/Denying Declining	(left person) doing		
30. Sailing		Boating	What kind of Boating
31. Colouring/Scribbling		Drawing	Besides Drawing…
32. Sledding		Yelling, Screaming	Besides Yelling, Screaming
33. Crossing			
34. Wiping	With (tissue)		
35. Blocking/Stopping	(front person) doing		
36. Interviewing	(right person) doing	Holding	Besides Holding…
37. Curling		Brushing/Combing	Besides Brushing Combing
38. Parachuting		Falling	Besides Falling
39. Fainting	(right person) doing	Falling	What kind of Falling
40. Mailing/Sending			

Target Verb	Pointed Object	First Answer	Prompt
41. Washing/Rinsing			
42. Kissing			
43. Painting		Drawing	Besides Drawing…
44. Riding	(person) doing		
45. Erasing			
46. Boxing		Fighting	What kind of Fighting
47. Mounting		Getting on the horse	What is the word for Getting on the horse
48. Winding		Turning	What kind of Turning
49. Wrestling			
50. Raking			
51. Tracing		Drawing	If you look more Carefully, besides Drawing…
52. Knitting			
53. Stirring			
54. Scratching/Itching			
55. Blowing/Extinguishing			
56. Laminating		Covering	What kind of Covering
57. Hugging/Celebrating/ Rejoicing			
58. Hanging			
59. Eating			
60. Standing			
61. Pushing			

Target Verb	Pointed Object	First Answer	Prompt
62. Spinning			
63. Smiling			
64. Straddling		Standing	What kind of Standing
65. Ducking/Dodging Avoiding			
66. Grazing		Eating	What kind of Eating
67. Tucking			
68. Swimming			
69. Spraying/Squirting			
70. Shooting/Hunting			
71. Shaking		Greeting	Besides Greeting…
72. Fishing			
73. Plugging			
74. Flexing			
75. Juggling			
Separated (Practice)			
Developed (Practice)			
Ripened (Practice)			
Healed			
1. Turned			
2. Framed			
3. Crumbled		*Broke*	What kind of Break

Target Verb	Pointed Object	First Answer	Prompt
4. Addressed			
5. Labeled/Filed/Named			
6. Nailed/Hammered/Pounded			
7. Toasted			
8. Chopped/Diced		Cut	What kind of Cutting
9. Poked/Punctured/Punched		Made a hole	What is the word for made a hole
10. Shredded			
11. Baked		Cooked	What kind of Cooking
12. Dropped			
13. Cracked		Broke	What kind of Breaking
14. Mashed			
15. Separated/Sorted			
16. Tied			
17. Fried		Cooked	What kind of Cooking
18. Chipped		Broke	What kind of Breaking
19. Lifted		Picked up	What is the word for Picked up?
20. Popped			

Possible "Pointed Object" Phrasings:

What is this person doing? OR what did this do?
What is the person doing with this? OR what was done with this?
What is the person doing to this? OR what was done to this?

Possible 2nd query phrasings:

Can you give an answer which specifies what kind of x the person is doing? OR what kind of x was done?

Can you give a single word, which means x?

Besides x, can you tell me what else the person is doing? OR what the person did… OR what was done?

Look again, and try to think of a more accurate name for what the person is doing. OR what the person did… OR what was done.

Note: x indicates an incorrect first answer. The words "animal" and "object" may be substituted for "person".

Appendix E

Normative Information (e.g., name agreement) for the Colour Single and Paired Photographs Derived from Fiez and Tranel's (1997) Corpus

Target Response	Name Agreement[1]	Image Agreement [2]	Familiarity [3]	Visual Complexity[4]
Cutting	100	4.3	3.25	1.8
Following	17	2.95	2.5	3.35
Roping	50	4.03	2.1	4.7
Galloping	63	4.75	2.65	2.65
Sewing	72	2.63	2.88	4.23
Racing	100	3.78	2.65	4
Bucking	45	4.4	2.33	4.38
Loading	81	2.98	2.3	3.78
Hobbling	5	2.41	1.65	3.93
Juggling	100	4.85	2.5	3.2
Marching	91	4.45	2.93	3.88
Crashing	52	3.6	1.9	4.38
Kicking	97	4.15	3	2.25
Skating	86	4.38	2.75	3.83
Leading	47	2.88	2.08	2.68
Slicing	33	4.5	3.95	2.33
Sawing	97	4.73	3.05	2.6
Weighing	100	4.78	3.6	1.88
Saluting	94	4.75	2.53	1.48
Dunking	52	3.1	2.8	2.38
Pouring	100	4.38	3.43	1.98

[1] Name Agreement was defined as the percentage of the participants who came up with the same label

[2] Participants were asked to rate the agreement between the picture and their mental image using a 5- point scale, 1 representing low and 5 representing high agreement

[3] Participants were asked to judge the familiarity of the picture using a 5-point scale 1 indicating very unfamiliar and 5 indicating very familiar

[4] Participants were asked to rate the complexity of each picture on a 5-point scale, I indicating very simple and 5 indicating very complex

Target Response	Name Agreement	Image Agreement	Familiarity	Visual Complexity
Melting	91	3.75	3.1	2.25
Sticking	50	2.1	2.43	2.45
Reaching	98	4.53	3.53	2.4
Dialing	91	4.78	4.85	2.1
Skiing	100	4.88	3.25	3.93
Yawning	73	3.65	3.18	3.03
Sneezing	89	4.53	4.2	2.15
Receiving	6	3.55	3.25	2.35
Refusing	50	4.1	3.5	2.18
Sailing	95	4.78	2.48	4
Colouring	94	4.48	3.15	2.4
Sledding	86	4.73	3.8	3.18
Wiping	53	3.3	3.63	1.75
Blocking	59	3.45	2.25	3.05
Interviewing	28	3.8	2.5	2.45
Curling	97	3.9	3.33	2.08
Parachuting	72	4.95	2.1	3.75
Fainting	77	4.48	2.08	2.6
Mailing	84	4.8	3.93	2.23
Washing	89	3.63	4.5	2.23
Kissing	95	4.25	4.3	2.1
Painting	91	4.35	2.98	2.5
Riding	89	3.5	2.53	3.68
Erasing	98	4.05	3.1	2.08
Boxing	94	4.95	2.68	4

Target Response	Name Agreement	Image Agreement	Familiarity	Visual Complexity
Mounting	70	3.8	2.45	3.45
Winding	70	2.88	2.13	2.03
Wrestling	95	4.98	2.85	4.33
Raking	100	4.95	3.18	3.03
Knitting	78	4.88	2.08	2.8
Stirring	95	4.13	3.88	1.8
Scratching	91	4.33	3.9	1.64
Blowing	95	3.8	3.08	2.08
Laminating	55	4.13	2.65	2.55
Hugging	48	4.47	3.68	3.88
Hanging	98	3.35	3.8	2.1
Eating	98	4.05	3.1	2.08
Standing	94	4.6	3.28	1.38
Pushing	97	3.78	3.1	1.88
Spinning	42	1.7	1.58	3.7
Smiling	100	4.88	4.15	1.25
Straddling	70	3.5	1.73	2.03
Ducking	28	3.65	2.63	2.3
Grazing	63	4.23	2.83	2.3
Tucking	84	3.85	4	2.1
Swimming	95	4.88	3.28	3.7
Spraying	83	4.23	3.3	1.9
Shooting	83	4.3	2.4	3.68
Shaking	84	3.38	4.38	1.95
Fishing	98	4.93	3.48	3.85

Target Response	Name Agreement	Image Agreement	Familiarity	Visual Complexity
Flexing	94	4.35	3.53	1.78
Plugging	97	4.18	4.28	1.6
Turned	86	3.13	3.85	1.7
Framed	100	4.73	3.38	2.43
Crumbled	53	3.75	3.48	1.95
Addressed	84	4.55	3.68	2.58
Labeled	75	4.35	3.33	2.05
Nailed	77	4.45	3.38	2.28
Toasted	95	4.93	4.23	2.08
Chopped	56	4.59	3.78	2.9
Poked	64	2.95	2.83	1.83
Dropped	95	4.03	3.63	1.53
Cracked	80	3.8	3.5	2.15
Separated	73	3.18	3.78	2.83
Tied	92	4.43	4.58	2.13
Fried	44	4.03	3.9	2.6
Chipped	83	4.25	3.05	2.2
Lifted	81	4.5	4.33	2.2
Popped	94	4.28	3.53	1.75
Shredded	92	4.58	2.73	2.88
Baked	83	4.33	3.95	2.68

Appendix F

The ANOVA Summary Tables (Experiment 2)

Table 7.

ANOVA Summary Table for Percentage Correct *Verb* Naming as a Function of Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Participant	1	7352.906	7352.906	66.543*
Error Term	19	2099.467	110.498	

$^{*}p < .05$

Table 8.

ANOVA Summary Table for Percentage Correct Naming as a Function of Semantic Category (verbs and nouns) and Participants

Source	*df*	*SS*	*MS*	*F*
Semantic Category	1	2262.279	2262.79	38.920*
Participants	1	8955.096	8895.096	112.011*
Interaction	1	652.013	652.013	34.201*
Subject	9	1311.556	145.728	
Error Term	9	171.579	19.064	

* $p < .05$

Table 9.

ANOVA Summary Table for Percentage Correct Naming as a Function of Semantic Category (verbs and nouns) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Semantic category	1	2671.657	2671.657	41.008*
Error Term	9	586.341	65.149	
	Controls			
Semantic category	1	297.646	297.646	25.494*
Error Term	10	116.751	11.675	

* $p < .05$

Table 10.

ANOVA Summary Table for Percentage Correct Naming as a Function of *Verb* Inflection (regularly inflected past tense –ed and present progressive – ing) and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Verb Inflection	1	846.369	846.369	17.451*
Participants	1	20701.438	20701.438	122.348*
Interaction	1	562.675	562.675	66.558*
Subject	9	2617.747	290.861	
Error Term	9	76.086	8.454	

* $p < .05$

Appendix G

Normative Information (Name Agreement Values) for the Short-Movies of Action

Verb	Name Agreement[1] (% followed by the number of individuals)	Other Labels (number of individuals)
1. Peeling	86.67 (13)	2 cutting
2. Bending	100 (15)	
3. Twisting/Wringing	(Twisting) 33.33 (5) (Wringing) 46.67 (7)	1 squeezing, 1 wrenching, 1 Raveling
4. Crumpling	(Crumpling) 53.33 (8) (Scrunching) 33.33 (5)	1 crushing, 1 squashing
5. Flipping	(Flipping) 60 (9) (Tossing) 20 (3)	1 Flicking, 1 Catching, 1 Grasping
6. Squeezing	100 (15)	
7. Crushing	(Crushing) 66.67 (10) (Squashing) 20 (3)	1 Squishing, 1 Squeezing
8. Spilling	(Spilling) 40 (6) (Spilled) 20 (3) (Spilling or Spilled)13.33 (2)	2 Kicking, 2 Knocked over
9. Folding	100 (15)	
10. Bouncing	80 (12)	3 Dribbling
11. Tiptoeing	33.33 (5)	4 Creeping, 2 Searching, 1 skulking, 1 Dragging, 2 Sneaking
12. Crawling	100 (15)	
13. Skating/Rollerblading	(Skating) 33.33 (5) (Rollerblading) 46.66 (7)	3 Rollerskating
14. Walking	80 (12)	3 Strolling
15. Running/Jugging	(Running) 40 (6) (Jugging) 53.33 (8)	1 Slow Jog
16. Climbing	93.33 (14)	1 Walking up
17. Hopping	86.67 (13)	1 Jumping up and down, 1 Exercising
18. Leaping/Leapfrogging	(Leaping) 26.66 (4) (Leapfrogging) 40 (6)	2 Leapfrog, 1 Jumping, 2 Jumping over

[1] The percentage of individuals arriving at the same label for the action conveyed in the movie.

Verb	Name Agreement (% followed by the number of individuals)	Other Labels (number of individuals)
19. Swinging	100 (15)	
20. Watching	93.33 (14)	1 Looking at the computer
21. Scanning	33.33 (5)	1 Thumbing down, 4 Searching, 2 Looking, 1 Hunting, 1 Checking, 1 Finding
22. Looking	46.67 (7)	1 looking or seeking, 1 Searching or Looking, 1 Sighting or Looking, 5 Searching
23. Tasting	93.33 (14)	1 Licking
24. Smelling	100 (15)	
25. Rolling/Rolling over	(Rolling) 86.66 (13) (Rolling over) 13.33 (2)	
26. Peeking	53.33 (8)	3 Playing peekaboo, 1 Peekabooing, 1 hiding her eyes, 1 looking, 1 had her eyes closed and now opened
27. Glaring/Squinting	53.33 Squinting 13.33 Glaring	1 Peeking, 1 thinking, 2 Staring, 1 Getting angry by the minute
28. Staring	20 (3)	1 Glancing, 3 Looking, 3 Looking back, 1 eyeing 2 Turned around and Glanced, 1 Checking, 1 Wondering
29. Listening	86.67 (13)	1 Hearing, Bending the ear to hear

Appendix H

The ANOVA Summary Tables (Experiment 3)

Table 11.

ANOVA Summary Table for Percentage Correct Action Naming as a Function of Participants (Patients and Controls)

Source	*df*	*SS*	*MS*	*F*
Participants	1	4903.314	4903.314	31.775*
Error Term	19	2932.000	154.316	

$^{*}p < .05$

Table 12.

ANOVA Summary Table for Percentage Correct Naming as a Function of Verb Category (Lexical Causatives, Movement Verbs, and Perception Verbs) and Participants (Patients and Controls)

Source	*df*	*SS*	*MS*	*F*
Verb Category	2	6449.790	3224.895	28.718*
Participants	1	14587.875	14587.875	29.339*
Interaction	2	338.830	169.415	1.295
Subject	9	4533.402	503.711	
Error Term	18	2355.436	130.858	

* $p < .05$

Table 13.

ANOVA Summary Table for Percentage Correct Naming as a Function of Verb Category (Lexical Causatives, Movement Verbs, Perception Verbs) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Verb Category	2	4826.667	2413.333	16.225*
Subject	9	8718.667	968.741	
Error Term	18	2677.333	148.741	
	Controls			
Verb Category	2	2041.011	1020.506	11.348*
Subject	10	630.570	63.057	
Error Term	20	1798.549	89.927	

* $p < .05$

Table 14.

ANOVA Summary Table for Item Analysis: Percentage Correct Naming Across the Participants as a Function of Verb Category (Lexical Causatives, Movement Verbs, Perception Verbs) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Verb Category	2	5099.617	2549.808	2.745
Error Term	26	24155.556	929.060	
	Controls			
Verb Category	2	1910.612	955.306	2.347
Error Term	26	10582.975	407.037	

$* p < .05$

Table 15.

ANOVA Summary Table for Percentage Correct Action Naming as a Function of Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Participants	1	4829.004	4829.004	19.923*
Error Term	19	4605.276	242.383	

* $p < .05$

Table 16.

ANOVA Summary Table for Mean Percentage Correct Naming as a Function of Verb Semantic Category (lexical causative verbs, movement verbs, perception verbs), and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Verb Semantic Category	2	1800.652	900.326	3.717*
Participants	1	12807.126	12807.126	21.81*
Interaction	2	2085.652	1042.826	2.948
Subject	9	6501.191	722.355	
Error Term	18	6366.815	353.712	

* $p < .05$

Table 17.

ANOVA Summary Table for Percentage Correct Naming as a Function of Verb Semantic Category (Lexical Causatives, Movement Verbs, Perception Verbs) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Verb Semantic Category	2	3875.000	1937.500	3.902*
Subject	9	11447.873	1271.986	
Error Term	18	9415.747	523.097	
	Controls			
Verb Semantic Category	2	19.697	9.848	0.165
Subject	10	389.394	38.939	
Error Term	20	1196.970	59.848	

$^*p < .05$

Table 18.

ANOVA Summary Table for Mean Percentage Correct Naming as a Function of Semantic Category (objects/nouns and actions/verbs), and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Semantic Category	1	36.427	36.427	.331
Participants	1	6894.913	6894.913	41.223*
Interaction	1	194.290	194.290	2.410
Subject	9	2031.849	225.761	
Error Term	9	725.418	80.602	

* $p < .05$

Table 19.

ANOVA Summary Table for Item Analysis: Percentage Correct Naming Across the Participants as a Function of Verb Category (Lexical Causatives, Movement Verbs, Perception Verbs) for Patients and Controls

Source	*df*	*SS*	*MS*	*F*
	Patients			
Verb Category	2	1818.333	909.167	1.634
Error Term	12	6675	556.250	
	Controls			
Verb Category	2	12.397	6.198	0.188
Error Term	12	395.325	32.944	

Table 20.

ANOVA Summary Table for Mean Percentage Correct Naming as a Function of Stimuli (single colour photographs and short-movies) Depicting Verbs, and Participants (patients and controls)

Source	*df*	*SS*	*MS*	*F*
Stimuli	1	2329.249	2329.249	31.26*
Participants	1	10537.708	10537.708	43.287*
Interaction	1	212.029	212.029	4.428
Subject	9	2194.360	243.818	
Error Term	9	430.911	47.879	

* $p < .05$

Appendix I

Responses to the Short Movies (Experiment 3) that Were Scored as Incorrect Across the Patients

Verb/Target Response	Responses Scored as Incorrect
1. Peeling	Scraping, Shredding, Cutting[1]
2. Bending	Flipping, Break, Breaking, Lifting up, Pulling, Scraping
3. Squeezing	Holding, Juicing
4. Folding	-----
5. Bouncing	Playing (n=2), Putting up and down
6. Twisting	Holding up, Squeezing, Rolling up, Breaking
7. Crumpling	Screwing up, Wrinkling, Crushing, Paper Scrawling, Folding (n=2), Rolling, Shrinking up
8. Flipping	Giving, Counting, Passing, Catching, Going up, Making a fist, Folding out, Lifting
9. Crushing	Standing, Squeezing, Pressing, Stepped
10. Spilling	Fell over, Don't Know
11. Skating	Walking, Running, Going across on Wheels
12. Running	-----
13. Swinging	Riding on a swing
14. Rolling	Turning over (n=2)
15. Crawling	------
16. Tiptoeing	Pulling, Sneaking, Carrying, Pulling, Creeping along, Don't Know, Creeping, Walking Slowly
17. Walking	---------
18. Climbing	Going up (n=2)
19. Hopping	Jumping[2] (n=5), Watching, Walking
20. Leaping	Jumping over (n= 5), Hopping over (n=3), Jumping (n=2)
21. Watching	Looking (n=5), Sitting
22. Scanning	Looking (n=3), Going down the list (n=2), Studying, Going down the page, Reading
23. Looking	Saluting (n=3), glassing hair, trying to observe
24. Tasting	Eating (n =3), Enjoying yogurt, Looking, Sipping, don't know

[1] *Cutting* for *Peeling* was considered an error only in scoring the high-naming agreement short movies

[2] *Jumping* for *Hopping* was considered an error only in scoring the high-naming agreement short-movies

25. Smelling	Looking, Licking, Sniffing
26. Listening	Looking, don't know, sat down
27. Peeking	Peeping, Holding hand, Hiding, Looking, Got hands on her eyes, Covering and Opening
28. Glaring	Grimacing, Staring, Peeking, Concentrating, Looking, Closing, don't know, Staring
29. Staring	Looking back, Turning around, Observing, Watching, Looking around, Looking (n=2), Standing