Exploring semantic memory organization using a proactive interference paradigm

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Abstract

Exploring semantic memory organization using a proactive interference paradigm

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Several decades of research into semantic memory have yielded two main perspectives as to how semantic memory may be organized. One hypothesis is that information is stored according to taxonomical categories (e.g., animals, objects); the other hypothesis suggests that information is stored according to featural attributes (e.g., functional and perceptual properties). Using a proactive interference (PI) paradigm, this study aimed to investigate these two hypotheses by contrasting the impact of categorical and featural cues on patterns of PI effects (i.e., buildup and release). Using the same stimuli and task, while examining recall performance and intrusion errors when featural and categorical information were opposed, allowed for a direct measure of the contribution of these two types of information for semantic organization. To explore semantic organization across the lifespan, 20 healthy younger and 20 healthy older participants were tested. Given that semantic memory deficits frequently occur in Alzheimer's disease (AD), the performance of the healthy older participants was also compared to 16 participants with AD to examine differences in semantic organization of featural and categorical information in individuals for whom there is a potential breakdown of semantic memory. All groups showed expected PI effects when stimuli were categorically cued. Participants also showed a release from PI when the featural cue changed (but the category remained the same). An unexpected release from PI effect was found in the featural PI continued condition in which the featural cue remained the same (e.g., USED FOR TRANSPORTATION) but there was an implicit switch in category (e.g., from OBJECTS to ANIMALS). The results are discussed in terms of the implications for the categorical and featural hypotheses of semantic memory organization.

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Semantic memory organization has been investigated extensively for several decades (Hart & Kraut, 2007). One major area that has yielded much speculation is the dissociation that can occur with a "living things impairment", in which knowledge of living things can be impaired while knowledge of non-living things remains relatively intact. Investigations of this impairment have yielded two main perspectives: one suggests that information is organized into taxonomical categories (i.e., a categorical hypothesis); the other proposes that information is organized according to featural attributes (i.e., a featural hypothesis). Using a proactive interference paradigm, the current study attempts to determine the relative importance of categorical and featural explanations of semantic memory organization by examining PI effects for stimuli that has been categorically and featurally cued.

Semantic Memory

Semantic memory can be thought of as encyclopedic knowledge. It is diverse in scope, as it encompasses our knowledge of words, objects, concepts, actions, facts, people, and places (Binder, Desai, Graves, & Conant, 2009; Warrington & Crutch 2007). Knowing that there are usually nine innings in a baseball game, Newcastle is a town in England, and Elmo is a fictional red monster from the television show Sesame Street are all examples of semantic memory. Tulving (1972), often credited with introducing the term "semantic memory", pointed out that it was Quillian in his unpublished dissertation research in 1966 who was the first to use the term. Tulving's influence cannot be overlooked, however, as he brought much needed attention to this type of memory and recognized the importance of distinguishing semantic memory from other types of memory (e.g., episodic memory).

Since that time, a plethora of studies has ensued. Research on semantic memory has evaluated possible gender differences (Barbarotto, Laiacona, & Capitani, 2008; Baxter et al., 2003; Bermeitinger, Wentura, & Frings, 2008; Scotti, Laiacona, & Capitani, 2010) and how semantic memory differs from other types of memory (Burianova, McIntosh, & Grady, 2010; Gainotti, 2006; Greenberg & Verfaellie, 2010; Henke, 2010; Hoscheidt, Nadel, Payne, & Ryan, 2010). In addition, studies have investigated how semantic memory is affected in psychological conditions (e.g., schizophrenia: Doughty & Done, 2009; bipolar disorder: Chang et al., 2011; autism: Crane & Goddard, 2008), pathological processes (e.g., dementias: Joubert et al., 2010; Reilly, Peelle, Antonucci, & Grossman, 2011; Wierenga et al., 2011), and across the lifespan (de Zubicaray, Rose, & McMahon, 2011; Quon & Atance, 2010).

Semantic Memory Organization and the Living Things Impairment

A central question in cognitive neuropsychology is how semantic memory is organized. Seminal investigations conducted by Warrington and Shallice (1984) provided compelling evidence for category-specific deficits. More specifically, from several experiments assessing performance of individuals diagnosed with herpes simplex encephalitis (HSE), a pattern emerged in which individuals showed a relative preservation of knowledge for non-living things (e.g., inanimate objects) and impairment for living things (e.g., animals). This difficulty in performance for items representing living things (e.g., animals, fruits, vegetables), in contrast with relative intact ability for items representing non-living objects (e.g., tools, furniture), has been termed the "living things impairment". Since that time, countless studies have observed this selective impairment in individuals with varying etiologies, including herpes simplex encephalitis (HSE), cerebro-vascular accident (CVA), closed head injury (CHI), Lewy body dementia, and semantic dementia (Forde & Humphreys, 1999; Gainotti, 2010; Laws, Crawford, Gnoato, & Sartori, 2007; Mendez, Kremen, Tsai, & Shapira, 2010; Moreno-Martinez, 2011).

A clear-cut example of a selective impairment for living things was observed in a 16-year- old male who had suffered a posterior cerebral infarction at one day of age (Farah & Rabinowitz, 2003). Performance on a confrontational naming task was lower for living things (i.e., 40% accuracy) as compared to non-living things (i.e., 75% accuracy). When tested with a questionnaire consisting of queries pertaining to visual and non-visual information, he showed comparable performance to controls for non-living items (both visual and non-visual questions). In contrast, his performance on questions relating to visual and non-visual properties of living things was at chance. Thus, he was able to successfully acquire knowledge for non-living things, but perinatal damage somehow prevented the acquisition of knowledge about living things. Farah and Rabinowitz argue that this case provides evidence for the likely existence of anatomical localization for living and non-living things that must be specified in the human genome.

Several researchers have suggested that the living things impairment may be accounted for by differences in processing complexity. More specifically, it has been proposed that living things have lower item frequency and familiarity and greater visual complexity as compared to non-living items that are usually tested (Funnell & Sheridan, 1992; Gaffan & Heywood 1993; Stewart et al., 1992). However, Farah and colleagues argue that the living things impairment is evident when possible confounding variables such as familiarity, word frequency, and visual complexity are controlled and sufficient items are presented (Farah, Meyer, & McMullen, 1996). Indeed, in a recent review of studies in which possible confounding variables were taken into account, Gainotti (2007) also reported that the living things impairment still existed in many individuals with varying etiologies of damage.

Coppens and Frisinger (2005) presented evidence that category effects may also be observed in healthy individuals. Using a confrontational naming task where performance for living and non-living items was assessed, they tested three groups of healthy participants (i.e., young, young elderly, and old elderly). Results showed that performance on the task decreased as a function of increasing age, as evidenced by an increase in overall errors. It should be noted, however that even though there were age effects, all groups performed at a relatively high level (young: 94.8%; young elderly: 90.8%; old elderly 82.9%). In addition, non-living items were named more often than living items, reaching significant levels for both of the elderly groups, but not for the younger participants. Of interest, variability in performance increased as a function of age for naming living items. The results could not be attributed to possible confounding factors as stimuli were controlled for variables such as familiarity, frequency, age of acquisition, complexity, and name agreement. The outcome of this study is interesting as it suggests that not only does naming ability decrease with age, but that in the absence of brain damage, there may still be an increased difficulty for naming living as compared to non-living items.

Living Things Impairment and Alzheimer's Disease

The presence of a living things impairment in individuals with Alzheimer's disease (AD) has been widely debated. Using a confrontational naming task with a selection of coloured pictures that included living and non-living exemplars, Silveri, Giustolisi, and Gainotti (1991) concluded that not only were AD participants impaired in their naming ability as compared to age-matched controls, they were particularly impaired for the pictures of living things compared to non-living things. Laws, Adlington, Gale, Moreno-Martinez, and Sartori (2007) critiqued this study by noting that, although the living and non-living pictures were matched for typicality and word frequency, other important stimuli characteristics (e.g., familiarity, visual complexity, age of acquisition) were not matched.

Even with more stringently controlled stimuli, determining whether individuals with AD show a category-specific impairment for living things remains inconclusive. Several studies have reported a living things impairment (Albanese, 2007; Zaitchik & Solomon, 2009), whereas other studies have shown variable or a similar level of impairment for living and non-living items (Laws, Gale, Leeson, & Crawford, 2005; Moreno-Martinez, Goni-Imizcoz, & Spitznagel, 2011).

Effect sizes were examined in a meta-analytic review of 21 studies that investigated confrontational naming performance for individuals with AD and healthy controls, whereby the larger the effect size, the greater the impairment (Laws, Adlington, Gale, Moreno-Martinez, & Sartori, 2007). Laws and colleagues found that although the effect size was larger for living things as compared to non-living things, there was no statistical difference. Of interest, the review uncovered moderated variables that had an impact on the effect sizes. Quite surprisingly, the meta-analysis revealed that the use of colour images in confrontational-naming tasks increased the effect size for living things, but not for non-living things. Moreover, results showed that when studies had a higher proportion of females the effect sizes for both living and non-living items increased. In addition, studies that had smaller sample sizes showed larger effect sizes for living things but not for non-living things. Laws et al. suggested that future studies should investigate subcategories of stimuli, and control for these moderator variables, to try and gain further understanding into the nature of semantic impairments.

Tippett, Meier, Blackwood, and Diaz-Asper (2007) conducted a series of experiments in which individuals with AD were administered confrontational-naming tasks with stimuli sets that varied according to different controlling variables (e.g., familiarity, frequency, complexity, age of acquisition). Tippett et al. were able to demonstrate that AD participants could show an impairment for living things, or for non-living things as a function of which variables were controlled.

In sum, the literature remains inconsistent as to whether individuals with AD have category-specific impairments, yet recent studies may shed light on variables that influence the presence or absence of a living things impairment. Fundamental to a neuropsychological approach for understanding the organization and function of the brain is the presence of a double dissociation, as it allows specific inferences to be made (Mahon & Caramazza, 2009). Although not as abundant as studies showing a living things impairment, several studies have lent evidence for a double dissociation in that individuals have shown deficits for non-living things but their memory remains intact for living things (Best, Schroder, & Herbert, 2006; Campanella, D'Agostini, Skrap, & Shallice, 2010; Cappa, Frugoni, Pasquali, Perani, & Zorat, 1998; Laiacona & Capitani 2001; Sacchett & Humphreys, 1992; Silveri et al., 1997; Warrington & McCarthy, 1983; Warrington & McCarthy, 1987). This double dissociation also seriously undermines arguments that processing complexity (e.g., familiarity and frequency) could account for these impairments (Farah & Grossman, 2005). Therefore, there appears to be compelling evidence that semantic knowledge can be selectively impaired according to a living/non-living classification.

Two Perspectives

A widely debated issue concerns whether or not semantic information is organized according to this living/non-living classification. Is it merely a coincidence that these items can be categorized according to whether they are living or not, or is it possible that some other factors account for the observed deficits? (Caramazza & Shelton, 1998; De Renzi & Lucchelli, 1994; Farah, Meyer, & McMullen, 1996; Farah & Rabinowitz, 2003; Gainotti, 2010; Marques 2000; Warrington & Shallice, 1984).

Indeed, increasing our understanding of this selective impairment may shed light as to how semantic memory is organized. Within the literature, there are two main perspectives that have been postulated. These perspectives have been labelled in a variety of manners; thus, for ease of discussion, the “domains of knowledge”, “evolutionary view” or “domain specific hypothesis” will be referred to as the “categorical” hypothesis, and what has been referred to as the “sensory functional theory” or “differential weighting hypothesis” will be labelled as the “featural” hypothesis.

Categorical hypothesis. Proponents for the categorical hypothesis hold the assumption that the first order constraint on the organization of semantic memory is categories (Caramazza & Shelton, 1998). Initially it was argued that from an evolutionary perspective it would have been important to develop networks that could distinguish the evolutionarily relevant categories of animals, plant life, and artifacts (Caramazza & Shelton, 1998). Categorization may have emerged in order for the human species to quickly identify and correctly classify potential predators (e.g., animals) and sources of food and medicine (e.g., plant life). As such, Caramazza and Shelton put forth the argument that “true” category specific impairments will not involve finer grained distinctions (e.g., aquatic animals, land animals, fruit, kitchen utensils, etc.) but will only include those involving animals, plant life, and artifacts. Caramazza and Shelton (1998) further postulated that organization in the brain would occur only for categories in which, “their successful recognition would have fitness value” (p. 20). Since that time, the evolutionarily relevant categories have been broadened to include living animate, living inanimate, conspecifics, and tools (Mahon & Caramazza, 2009).

Caramazza and Shelton (1998) also noted that the categorical hypothesis explains only why these categories may exist in distinct neural networks. These investigators have not speculated about how knowledge is organized within these broader categories. In fact, Caramazza and Shelton expressed the possibility that within a category, organization may occur according to sensory and functional attributes.

Featural hypothesis. Warrington and Shallice (1984) were the first to speculate about the featural hypothesis, suggesting that a semantic system based on different sensory and functional attributes of stimuli may have evolved. More specifically, the authors proposed that functional features were necessary for the identification of non-living things (e.g., what the object is for, how it is used), whereas perceptual features were crucial for living things (e.g., colour, size, shape). For example, describing an axe by its perceptual attributes (e.g., wooden handle and metal end) does not help in the identification of an axe as one could be describing any number of tools (e.g., hammer, spade, and screwdriver). Therefore, it is more informative to describe the function of an axe (e.g., used for chopping wood). In a similar manner, describing the function of a lemon (e.g., can be eaten) does not differentiate it from any number of fruits (or other foods, for that matter). Thus, describing a lemon by its perceptual attributes (e.g., yellow skin, small, oval, and sour) is more likely to result in correct identification.

Warrington and McCarthy (1987) further refined the featural hypothesis suggesting that different types of semantic information (e.g., visual, motion, sound) might be stored in modality-specific channels. Moreover, these channels would be fine grained and the contribution of knowledge and pattern of activity across these channels would vary for different categories. For instance, there would be colour, shape, and size channels for visual information, which would have differing levels of activity specific to the type of object. In general, living things would have higher weightings in sensory channels (i.e., because of the importance of distinguishing between size, colour, shape, etc.) and non-living things would have higher weightings in motor channels (i.e., due to the relevance of knowledge pertaining to manipulability, movement and use). However, there may be differences within the classification of living and non-living things. For example, colour may be more important for fruits and vegetables (e.g., differentiating between a lime and lemon) than it would be for animals (e.g., horses that can be different colours but would be considered the same type). Therefore, the authors would propose that a category-specific impairment may be better understood as selective damage to a modality-specific channel.

Current Review

By examining data from diverse populations, under various paradigms, using different measurement techniques, we can uncover the status of our current understanding of semantic memory. Indeed, prior to the development of more sophisticated neuroimaging techniques, the sole source of information about semantic memory structure was derived from investigations of individuals with brain damage. Even today, studies involving individuals with diffuse or focal brain damage and their accompanying selective impairments have added to our knowledge about semantic memory organization. Moreover, studies with healthy participants can uncover information about how an intact brain may be organized.

Therefore, in order to examine each of these perspectives, a brief review of relevant research will be presented. Furthermore, rather than solely provide a critique of each hypothesis, a more general review will focus on the importance and shortcomings of the categorical versus featural viewpoints in explaining semantic memory organization. Delivering a review in this manner will allow for the inclusion of other theories that have been hypothesized.

The importance of categories. One of the major beliefs about the categorical hypothesis is that organization of semantic knowledge is based on evolutionarily relevant categories. Consistently observed gender differences may lend evidence for this evolutionary perspective. For instance, in the literature it has been reported that females, as compared to males, show an advantage in their knowledge of plant life (i.e., fruits and vegetables; Laws, 2004). Moreover, males represent 95% of reported cases of the selective impairment for fruits and vegetables (Gainotti, 2010). The argument has been put forth that an evolutionary account favoured a higher competence in knowledge and gathering of plant life for females (Laiacona, Barbarotto, & Capitani, 2006; Scotti et al., 2010). Specifically, it has been suggested that females may have developed more efficient neural mechanisms dedicated to the detection, identification, and use of plant life as a source of food or medicine. Within an evolutionary perspective one may assume that females would demonstrate less animal knowledge as they were not involved in hunting. However, this disadvantage is not usually observed. The above-mentioned researchers suggest that it may be because the correct identification of animals as predators or prey was a matter of survival for both sexes.

Striking evidence for the importance of categories can also be found in case studies in which a disproportionate impairment has been reported for only one domain, or conversely the relative sparing of knowledge of only one domain has been found. This type of pattern has been found for the classic taxonomical categories of animals (Blundo et al., 2006; Caramazza & Shelton, 1998; Hart & Gordon, 1992) and fruits and vegetables (Crutch & Warrington, 2003; Hillis & Caramazza, 1991; Laiacona, Barbarotto, & Capitani, 2005; Samson & Pillon, 2003). Indeed, in a review of single case studies, Gainotti (2010) found 21 reports of individuals with a prevalent impairment for fruits and vegetables and 11 reports of a prevalent impairment for animals. Investigations have yielded selective impairments for the domains of tools (Laiacona, Capitani, & Barbarotto, 2000), body parts (Kemmerer & Tranel, 2008; Laiacona, Allamano, Lorenzi, & Capitani, 2006; Shelton, Fouch, & Caramazza, 1998), and countries (dellaRocchetta & Cipolotti, 2004). These studies demonstrate the fact that preservation or damage of semantic knowledge is not always rigidly in line with living versus non-living items. It appears that quite often the impairment is contained within a taxonomical category rather than accounted for by an impairment of specific features.

Proponents of the categorical hypothesis would assume that individuals with category-specific deficits should show comparable deficits for perceptual and functional attributes of a concept. This assumption reflects the belief that areas of the brain are categorically organized storing all types of information pertinent to that domain (Caramazza & Shelton, 1998). Evidence for the categorical organization of semantic knowledge has come from case studies in which all or most types of knowledge within a category have been impaired (Blundo et al., 2006; Lambon Ralph, Howard, Nightingale, & Ellis, 1998).

A classic example was provided by Caramazza and Shelton (1998) who discussed the assessment of a patient who, after experiencing a stroke, developed an apparent impairment for knowledge pertaining to the category of animals. Certainly, her naming performance was impaired for animals (e.g., 34% accuracy) as compared to non-animal pictures (e.g., accuracy of 93%). When an analysis was conducted on her naming performance for stimuli that were matched for familiarity, frequency, and visual complexity, the disproportional impairment for animal stimuli was still present. In fact, she even showed greater difficulty naming high familiarity animals (e.g., 54% accuracy) than low familiarity non-animal items (e.g., 81% accuracy). She performed within normal limits on measures of visual processing, showing her deficit could not be accounted for by generalized processing deficits. Her impairment for animals continued to be evident on tasks assessing different types of semantic knowledge (e.g., sound, size). In addition, her ability to make judgments about animals was impaired regardless of whether the judgments required functional or perceptual knowledge. Notably she was able to distinguish animals from objects and correctly identify general attributes for animals (e.g., has a mouth); however, she had great difficulty identifying specific perceptual and functional attributes of animals (e.g., 74 and 77% accuracy, respectively), but showed intact performance for non-animal stimuli (e.g., 100% and 99% accuracy, respectively). Of interest, she showed perfect naming performance for fruits and vegetables, demonstrating a finer grain impairment that did not appear to apply to the entire category of living things. Thus, the specificity of semantic knowledge that was impaired could not be easily explained according to shared features; rather, it appears that the taxonomical category accounted for the observed deficits.

Case studies certainly provide compelling evidence that category plays an important role in the organization of semantic memory. In a similar manner, neuroimaging studies have shown areas of increased activation for specific taxonomical categories. For instance, studies have shown different areas in the brain that appear to respond selectively to tools (Beauchamp & Martin, 2007; Cattaneo, Devlin, Salvani, Vecchi, & Silvanto, 2010; Johnson-Frey, 2004; Mahon, Schwarzbach, & Caramazza, 2010), animals (Perani et al., 1995), faces (Liu, Harris, & Kanwisher, 2010), and body parts (Peelen & Downing, 2007).

A cautionary note needs to be made about neuroimaging studies that investigate activation as a function of taxonomical category. Studies of this nature often require participants to make judgments about aspects of stimuli, or include line drawings or fragmented pictures of stimuli. It is possible that the brain selectively responds to certain taxonomical categories, yet these studies are often far removed from real life experiences of how individuals encounter such stimuli. As such, the implications of these studies need to be interpreted with caution and restricted to the context of the paradigm used. Although these studies have merit, one cannot conclude that they unequivocally inform us about semantic memory organization.

Shortcomings of a categorical explanation. In a discussion of the categorical perspective, Semenza (2006) stated, “The most serious problem, however, with the evolutional theory is that it is hard to prove empirically" (p. 273). Indeed, how does one prove or disprove the possibility that the brain is organized according to categories that are relevant from an evolutionary perspective? Earlier in the review, there was a discussion about how an evolutionary perspective may explain gender differences (i.e., the seeming advantage that women have for plant life). It is interesting that investigators speculate in order to explain some of the observed results, yet it remains difficult to hold such a theory to an empirical test.

While there have been several neuroimaging studies that have shown activation for specific categories, there are other investigations that have not observed such a pattern. For instance, Tyler et al. (2003) conducted a PET study and did not find activation patterns that differed as a function of categories. Participants in this study were shown trials in which three cue pictures belonging to the same category were shown, followed by a fourth picture for which a same/different judgment was required by pressing the left or right mouse button. Pictures were from four categories (i.e., animals, fruits and vegetables, tools, and vehicles) and sorted further into subcategories (e.g., animal category was sorted into birds, mammals and insects). Half of the trials required a "same" response (e.g., cue pictures: *screwdriver*, *spade*, *chisel*; target picture: *axe*) and half required a "different" response (e.g., cue pictures: *sheep*, *pig*, *horse*; target picture: *wasp*). A baseline task was also used which also involved a same/different judgment and consisted of meaningless shapes made up of small squares that varied in colour, shape, and size. Initially, the authors reported a significant difference in activation for animal stimuli, but after further analyses the investigators attributed the heightened activation to participants requiring greater visual processing demands to distinguish between the animal stimuli. Tyler and colleagues concluded that there was similar activation for each category when measured against the baseline task.

While introducing the categorical hypothesis, Caramazza and Shelton (1998) put forth certain evidence that appears to be somewhat flawed. Specifically, the authors suggested that functional attributes of various foods may be of equal or, perhaps, of more importance than visual attributes. To back up this claim, Caramazza and Shelton provided a list of several foods (e.g., carrot, celery, apple, orange, avocado) and suggested that the function of each is of particular importance (e.g., used to make juice, used for dessert, used for minestrone). While the function may provide additional information, it does not appear to be an attribute that distinguishes one type of food for another. For instance, the function “used to make juice” does not distinguish between the listed examples of carrot, apple, or orange. Similarly, the function “used for dessert” does not differentiate amongst items: Oranges can be part of a fruit salad or sorbet; apples can be made into a variety of pies or cobbler; and carrot can be made into cake. Thus, function may be one attribute for these examples, but it is definitely not an attribute that distinguishes it from other exemplars.

Moss and Tyler (2003) challenged the categorical perspective by questioning how this viewpoint can account for the fact that in most patient cases the deficits are usually graded, rather than all-or-none. The authors further explained that it is the exception in the literature to find a patient who performs within normal limits in the categories that are deemed intact. Moss and Tyler questioned how the categorical hypothesis could explain how graded impairments appear to be more of the norm. Mahon and Caramazza's (2003) sole response to this query was to cite one case study in which the patient showed near perfect performance for the intact categories. Indeed, while evidence from one case should not be overlooked, Moss and Tyler's argument still appears to be valid. However, it may also be an argument that could be advanced to proponents of the featural hypothesis, as it is rarely the case that functional features remain perfectly intact in individuals with an impairment for living things. Nevertheless, given that a categorical account cannot explain all results that have been found in the literature, it would be prudent to investigate the contribution of an organizational perspective based on featural attributes.

The importance of features. One advantage of the hypothesis that semantic knowledge is organized according to modality specific channels is the parsimony of this perspective. If semantic information is organized in such a way, it would be congruent with the sensorimotor organization that has been shown to exist in the brain (Farah, Meyer, & McMullen, 1996; Thompson-Schill, Aguirre, D'Esposito, & Farah, 1999).

Evidence from neuroimaging studies has supported the possibility of a modality specific organization of semantic knowledge. Several studies have examined brain areas involved in action, manipulation, and location (Weisberg, van Turennout, & Martin, 2007; Yee, Drucker, & Thompson-Schill, 2010; see Martin, 2007a and 2007b for a review).

Other studies have shown distinct regions associated with the knowledge of perceptual attributes (Grill-Spector & Malach, 2004; Hsiao, 2008; Matheson &

McMullen, 2010; Miceli et al., 2001; Simmons et al., 2007). For instance, Cavina-Pratesi and colleagues presented participants with visual material, consisting of computer generated irregular shaped 3D objects that either remained the same or differed as a function of colour, texture, or shape (Cavina-Pratesi, Kentridge, Heywood, & Milner, 2010). Results showed different areas of activation for the properties of colour, shape, and texture.

In a study investigating gustatory areas, Simmons and colleagues did not use items derived from the category of fruits and vegetables or animals, but instead presented stimuli of processed foods (e.g., cookies, hamburgers) that were considered high in fat and caloric content (Simmons, Martin, & Barsalou, 2005). Results showed a similar pattern of activation for participants who viewed pictures of processed foods as was observed when food was tasted. In addition, researchers have also found areas in the brain that are activated for combined taste and smell and separate areas that are activated solely for taste and solely for smell (de Araujo, Rolls, Kringelbach, McGlone, & Phillips, 2003).

Congruent with a modality specific organization of semantic knowledge, Mummery et al. asked healthy participants to make judgments about triads of words representing living and non-living things (Mummery, Patterson, Hodges, & Price, 1998). There were three judgment tasks in which participants were required to press a response key to decide which of the two words was most similar to the target word (indicated here in bold type) based on judgments of colour (e.g., LIVING: ***frog***, *lettuce*, *onion*; NON-LIVING: ***armour***, *tinfoil*, *vaseline*); location (e.g., LIVING: ***mole***, *termite*, *toad*; NON-LIVING: ***saucepan***, *ladle*, *toothbrush*); and syllable length (e.g., LIVING: ***swan***, *pear*, *lion*; NON-LIVING: ***cannon***, *guitar*, *bikini*). The syllable task was a control task to show the difference between semantic processing (e.g., judgments of colour and location) and phonological processing (e.g., judgment of number of syllables). Results from positron emission tomography (PET) techniques showed that there was no difference in activation for living and non-living things when the task and stimuli demands were controlled. Instead, participants showed differential activation as a function of the type of semantic judgment (i.e., colour or location). These findings suggest that featural attributes caused differential activation irrespective of category.

Kraut et al. provided further evidence for the significance of features in the organization of semantic information (Kraut, Moo, Segal, & Hart, 2002). Using functional magnetic resonance imaging (fMRI) in a study with healthy participants, they administered a category judgment word pair task. Participants were asked to press a button if the two words were from the same semantic category (e.g., *drill*, *screwdriver*) and to refrain from responding if the words were from different categories (e.g., *drill*, *bear*). Results showed that the same pre-motor regions were active for those stimuli that were tools as well as those that were fruits and vegetables. Kraut and colleagues proposed that the active region may be responsible for detecting features of motor manipulability or hand movements that are common to both categories (e.g., movements required while using a screwdriver may be similar to those needed to peel an orange). The authors further claimed that if information was primarily organized by categories, then activation would have been predicted to occur in one region for tools and another region for fruits and vegetables. That similar pre-motor regions were activated for the categories of tools and fruits and vegetables suggests that features (e.g., motor manipulability) irrespective of categories, are important for classification.

A recent study by Campanella and Shallice (2011) demonstrated the importance of manipulability (i.e., a functional attribute) as compared to visual similarity (i.e., a perceptual attribute) for the identification of objects. In a word-to-picture matching task conducted with healthy young participants, target pictures were paired with manipulability distractors (i.e., pictures of objects with similar manipulation) and visual distractors (i.e., pictures of objects that were visually similar but with a different manipulation). Results showed that manipulability distractors interfered significantly with the identification of the target, and to a much greater extent than the visual distractors. In accord with the featural hypothesis, these results show that functional information, in this case an object`s manipulability, is an important distinguishing factor in identifying an object.

A study conducted by Thompson-Schill and colleagues lent further evidence to the importance of perceptual attributes for living things (Thompson-Schill, Aguirre, D'Esposito, & Farah, 1999). Functional MRI was used to determine cortical activation while healthy young participants were asked a series of yes or no questions about the visual or non-visual characteristics of living and non-living items. Results showed heightened activity in the fusiform gyrus for both non-visual (e.g., *are pandas found in China?*) and visual questions (e.g., *do ducks have long ears?*) for living things. In contrast, for non-living things, only visual questions (e.g., *are bows of violins longer than* *violins?*) generated activation in this area. Thus, it appeared that perceptual information was accessed and seemed critical even when answering about functional (i.e., non-visual) properties of living things, suggesting that the visual representation may have been accessed regardless of task conditions. However, the inverse does not appear to be true, as the retrieval of visual information about non-living things occurred only when such information was required.

Ventura et al. conducted a series of experiments assessing the importance of features in distinguishing living and non-living items within a healthy young population (Ventura, Morais, Brito-Mendes, & Kolinsky, 2005). Although the results were not all in support of a featural hypothesis, the study contributed several relevant outcomes. Participants were able to generate a higher proportion of sensory features for living things as compared to non-living things. In an experiment in which living and non-living items were cued, there appeared to be an advantage of functional cues for non-living items. Another experiment revealed that participants were significantly faster at correctly determining the functional attributes of non-living stimuli than they were at determining visual attributes. Of interest in this latter experiment, there appeared to be no difference in reaction time for living stimuli as a function of visual or functional features. Ventura and colleagues attempted to explain these results by proposing that the overlap of sensory and functional features for animals contributed to the lack of difference in reaction times. In sum, while all the results were not perfectly aligned with a featural hypothesis, several of the outcomes from the experiments showed the importance of functional features for non-living items and sensory features for living items.

The priming literature has also provided evidence for the importance of features. Semantic priming effects were assessed in healthy young participants while they focused on different featural attributes (Bermeitinger, Wentura, & Frings, 2011). Specifically, a task in which participants had to focus on perceptual or action features was interspersed with a priming task with items belonging to natural categories (i.e., vegetables, fish, spices, and predators) and artificial categories (i.e., tools, clothing, furniture, and dishes). Results showed that semantic priming effects were observed only for natural categories when participants had focused on perceptual features. Likewise, priming was evident for items belonging to artificial categories solely when participants had focused on action features.

In addition, Frenck-Mestre and Bueno (1999) found stronger priming effects for word pairs in which there was high semantic overlap between the prime and target word. More specifically, pairs that shared both features and category membership (e.g., *pumpkin – squash*) showed larger priming effects than those only having membership to the same semantic category (e.g., *shirt – pants*). Another study revealed that greater priming effects were observed for living items when visual judgments were made as compared to non-living items (Sim & Kiefer, 2005).

The studies that have been described in this section lend support to the importance of features. There are many other investigations that have come to similar conclusions pertaining to the value of a featural classification (Basso, Capatani, &

Laiacona, 1988; Brambati et al., 2006; De Renzi & Lucchelli, 1994; Marques, Canessa, Siri, Catricala, & Cappa, 2008; Sacchett & Humphreys, 1992).

However, there is evidence to suggest that a further fine grained view of features may be required. Noppeney (2007) examined the literature on function and manipulability of tools and reviewed studies in which there was a double dissociation between these two factors. Indeed, if one thinks of these two factors, there are relatively few items that have similar function and manipulability (e.g., saw and knife). Most items have different manipulation and functional properties. For example, an axe and a saw have similar functions (e.g., cut wood) but are manipulated differently, while an axe and a baseball bat have different functions but are manipulated similarly. Thus, the complexity of the stimuli and the possibility that more fine grained distinctions exist for featural attributes contribute to the variability and inconsistencies that are frequently observed in behavioural and neuroimaging studies.

The possibility of a finer grained distinction for featural properties may help with interpreting puzzling results that are often described in the literature. For example, Sartori et al. described a patient with Herpes Simplex Encephalitis (HSE) who had profound difficulties with visual properties of living things across a variety of tasks (Sartori, Job, Miozzo, Zago, & Marchiori, 1993). This patient was unable to judge whether pictures of animals were complete, to differentiate between pictures of real and non-real objects, and to add in missing parts to animal drawings. Of interest, she was able to correctly determine other aspects about animals (e.g., size, their level of ferocity, sounds they made). The featural hypothesis would predict that individuals showing impairments for living things would have difficulty accessing visual and sensory information about these items. However, the perceptual attribute of size did not seem to be impaired in this individual. It is possible that this pattern of results could be explained by the existence of a finer grain distinction among perceptual attributes and that these fine-grained attributes may be weighted differently. Thus, in this instance, smaller details that were required to make judgments about the 'completeness' or 'realness' of an animal may have been lost, but general information pertaining to size and fierceness may have remained intact.

In addition, it has been postulated that category specific deficits may arise due to the structural similarity of exemplars, making it necessary for more detailed visual processing to occur in order to differentiate successfully among items within the living things category (Forde & Humphreys, 1997; Gaffan & Heywood, 1993; Sartori et al., 1993). For example, one of the major visual differences between a tiger, leopard, jaguar, and cougar is the presence or absence of stripes or spots. For the correct visual differentiation between a lemon and lime, colour appears to be the sole distinguishing factor.

Certainly, within experimental tests, attention to small details is often required in order to provide correct responses. The Reality Decision Test is a prime example of an experimental paradigm containing stimuli in which small details need to be examined (see Blundo, Ricci, & Miller, 2006 for stimuli exemplars). For instance, in order to determine that an animal with a head and torso similar to a horse is unreal, one would be required to inspect the drawing with sufficient detail to recognize that the tail is too bushy and the legs are not quite long enough.

Several investigators have put forth the argument that certain features may be more informative than others (Devlin et al., 2002; Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Randall, Moss, Rodd, Greer, & Tyler, 2004; Taylor, Moss, & Tyler, 2007). For instance, having eyes and a nose may indicate category membership to animals, but these characteristics are not useful in identifying the specific member. On the other hand, a feature such as “having a hump” is distinctive and provides more specific information. It is postulated that loss of information, or access to the distinct features, may account for the living things impairment. Of interest, Taylor et al., (2007) have discussed their anecdotal observations of individuals showing deficits for distinctive features of living things more so than for non-living distinctive features. Taylor and colleagues suggest that the degree to which features correlate with other features may shed light on the selective impairment. Highly correlated features (e.g., has a nose, can see) may be more resilient to the effects of brain damage due to a strengthening of connections from mutual co-activation. Lower correlated features (e.g., has a hump, has a nose) do not have a strengthened association as they do not co-occur as frequently. As such, distinct features of living things, because of their low correlation, may be more vulnerable to effects of brain damage. In contrast, Taylor et al. suggest that non-living things have distinct features that are highly correlated due to strong form-function mappings (e.g., has a blade, used for cutting) which may make them more resilient to damage.

The suggestion that living things may be more vulnerable to damage because of the lower correlation for distinguishing characteristics, coupled with the idea that structural similarity may be higher for these items, have both been put forth as plausible reasons why general information about an item may be better preserved than specific knowledge. Indeed, Taylor et al. (2007) argue that the specific and distinguishing characteristics for living things are usually the first to be lost. Thus, in situations in which the brain is compromised, the distinguishing feature that a tiger has stripes may be lost, whereas non-distinct information that a tiger would share with other living things (e.g., has four legs, eyes, and a tail) may be relatively spared. This proposal may account for the frequent observation of patients being able to correctly sort items or name the superordinate categories (Done & Gale, 1997; Mondini, Borgo, Cotticelli, & Bisiacchi, 2006), as the highly correlated features necessary for successful classification at this level remain relatively intact. Consistent with this proposal, there are several studies showing that individuals with a living things impairment are able to provide general superordinate information (e.g., animal) but unable to provide the name (e.g., tiger) or generate specific details (Blundo et al., 2006; Hillis & Caramazza, 1991; Mauri, Daum, Sartori, Riesch, & Birbaumer, 1994; Sartori et al., 1993).

Shortcomings of a featural explanation. Unfortunately, it appears that features, although important, may not completely explain category-specific effects. In their refinement of the featural hypothesis, Warrington and McCarthy (1987) proposed fine-grained channels that would be differentially weighted for specific categories. An illustrative example used earlier was that colour may be a more important feature for fruits and vegetables as compared to animals and objects. Contradicting this proposal, Samson and Pillon (2003) reported data from a patient who had experienced a stroke and who demonstrated a category specific impairment for fruits and vegetables. Several tasks were devised to assess various aspects of colour knowledge, in the hope of determining the possible importance of this perceptual attribute for the domain of fruits and vegetables. When required to retrieve the correct colour associated with a line drawing of a selection of fruits and vegetables, the patient`s performance was comparable to a matched control. However, the patient did show difficulty selecting the appropriate colour when auditorally presented with the names of fruits and vegetables (e.g., accuracy of 65%, compared to 95% accuracy for the matched control). Of interest, he showed relatively intact performance (e.g., accuracy of 80%) on this same task for man-made objects that have a typical colour (e.g., golf ball, tire). Samson and Pillon argue that this pattern of results was incongruent with a featurally based organization which should have resulted in impaired colour knowledge across all tasks and stimuli.

In a recent review and critique of the featural hypothesis, Mahon and Caramazza (2009) commented further on the issue of colour knowledge. The authors discussed studies that have shown individuals with deficits for colour knowledge who have not shown a disproportionate impairment for fruits and vegetables as compared to other categories.

Using an object decision task, Ikeda and colleagues also assessed the importance of featural attributes (e.g., size, orientation, and colour) for individuals with semantic dementia (Ikeda, Patterson, Graham, Lambon Ralph, & Hodges, 2006). Results showed that colour was an important distinguishing characteristic for both living things and non-living things. It appears that performance did not differ as a function of category, although it was pointed out that items were not chosen on a categorical basis and as such were not balanced for factors such as familiarity (K. Patterson, personal communication, July 25, 2011). Thus, while colour was an important attribute, the degree of importance did not appear to differentiate as a function of living or non-living category membership. That patient performance was also negatively impacted for items in which colour is not a distinguishing characteristic (e.g., the colour of a toothbrush handle) suggests that the predicted higher weightings in sensory channels for living things was not observed.

Another example of deficits not falling in line with a purely featural based organization was presented by Laiacona, Barbarotto, and Capitani (1993). Data were presented from experiments involving two individuals (FM and GR) who had both been in motor vehicle accidents and suffered brain damage. Among their observed difficulties, both individuals showed an impairment for living things. A semantic questionnaire was administered that queried semantic knowledge of a selection of living and non-living items. Results were further analyzed according to questions pertaining to visual and non-visual attributes. As expected, both individuals showed an overall stronger performance for non-living (FM: 96%; GR: 88%) as compared to living items (FM: 72%; GR: 56%). The featural-based prediction of greater difficulty for visual items was not found. Both individuals had a similar level of accuracy for visual as compared to non-visual questions (FM: visual: 73%, non-visual: 69%; GR: visual: 55%, non-visual: 58%).

For individuals with an impairment for living things, a similar pattern of relatively equal deficits for visual and functional features has been reported by other investigators (Laiacona, Capitani, & Barbarotto, 1997; Samson, Pillon, & De Wilde, 1998; Sheridan & Humphreys, 1993; see Mahon and Caramazza, 2007 for a review). Results from all of these studies are suggestive that other organizational principles are likely involved.

Lambon Ralph et al. reported data from two individuals who were tested on a variety of experimental tests and showed a double dissociation in regards to category-specific impairments (Lambon Ralph, Howard, Nightingale, & Ellis, 1998). The first participant was diagnosed with Alzheimer's disease and showed a persistent impairment for living things. As expected, on the definition-to-naming task, there was a clear difference in her performance for animals (e.g., 69% accuracy) as compared to objects (e.g., 100% accuracy). Interestingly, she showed no significant difference in performance as a function of the type of attributes assessed. For instance, on the same definition-to-naming task, she answered an equal number of items correctly for perceptual definitions and functional definitions (i.e., 11 out of 16 for each). The second participant was diagnosed with semantic dementia and demonstrated an impairment for perceptual information. On the same definition to word matching task discussed above, she had greater difficulty for perceptual definitions (e.g., 46% accuracy) compared to functional definitions (e.g., 79% accuracy). If features were the guiding principle for organization, it would be predicted that this patient would show a disproportionate impairment for living things. This prediction did not hold true, however, as comprehension for living items was similar to non-living items. For instance on the definition-to-word matching task, this patient showed no significant difference between items assessing her knowledge of animals (e.g., 66% accuracy) as compared to objects (e.g., 58% accuracy). This double dissociation presented by Lambon Ralph and colleagues provides evidence that perceptual features are not always impaired for those individuals who have a deficit for living things, and that a perceptual deficit does not always mean that a living things impairment will be present. The featural perspective would have greater difficulty interpreting these results.

Proponents of the featural hypothesis would argue that the nature of the featural deficit (i.e., perceptual or functional) is more important than whether the impairment is for living or non-living items. This issue has been explored for items that contradict the expected alignment of perceptual importance for living things and functional importance for non-living things. For instance, it has been argued that non-living musical instruments may be best defined by their perceptual attributes (Dixon, Bub, & Arguin, 1997) and that animate body parts may be best defined by their functional attributes (Warrington & McCarthy, 1987). Thus, proponents of the featural hypothesis would expect that musical instruments would show a similar level of damage as other living things, and that body parts would show a level of damage comparable to other non-living things. There are several studies that show that this expected pattern of deficits does not occur (Laiacona, Allamano, Lorenzi, & Capitani, 2006; Levin, Ben-Hur, Biran, & Wertman, 2005). According to Capitani and colleagues, in a review of the clinical evidence of category specific deficits, knowledge pertaining to musical instruments is often impaired whereas information about body parts is relatively spared (Capitani, Laiacona, Mahon, & Caramazza, 2003). However, Capitani et al. provide evidence from case study reviews showing that the pattern of impairments is not systematic, suggesting that musical instruments and body parts do not appear to align with a living/non-living classification. As such, features may not be the sole organizational factor at play.

Caramazza and Shelton (1998) discuss the necessity of the featural hypothesis to create additional subdivisions or weightings (e.g., colour being more important for fruits and vegetables) to explain dissociations of certain categories. Indeed, the more subdivisions that need to be created in order to explain research findings, the less helpful the perspective becomes in providing a parsimonious explanation.

Summary

Given the research that has been reviewed thus far, the importance of features cannot be overlooked. Indeed, there are instances in which the deficit does not appear to be within a taxonomical category, but rather a deficit of featural knowledge. A similar argument may be made for the importance of categories, in that impairments have been reported in the literature that appear to be restricted to a taxonomical category, regardless of attributes.

An interesting case that illustrates the difficulty that often arises in interpreting results (i.e., either in favour of features or categories) was reported by Hart and Gordon (1992). The investigation involved a patient who had experienced a sudden onset neurological illness at the age of 70 which resulted in difficulties in several cognitive areas (e.g., attention and concentration), and a selective impairment for animals. When assessed verbally, she demonstrated near-perfect performance answering questions pertaining to the functional and perceptual attributes of non-living things. Moreover, she was able to successfully verify functional properties of animals. Her deficit arose in her inability to verify the perceptual attributes of animals. More specifically, she was impaired in answering direct questions about physical attributes of animals (e.g., answering "orange" to the question "what colour is an elephant?). Additionally, she had profound difficulties on a forced-choice recognition task in which she had to choose between a correct response and her error on the earlier direct question task (e.g., is an elephant orange or grey). In this latter task, she only got 1 out of 55 responses correct.

The results of this case can be interpreted in several ways. On one hand, it shows clear evidence of an impairment for perceptual knowledge of animals. However, the fact that she had near-perfect or perfect performance with perceptual attributes for other items casts doubt on the possibility that features are the only organizational factor. If examining the importance of category, one must conclude that her difficulties did appear to be solely within the category of animals. However, an argument cannot be made for solely categorical organization, as she was able to answer several questions that pertained to the functional attributes of animals (even animals she was unable to name). Of interest, Caramazza and Shelton (1998) discussed this case at length and suggested that it provides evidence of how the featural hypothesis is flawed. However, Caramazza and Shelton do not explain how the categorical hypothesis would better account for the results. Thus, data from this case may suggest that categories and features may both be important for the organization of semantic memory. As such, this case demonstrates the inconsistent results that can often be found in this area of research.

In truth, from the brief review of the literature, only one thing can be said with any degree of certainty: results are ambiguous and there does not appear to be overwhelming evidence that favours one hypothesis over the other. Inconsistencies have been found between lesion sites in patients and patterns of activation in neuroimaging studies. More specifically, results from neuroimaging studies have suggested the involvement of certain neuroanatomical regions for semantic tasks, yet individuals who have damage to those areas do not always show impairments for the expected type of knowledge (Zannino et al., 2009). As reported, conflicting results have also been found in behavioural and neuroimaging studies of healthy participants.

It is perplexing how such a widely investigated area has yielded so many inconsistent results. It appears that various methodological issues may contribute to our understanding of why it is often difficult to reconcile the data from this area of study.

Methodological Issues

One of the major limitations of the featural hypothesis is findings in which individuals with impairments for living things have not consistently shown a greater difficulty on tasks assessing perceptual properties as compared to functional properties. Gainotti (2007) noted that the inconsistency in the literature may be partially due to a methodological problem with test material. He further explained that it is quite difficult to generate questions in regards to the function of certain biological items. Indeed, Gainotti cites an example of a patient with herpes simplex encephalitis who showed an unusual deficit for solely the functional properties of animals using one battery of tests (Laws et al., 1995) and the opposite pattern of a deficit for visual attributes of living things when tested with a different battery (Moss, Tyler, & Jennings, 1997). Therefore, the type of tests used to assess semantic knowledge appears to play a large role in regards to the deficits that can be observed.

Consistent with the proposal that the type of semantic task does matter, were results of a meta-analysis that reviewed patterns of brain activation as a function of category membership (Joseph, 2001). Joseph concluded that the type of semantic task (e.g., matching vs. naming tasks) predicted neural activation to a similar level as category membership. Thus, it is not surprising that neuroimaging results have at times yielded conflicting results. Not all tasks that assess semantic memory are created equal, nor do they necessarily activate similar areas in the brain.

In the way that the type of task can have an impact on the results, so too can the measurement technique. Visser, Jefferies, and Lambon Ralph (2010) conducted a meta-analytic review of neuroimaging studies investigating the role of the anterior temporal lobes (ATL) in processing of semantic information. An interesting finding was that the type of semantic stimuli used appeared to influence whether or not ATL activation was observed. Visser and colleagues reported that studies that had used auditory sentences as compared to those using visual words and pictures were more likely to generate activation. Another key finding was that the type of neuroimaging technique appeared to have a profound impact on the observation of ATL activation. More specifically, the meta-analysis revealed that studies involving PET were more likely to observe activation than were studies using MRI. Visser et al. explained why this may occur, citing there is a "susceptibility artifact" for fMRI studies, which results in loss of signal or increased distortion due to magnetic susceptibilities of brain, bone, and air in these regions. Of note, other measurement techniques also had an impact on the presence or absence of ATL activation in studies (i.e., FOV – field of view size, baseline task; see Visser et al. for a complete review).

Chan and colleagues provided additional evidence of the variability that can be found as a function of the technique used (Chan, Halgren, Marinkovic, & Cash, 2011). In a study using magnetoencephelography (MEG) and electroencephalography (EEG), the investigators suggested that activation of different brain areas may occur for living and non-living items at different latencies. Chan et al. postulated that inconsistencies in other imaging studies may be due to PET and fMRI techniques not having sufficient time resolution as the authors estimated the difference in latencies to be only a few hundred milliseconds. Thus, previous studies using less time-resolute techniques may only detect larger activations or those activations that occur for a lengthier period.

Therefore, the inconsistencies in neuroimaging studies investigating semantic processes are not surprising. Variability in baseline tasks, experimental stimuli, and the type of neuroimaging technique that is used across studies may in part explain why a clear-cut answer has not been revealed. It may also help explain the observation that compromised brain areas in individuals with semantic deficits frequently do not correspond to areas of activation found in neuroimaging studies of healthy individuals performing semantic tasks (Simmons & Martin, 2009). Moreover, these inconsistencies speak to the point that semantic processes are likely quite complex, and that our current methods for assessing neural substrates are perhaps not sufficiently fine-tuned to further our understanding.

Individual Differences

Another issue that needs to be considered is that of individual differences. An informative example was reported by Giussani and colleagues who investigated possible anatomical correlates for living and non-living categories in patients who had been operated on for various lesions (Giussani et al., 2011). Using brain-mapping procedures while assessing confrontational naming ability for living and non-living items, the investigators found high individual variability. Even though the investigators found a preferential localization for non-living items in the posterolateraltempropariet al lobe, this result emerged only following an analysis at the group level. Indeed, Giussani et al. commented that when looking at the brain mapping for each individual, they found heightened activation for some participants, but not for others. Therefore, they emphasized the high level of individual variability that could not be overlooked. Certainly, it is important not to discount the factor of variability given that a large part of the research in this area has involved single case studies.

Lambon Ralph and colleagues raise the interesting question of when can it be claimed that a true deficit exists and that results are not a mere artifact reflecting individual differences (Lambon Ralph, Patterson, Garrard, & Hodges, 2003). Multiple assessments of tasks can help assure stability in performance within an individual, and ensure that results are not due to fluctuations in performance on a given day. Moreover, credibility for the existence of a phenomenon will be yielded if several patients with similar etiological factors show similar impairments. However, what about a single case study that shows results that are inconsistent with existing research or predicted results? There is definitely a necessity to interpret such single case study results with caution.

Within the normal population it is well established that there are significant differences in semantic memory. Indeed, studies have shown substantial variability in individuals pertaining to their general knowledge (Rolfhus & Ackerman, 1999) and on specific semantic tasks (e.g., semantic priming: Stolz, Besner, & Carr, 2005). Also, incorrect information can be part of an individual's semantic memory (Martin, 2007). For instance, if an individual believes that penguins can fly, that information will be part of semantic memory.

Moreover, an individual's personal experience can impact semantic memory. Dixon et al. tested ELM, a patient with visual agnosia who had suffered a stroke (Dixon, Desmarais, Gojmerac, Schweizer, & Bub, 2002). Prior to this incident, it had been well documented that ELM played a brass instrument for several years in a military band. Results from the study showed that on a variety of measures contrasting knowledge of brass instruments with string instruments, the patient's performance was superior for stimuli involving brass instruments. Dixon and colleagues suggested that ELM's years of exposure to brass instruments as a member of a band, resulted in increased semantic knowledge for these items.

Lambon Ralph et al. (2003) discuss evidence that significant individual differences in semantic knowledge exist within the normal population. The authors astutely highlighted the fact that without a measurement or estimate of pre-morbid functioning on semantic tests, results of case studies always run the risk of being no more than individual differences that require careful examination. Lambon Ralph and colleagues (2003) sum up their argument quite eloquently, writing that individual differences remain “a leading contender for explaining an otherwise puzzling set of patterns in the domain of category specificity” (p. 323).

The methodological issues shed light on some of the potential reasons why the organization of semantic memory remains unclear. Moving forward, it is necessary to conduct additional research with carefully selected materials. In due course, it is hoped that convincing evidence for the categorical or featural hypothesis will be found, or that results may generate a new, more integrative theory. The broader goal is that a clearer understanding will slowly emerge.

Moving Forward Using a Proactive Interference Paradigm

Proactive interference. Proactive interference (PI) refers to the detrimental effects of previously presented information on the recall of newly learned material. Release from PI occurs when the previously presented information no longer interferes with newly learned material. For instance, in a standard PI paradigm, successive lists of different animals would result in decreased recall across trials; however, if a list of fruits was presented following the last list of animals, then release from PI would occur resulting in an increase in recall for the new category (i.e., compared to recall of the last animal list).

Wickens et al. conducted one of the earliest studies investigating PI release patterns as a function of attribute overlap (Wickens, Dalezman, & Eggemeier, 1976). Two similar experiments were conducted, employing a between-groups design in which all groups were presented with the same final triad, but had varied stimuli for the first three triads in terms of attribute overlap.

In the first experiment, each group's presentation of the first three triads had varying degrees of attribute overlap with the final triad of fruits as follows: vegetables (i.e., edible and grown from the ground); flowers (grown from the ground, not edible); meats (edible, not grown from the ground), professions (no attribute overlap). In this experiment, a pattern emerged whereby degree of PI release was inversely related to number of attributes that overlapped. Thus, greater release was observed for the switch from professions to fruits (in which there was no attribute overlap), followed by less PI release for the groups who were shown meats and flowers (one attribute overlap), with the least PI release observed for the group who had the switch from vegetables to fruits (i.e., in which there is greater attribute overlap).

Proactive interference in healthy aging and Alzheimer's disease. Several authors have suggested that proactive interference paradigms require less effortful encoding and retrieval of stimuli characteristics, allowing for a more indirect investigation of semantic memory (Belleville et al., 1992; Darling & Valentine, 2005). If this is indeed the case, it would provide an advantage for testing healthy older adults and individuals with Alzheimer's disease.

Multhaup, Balota, and Faust (2003) argued that the pattern of results obtained on a PI paradigm can provide information about the nature of the deficits in semantic memory for Alzheimer's disease. If PI and release from PI is obtained in individuals with AD, it has been suggested that semantic information was utilized, albeit in an automatic process. Thus, if PI effects are obtained, there is a strong argument for difficulties in accessing an intact semantic memory system. In contrast, if buildup of PI does not occur, then Multhaup et al. have argued that it provides evidence of a deterioration in semantic networks rather than a failure to access information, as it would be assumed that patients were not hindered (i.e., by showing PI buildup) nor did they benefit (i.e., by showing PI release) from semantic information.

Only a handful of studies have used a PI paradigm in a healthy aging and AD population. Participants in a study conducted by Binetti et al. were presented with trials consisting of five triads: the first four triads from the same semantic category and the fifth from a different category (Binetti et al., 1995). Stimuli were generated from the categories of animals, colours, fruits, and vegetables. The healthy older participants and AD participants both showed PI effects as measured by recall of target stimuli. As expected, individuals with AD recalled fewer words than age-matched controls.

Belleville et al. (1992) tested healthy older participants and individuals with AD using a PI paradigm comprising of five five-word lists. For the purposes of this review, only the relevant semantic condition in which the first four lists were body parts, and the final list was animal exemplars will be reviewed. Results showed that healthy older participants showed PI effects, in that recall decreased over the first four lists and increased when the category switched. For the participants with AD, buildup of PI as measured by recall of target words was not observed. Visual inspection of that data showed an irregular and fluctuating pattern of recall across stimuli presentation. However, when intrusions were examined, both healthy old participants and AD participants showed PI effects. Thus, intrusions increased across the four lists of body parts, but decreased when the fifth list of animals was presented.

Results from a study conducted by Loewenstein and colleagues demonstrated that individuals with AD showed greater proactive interference than age-matched controls when data were adjusted for differences in memory performance (Loewenstein, Acevedo, Agron, & Duara, 2003). Unfortunately, Loewenstein et al. failed to discuss intrusions, which may have yielded additional information.

A study conducted by Cushman and colleagues failed to show PI effects for individuals with AD (Cushman, Como, Booth, & Caine, 1988). The PI paradigm used in their study involved the presentation of five eight-word lists. The first four lists were animal exemplars, the fifth list was defined as kitchen implements. Healthy older participants showed PI buildup and release effects as measured by recall of target words. Participants with AD did not show PI effects. Visual inspection of the data showed that performance for AD participants fluctuated across presentations of stimuli generated from the same category.

It could be argued that the tasks used in some studies may have been too difficult for the AD participants as they often involved lengthier word lists (8 words: Cushman et al., 1988; 12 words: Wilson, Bacon, Fox, & Kaszniak, 1983). Moreover, several studies with healthy older adults and AD participants have only included shift trials (Belleville et al., 1992; Binetti et al., 1995). This design parameter may be a flaw, as when a PI paradigm has only shift trials, with no continued PI buildup trials, participants are more likely to learn to expect that the final triad or list will differ, something which may further contribute to a release from interference.

Marques' paradigm. Marques (2000) used a PI paradigm to investigate semantic memory organization by contrasting categorical and featural attributes while using the same stimuli. Using a between-groups design, Marques tested young participants with pictorial or word stimuli triads. For each triad, participants were asked either to silently read the word or to identify the picture; written responses were recorded by each participant during the recall period that immediately followed a backward counting task. Categorical conditions were not cued, whereas featural conditions were presented with a cue at the beginning of the trial. For instance, in one of the categorical conditions, four triads of animals were presented to a control group, and the experimental group was presented with three triads of vehicles and a final triad of animals (i.e., the shift trial). The same stimuli were presented to another group of participants but in this case the triads were featurally cued. The control group was presented with triads that were all cued as MEANS OF TRANSPORTATION but were from different categories (i.e., the first three triads were vehicles, and the fourth triad were animals that could also be used for transportation, such as an *elephant*, *horse,* and *camel*). The experimental group was presented with triads that were all from the category of animals: the first three triads were cued as NOT MEANS OF TRANSPORTATION and consisted of animals that would not be considered for use as transportation (e.g., *monkey*, *mouse*, and *rabbit*); for the fourth triad the cue changed to MEANS OF TRANSPORTATION and consisted of animals that may be used for transportation (e.g., *horse*, *elephant*, *camel*). The expectation was that if features were important, then for this experimental group, PI release should be observed on the fourth triad even though the category (i.e., animals) had not changed.

Marques (2000) conducted four experiments that examined PI buildup and release patterns for stimuli that were presented in the standard categorical manner (e.g., OBJECTS/ANIMALS) and with the featural cues of NOT TRANSPORTATION/TRANSPORTATION, DANGEROUS/NOT DANGEROUS, SMALL/BIG, and LESS THAN FOUR LEGS/FOUR LEGS. Results showed that young healthy participants showed PI effects for all of the standard categorical conditions. Results were less consistent for featurally cued items that were in direct opposition to categorical shifts. PI effects were observed for cues that were based on functional features (i.e., NOT TRANSPORTATION/TRANSPORTATION, DANGEROUS/NOT DANGEROUS) more so than for cues that were perceptually based (i.e., SMALL/BIG, and LESS THAN FOUR LEGS/FOUR LEGS). Marques concluded that the data were more in accordance with the importance of features.

While the experiments conducted by Marques (2000) should be acknowledged for their ingenuity in using the same material to contrast category and features, it could be argued that some of the experimental stimuli were ambiguous. For instance, *telephone* was used for an exemplar of furniture with FOUR LEGS, and *dog* was used for an exemplar of an animal NOT TRANSPORTATION. In the third experiment, the featural cue was size, where participants were told items would be BIG or SMALL compared to a human being. In this instance, *pig* was used as an exemplar of BIG. Most individuals would consider a pig to be smaller than a human being, at least in terms of height. Of note, a pig can also be smaller than several dog breeds, yet *dog* was one of the selected stimuli used for the cue SMALL. It is possible that stimuli selection may have been restricted because the experiments involved word and pictorial presentations.

In addition, because a between-subjects design was used, a comparison of the effects of presenting the same stimuli under different conditions could not be assessed for each individual. Moreover, only the featural conditions were cued, resulting in half of the participants having viewed stimuli without a cue.

Present Study

The purpose of this current study was to investigate semantic memory organization and impairment using a PI paradigm similar to the one developed by Marques (2000). To minimize difficulties with stimuli selection, the stimuli were presented only in word format. Cues were presented before each triad and used for all stimuli. The first three triads in each condition used the same cue and were the buildup triads (e.g., ANIMALS). In the PI continued condition, the final triad was similar to the buildup triads (e.g., ANIMALS); whereas in the PI release condition, the cue switched on the final triad (e.g., OBJECTS).

The current study employed a within-subjects design. Over two separate testing sessions, all participants viewed the stimuli twice; the stimuli that were cued categorically during the first session were cued featurally on the second session and vice versa. Thus, there were PI continued and PI release conditions for categorically cued and featurally cued stimuli. A categorical PI continued condition (e.g., all triads cued as ANIMALS) had the same stimuli as the corresponding featural PI release condition (e.g., animals cued as NOT USED FOR TRANSPORTATION for the first three triads, and animals cued as USED FOR TRANSPORTATION on the final triad). Furthermore, a categorical PI release condition (e.g., first three triads cued as OBJECTS, and final triad cued as ANIMALS) would have the same stimuli as one of the featural PI continued conditions (e.g., all triads cued as USED FOR TRANSPORTATION, with the first three triads consisting of objects that were vehicles, and the final triad consisting of animals that were used for transportation). Furthermore, to make the cue more salient, distractor words were paired with each target stimuli, requiring the participant to select the appropriate word. Participants were also required to say each target word aloud, to ensure that the correct words were selected.

As reviewed above, it has been widely acknowledged that category membership can affect PI buildup and release. Consistent with these studies, it is expected that PI buildup will be established across the first three triads in all conditions. Furthermore, it is expected that continued buildup will occur in the categorically PI continued condition (i.e., where the cue remains unchanged), and that release from PI will occur when there is a switch in categorical cue (i.e., in the PI release condition). The results for the featurally cued items will be of most importance in shedding light on this issue. If PI buildup and release are observed as a function of category (irrespective of a featural shift) this will lend support to the categorical hypothesis. On the other hand, if PI release occurs when featural attributes change but when the category remains unchanged, this will provide evidence of the importance of featural information in semantic memory organization.

This paradigm was tested in healthy young participants to establish a baseline of performance. Given that semantic memory is thought to be relatively stable across the lifespan (Peraita, 2007), a healthy older population was tested to examine any possible aging effects.

In addition, with modifications of the paradigm, a group of individuals with Alzheimer's disease (AD) was tested. There are several advantages of studying individuals with Alzheimer's disease when investigating semantic memory. First, studies involving patient populations offer unique insights into cognitive processes that are not always readily available in a neurologically healthy sample. Second, there is a fairly gradual pathological deterioration in AD as compared to other disorders (Henderson, 1996). Third, semantic memory impairments are consistently observed in this disorder (Farah & Grossman, 2005). Finally, it is a common disorder (Brookmeyer et al., 2011); therefore, it can be studied at group level. Thus, by testing this patient population, further light may be shed on the nature of semantic memory organization.

To date, various pathways have been explored to try to further our understanding of semantic memory organization and more specifically to provide evidence for the categorical or featural hypothesis. The aim of this study is to investigate semantic memory systematically using a cued PI paradigm that contrasts featural and categorical semantic material. Thus, by opposing featural and categorical information while making the cue more salient, using the same stimuli, and having each participant view both types of cues, the importance of these two types of information can be evaluated. Moreover, by testing three groups of participants, the emerging results will contribute to our current understanding of semantic memory organization.

Methods

Participants

Three groups were tested: healthy younger adults, healthy older adults, and individuals with Alzheimer's disease (AD). Data from one healthy older adult were replaced because he found the task too tiring, and data from four AD participants were excluded because they did not understand the experimental task. One AD participant was replaced because she was unavailable for the second testing session. Therefore, data were collected and analyzed for 20 healthy younger adults, 20 healthy older adults, and 16 individuals with probable AD.

Table 1 shows the demographic information for each of the groups. Although the goal was to match the older control group and AD participants on age, the patient group was older than the control group of older adults, t (34) = -3.06, p = .004. To determine if the age difference was a factor, four of the youngest participants from the older control group and three of the oldest AD participants were removed, in order to match the two groups on age. The matched groups yielded a similar pattern of results on the experimental paradigm; thus, the full sample was used and is reported here.

Healthy younger adults had more years of formal education than the healthy older adults, t (34) = 3.43, p = .002. There was no statistical difference in years of formal education between the healthy older adults and participants with AD, t (34) = .68, p = .50.

All participants were required to be fluent in English. Younger adults consisted mainly of undergraduate students; older adults were community-dwelling volunteers.

Table 1

Average Demographic Data for the Younger Adults, Older Adults and AD Participants

Group	Sex	Age (SD)	Education (SD)
Younger Adults	10 females	23.0	14.4
	10 males	(3.6)	(1.8)
Older Adults	10 females	73.8	12.1
	10 males	(7.5)	(2.9)
AD participants	7 females	81.4	11.3
	9 males	(7.3)	(4.3)

According to a self-report health screening questionnaire (see Appendix A), all control participants were free of neurological or cardiovascular diseases. Individuals with probable AD were recruited from the Memory Clinic at the Sir Mortimer B. Davis Jewish General Hospital (a tertiary-care facility). Diagnosis for probable AD was made by an experienced physician and was established according to the diagnostic criteria for dementia in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV; American Psychiatric Association, 1994), and the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and Alzheimer's Disease and Related Disorders (ARDRA) Work Groups (McKhann et al., 1984). A comprehensive neuropsychological assessment had been completed on each patient at the Memory Clinic, allowing for a classification of disorder severity. The AD participants in this study were in the mild or moderate stage of the disease.

Participants were tested in two separate sessions conducted approximately one week apart. Testing took place at the university laboratory, the Sir Mortimer B. Davis Jewish General Hospital, or at the older participants' homes. Informed consent was obtained (see Appendix B), and all participants were remunerated $10 per hour for each session. Procedures were thoroughly explained at the beginning of each session, and all participants were debriefed at the end of the second testing session.

Materials

Experimental paradigm. The goal of the study was to determine the impact of categorical and featural cues on recall and intrusion errors and to establish patterns of PI effects (i.e., buildup and release) in healthy younger adults, healthy older adults, and participants with AD. A within-group design was used, so that all participants viewed all stimuli with both categorical and featural cues.

The target stimuli consisted of 96 English words that could be sorted into three categories (i.e., animals, fruits and vegetables, and objects) and four features (i.e., two perceptual: shape and size; two functional: transport use and eating use). In order to manipulate the categorical and featural components of the stimuli, semantic cues were used. To further ensure that the words were encoded according to the semantic cue, each word was paired with a distractor word. Figure 1 shows an example of a categorically cued triad. As can be seen in this figure, the distractor words were chosen according to their opposition of each cue (e.g., when the semantic cue was ANIMALS, one of the target words was *elephant* and the accompanying distractor word was *titanium*). In order to prevent the use of distractors during encoding and recall (e.g., to prevent a participant being able to say "the words were paired with types of metal"), distractor words were arranged such that in a given trial they did not all belong to a similar category. For example, the distractors in Figure 1 were *pewter*, *titanium*, and *ankle* (i.e., two types of metal, and one body part).

A list of all target and distractor stimuli is presented in Appendix C. Ratings of concreteness, imageability, and frequency were obtained from the Medical Research Council lexical database (www.psy.uwa.edu.aau/mrcdatabase/uwa_mrc.htm). An effort was made to match target and distractor stimuli on these characteristics, while ensuring that stimuli were appropriate for the featural and categorical cues. Given the nature of

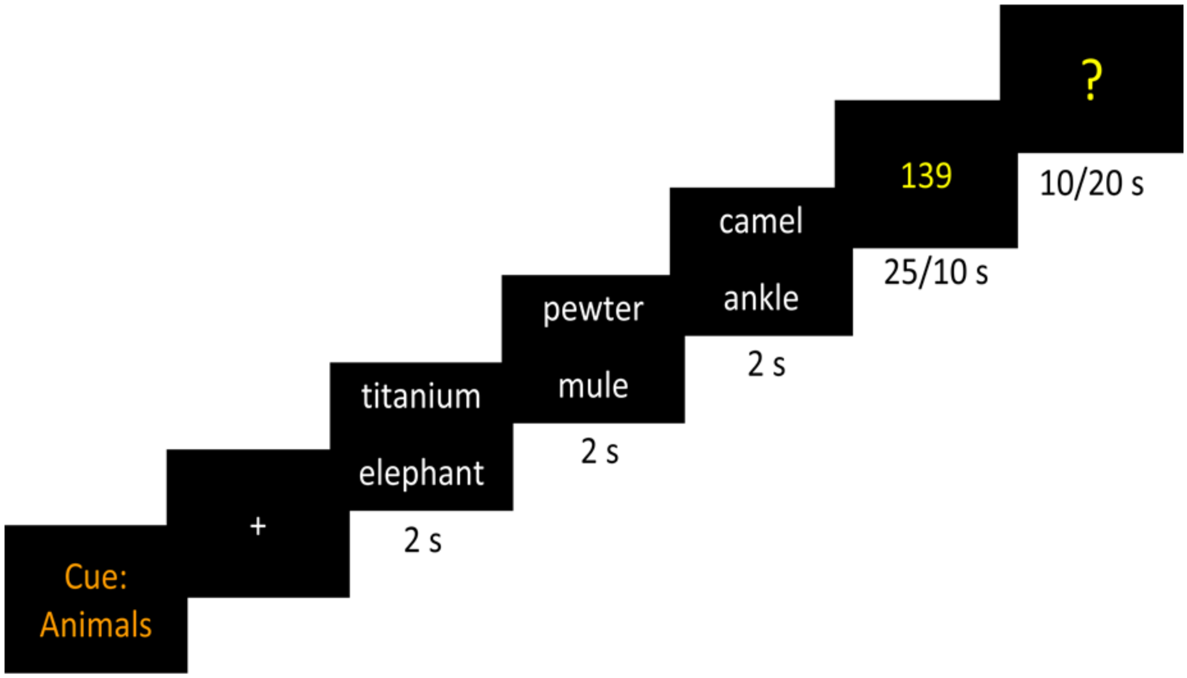

Figure 1. Example of a categorically cued triad.

the design it was not critical for the stimuli to be perfectly matched, as all stimuli were used in all conditions (i.e., all stimuli were categorically and featurally cued and presented in PI continued and PI release trials).

Ten different versions of the experiment were created to ensure that stimuli and cues were presented in a random order across participants; the versions were assigned in the order that participants were booked into the study. For each participant, verbal responses for the PI paradigm were recorded on a recall sheet by the examiner.

As illustrated in Figure 2, each trial consisted of four triads of words. The first three triads were presented with the same cue (e.g., ANIMALS) and constituted the PI buildup triads for each trial. The fourth triad was presented with the same cue in the PI continued condition, or with a different, contrasting, cue in the PI release condition (e.g., OBJECTS). During each testing session, eight trials were presented (i.e., two categorical conditions and two featural conditions, each having both a PI continued and PI release trial).

The factors of a trial in the first testing session were switched in the second session (i.e., a featural PI continued trial in the first session was a categorical PI release trial in the second session). Table 2 shows an example of stimuli for two experimental trials. In one session, the trial was presented with categorical cues: panel A illustrates a categorical PI continued condition (e.g., ANIMALS/ANIMALS); panel B shows a categorical PI release condition (i.e., OBJECTS/ANIMALS). In another session, the same stimuli would be presented with featural cues: panel A shows a featural PI release

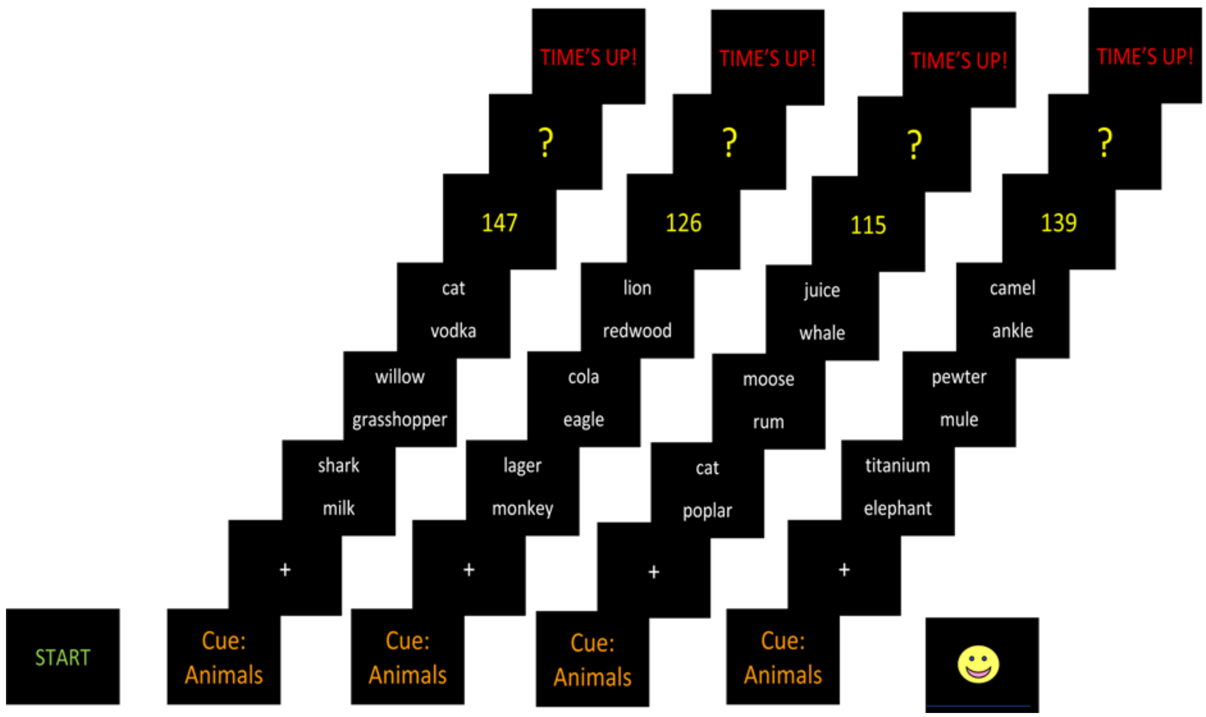

Figure 2. Example of a categorically cued PI continued trial.

Table 2

Example Stimuli from Experimental Trials

Panel A

Triad 1	Triad 2	Triad 3	Triad 4
SHARK	MONKEY	CAT	ELEPHANT
GRASSHOPPER	EAGLE	MOOSE	MULE
CAT	LION	WHALE	CAMEL

Note. Categorical PI Continued Trial: Cue for T1 to T3: Animals; Cue for T4: Animals

Featural PI Release Trial: Cue for T1 to T3: Not Used for Transportation; Cue for T4: Used for Transportation

Panel B

Triad 1	Triad 2	Triad 3	Triad 4
AIRPLANE	BUS	FERRY	HORSE
SUBWAY	TRAIN	HELICOPTER	OX
MOTORCYCLE	BICYCLE	TRUCK	MULE

Note. Categorical PI Release Trial: Cue for T1 to T3: Objects; Cue for T4: Animals

Featural PI Continued Trial: Cue for T1 to T3: Used for Transportation; Cue for T4: Used for Transportation condition (e.g., NOT USED FOR TRANSPORTATION/USED FOR TRANSPORTATION); panel B illustrates a featural PI continued condition (e.g., USED FOR TRANSPORTATION/USED FOR TRANSPORTATION).

The experiment was presented on a laptop computer using Microsoft PowerPoint software. All stimuli were presented on a black background using Arial font. Cues were presented using an orange 66pt font; fixation point and word pairs were in a white 48pt font; and numbers and question marks in a yellow 66pt font. A message indicating the start of each new trial was presented in green 66pt font; a message indicating the time limit for a response had ended was in a red 66pt font; and a smiling face graphic specifying a break between trials was yellow.

Neuropsychological tests. The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) were used as brief tests of global cognitive functioning. From the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III; Wechsler, 1997) two subtests were administered: Letter Number Sequencing (LNS) and Similarities. The LNS subtest was administered in order to obtain an independent measure of working memory. The Similarities subtest was administered as it requires participants to understand semantic properties and to show abstract verbal reasoning abilities.

In addition to standardized neuropsychological instruments, a sorting task was created in which each of the 96 stimulus words used in the PI experiment were presented individually in Times New Roman 48 point black font on white cardstock. Participants were required to sort the word on each card according to the different featural cues that were used during the experiment (i.e., SMALL/LARGE; LONG/ROUND; USED FOR TRANSPORTATION/NOT USED FOR TRANSPORTATION; EATEN/NOT EATEN). The purpose of this task was to determine if participants could accurately sort the stimuli according to the featural attributes that were cued during the PI paradigm. Sorting responses were recorded on an answer sheet.

Procedure

Participants were tested individually in two sessions. At the beginning of each session, verbal instructions were read aloud (see Appendix D), and the participant was given the opportunity to ask questions. Participants were informed that the experiment involved a memory component (i.e., to recall three cued words in the order they were presented) and a learning component (i.e., accuracy and speed of counting by threes). Following verbal instructions, a practice trial was administered.

Each trial consisted of four triads (see Figure 2). At the beginning of each triad, the semantic cue was presented followed by a fixation cross. Each of the three word pairs was presented (i.e., one pair per slide) for two seconds each and participants were instructed to choose and say aloud each word that went with the cue. Following the pairs, a three digit number was presented which was the starting point for counting backwards by threes. The duration of the counting task was 25 seconds for younger participants and ten seconds for older participants. Participants with AD counted forwards by threes for ten seconds. When the counting task time had elapsed, a question mark appeared indicating that participants should stop counting and attempt to recall the triad. Younger participants were given eight seconds to recall the triad;

healthy older participants and AD participants were given 20 seconds. A slide with "TIME'S UP" appeared which indicated the end of the recall period. At the end of four triad presentations, a slide with a happy face appeared for one minute, which marked a break period for each participant.

As noted above, modifications were made to the task for the different groups. Administering the exact same paradigm to all participants would likely have yielded floor or ceiling performance (i.e., the younger participants may have found the task too easy, or the AD participants may have found it too difficult). Given this expectation, the length of the distractor task was reduced for all older participants (i.e., older control group and AD participants). In addition, adjustments were made to the duration of the recall period, which allowed the older participants to have more time to respond. Moreover, the content of the counting task was modified for the AD participants, making the task more manageable but still allowing for it to serve its purpose of providing a distraction during the delay period.

During the first testing session, eight experimental trials were presented, with half of the stimuli cued categorically and half cued featurally. Approximately one week later, a second testing session occurred, whereby the stimuli and semantic cue assignments were reversed. At the end of the experimental trials on the second session, additional neuropsychological tests were administered in the following order: the MMSE, MoCA, LNS subtest and Similarities subtest from the WAIS-III. For participants with AD, the LNS and Similarities subtests were omitted as this data had been collected in a recent neuropsychological assessment. Following these tests, the sorting task was administered. At the end of the second session, each participant was fully debriefed as to the purpose of the experiment.

Results

Repeated measures analyses of variance (ANOVAs) and t-tests were conducted to analyze the data using SPSS v.20 statistical software. Age-related differences were assessed by comparing younger and older control groups. Healthy older adults and individuals with AD were compared to assess differences due to disease pathology. Main effects of variables are analyzed and reported, and interactions are described when significant. The highest order interaction is reported in the case of multiple significant interactions. Simple effects were conducted on findings that were statistically significant at an alpha .05 level.

Breakdown of responses

Through visual inspection of participants' responses across the two separate testing sessions, there did not appear to be any notable differences, or carryover effects. A response was recorded as correct if it was one of the three target words that had been presented in the triad. An error of omission was defined as a lack of response (e.g., failing to recall one of the three target words). An intrusion error was a response in which a word was provided that was not one of the three target words.

Figure 3 shows a breakdown in the type of responses for each of the three groups. As can be seen, the majority of responses for the healthy younger participants were target words (e.g., 81%). For younger participants, 16% of responses were classified as errors of omission (i.e., failure to provide a response), and only 3% were intrusion errors. The majority of responses for healthy older participants were also

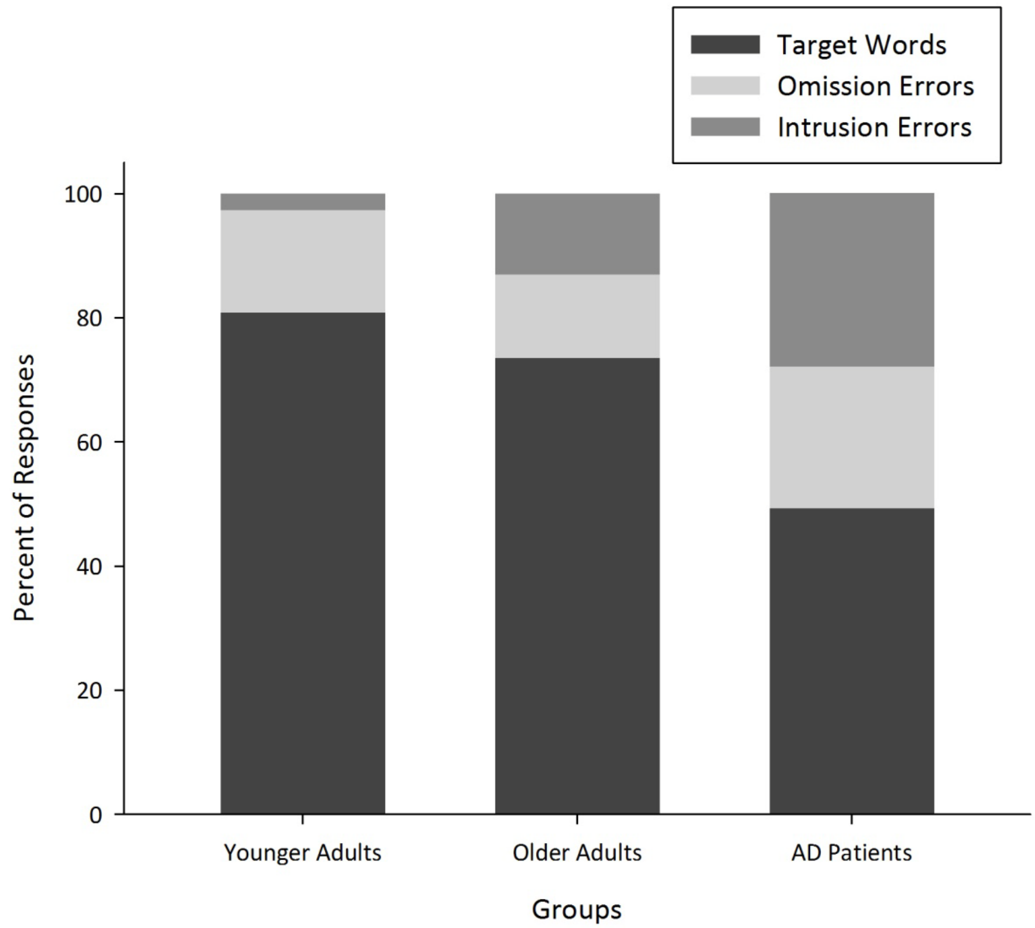

Figure 3. Breakdown of responses for younger adults, older adults, and AD participants.

target words (e.g., 74%). The remainder of the responses for the older control groups were split evenly between omissions (e.g., 13%) and intrusion errors (e.g., 13%). For the AD participants, approximately half of their responses were target words (e.g., 49%). For the remaining response breakdown, participants with AD made a similar number of omission and intrusion errors (e.g., 23% and 28% respectively).

Experimental Data: Recall

The 16 experimental trials were collapsed and analyzed by the following conditions: categorical PI continued, categorical PI release, featural PI continued, and featural PI release. There were minor variations in results from the experimental trials; however, the majority of trials were generally in accordance with the collapsed conditions.

A series of 2 x 2 x 2 (Group x Condition x Triad) ANOVAs were conducted with the between factor of Group (Young, Old; or Old, AD participants) and the within factors of Condition (PI Continued, PI Release) and Triad (First, Third; or Third, Fourth). As noted above, each of these analyses was conducted comparing the younger and older controls, followed by separate analyses examining differences between the healthy older participants and AD participants.

Mean recall scores representing the number of words recalled (0, 1, 2, or 3 words) were computed for each triad and are presented in Appendix E. Recall data were scored on a three point (i.e., one point for each correctly recalled word) and six point scales (i.e., one point for each correct word and one point for the correct order). In general, the six point scale provided a similar pattern of results as the three point scale (see Appendix F for visual comparisons of each scale). As such, results from the three point scale are presented below. Thus, Figure 4 depicts data for categorically cued stimuli, and Figure 5 for featurally cued stimuli for all groups.

Triads 1 to 3. It was predicted that all conditions would show PI buildup (i.e., reduced recall) across the first three triads. 2 x 2 x 2 (Group x Condition x Triad) ANOVAs were conducted in which mean recall scores for the first and third triads were compared (i.e., T1 and T3 respectively). The second triad was omitted from analyses to allow for a direct comparison of the first triad presentation (i.e., where recall performance was expected to be optimal) to the third triad (i.e., the last buildup triad where recall performance was expected to decrease prior to the critical switch or PI continued triad), in order to show evidence of PI buildup.

Categorically cued.

Younger vs. older controls. For healthy younger and older participants, there was a main effect of Group, $F(1,38) = 4.25$, $p = 0.046$, indicating that overall, the younger adults recalled more words ($M = 2.53$, $SE = 0.05$) than the older adults ($M = 2.38$, $SE = 0.05$). There was a main effect of Triad, $F(1,38) = 163.79$, $p < 0.001$, in that the mean recall scores for the first triads ($M = 2.96$, $SE = 0.02$) were significantly higher than for the third triads ($M = 1.95$, $SE = 0.08$). This showed that PI buildup across the first three triads was demonstrated in all categorically cued conditions. There was no main effect of Condition, $F(1,38) = 0.79$, $p = 0.379$, or interaction with Condition, suggesting that, as expected, PI buildup was similar across the first three triads in both the categorical PI continued and categorical PI release conditions.

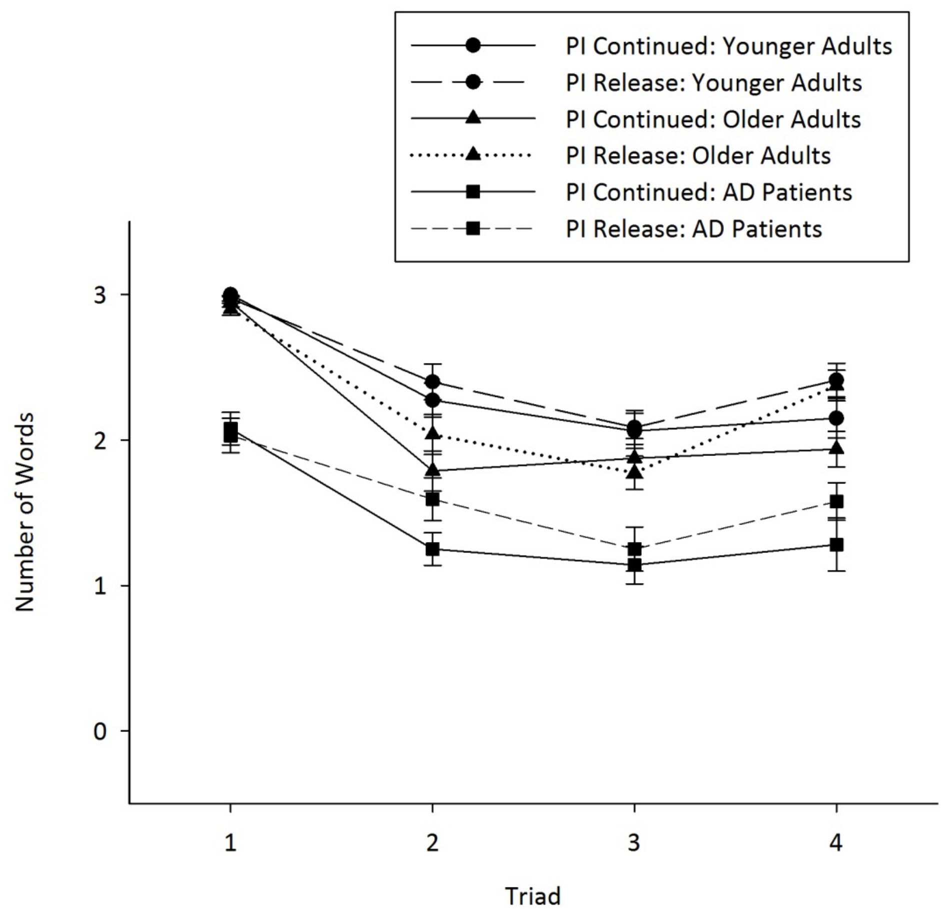

Figure 4. Average recall for categorically cued stimuli for younger adults, older adults, and AD participants.

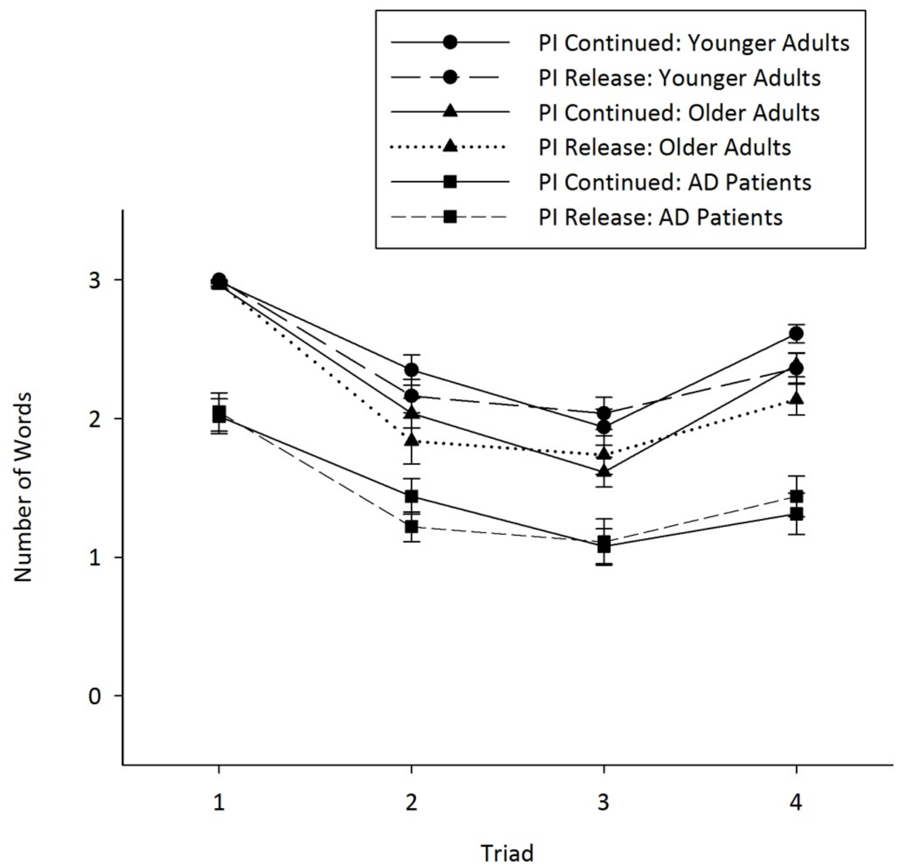

Figure 5. Average recall for featurally cued stimuli for younger adults, older adults, and AD participants.

Older controls vs. AD participants. There was a main effect of Group, F (1,34) = 49.12, p < 0.001, revealing that the older controls recalled more words (M = 2.38, SE = 0.07) than the AD participants (M = 1.62, SE = 0.08). Higher mean recall scores for T1 (M = 2.49, SE = 0.05) as compared to T3 (M = 1.51, SE = 0.08) were observed in all categorically cued conditions, indicating PI buildup for all participants across the first three triads, F (1,34) = 127.82, p < 0.001. Similar to results for the younger and older controls, there was no main effect or interaction with Condition, F (1,34) = 0.19, p = 0.668.

Featurally cued.

Younger vs. older controls. A main effect of Group, F (1,38) = 4.70, p = 0.04, revealed that the younger adults recalled more words (M = 2.49, SE = 0.06) than the older adults (M = 2.32, SE = 0.06). As expected, PI buildup was evident, in that mean recall for T1 (M = 2.98, SE = 0.01) was significantly greater than for T3 (M = 1.83, SE = 0.08), F (1,38) = 225.90, p < 0.001. There was a trend for a Group x Triad interaction, F (1,38) = 3.53, p = 0.068, showing a pattern of similar recall for both groups on T1 (younger: M = 2.99, SE = 0.01; older: M = 2.97, SE = 0.01), but fewer words for the older as compared to the younger on T3 (younger: M = 1.99, SE = 0.11; older: M = 1.68, SE = 0.11). There was no main effect of Condition, F (1,38) = 2.04, p = 0.161, or interaction with Condition.

Older controls vs. AD participants. A main effect of Group, F (1,34) = 38.44, p < 0.001, and a main effect of Triad were obtained, F (1,34) = 44.25, p < 0.001. There was a significant Group x Triad interaction, F (1,34) = 6.01, p = 0.020 for featurally cued stimuli.

Post-hoc analysis revealed that healthy older participants had greater recall for both triads in comparison to AD participants. Moreover, mean recall was higher for T1 than T3 for both groups, but that the difference between recall for T1 and T3 was greater for older controls (T1: $M = 2.97$, $SE = 0.07$; T3: $M = 1.68$, $SE = 0.11$) as compared to participants with AD (T1: $M = 2.03$, $SE = 0.08$; T3: $M = 1.09$, $SE = 0.13$). Consistent with other analyses, there was no main effect of Condition, $F(1,34) = 0.95$, $p = 0.337$, or interaction.

Triads 3 to 4. Expected patterns of PI buildup and release were examined by comparing the third and fourth triads (i.e., T3 and T4). Separate 2 x 2 x 2 (Group x Condition x Triad) ANOVAs were conducted contrasting PI continued and PI release conditions for categorically cued and featurally cued stimuli. Thus, it was predicted that when a cue changed on the fourth triad (i.e., the PI release condition), recall would improve in comparison to the third triad. However, when the cue remained the same on the fourth triad (i.e., the PI continued condition) recall should remain similar to the third triad or continue to decrease.

Categorically cued.

Younger vs. older controls. There was no Group main effect, $F(1,38) = 1.91$, $p = 0.175$, or Group interaction, suggesting that the healthy younger and older adults did not differ significantly in mean recall across conditions and triads. A main effect of Triad, $F(1,38) = 19.04$, $p < 0.001$, and a main effect of Condition were obtained, $F(1,38) = 5.11$, $p = 0.03$. A significant Condition x Triad interaction was observed, $F(1,38) = 15.12$, $p < 0.001$. Post-hoc analysis revealed a statistical difference in mean recall score for the third and fourth triad in the categorical PI release condition (T3: M = 1.93, SE = 0.08; T4: M = 2.39, SE = 0.08); but no difference in the categorical PI continued condition (T3: M = 1.97, SE = 0.09; T4: M = 2.04, SE = 0.09). Thus, as expected, recall increased on the fourth triad in the PI release condition when the categorical cue switched.

Older controls vs. AD participants. A main effect of Group, $F(1,34) = 18.32$, $p < 0.001$, indicated that, overall, the older controls recalled more words (M = 1.99, SE = 0.11) than the AD participants (M = 1.31, SE = 0.12). A main effect of Triad, $F(1,34) = 21.32$, $p < 0.001$, and a main effect of Condition were obtained, $F(1,34) = 7.60$, $p = 0.009$. There was a significant Condition x Triad interaction, $F(1,34) = 13.13$, $p = 0.001$. Post-hoc analysis indicated that there was no difference in mean recall score for T3 (M = 1.51, SE = 0.09) and T4 (M = 1.61, SE = 0.11) in the PI continued condition; however, recall increased on the fourth triad (T4: M = 1.98, SE = 0.08) as compared to third triad (T3: M = 1.51, SE = 0.09) in the PI release condition. There was a trend for a Group x Condition x Triad interaction, $F(1,34) = 3.06$, $p = 0.089$, showing a tendency for both groups to have increased recall for the fourth triad as compared to the third triad for the PI release condition, but that the magnitude of the difference in recall between T3 and T4 was greater for the healthy older adults (T3: M = 1.78, SE = 0.12; T4: M = 2.38, SE = 0.110) than for the participants with AD (T3: M = 1.25, SE = 0.14; T4: M = 1.58, SE = 0.12).

Featurally cued.

Younger vs. older controls. Younger adults recalled more words (M = 2.24, SE = 0.08) than older adults (M = 1.97, SE = 0.08), as evidenced by a main effect of Group, F

$(1,38) = 5.64$, $p = 0.023$. A main effect of Triad, $F(1,38) = 58.67$, $p < 0.001$ was observed; however, there was no main effect of Condition, $F(1,38) = 1.44$, $p = 0.238$. A significant Condition x Triad interaction, $F(1,38) = 9.52$, $p = 0.004$ demonstrated that recall for the fourth triad was higher than the third triad for both conditions, but that the difference between T3 and T4 was greater for the PI continued condition (T3: $M = 1.78$, $SE = 0.08$; T4: $M = 2.50$, $SE = 0.06$) as compared to the PI release condition (T3: $M = 1.89$, $SE = 0.09$; T4: $M = 2.25$, $SE = 0.08$). Thus, it appeared that both featurally cued PI continued and PI release conditions showed a pattern consistent with release, but that there was a larger release for the PI continued condition, in which the featural cue remained the same, but there was an implicit switch in category, as compared to the PI release condition, in which the featural cue switched.

Older controls vs. AD participants. A main effect of Group, $F(1,34) = 25.14$, $p < 0.001$, and a main effect of Triad was observed, $F(1,34) = 40.64$, $p < 0.001$. No main effect of Condition was found, $F(1,34) = 0.02$, $p = 0.888$. There was a significant Group x Triad interaction, $F(1,34) = 5.05$, $p = 0.031$ for featurally cued stimuli. Post-hoc analysis revealed that the older control group recalled more words than the participants with AD. Furthermore, recall for T4 was higher than for T3 for both groups, but that the difference between the third and fourth triad was greater for the healthy older participants (T3: $M = 1.68$, $SE = 0.11$; T4: $M = 2.26$, $SE = 0.10$) than for the AD participants (T3: $M = 1.09$, $SE = 0.13$; T4: $M = 1.38$, $SE = 0.11$). There was a trend for a Group x Condition x Triad interaction, $F(1,34) = 3.03$, $p = 0.091$, showing a tendency for both groups to have increased recall for the fourth triad as compared to the third triad for both PI continued and PI release conditions; however, for older controls, there was a tendency for a larger difference in recall between T3 and T4 for the featural PI continued condition as compared to the featural PI release condition, whereas the AD participants showed the opposite trend with a greater release for the featural PI release condition relative to the PI continued condition.

Same stimuli cued differently. Given that the experimental paradigm presented identical stimuli with a featural cue on one session and a categorical cue at another session, the function of these different cues was also directly compared. As such, additional analyses compared the categorical PI continued condition to the featural PI release condition and the categorical PI release condition to the featural PI continued condition (refer back to Table 2 panels A and B respectively for an example of stimuli for these conditions). For all groups, these data are replotted in Figures 6 and 7 respectively for these comparisons). If the cue had no impact on recall, it was expected that these comparisons would not differ. However, if cues were utilized, then the PI release condition with a switch in cues on the fourth triad should yield a higher recall.

Categorical PI continued condition vs. featural PI release condition.

Younger vs. older controls. There was a trend for a main effect of Group, $F\,(1,38) = 3.08$, $p = 0.087$, showing a pattern of overall increased recall for the younger ($M = 2.15$, $SE = 0.09$) as compared to the older control group ($M = 1.92$, $SE = 0.09$). A main effect of Triad, $F\,(1,38) = 9.36$, $p = 0.004$ was obtained; yet there was no main effect of Condition, $F\,(1,38) = 0.79$, $p = 0.381$. There was a significant Condition x Triad

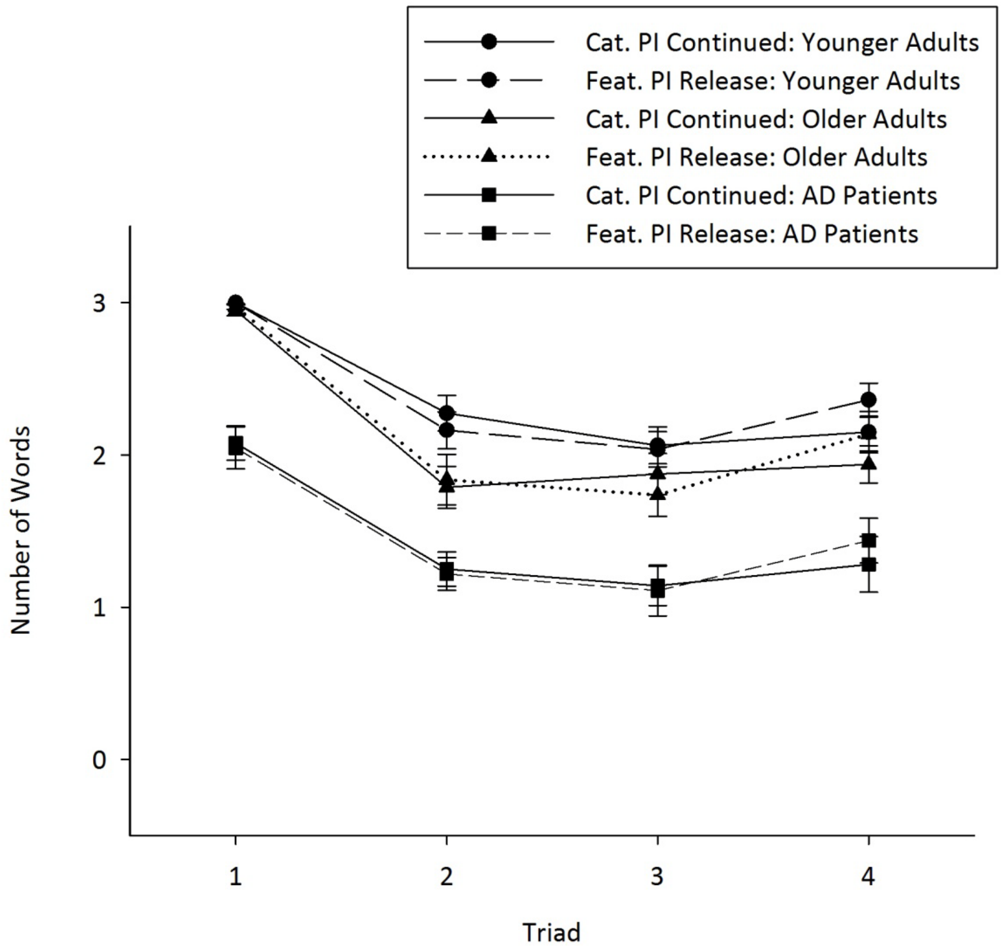

Figure 6. Average recall for the categorical PI continued and featural PI release conditions in which the same stimuli were cued differently, for younger adults, older adults, and AD participants.

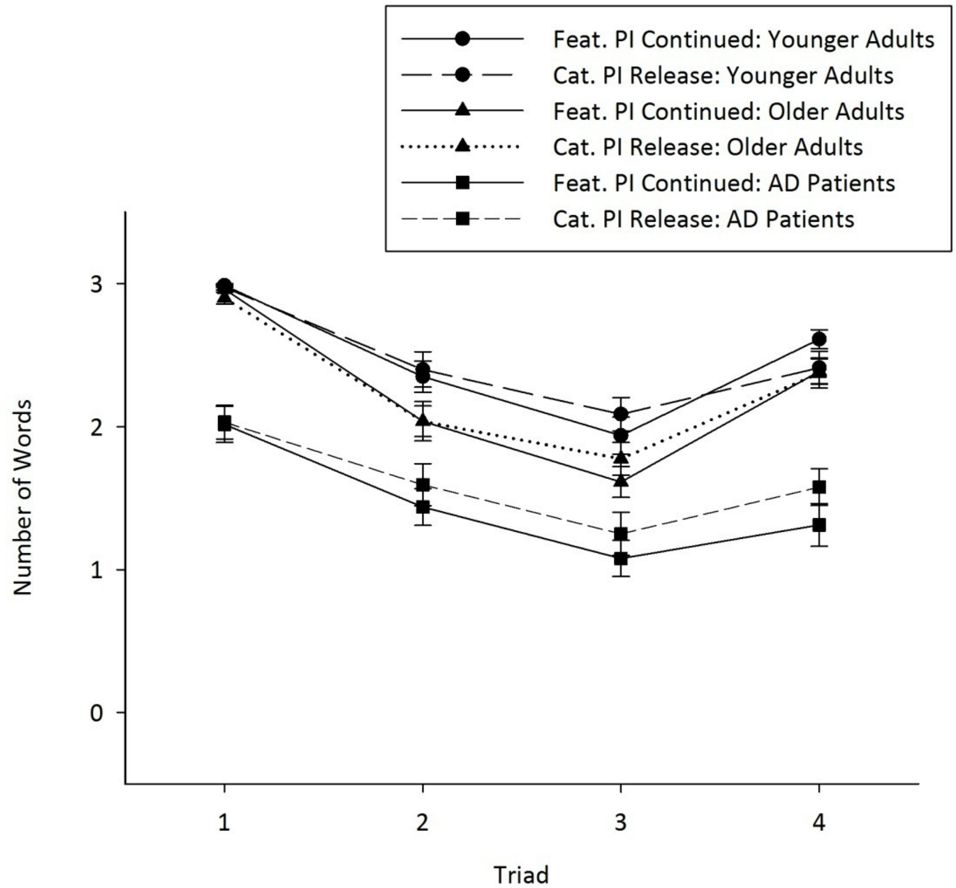

Figure 7. Average recall for the categorical PI release and featural PI continued conditions in which the same stimuli were cued differently, for younger adults, older adults, and AD participants.

interaction, F (1,38) = 5.75, p = 0.021, indicating a difference between T3 and T4 in the featural PI release condition (T3: M = 1.89, SE = 0.09; M = 2.25, SE = 0.08), but no such difference in the categorical PI continued condition (T3: M = 1.97, SE = 0.09; T4: M = 2.04, SE = 0.09). Thus, recall increased only on the fourth triad when stimuli were cued featurally and the cue switched.

Older controls vs. AD participants. Overall, the healthy older adults recalled more words (M = 1.99, SE = 0.11) than the AD participants (M = 1.24, SE = 0.12) as indicated by a main effect of Group, F (1,34) = 16.37, p < 0.001. A main effect of Triad, F (1,34) = 13.87, p = 0.001 was observed; however, there was no main effect of Condition, F (1,34) = 0.53, p = 0.472. There was a significant Condition x Triad interaction, F (1,34) = 4.31, p = 0.046. Post-hoc analysis revealed that there was no statistical difference between recall scores for T3 (M = 1.51, SE = 0.10) and T4 (M = 1.61, SE = 0.11) in the categorical PI continued condition; however, recall increased on the fourth triad (T4: M = 1.79, SE = 0.09) as compared to third triad (T3: M = 1.42, SE = 0.11) in the featural PI release condition.

Categorical PI release condition vs. featural PI continued condition.

Younger vs. older controls. There was a trend for a main effect of Group, F (1,38) = 3.95, p = 0.054, indicating a pattern in which the younger adults recalled more words (M = 2.26, SE = 0.08) than the older adults (M = 2.04, SE = 0.08). A main effect of Triad, F (1,38) = 112.44, p < 0.001 was observed; however, there was no main effect of Condition, F (1,38) = 0.15, p = 0.701. There was a significant Condition x Triad interaction, F (1,38) = 5.88, p = 0.020. Post-hoc analysis revealed that both conditions showed an increase in recall from T3 to T4, but that the difference was greater for the featural PI continued condition (T3: M = 1.78, SE = 0.08; T4: M = 2.50, SE = 0.06) as compared to the categorical PI release condition (T3: M = 1.93, SE = 0.08; T4: M = 2.39, SE = 0.08). Thus, it appeared that both featurally cued PI continued and categorical PI release conditions showed a pattern consistent with release, but that there was a larger release for the featural PI continued condition. As noted earlier, in the featural PI continued condition, the featural cue remains unchanged, but there is an implicit change in the category from which the stimuli is drawn (see Table 2, panel B for example).

Older controls vs. AD participants. A main effect of Group, $F(1,34) = 30.54$, $p < 0.001$, and a main effect of Triad were obtained, $F(1,34) = 56.37$, $p < 0.001$. There was a main effect of Condition, $F(1,34) = 5.15$, $p = 0.030$, revealing increased recall for the categorical PI release condition (M = 1.74, SE = 0.08) as compared to the featural PI continued condition (M = 1.598, SE = 0.071). A significant Group x Triad interaction, $F(1,34) = 9.91$, $p = 0.003$ demonstrated that both groups showed an increase in recall for T4 as compared to T3, but that the difference was greater for the older controls (T3: M = 1.69, SE = 0.10; T4: M = 2.38, SE = 0.10) than for the AD participants (T3: M = 1.16, SE = 0.11; T4: M = 1.44, SE = 0.11).

Breakdown of intrusion errors

As noted above, for each triad, an intrusion was defined as any word that was not one of the three target words. Intrusion errors were characterized in the following manner: consistent with the cue (CC); not consistent with the cue (NCC); previously presented (p); not previously presented (n); and distractors. Thus, CCp errors were intrusions that were consistent with the cue and had been previously presented in a prior triad during the experimental trial. CCn intrusion errors were those that were consistent with the cue but had not been previously presented in the experimental trial. NCCp errors were intrusions that were not consistent with the cue, but had been previously presented during the experimental trial (e.g., a participant responding with one of the words from the first three buildup triads during the final release triad when the cue had changed). NCCn errors were intrusions that were not consistent with the cue, nor had they been previously presented in the experimental trial. Distractor intrusion errors occurred when a participant recalled one of the distractor words rather than the target word.

Figure 8 shows a breakdown of the total number and type of intrusion errors for the three groups. The younger control group made very few intrusion errors (i.e., 99 total intrusion errors, averaging to less than five intrusion errors for each young participant for the entire paradigm). Healthy older participants made a total of 499 intrusion errors (i.e., averaging to approximately 25 intrusion errors for each older control). On average, participants with AD made twice the number of intrusions as the older control group (i.e., 854 total intrusion errors, averaging to approximately 53 errors for each AD participant). Mean intrusion errors are reported for all groups in Appendix G. For all groups, the majority of intrusion errors were consistent with the cue (younger: 83.1%; older: 98.1%; AD participants: 87.9%). Of interest, approximately 10% of the CC errors for the younger and older control groups were words that had not been

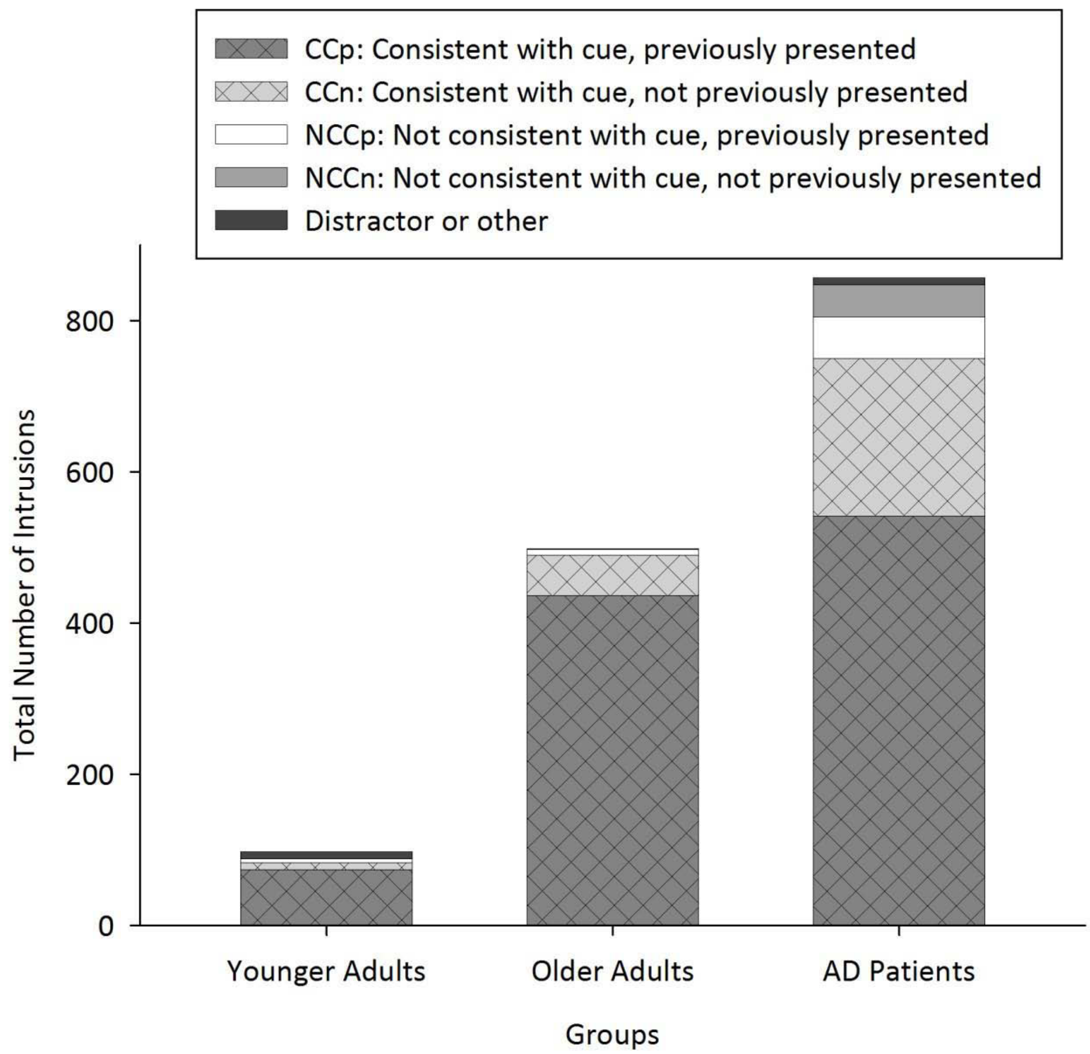

Figure 8. Breakdown of total intrusion errors for younger adults, older adults, and AD participants.

previously presented; whereas for the AD participants approximately 24% of the intrusion errors were words that had not been viewed during the experimental trial. In addition, NCCn errors were made only in the AD patient group and were usually perseverative responses from the buildup triads that continued during the final release triad.

Experimental Data: Intrusion Errors

Consistent with analyses conducted on recall scores, the 16 experimental trials were collapsed and analyzed for intrusions according to the following conditions: categorical PI continued, categorical PI release, featural PI continued, and featural PI release. Total intrusion errors were analysed, with separate analyses conducted for categorically cued and featurally cued stimuli. In addition, each of these analyses was conducted comparing the younger and older controls, followed by separate analyses examining differences between the older participants and AD participants. For all groups, intrusions across the four triads are presented for categorically cued stimuli in Figure 9 and for featurally cued stimuli in Figure 10.

Triads 1 to 3. A series of 2 x 2 x 2 (Group x Condition x Triad) ANOVAs were conducted similar to those carried out for recall scores. To determine whether the number of intrusions increased for the first three triads across all conditions, mean intrusions scores for the first and third triads were compared (i.e., T1 and T3 respectively).

Categorically cued.

Younger vs. older controls. A main effect of Group, $F(1,38) = 23.25$, $p < 0.001$,

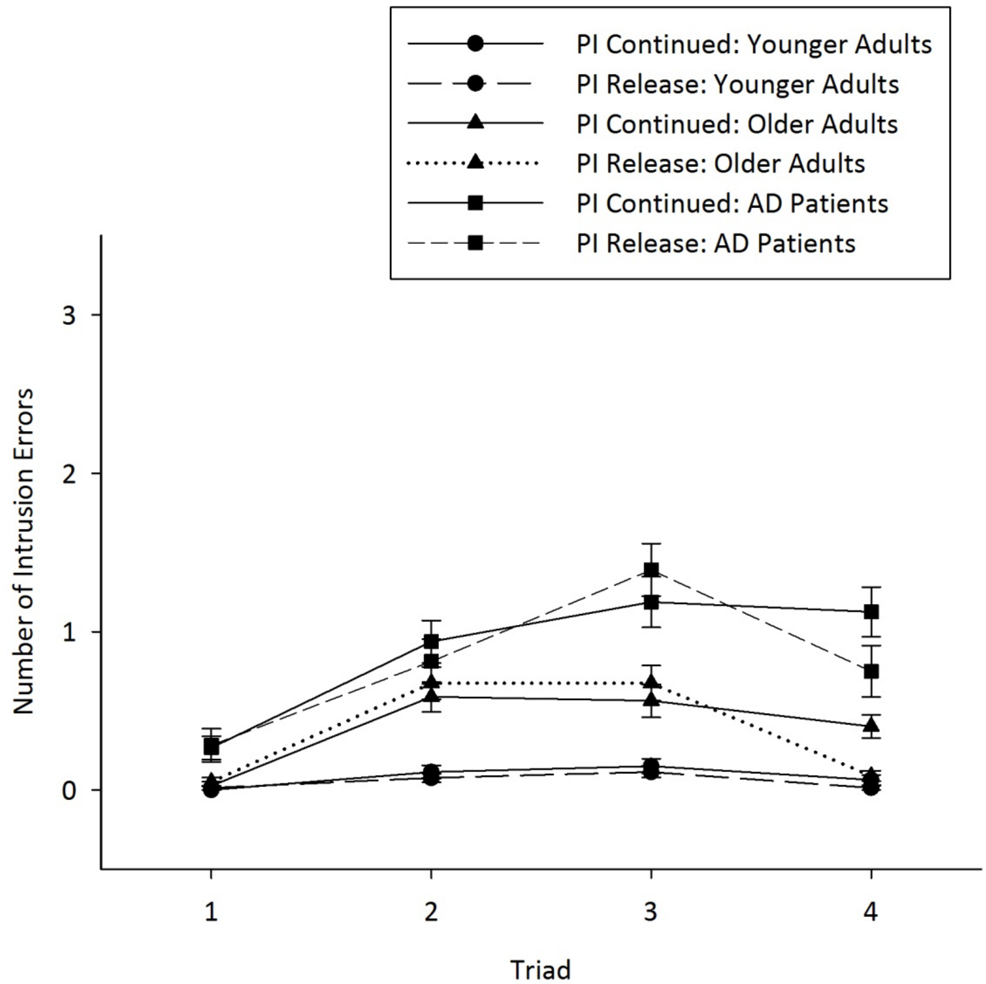

Figure 9. Average intrusion errors for categorically cued stimuli for younger adults, older adults, and AD participants.

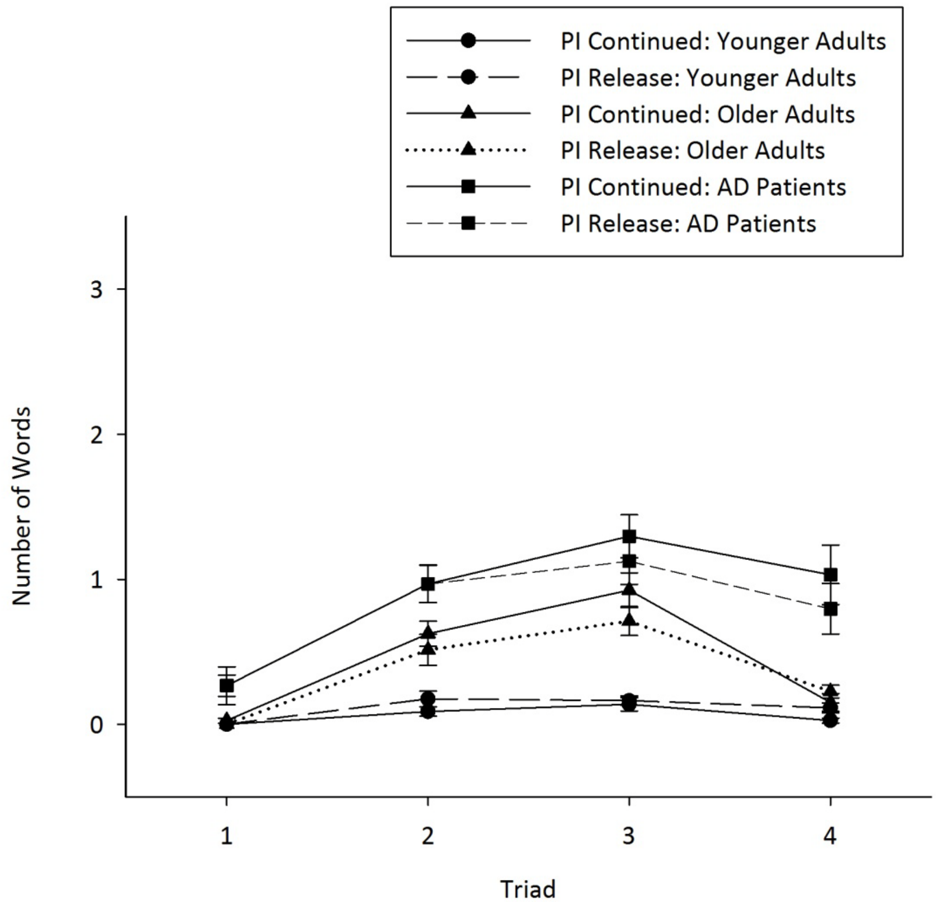

Figure 10. Average intrusion errors for featurally cued stimuli for younger adults, older adults, and AD participants.

and a main effect of Triad were observed, F (1,38) = 45.85, p < 0.001. There was a significant Group x Triad interaction, F (1,38) = 19.14, p < 0.001. Post-hoc analysis revealed that both groups had a similar number of intrusions for the first triad (younger: M = 0.01, SE = 0.02; older: M = 0.04, SE = 0.02), but that the older controls had a higher number of intrusions for the third triad than the younger control group (younger: M = 0.13, SE = 0.07; older: M = 0.62, SE = 0.07). There was no main effect of Condition, F (1,38) = 0.93, p = 0.341, or interaction with Condition, suggesting that number of intrusions was similar across the first three triads in both the categorical PI continued and PI release conditions.

Older controls vs. AD participants. A main effect of Group, F (1,34) = 16.76, p < 0.001, and a main effect of Triad were observed, F (1,34) = 113.57, p < 0.001. A significant Group x Triad, F (1,34) = 8.40, p = 0.007, indicated that both groups had a greater number of intrusions for T3 than for T1. Moreover, the AD participants made more intrusions, and their difference in intrusion error rate between T1 and T3 was greater (T1: M = 0.27, SE = 0.05; T3: M = 1.29, SE = 0.13) than that of the older control group (T1: M = 0.04, SE = 0.05; T3: M = 0.62, SE = 0.12). There was a trend for a main effect of Condition, F (1,34) = 3.73, p = 0.062, indicating a pattern that the PI release condition showed a marginally higher number of intrusions (M = 0.60, SE = 0.06) than the PI continued condition (M = 0.51, SE = 0.06).

Featurally cued.

Younger vs. older controls. A main effect of Group, F (1,38) = 46.31, p < 0.001, and a main effect of Triad were obtained, F (1,38) = 99.21, p < 0.001; yet there was no main effect of Condition, F (1,38) = 2.48, p = 0.124. Similar to the results for the categorically cued conditions, there was a significant Group x Triad interaction for featurally cued conditions, F (1,38) = 46.78, p < 0.001, demonstrating that healthy younger and older participants had a greater number of intrusions for T3 than for T1. In addition, the difference in intrusions between T1 and T3 was greater for the older control group (T1: M = 0.01, SE = 0.01; T3: M = 0.82, SE = 0.07) than for the younger group (T1: M = 0.00, SE = 0.01; T3: M = 0.15, SE = 0.07). There was a trend for a Group x Condition interaction, F (1,38) = 3.78, p = 0.059 showing a pattern that older adults had more intrusions than younger adults in the featural PI continued condition than the featural PI release condition.

Older controls vs. AD participants. A Group main effect, F (1,34) = 8.11, p = 0.007, revealed that the AD participants had more overall intrusion errors (M = 0.74, SE = 0.08) than the older controls (M = 0.42, SE = 0.08). A main effect of Triad, F (1,34) = 179.34, p < 0.001 indicated that there was an increase in intrusions from T1 (M = 0.14, SE = 0.04) to T3 (M = 1.02, SE = 0.08). There were also more intrusions for the featural PI continued condition (M = 0.63, SE = 0.06) than for the featural PI release condition (M = 0.53, SE = 0.07), as evidenced by a main effect of Condition, F (1,34) = 4.81, p = 0.035. In addition there was a trend for a Condition x Triad interaction, F (1,34) = 3.41, p = 0.074, showing a trend for a larger number of intrusions for T3 in the PI continued condition relative to the PI release condition.

Triads 3 to 4. Comparisons of intrusion scores for the third and fourth triads were investigated. A decrease in number of intrusions was expected for PI release conditions, whereas intrusions were expected to increase or remain constant for PI continued conditions.

Categorically cued.

Younger vs. older controls. A main effect of Group, $F(1,38) = 27.07$, $p < 0.001$, a main effect of Triad, $F(1,38) = 27.02$, $p < 0.001$, and a main effect of Condition were observed, $F(1,38) = 4.75$, $p = 0.036$. There was a significant Condition x Triad x Group interaction, $F(1,38) = 10.87$, $p = 0.002$. Post-hoc analysis indicated that older participants had more intrusions for both triads than younger participants. Furthermore, the older participants showed a reduction in number of intrusions for T4 in the categorical PI release condition ($M = 0.09$, $SE = 0.02$) than in the categorical PI continued condition ($M = 0.40$, $SE = 0.06$). In contrast, the younger participants showed few intrusion errors across all conditions; and as such, did not show a difference in intrusion errors for T4 for the PI release ($M = 0.01$, $SE = 0.02$) and PI continued condition ($M = 0.06$, $SE = 0.05$).

Older controls vs. AD participants. A main effect of Group revealed that, overall, the AD participants had more intrusions ($M = 1.11$, $SE = 0.11$) than the older controls ($M = .431$, $SE = 0.10$), $F(1,34) = 20.47$, $p < 0.001$. A main effect of Triad, $F(1,34) = 39.82$, $p < 0.001$ and a main effect of Condition were observed, $F(1,34) = 4.22$, $p = 0.048$. There was a Condition x Triad interaction, $F(1,34) = 31.26$, $p = 0.001$. Post-hoc analysis revealed a significant decrease in intrusions from T3 ($M = 1.03$, $SE = 0.10$) to T4 ($M = 0.42$, $SE = 0.08$) for the categorical PI release condition, in contrast to the categorical PI continued condition in which there were a similar number of intrusions for the third and fourth triad (T3: M = 0.88, SE = 0.09; T4: M = 0.76, SE = 0.08).

Featurally cued.

Younger vs. older controls. A main effect of Group, $F(1,38) = 45.33$, $p < 0.001$ and a main effect of Triad were obtained, $F(1,38) = 53.33$, $p < 0.001$; however, there was no main effect of Condition, $F(1,38) = 0.03$, $p = 0.870$. There was a significant Group x Triad interaction, $F(1,38) = 31.78$, $p < 0.001$. Post-hoc analysis revealed that older adults made more intrusion errors than younger adults for both T3 and T4. Moreover, the older participants showed a reduction in number of intrusions for T4 (M = 0.19, SE = 0.03) as compared to T3 (M = 0.82, SE = 0.07), whereas the younger participants did not show a significant difference (T3: M = 0.15, SE = 0.07; T4: M = 0.07, SE = 0.03). Analyses also revealed a Condition X Triad interaction, $F(1,38) = 5.234$, $p = 0.028$, revealing a reduction in intrusion errors for T4 as compared to T3, with a larger reduction for the PI continued condition (T3: M = 0.53, SE = 0.06 ; T4: M = 0.09, SE = 0.03) compared to the PI release condition (T3: M = 0.44, SE = 0.05 ; T4: M = 0.17, SE = 0.03).

Older controls vs. AD participants. A main effect of Group, $F(1,34) = 14.37$, $p = 0.001$ and a main effect of Triad were obtained, $F(1,34) = 47.78$, $p < 0.001$. A main effect of Condition, $F(1,34) = 4.458$, $p = 0.042$ revealed that in general there were fewer intrusions for the featural PI release condition (M = 0.72, SE = 0.08) as compared to the featural PI continued condition (M = 0.85, SE = 0.08). AD participants made more intrusion errors than healthy older participants for both T3 and T4, as indicated by a Group x Triad interaction, $F(1,34) = 6.20$, $p = 0.018$. Furthermore, both groups showed a statistically significant reduction in intrusions from T3 to T4; however, the older controls showed a greater difference between T3 and T4 (T3: M = 0.82, SE = 0.11; T4: M = 0.19, SE = 0.11) than did the AD participants (T3: M = 1.21, SE = 0.12; T4: M = 0.91, SE = 0.12).

Neuropsychological Data

Independent samples t-tests were conducted to compare the younger and older control groups, and the older controls and AD participants. Table 3 shows the mean total scores for select neuropsychological tests along with p values.

As evidenced by Table 3, the younger and older groups differed for the MMSE and MoCA. As expected, healthy younger participants performed better than healthy older participants when raw scores were analyzed for the Similarities (SIM) and Letter Number Sequencing (LNS) subtests. However, no statistical difference was observed between these groups on the SIM and LNS subtests of the WAIS-III when scaled scores were analyzed. In addition, no difference was observed between the healthy younger and older participants on the Sorting Task. As expected, the healthy older group and AD participants differed on all neuropsychological measures, with the older controls having higher scores than the participants with AD.

Table 3

Average Neuropsychological Scores for the Younger Adults, Older Adults and AD participants

Test	Younger Adults	Older Adults	AD Participants	p value (Y vs. O)	p value (O vs. AD)
MMSE					
M	29.43	28.29	*23.73*	0.013*	< 0.001*
(SD)	(0.51)	(1.53)	*(1.95)*		
MoCA					
M	28.20	25.85	*17.88*	<0.001*	< 0.001*
(SD)	(1.58)	(1.84)	*(2.90)*		
WAIS LNS – Raw Scores					
M	12.90	9.95	*6.21*	0.007*	< 0.001*
(SD)	(3.52)	(3.00)	*(2.29)*		
WAIS LNS – Scaled Score					
M	12.05	11.90	*8.71*	0.886	0.003*
(SD)	(3.66)	(2.86)	*(2.87)*		
WAIS SIM - Raw Scores					
M	25.55	20.85	*14.29*	0.002*	0.001*
(SD)	(3.26)	(5.52)	*(4.60)*		
WAIS SIM - Scaled Score					
M	12.00	10.85	*8.88*	0.175	0.006*
(SD)	(2.25)	(2.96)	*(0.34)*		
Sorting Task					
M	94.06	94.30	*91.44*	0.663	< 0.001*
(SD)	(1.82)	(1.53)	*(2.68)*		

Note. MMSE = Mini-Mental Status Examination; MoCA = Montreal Cognitive Assessment; WAIS = Wechsler Adult Intelligence Scale – 3rd Edition; LNS = Letter Number Sequencing Subtest; SIM = Similarities Subtest; Y = Younger Adults; O = Older Adults; * = statistically significant

Discussion

The present study evaluated the two main hypotheses of semantic memory organization by examining the contribution of featural versus categorical cues using a proactive interference paradigm. In the current study, evidence of PI buildup was demonstrated by decreased recall of target words or increased intrusion errors across additional presentations of triads with the same cue. An increase in recall of target words, or a decrease in intrusion errors following a switch in cue, was an indication of PI release.

A within-subject design was used in order to be able to compare the pattern of recall and intrusions with the same participants. The goals of the study were as follows: first, to establish the pattern of PI buildup and release that younger participants showed with stimuli that were categorically and featurally cued; second, to determine differences as a function of healthy aging by comparing healthy younger and older adults; and third, to explore the pattern of PI release and buildup when there is a breakdown in the semantic memory system by examining participants with AD.

Unless otherwise specified, most results from the experimental paradigm showed that younger participants recalled more words than healthy older participants; and in turn, the older control group recalled more words than the AD participants. The inverse relationship was true for intrusion errors, in that participants with AD made more intrusion errors than the healthy older participants; and the older control group made more intrusion errors than the younger control group. Recall data will be presented first, followed by intrusion errors.

Overview of Experimental Paradigm: Recall Measures

Triads 1 to 3. Healthy younger and older participants demonstrated PI buildup from the first to third triads, showing a reduction in recall across featurally and categorically cued conditions ranging from 31 to 35% for the young, and 35 to 45% for the old. Participants with AD also showed PI buildup for the first three triads, as evidenced by a 26 to 31% reduction in recall of words across conditions. For all groups, PI buildup across the first three triads was similar for categorically and featurally cued conditions, and for conditions in which the fourth triad indicated a PI continued or PI release condition. Thus, it appears that all participants showed a pattern consistent with buildup of proactive interference in that recall decreased across the three triads that were presented with the same cue, regardless of whether the cue was featural or categorical. It was important to demonstrate that PI buildup occurred across the first three triads in order to interpret the results of the final triad with confidence.

Triads 3 to 4. For PI continued trials, where the cue remained the same for all four triads, the fourth triad was expected to have similar or decreased recall as compared to the third triad. For PI release trials, in which the cue was the same for the first three triads and switched on the final triad, recall was expected to increase for the fourth triad relative to the third triad.

For categorically cued conditions, healthy younger and older participants and AD participants all showed the expected pattern of results. When the categorical cue remained the same, there was no difference in recall between the third and fourth triad. As predicted, when the categorical cue changed on the final triad (e.g., from ANIMALS to OBJECTS), recall increased. There was no difference in mean recall between younger and older participants; however, the older controls recalled more words than the AD participants.

Turning to the results for the featurally cued conditions, healthy younger and older participants showed an increase in recall for the final triad in the PI release condition. Thus, even though the category remained the same (e.g. ANIMALS), when the featural cue switched (e.g. from NOT USED FOR TRANSPORTATION to USED FOR TRANSPORTATION), both control groups showed increased recall, indicating a release from proactive interference.

Contrary to expectations, the younger and older controls also showed a pattern consistent with PI release for the PI continued condition in which the featural cue remained the same (e.g., USED FOR TRANSPORTATION for all four triads), but the category from which the stimuli were drawn changed (e.g. from OBJECTS to ANIMALS). In fact, the difference between recall for the third and fourth triad was significantly larger for the PI continued as compared to the PI release condition for featurally cued items. This finding suggests that the implicit switch of category in the PI continued condition over-rode the featural information, and provided a greater release from PI than the condition in which there was an explicit switch in featural cues.

For all featurally cued stimuli (i.e., from PI continued and PI release conditions), the older control group and AD participants showed higher recall for the fourth triad relative to the third triad. Moreover, the healthy older participants showed a greater difference between T3 and T4, demonstrating a greater release from PI than the AD participants. The analysis also revealed a trend which suggested a pattern whereby the older controls had a larger difference between T3 and T4 for the PI continued condition as compared to the PI release condition, yet the AD participants showed a tendency for the opposite pattern (i.e., a greater difference between T3 and T4 for the PI release condition relative to the PI continued condition). This trend suggests that the AD participants did not appear to benefit from the implicit switch of category in the featural PI continued condition to the same degree as the healthy older participants.

Same Stimuli Cued Differently. One of the advantages of the current study was that it allowed for an exploration of the differences between featurally and categorically cued stimuli through a direct comparison of identical target stimuli presented with different cues.

Categorical PI continued condition vs. featural PI release condition. All groups showed no difference between the third and fourth triad in the categorical buildup condition. In other words, when the categorical cue remained the same across all four triads, recall decreased or remained the same. However, when the exact same stimuli were cued with featural attributes, the results differed. All participants showed a pattern consistent with release (i.e., greater recall on fourth triad) when the featural cue changed on the fourth triad, even though the category from which the stimuli were drawn remained the same. This finding suggests that featural information was utilized during encoding and impacted recall by allowing participants to benefit from a switch in featural attributes.

Categorical PI release condition vs. featural PI continued condition. All groups showed an increase in recall from the third to the fourth triad in both of these conditions. This result suggests that release from PI occurred when the category changed, regardless of whether the stimuli were cued categorically (i.e., with a switch in cue in the categorical PI release condition) or featurally (i.e., when the cue remained the same in the featural PI continued condition). Of interest, it appears that the healthy younger and older participants showed a larger release when the items were cued featurally and there was no switch in featural cue, than was observed when the items were cued categorically and the category from which the stimuli were drawn switched on the final triad. The latter finding suggests that there was an increased benefit for healthy younger and older participants when they attended to featural information but were also aware of the implicit categorical switch. Thus, the awareness of both aspects of stimuli in the featural PI continued condition (i.e., featural attributes and implicit categorical switch) had more impact than being solely aware of the explicit switch in category in the standard categorical PI release condition.

Overview of Experimental Paradigm: Intrusion Errors

As can be seen in Figures 9 and 10, the younger participants made very few intrusions across the four triads in all conditions. As such, only the intrusion errors from the healthy older participants and the AD participants will be discussed.

Triad 1 to 3. The healthy older and AD group had an increase in the number of intrusion errors from the first to the third triad. There were no differences in number of intrusions for the different categorically cued conditions. However, for featurally cued trials, there was a trend toward greater intrusion errors observed in the PI continued as compared to the PI release condition. Upon inspection of this trend, the difference in intrusions is marginal (i.e., an increase in mean errors from 0.51 to 0.60) and as such is likely not a meaningful difference.

Triads 3 to 4. Both older controls and AD participants showed a reduction in number of intrusions for the fourth triad in the categorical PI release condition (i.e. when the categorical cue changed) as compared to the PI continued condition when the categorical cue remained the same. This result provides further evidence that a reduction in interference occurred for the final triad when the category switched. For both featurally cued conditions, healthy older participants and participants with AD showed a reduction in the number of intrusions for the fourth triad relative to the third triad. As expected, the healthy older participants showed a larger reduction than the AD participants. Overall, fewer intrusions were observed in the featural PI release condition as compared to the featural PI continued condition, but the difference between the conditions is small and may not be clinically relevant.

The pattern of intrusion errors is consistent with the recall data from the experimental paradigm. For the healthy older participants and the AD participants, intrusion errors were inversely related to recall in that as recall decreased across buildup triads, intrusions increased. Moreover, when recall increased in the final triad in the PI release condition, intrusions decreased.

In addition, an examination of the type of intrusion errors suggests that the majority of intrusions for all participants were consistent with the cue presented. Of interest, participants with AD made more intrusion errors that were consistent with the cue but had not been previously presented. This finding suggests that AD participants also attended to the cue, but quite frequently appeared to guess a response, as the intrusions were often common exemplars for a given cue rather than a previously presented target word (e.g., a response of *cat* or *dog* when the cue was ANIMALS).

Overview of Neuropsychological Measures

Sorting task. As predicted, the younger and older control groups were able to correctly sort most stimuli with an average accuracy of between 97 to 98% for both groups. The AD participants performed at a lower rate than the older controls, but still achieved a relatively high level of accuracy (i.e., 95%). It was important to show that all participants were able to correctly sort the stimuli used in the experimental paradigm into the different featural attributes that were used as cues.

Other neuropsychological tests. As expected, the healthy younger and older participants performed well within the expected norms for most of the neuropsychological tests. Indeed, scaled scores of the subtests of the WAIS-III, and the MMSE score revealed that both groups performed within the average range for their cohort.

An exception was on the MoCA, in which the healthy older participants' average score was under the cut-off for normal functioning. Of note, most of the points that were lost on the MoCA were during the delayed recall measure, whereby participants quite frequently "blanked" and forgot items, which often resulted in losing up to 5 of the 30 available points. The older controls' mean score on the MMSE was above the cut-off score, indicating intact performance on this brief measure of cognitive functioning. Moreover, additional evidence that the older controls were cognitively intact can be taken from the subtests of the WAIS-III as discussed above, as the healthy older participants performed at a similar level to the age-matched normative sample.

Even though both healthy younger and older participants performed overall within normal limits, age-related differences on these measures were observed. As predicted, healthy younger participants scored higher than healthy older participants on the cognitive screening measures, and on the subtests of the WAIS-III when raw scores were analyzed.

As predicted, the participants with AD scored below cut-off scores on cognitive screening measures. In general, the AD participants scored in the *low average* range on the subtests of the WAIS-III. As expected, the AD participants differed from the healthy older adults on all neuropsychological measures, providing evidence that the AD participants scored lower than the older controls on measures of cognitive impairment, abstract reasoning and working memory.

Implications of Results

Categorical cues. Most studies using PI paradigms consist of stimuli presented on the basis of different categories; thus, the results in which stimuli were categorically cued will be discussed first. The expected patterns of results were observed in the conditions in which stimuli were cued according to category membership (e.g., objects, fruits and vegetables, and animals). Unchanged cues led to PI buildup as evidenced by a decrease in recall of target words across triads for all groups, and an increase in intrusion errors for the healthy older and AD groups. When the categorical cue was switched on the final triad, release from PI was observed for all groups through an increase in recall of target words, and for the older individuals (i.e., controls and AD participants) through a decrease in intrusion errors.

It was important to establish this pattern of results for categorically cued items to validate the current stimuli and paradigm. Indeed, these results are consistent with other studies of proactive interference (Wickens, Dalezman, & Eggemeier, 1976; Darling, Martin, & Macrae, 2010).

Featural cues. The findings for the featurally cued conditions in the present study are not so clear-cut and the ramifications of these results will be discussed below. For all groups, PI release was observed in the featurally cued PI release condition, as evidenced by greater recall on the fourth triad as compared to the third triad. Moreover, healthy older participants and AD participants showed a decrease in intrusion errors for the final triads.

It is important to remember that in this PI release condition the category membership of the stimuli remained the same across all four triads. Thus, one could argue that if categorical information were of sole importance, then PI release would not be expected to occur when the featural cue switched but the category remained the same. Indeed, the fact that stimuli in which a featural cue switched (e.g., NOT USED FOR TRANSPORTATION to USED FOR TRANSPORTATION) generated a release pattern even though all items belonged to same category (e.g., ANIMALS) is of some significance. First, this result shows that the paradigm design was successful in having participants attend and use both categorical and featural cues. Second, it suggests the possible importance of featural attributes in semantic memory organization.

An unexpected finding was in the PI continued condition, in which a pattern consistent with PI release occurred. That is, participants showed an increase in recall on the final triad as compared to the third triad; and older controls and AD participants showed a reduction in intrusions. Although this result seems surprising, it may be explained by the fact that even though the featural cue remained the same, the category changed. Thus, it is likely that the categorical change was noticeable to the participants and used as another means of recall, thereby reducing interference.

For instance, in the final triad for the featural PI continued condition (see Table 2, panel B), a participant may have been able to determine “the words are USED FOR TRANSPORTATION, and the category has just changed from OBJECTS to ANIMALS”. This realization may have facilitated recall, possibly by increasing the specificity of the stimuli or even allowing the participant to make a more educated guess. In contrast, when participants viewed the final triad in the categorical PI continued condition (see Table 2, panel A), they may have only been aware that the category had remained the same (e.g., all ANIMALS) and may not have noticed that featural attributes of the stimuli had changed (e.g., switching from stimuli that were NOT USED FOR TRANSPORTATION to those USED FOR TRANSPORTATION). Furthermore, the information provided with the categorical cue alone may not have been as helpful (i.e., ANIMALS is a very broad category with many exemplars). The implications of this will be considered later in the discussion.

There are only a handful of studies that examine featural attributes using a proactive interference paradigm. Of note, Wickens et al. (1976) demonstrated the importance of featural characteristics by showing that the magnitude of PI release was inversely related to the degree of attribute overlap. Thus, switch trials in which stimuli had greater overlap (e.g., vegetables to fruits) produced a smaller release from PI than switches in which there was less overlap (e.g., professions to fruits).

Results from Wickens and colleagues (1976) provided a solid foundation for using a PI paradigm to demonstrate the importance of features. Indeed, the fact that the current findings showed that featural cues were able to generate PI during the buildup triads and release from PI in the presence of category continuity with a switch in featural attributes, demonstrates that features likely play a significant role. Of note, the stimuli used in the first three buildup triads versus the final release triads did not greatly overlap. For categorically cued stimuli, there was minimal overlap for the switches in category (e.g., from OBJECTS to ANIMALS) and the features were opposite contrasts (e.g., LARGE to SMALL; USED FOR TRANSPORTATION to NOT USED FOR TRANSPORTATION). Thus, the robust PI effects that were observed in the present study were likely influenced by the lack of attribute overlap of the stimuli in buildup versus release triads.

Comparison to Marques. In order to determine if results from the present study replicate previous findings, a detailed comparison with experiments conducted by Marques (2000) will follow, as the paradigm most closely resembles the design of the current study.

For all four experiments in the Marques (2000) study, the predicted pattern of PI buildup was demonstrated when triads were presented with the same category[1]; and release from PI was observed when there was a shift in category for the final triad. This result is consistent with the present findings in which all participants showed expected PI effects with stimuli that were categorically cued.

For featurally cued stimuli, Marques (2000) found that participants showed a pattern consistent with PI release for two of the experiments, when functional cues switched from NO TRANSPORT to TRANSPORT, and DANGER to NO DANGER, but only in the word modality. In the third experiment, Marques reported that no release from PI was observed in the featurally cued condition (e.g., when the cue switched from SMALL to BIG) with either visual or verbal stimuli. In the fourth experiment, there was no PI release in the verbal modality.

Therefore, Marques (2000) showed the expected PI release effects for two of the four experiments when stimuli were featurally cued. Of interest, these two experiments were ones in which the cues were functional rather than perceptual. Across all four experiments, there was a large amount of inconsistency for PI effects between visually and verbally presented material. Only one experiment from Marques showed PI release for visual stimuli in the PI continued condition (i.e., when the featural cue of FOUR LEGS remained the same, but there was an implicit switch of category from FURNITURE to ANIMAL exemplars). As such, results from Marques' experiments were not consistent

[1] Note that in the Marques (2000) study, the categorical stimuli were not cued.

with the pattern that was observed in the current study of a robust and consistent release from PI for the PI continued conditions when stimuli were featurally cued.

The current study provides more consistent results and stronger evidence for the importance of features (i.e., pattern of PI release for featurally cued stimuli) than the series of experiments conducted by Marques (2000)[2]. The difference in results between the two studies could be due to the modifications that were made in the design of the current paradigm. In the present study, the cue was presented visually and orally prior to each triad (i.e., four times per trial); whereas for the paradigm used by Marques, participants were informed orally about the cue at the beginning of the trial (i.e., once per trial). This modification was employed for a number of reasons: First, because a within-subjects design was used and participants viewed more trials than those completing Marques' study, I did not want participants to become confused or forget a cue for a particular trial. Second, because the study was expanded to test healthy seniors and participants with AD, I wanted to reduce the possibility of forgetting a cue within a trial (i.e., between triads). Third, I hoped that making the cue more salient would increase the likelihood that participants attended to the cue.

In addition, the current paradigm paired the target stimuli with distractors (i.e., words that were incongruent to the cue), thus requiring that participants choose the target word based on the cue. The aim of this modification was to encourage focus to the cue, as this was the sole means of selecting the target words, thereby increasing the

[2]Although Marques analyzed data for each of the separate experiments, in the current study conditions were collapsed. The motivation to do this was for ease of interpretation, because, even though there were a few idiosyncrasies present in some of the conditions, overall the pattern of PI effects was generally consistent across all 16 conditions.

likelihood that the cue would be used for encoding. In contrast, participants in Marques' study (2000) viewed solely the target stimuli.

Furthermore, participants in the present study had to say aloud each target word, whereas in Marques' study (2000) participants were instructed to silently identify or read the word. Research has shown that reading aloud results in fewer intrusion errors (Rummer & Engelkamp, 2003). Moreover, because participants needed to make a choice in the current paradigm (i.e., between target and distractor) the examiner was able to confirm that the individuals were attending to the experiment, and understanding and carrying out the task requirements.

One of the advantages that Marques (2000) outlined with his study was the use of identical stimuli that could be manipulated by contrasting different categorical and featural shifts. I wholeheartedly agree with this advantage, and it was one of the main reasons that the present study was conducted using a similar paradigm. However, one could argue that the design employed by Marques did not allow for equivalent experiences for categorical and featural conditions because only the featural conditions were cued. To fully assess the impact of categorical membership and featural attributes, the PI paradigm used in the current study cued all experimental stimuli, both featurally and categorically. The fact that all stimuli were cued also weakens any argument that could be raised suggesting that too much emphasis was placed on featural attributes, as categorical conditions were treated in exactly the same manner.

It could be argued that the presence of both types of cues within a testing session may have opened up the possibility of participants thinking about new strategies to recall the information (i.e., other than the actual cue presented on that specific trial). As will be discussed later, participants used other strategies, but it is difficult to determine how this could have been prevented. It is my belief that the presence or absence of categorical cues alone would not have changed a participant's attempts at using strategies. Nonetheless, it is possible that the type of strategy utilized may have been affected by the general presence of cues.

Another difference between the two studies was in the way participants recalled the target stimuli. Participants in Marques' study (2000) wrote their responses on a record form. The current study did not use a written format, primarily because of the concern that it would make the task too demanding for the healthy older participants and the AD participants. In addition, the examiner was able to hear valuable information during the recall period. Given the length of the task, the examiner was also able to gauge if participants were appearing overly fatigued. Furthermore, when providing their responses, participants would frequently make reference to their belief that they were missing the first or second word, or were unsure if their answer was from a previous triad. Of interest, participants also disclosed other strategies that were employed which will be reviewed later in this discussion.

Implications for Semantic Memory Organization

The present study was designed to gain further insight into semantic memory organization. The current findings provide strong support for the use of a PI paradigm. PI buildup occurred across the first three triads for all participants, regardless of cue (i.e., featural, categorical) or condition (i.e., buildup, release). The fact that categorically cued items showed predictable release from PI effects is not surprising, given the decades of research that have provided similar results. Indeed, it is hard to argue against the significance of categorical information when discussing semantic memory organization.

Findings from the featurally cued conditions suggest that features are likely relevant organizational attributes. More specifically, the finding that PI release was observed when the featural cue switched but the category remained the same provides strong evidence of the use of featural attributes in semantic memory organization that cannot be dismissed. However, one cannot ignore that the strongest release from PI effect was found in the unexpected featural PI continued condition. This latter result suggests that participants were attending to information in addition to the featural attribute of the target word (i.e. the implicit switch in category). It appears that the implicit categorical switch over-rode the featural information. In contrast, in the categorical PI continued condition, participants did not benefit when there was an implicit switch in features (e.g., stimuli cued as ANIMALS, but switched features from those NOT USED FOR TRANSPORTATION to those that could be USED FOR TRANSPORTATION), suggesting that the featural attributes may not have been as salient as categorical membership.

When attempting to gain insight into the organization of semantic memory, it is possible that categories and features are both important and that it is not an either/or situation. Darling and Valentine (2005) conducted a series of interesting PI experiments that may facilitate the interpretation of the results of the current study; as such, the experiments will be discussed in some detail. All experiments included presentations of four words at a time, with buildup and release trials. A between-groups design was used in which half of the participants received stimulus cues and half did not.

Stimuli from the first experiment consisted of the names of famous actors and musicians, with each of these occupation sets (i.e., ACTORS and MUSICIANS) serving as stimuli for both buildup and release trials. Results from this experiment showed expected patterns of PI buildup and release, with no difference in PI effects as a function of whether the stimuli were cued or not. The same stimuli were used in the second experiment, but were presented according to nationality (i.e., UK CELEBRITIES, US CELEBRITIES). For this experiment, release from PI was observed only in the cued condition (i.e., when participants were cued on the nationality of the names). Thus, when the stimuli were uncued, participants showed continued buildup of PI even when there was a shift from US to UK entertainers.

Darling and Valentine (2005) interpreted these results in the context of semantic memory organization, drawing upon the distinction between “categories” and “properties” made by Johnston and Bruce (1990) who gave the label of “categories” to superordinate information, and “properties” to subordinate information. It is suggested that categories and properties could be employed as a way of organizing information within semantic memory (as evidenced by possible release from PI). Darling and Valentine proposed that organization is implicit at the categorical level, and therefore does not need to be cued (e.g., as was observed with the category OCCUPATION). In contrast, properties of stimuli are not a main organizational principle (e.g., NATIONALITY), and as such, will only show release from PI when cued explicitly.

In an attempt to further test the validity of the concepts of categories and properties, Darling and Valentine (2005) conducted additional experiments. The researchers expressed concern that the OCCUPATION "category" may have competed with the NATIONALITY "property" in the second experiment, as the nationality stimuli (i.e., UK CELEBRITIES, US CELEBRITIES) consisted of actor and musicians. Hence, the third experiment comprised solely of names of musicians. Results of this experiment were similar to the second experiment in that release from PI was observed when NATIONALITY switched (e.g., from US to UK) but only when the property was cued. When the property of NATIONALITY was not cued, there was an absence of release from PI.

Darling and Valentine (2005) raised the possibility that release from PI effects may have been achieved in the cued condition because participants were able to organize information according to the demands of the experiment, but that this may not necessarily reflect how information is stored within the semantic system. A fourth experiment explored this possibility, utilizing stimuli consisting of celebrities from various occupations, who performed SITTING or STANDING UP. Interestingly, results showed that there was no release from PI when the stimuli switched from SITTING to STANDING in either the uncued or cued condition. The authors interpreted these results as evidence that a sorting principle that can be understood and completed by participants, but likely not relevant in daily life, would not be used in encoding.

Moreover, Darling and Valentine concluded that the pattern of PI effects that were found in their earlier experiments likely reflects underlying categorical and property structures of organization in semantic memory.

Darling and Valentine's research (2005) may be particularly relevant to the current findings. As discussed, it is believed that release from PI occurred in the featural PI continued condition because an implicit categorical switch occurred. Furthermore, it could be argued that organization of taxonomical categories is implicit, as the category switch did not need to be cued (i.e., similar to Darling and Valentine's results for OCCUPATIONS). It could also be speculated that the reason that there was not a similar release in the categorical PI continued condition (i.e., when there was an implicit switch in features), was that the feature may be a property. Thus, because the feature was not explicitly cued in this condition, there was no release from PI. Indeed, when features were explicitly cued and there was a switch in featural attributes, release from PI was observed even though the category remained the same.

Further support for this argument can be found from the design of the current study in that all stimuli were cued. If the featural and categorical cues were of equal importance, then similar results should have been observed for featurally and categorically cued conditions. That such a pattern did not occur likely speaks to the underlying structure of semantic memory, rather than being a reflection of the salience of the cues used. Indeed, categorical switches in the presence of consistent featural cues had a significant impact on recall. I believe that this was not due to the cues themselves, but likely because categorical membership is an important organizational principle within the semantic memory system.

Although results from the present study may provide evidence that features are not the dominant sorting principle, one cannot deny that featural attributes are likely involved in semantic memory organization. The current findings of PI buildup (i.e., from T1 to T3) and PI release for switches in featural attributes when categories remained unchanged provide a strong argument that features are not merely an ad hoc sorting principle as was observed for the SITTING and STANDING UP celebrity stimuli in the Darling and Valentine (2005) study. Thus, being able to obtain release from PI with a featural shift in stimuli reflects that this information is stored in semantic memory and can be a useful, but perhaps not primary, organizational principle.

A future study including the same stimuli, but with featurally and categorically cued and uncued conditions, may provide additional knowledge about this issue. Indeed, it would be interesting to determine if PI effects could be obtained in an uncued featural PI release condition, in which categorical membership remains the same but featural attributes shift. Exploring this issue, in a methodical manner similar to Darling and Valentine (2005), may tell us about the degree of importance of various featural attributes as organizational principles.

In discussing PI release, Wickens et al. suggest that the “magnitude of the release is a function of the psychological distance between the classes to which the items belong” (Wickens, Dalezman, & Eggemeier, 1976, p. 307). As already noted, the most robust release from PI in this study occurred in the featural PI continued condition in which featural attributes remained the same, but there was an implicit categorical switch (see Figures 5 and 7). Therefore, if Wickens and colleagues' statement is valid, the implication would be that the distance between the classes of stimuli in the featural PI continued conditions was large. Thus, using the illustrative example in Table 2, panel B in which stimuli were preceded by the featural cue of USED FOR TRANSPORTATION, the following claim would be made: objects and animal stimuli that can be classified as used for transportation are further away in organization from each other than stimuli cued as ANIMALS in which certain exemplars are used for transportation and others are not. If indeed, the psychological distance between stimuli determines the magnitude of release, then the current findings provide compelling evidence for a categorical hypothesis of semantic memory organization.

Although this interpretation is possible, there is another plausible explanation. It is possible that when participants recognized that the feature remained the same (e.g. USED FOR TRANSPORTATION) but the category changed (e.g., from OBJECTS to ANIMALS), there was an additive effect in terms of information acquired, resulting in a large and unexpected release from interference. For instance, participants may have noticed other distinctive attributes between the stimuli (e.g., motorized vs. non-motorized transport; man-made vs. natural transport). If indeed, there was an awareness of these notable differences, it may explain the increased release from PI as there would be an increase in attribute difference. One could further hypothesize that the reason that this did not occur in the categorically cued PI continued conditions (i.e., in which there was an implicit change in featural attributes) was perhaps because participants were focused on explicitly cued categorical information, so the differences in featural attributes were not brought to the attention of the participant and may not have activated the semantic network. As such, the current results are not entirely incongruent with Wickens and colleagues' (1976) statement, nor do the findings necessarily count as definitive evidence for categorical organization.

Semantic Memory and Aging

It has been postulated that the semantic memory system does not show a systematic decline as a function of aging, but rather the system develops over a lifespan as an individual acquires knowledge and gains a deeper understanding of the relationships between concepts (Peraita, 2007). Furthermore, Peraita has argued that lexical access is affected in healthy aging, making the process less automatic, which can result in word finding difficulties. Thus, the meaning of the word does not appear to deteriorate in a healthy individual across the lifespan, but instead, access to the word itself can sometimes be affected.

The present study demonstrated that healthy older participants were able to show both PI buildup across stimuli sharing semantic categories and features and release from PI when the semantic information for the stimuli switched. As expected, the older control group recalled fewer words than the younger participants, which is likely due in part to a lower working memory capacity (i.e., as evidenced by lower raw scores on the LNS subtest).

In addition, Robert and colleagues argued that older adults have more difficulty inhibiting irrelevant information from working memory (Robert, Borella, Fagot, Lecerf, &

Ribaupierre, 2009). Robert et al. found that compared to younger participants, older adults exhibited greater PI buildup, a finding which they attributed to the possibility that older adults are more susceptible to interference of past material resulting in greater intrusion errors.

Indeed, the current findings showed that healthy older participants made significantly more intrusion errors than younger participants. Other researchers have shown a similar pattern of results (Jacoby, Wahlheim, Rhodes, Daniels, & Rogers, 2010), with some studies only showing this difference when contrasting younger adults with old-older adults (e.g., over 75 years old; Borella, Caretti, & Mammarella, 2006; Caretti, Mammarella, & Borella, 2012).Thus, it is believed that the age-related differences in the current PI paradigm can be attributed to differences in working memory capacity and susceptibility to interference, rather than a decline in the semantic system.

Semantic Memory and Alzheimer's Disease

There are only a handful of studies that have used a PI paradigm with AD participants. Several of these studies have not shown PI effects as measured by recall of target stimuli (Belleville et al., 1992; Cushman et al., 1998). In many of these studies, AD participants have failed to show PI buildup. For instance, visual inspection of data from the study conducted by Belleville and colleagues showed that AD participants exhibited fluctuating levels of recall on buildup trials. More specifically, it appeared that recall increased and decreased across trials with stimuli derived from the same category (e.g., BODY PARTS). From this irregular pattern, it was not surprising that release from PI was not observed, as PI buildup had not accumulated.

Of interest, when Belleville and colleagues (1992) examined intrusion patterns, they found that AD participants did show PI effects, with intrusion errors increasing across buildup trials, and then decreasing in the release trial (i.e., when stimuli changed from BODY PARTS to ANIMALS). Unfortunately many studies do not provide data or analysis of intrusions (Binetti et al, 1995; Cushman et al., 1998; Loewenstein et al., 2003).

When examining measures of recall, several studies have shown PI effects for individuals with AD (Binetti et al, 1995; Loewenstein et al., 2003; Multhaup, Balota, & Faust, 2003). For the most part, this research has shown that participants with AD recalled fewer words than age-matched controls, which is similar to the results from the current study.

Of note, in the study conducted by Multhaup and colleagues (2003), healthy older participants and participants with AD showed expected PI effects as measured by recall and intrusion errors. Healthy older participants had greater recall than AD participants, but both groups made a similar number of intrusion errors. The authors speculated that this lack of difference was due to the design of the task. More specifically, it was argued that intrusion errors were limited because participants knew that there were only three words to recall.

Multhaup and colleagues' (2003) argument is inconsistent with data from the current paradigm showing that AD participants made more intrusion errors than healthy older participants. The increased number of intrusion errors for AD participants in the present study was not due to AD participants making excessive intrusion errors on trials.

Indeed, none of the participants provided more than three responses per triad. Although both studies involved recall of triads, it is possible that other differences in design may explain the inconsistent results. For instance, in the current paradigm participants were required to choose the correct target stimuli based on cues; this may have increased a participant's willingness to guess, resulting in increased intrusion errors. Another possible explanation for the contrasting results may be due to the difference in recall period. Participants in Multhaup and colleagues' study had a ten-second recall period, whereas, healthy older participants and AD participants in the current study had 20 seconds. Several of the participants in the present study benefitted from a lengthier recall period. Anecdotal evidence suggests that if the recall period had been limited to ten seconds, additional responses would have been missed that included correct target words along with intrusion errors.

The design of the current paradigm may have allowed for the AD participants to show relatively strong PI effects, as measured by recall and intrusion errors. Indeed, it could be postulated that AD participants benefitted from categorical and featural cues. Evidence for this argument can be obtained by looking at intrusion errors which show that the majority of intrusions errors were aligned with the cue, suggesting that AD participants and healthy older participants initially designated the target stimuli on the basis of cues, and that cues were further utilized during the retrieval period.

In general, AD participants in the current study did not show as large a release from PI as healthy older participants, perhaps indicating that encoding and recall strategies were not utilized to the same extent. In examining buildup triads (i.e., T1 to

T3), overall recall performance was lower for the AD participants than for the older control group, which may also explain why release from PI was not as large (i.e., although AD participants were not performing at floor, they were recalling at a lower level than the control group). It is unlikely that the lower performance of AD participants was solely due to faster forgetting, because if that were the case, one would expect fewer previous list intrusions. The fact that AD participants had a large number of previous triad intrusions (i.e., 87.9%) suggests that interference from earlier presented material had an impact on recall.

It could be argued that the AD participants did not benefit as much from featural cues as the healthy older participants, based on the finding that AD participants generally recalled more words in the categorically cued as compared to featurally cued conditions. This latter result may be because the featural cues were more difficult for the AD participants to process and utilize as compared to categorical cues. Thus, it is possible that taxonomical categories reflect superordinate information (i.e., "categories" as proposed by Johnson and Bruce) that likely remains intact longer than featural attributes that reflect subordinate information (i.e., "properties").

The sorting task employed in this study provides moderate support to the loss of featural information, as evidenced by the lower performance of AD participants relative to older controls. The AD participants' lower score may reflect loss of semantic information about various attributes of the stimuli used in the experimental paradigm. Yet it should be noted that AD participants, although differing from controls, still had a very high performance (i.e., approximately 95% correct). It would have been interesting to see how the AD participants would have performed if the sorting task had included sorting the stimuli along categorical dimensions (e.g., ANIMALS, FRUITS AND VEGETABLES, OBJECTS). Based on the current findings, it is likely that performance on a categorical sorting task would have been higher than sorting on a featural basis. Unfortunately we did not obtain information on sorting ability for taxonomical categories, so we cannot move beyond speculation on this point.

In addition, participants with AD did not seem to benefit from the implicit switch of category in the featural PI continued condition. This result suggests that AD participants may have allocated most of their attentional resources to the information provided by the cues, and as such, may not have been cognizant of the switch in categories when it was not directly cued.

In sum, it is notable that the current paradigm, albeit with modifications for the AD population, demonstrated that individuals with AD can exhibit PI effects for categorically and featurally cued stimuli. Moreover, the present study demonstrated that when a task is administered at an appropriate difficulty level, AD participants can show an ability to encode and recall semantic information.

Limitations and Future Directions

As with all studies, no design is perfect or immune to criticism. Below are some of the limitations that were observed in the current paradigm. A few of the limitations were recognized beforehand, but were inherent to the design and could not be changed. Other limitations were determined after the completion of the study, and following an analysis and interpretation of the results. Whenever possible, future directions for addressing these limitations have also been included.

Modified PI paradigm. It has been suggested that because a standard PI paradigm may not require effortful encoding of dimensions of the stimuli, investigators are able to study semantic memory in an indirect manner (Belleville et al., 1992; Cushman et al., 1998; Darling & Valentine, 2005), which would be an advantage when testing healthy older adults and patient populations. One could argue that the current study may have lost such an advantage, as the cues and distractors likely provided more structure at the encoding phase and required more attentional resources. On the other hand, it could be argued that the structure provided by the design of the paradigm may have allowed participants to use fewer resources, because the encoding strategy was supplied and did not need to be created. Although a more simplistic standard PI paradigm was not used, I believe that the design allowed for gathering of information that was not possible through a standard paradigm. Moreover, results suggest that healthy older adults and participants with AD were able to complete and perform the task relatively well.

Use of cues and distractors. In the current study, a question mark was presented following the counting task to indicate that recall of the triad was required. It would be interesting to see what would occur if the question mark was replaced with the cue that had been presented before each triad. One can speculate that having the cue at the start of the recall period may increase retrieval. Yet, it is also possible that participants may rely on the cue, a reliance which could have an impact on the frequency and type of intrusion errors.

Likewise, it may be useful for future research to include the same stimuli and paradigm, but without any cues and distractors. This suggested design would provide further information about semantic memory organization, as the importance of the overlapping features or categories would be determined. Thus, if no PI effects were observed for featurally grouped items, it would suggest that the present results may have been a result of experimental design and participants' ability to carry out a task, rather than an indication of underlying organizational mechanisms of semantic memory.

Possible ceiling effects and modification of the task. It was also observed that approximately 19% of the trials for younger participants (i.e., 61 of 320) were at ceiling performance. I was surprised by this result as the younger participants had similar task demands as those tested by Marques (2000).

In addition, modifications of the paradigm were made so that different groups could meet task requirements (e.g., changing the counting task, length of recall period). Adjustments to experimental tasks are fairly common when testing individuals across the lifespan and with selective impairments (Multhaup et al., 2003), as flexibility is often required in testing patient populations. For instance, when an individual with AD was unable to count backwards, the task was modified so that the participant could count forwards. The objective was to provide a sufficient distraction during the delay period to prevent rehearsal. If a rigid approach had been used so that all participants were required to complete the same task, it would likely have resulted in decreased effort at best, and possibly increased participant dropout.

It may be interesting to conduct future studies employing different delay periods and shorter recall times to ascertain what impact this may have on recall for younger participants. However, I would be cautious about subjecting healthy older participants and AD participants to an overly demanding task due to the increase likelihood of floor performance, or an ensuing low morale.

Issue of carryover effects. Given the inherent heterogeneity that is often present in experiments involving AD participants, a within-subjects design was employed in the hopes of reducing the possibility of individual differences skewing the results. Moreover, it allowed for the conditions to be collapsed during analysis, which facilitated interpretation of the results. Most importantly, a direct contrast of how the stimuli cues impacted recall could be ascertained. One of the possible disadvantages is that participants were exposed to all cues. Although the testing sessions were a week apart, and the order and configuration of triads were rearranged, there may have been carryover effects. Anecdotally, participants did not appear to notice that the stimuli were the same. Indeed, upon debriefing at the end of the second testing session, most participants were surprised to realize that the stimuli, although rearranged and cued differently, were identical for each testing session.

Stimuli selection. As can be seen in Appendix C, the stimuli chosen are not without limitations. First, the stimuli that needed to be selected in order to be in accordance with certain featural cues were often restricted in number of exemplars.

For instance, there are only a handful of animals that are congruent with the cue USED FOR TRANSPORTATION. Similarly, there are not many fruits and vegetables that fit the criteria of LONG. It can be argued that with any recall paradigm, guesses may be made. However, having cues with only a few exemplars made it possible for participants to make more educated guesses. Thus, a correct response in such a case may not be due to a participant having successfully encoded and retrieved information, but rather because a guess was made from a limited number of options.

In addition, certain stimuli could not be used because of their ambiguous relationship with the cues (i.e., neither congruent nor incongruent). For instance, would a mango be classified as round or long? Would most individuals think of a dog as an animal used or not used for transportation?

Furthermore, the stimuli were not always presented with featural cues that captured the most distinguishing characteristic for each item. For instance, the word stimuli *porcupine* and *skunk* were cued as NOT EATEN; although these items are congruent with the cue, it is likely not a primary organizational principle for either of these exemplars. Thus, this could have been a limitation in the study, but one that was difficult to overcome given the desire to be able to have buildup and shift trials that contrasted categorical and featural information.

Without a doubt, it is difficult to think of a solution to this confound. Even if a standard PI paradigm was created that utilized cues on more distinguishing featural characteristics, there would still be difficulties. For instance, if the cue SMELLS was presented, which may be a more appropriate characteristic of certain items (e.g., *skunk*, *rose*, *perfume*), there would still exist a difficulty with finding an appropriate release triad, as no stimuli come to mind that are characterized for NO SMELL. Thus, exemplars could be generated (e.g., *glass*, *wasp*, *necklace*), but the same problem of certain stimuli not being cued on their most distinguishing attributes would exist.

Anecdotal evidence garnered from listening to participants' comments suggest that participants used the salient features of an item to recall, even if it was not what was originally cued. Thus, this irreconcilable flaw may have introduced a confound, as stimuli may have been encoded and retrieved with the use of other features or organizational properties. As such, the results may need to be interpreted with this in mind.

In addition, results from Marques' (2000) study showed fluctuating patterns of results as a function of whether word or picture stimuli were used. Marques was very limited in stimuli selection by requiring standardized pictures. As discussed in the introduction, there were several stimuli choices that were questionable (e.g., *telephone* cued as having FOUR LEGS, *pig* being cued as LARGE, which meant larger than a human). Upon creation of the current paradigm, finding adequate stimuli was difficult even without the restriction of selecting from standardized pictures. Moreover, if pictures had been used and paired with distractors, it would have required a change in task to a pointing or naming task which would have generated another confound. Thus, comments on the current study can be made only in the context of word stimuli.

A possible future study could include a more limited version of the task for participants with AD and have the name and picture together, which would offer more information. Given that the current study appeared to show more robust PI effects than those obtained in Marques (2000), any future studies would likely benefit from the continued inclusion of distractors in order to increase the likelihood of participants using the cues.

Knowledge of stimuli. It was observed that several of the younger participants had minor difficulties with a selection of the fruits and vegetable stimuli. For instance, two or three participants expressed that they had never encountered the word *rhubarb*. Moreover, in one debriefing session, a younger female stated that she ate *cucumber* often, but did not know the shape “as it’s always cut up for me”. As discussed, there were a limited number of exemplars for certain cues. One could argue that the high accuracy obtained for the sorting task suggests that the majority of participants were able to correctly sort stimuli according to featural attributes. Yet, it is likely that individual differences existed for familiarity with the stimuli.

Scope of attributes. A further limitation of the study concerns its scope and the extent to which the results can be generalized, as only four attributes were tested (i.e., transportation use, eating use, shape, and size). Marques (2000) also used four featural cues (i.e., level of danger, transportation use, size, and number of legs) and cautioned that it is possible that the attributes that were tested may not be representative of all featural information.   Indeed, there was overlap in the attributes used in the Marques paradigm and the present study; however, as already discussed, even with a similar design results were not replicated.

It could be argued that a limitation of the study and one of its strengths was that the stimuli in a given triad all belonged to the same category and had the same feature. As such, it may be helpful to conduct a study in which stimuli have the same featural cue, but are from different categories and vice versa. For example, ROUND exemplars could consist of fruits (e.g., *oranges*, *blueberries*), and objects (e.g., *wheel*, *globe*). Of course, it would not allow for direct contrast of identical stimuli for categorical and featural cueing, but may add to our knowledge about the importance and relevance of featural attributes when categorical membership is no longer a factor.

Demographics. One of the goals was to match groups as well as possible on demographic measures. The ratio of males to females was successfully matched for the younger and older control groups, and closely matched for the AD participants (i.e., seven female, nine male). Unfortunately, the younger group had more years of education than the older participants, a circumstance which can be quite typical of the different age cohorts. It should be noted that there was substantial overlap in the range of education with the younger having 12 to 18 years and the older control group having 9 to 17 years of education. Of importance was also the fact that the healthy younger and older participants did not differ on measures of working memory and verbal abstract reasoning when scaled scores were compared. The difficulty, when attempting to match younger and older controls on level of education is that it often means selecting older participants with a higher level of education than would be expected of this age cohort in the general population. In addition, if the older participants had matched with the younger controls on education, it would have been more difficult to match the older control group with the AD participants. Given that the healthy older participants and AD participants were expected to differ on many measures, it was important to attempt to match the groups as well as possible in order to make direct comparisons that can be interpreted with confidence.

As noted earlier, the AD group were older than the healthy older participants. However, when several of the younger aged older controls and older aged AD participants were removed, similar results were obtained on the experimental paradigm as has been reported in the Results section with the whole groups. Thus, the age difference did not appear to have an impact on the results of this study.

The resourcefulness of participants. Several precautions were used in this paradigm to minimize participants' use of other strategies during the process of encoding and recall. As previously discussed, adding distractors to the encoding task and requiring participants to select the target word made the cue more relevant as participants needed to pay attention to it in order to correctly execute the task. In addition, distractors in any given triad did not all belong to the same category (or share the same attributes) in order to reduce the likelihood that participants would select the target solely on the basis of it not being from a given category for the distractor (i.e., "not an occupation, piece of jewelry, etc. ").

Even with these measures in place, the current study demonstrated that several individuals were resourceful in performing the task. Participants appeared motivated to do well. It was observed that several participants from all of the test groups used a variety of means to retain and recall information. Thus, even though information may have been cued in one way, it did not stop individuals from using other information if it helped improve performance. As already discussed, in the PI continued featural condition, participants appeared to use categorical information even when featural cues were presented.

During the experiment and in the debriefing session, participants also disclosed other strategies that they used. These additional strategies were not cued in the entirety of the experiment and included the following: using the first letters of each word; classifying the stimuli on a personal basis (e.g., foods my husband does not like; all of these are in my fridge); visualizing stimuli (e.g., imagining that *stove* sets *cabinet* on fire and there is a *ladder* on the fire truck). When one participant was asked to disclose strategies that were used, she responded "you relate them to things in your life". These strategies show that ingenuity, although hard to control for, should not be discouraged. Moreover, it likely reflects what is occurring outside the laboratory experiment.

According to Mahon and Caramazza (2009), "An understanding of the architecture of the conceptual system must therefore be situated in the context of the real-world computational problems that the conceptual system is structured to support" (p. 44). Thus, future directions for this research should incorporate paradigms that are closer to real life situations, for example, a paradigm in which a participant needs to recall grocery items or is given different scenarios of what they saw at a mall or zoo. In addition, it may be interesting for future studies to include a measure that assesses creativity and ingenuity of participants in using different strategies. An interesting question would be to test whether participants who score higher on this measure (i.e., showing greater creativity and flexibility) differ in their performance on the paradigm and subjective measures of satisfaction of memory abilities in everyday life.

Personal experience. One of the concluding issues brings us full circle to Tulving's (1972) first writings contrasting episodic and semantic memory, noting that episodic memory is temporal in nature. Even though it is not necessary to remember when encyclopedic knowledge of semantic memory was learned, one thing is certain: life experiences shape what is stored in semantic memory. Culture, environment, and self-interest all play a vital role in what is inputted and can affect an individual's motivation, understanding, contact, and frequency of retrieval of such information.

Wickens et al. (1976) also suggest that words are not necessarily stored in one way in semantic memory, but rather there is an influence of the denotative and connotative dimensions. Thus, a word has its global meaning (i.e., definition) and subsequent attributes, but it also has associations and personal meaning that may affect how it is organized within the semantic system. Our encounters with such stimuli and how we classify them may play a role in how the information is encoded, stored, and retrieved. Therefore, it is quite possible that some of these processes are idiosyncratic, and that we likely utilize all information that is available and of use.

Although the obvious implication is that these idiosyncrasies may make semantic memory more difficult to study, I believe that this is good news rather than bad. It shows the possible flexibility that is required of the semantic memory system to accommodate the necessary global meaning (i.e., encyclopedic type knowledge) and to allow for the creation of personal meaning. Indeed, plasticity is required when we think about how our personal experiences shift our semantic representations and knowledge, both in scope and depth, depending on our interactions and interests. For example, prior to visiting Australia, my knowledge of koala bears was limited to them being furry creatures that lived in trees. Having seen one up close, I now have additional information pertaining to the texture of its fur, its smell, and other facts that were learned on a day spent at a wildlife park.

Gainotti (2007) recognizing that personal experience likely plays an important role in semantic memory, argues that structured interviews or checklists assessing premorbid interests of each participant prior to testing should be mandatory in order to attempt to control for these factors in a systematic manner. An argument can be put forth that the sorting task in the current study attempted to determine semantic knowledge of featural aspects of the stimuli. However, one cannot overlook the anecdotal reports made by participants, including the following: a student who admitted that she does not know what vegetables look like because her mother prepares her meals; an older adult who grew up in a time and place where vegetables were limited; and an older adult who cooks and peruses the grocery aisle. All of these factors contribute to the degree of knowledge that is acquired.

Although it can be argued that it is worthwhile to explore individual differences and personal experiences, it may be a difficult to do so. For instance, Peraita (2007) discussed how hard it may be for older adults to remember when they acquired knowledge of a concept, and how to rate how familiar they are with a concept.

Therefore, although this is an interesting avenue to explore, it will not be without its inherent complications.

Conclusion

The current study attempted to shed further light on the organization of semantic memory. By using the same target words and task, the goal of the study was to contrast categories and features. Compelling evidence was found for the significance of categories as an organizational principle. Additionally, it appears that features, although important, may not completely explain semantic memory organization. It seems unlikely that information is organized solely on one of these principles.

Semantic memory is complex. It is no longer safe to assume it is merely encyclopedic knowledge; personal experience and how that knowledge was obtained needs to be taken into consideration. Researchers in this field seem to be in agreement that this issue is not resolved and that a broader, more integrative theory needs to be created and empirically tested. Thus, the organization of semantic memory, although studied for over a quarter of a century, is still not fully understood. With additional studies, such as the current paradigm, our hope is that progress can be made to gain further insight into this important memory type.

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Appendix A

Health Screening Questionnaire

ID: ____________________ Date: ____________________

History Questionnaire

We are interested in your personal history because it may help us to better understand the results of our study. Your answers to a few short questions will aid us in this effort. All answers will be kept strictly confidential. Thank you for your help.

Demographics:
1. Date of Birth (D/M/Y):______________ 2. Age:___________
3. Gender: (circle response) (1) Male (2) Female
4. Handedness: (circle response) (1) LEFT (2) RIGHT (3) BOTH
5. Present marital status: (circle response) (1) Single – never married
(2) Married (3) Separated
(4) Divorced (5) Widowed (6) Cohabit

Language:
6. Place of Birth:____
7. Languages Spoken (in order of fluency):____________________________
8. Primary Language/Language of Choice:_____________________________
9. Language at home:______________________ 8. At Work:________________________
10. Language of Education:___________________________________
11. At what age did you first learn English? ______________________
12. At what age did you become fluent in it?_____________________
13. .How many years of education do you have at this time? (i.e., what is the highest level achieved?)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Elementary Secondary Cegep Undergrad Graduate Professional

14. What is or was your main occupation? ___________________________

Medical History

15. Do you have now, or have you had in the past -(please circle your response)
- Visual problems: A) Nearsighted / Farsighted B) Glasses / Contact lenses
C) Cataract: Left / Right D) Colour blind: NO / YES
- Trouble hearing: E) NO / YES F) Hearing Aid: Left / Right
16. Have you ever been unconscious, had a head injury or had blackouts?
A) NO / YES
B) Cause:_______________________________________
C) Duration:_____________________________________
D) Treatment:____________________________________
E) Outcome:_____________________________________
17. Have you been seriously ill or hospitalized in the past 6 months?
A) NO / YES
B) Cause:_______________________________________
C) Duration:_____________________________________

Do you have now, or have you had in the past :
18 a)A stroke NO / YES
b) Transient ischemic attack? NO / YES

19. Heart disease? NO / YES Nature (MI, angina, narrowing of arteries):
20. High blood pressure? NO / YES Is it controlled?
21. High Cholesterol? NO / YES
22. Bypass surgery? NO / YES
23. Other Surgery? NO / YES Nature:
    Age Onset:________ Frequency:___________
24. Seizures? NO / YES Cause:___________Treatment:_____________
25. Epilepsy? NO / YES
26. a) Diabetes? NO / YES Type I / Type II Age of Onset:___________________
    b) Insulin dependent? NO / YES
Treatment:______________________
27. Thyroid disease? NO / YES
28. Frequent headaches? NO / YES Tension / migraine
29. Dizziness? NO / YES
30. Trouble walking? (unsteadiness) NO / YES
31. Arthritis? NO / YES
32. Any injuries to the lower limb? NO / YES (e.g. hip, knee, ankle)
33. Serious illness (e.g. liver disease)? NO / YES
34. Neurological disorders? NO / YES
35. Exposure to toxic chemicals(that you know of)? NO / YES
36. Depression? NO / YES
37. Anxiety? NO / YES
38. (Other) psychological difficulties? NO / YES
    G) Hormone replacement? NO / YES
    H) Steroids? NO / YES

Medication you are currently taking & any other meds that you have taken in the past year

Type of medication	Reason for consumption	Duration of consumption/

Approximately how many drinks of alcohol do you have per week?
(1 drink = 1 beer, 1 glass of wine, 1 oz of liquor)
____
Do you use non-prescription drugs for recreational purposes? NO / YES
    If YES, How many times per week: (A) 1 - 3 (B) 4 - 6 (C) more than 6
Do you smoke? NO / YES If YES, How many packs a day? ____________________

Present Problems - Are you currently troubled by any of the following?

A) Concentration / Attention problems NO / YES Nature:

B) Memory problems NO / YES Nature:

C) Difficulties finding words NO / YES Nature:

How would you rate your health? (circle response)

1) poor 2) fair 3) good 4) very good 5) excellent

Participant contact information:

Name: ____

Address:____

____

____

____

Phone Number: _______________________________

Are you willing to be contacted for future research? NO / YES

What year will you graduate?

Can we give your information to other Concordia researchers? NO / YES

Source: ____

Appendix B

Consent Form

Sir Mortimer B. Davis Jewish General Hospital
Department of Clinical Neurosciences
Investigation of Memory and Learning

Consent Form for the
Investigation of Memory and Learning

Purpose of the Study:

The purpose of this study is twofold: to determine the benefits of cues in a short-term memory task and to see how a new task can be learned.

Details of the Study:

The study will take place in the participant's home, the laboratory of the Department of Neurology, Jewish General Hospital or at the Psychology Department, Loyola Campus, Concordia University. One of the tasks will involve recalling words that are presented either with or without cues. The learning task will involve counting backwards as quickly as possible. I will also be given other tasks that measure my memory and ability to learn. I understand that while I may not be able to perform each task perfectly, the most important thing will be that I will try to do my best.

This study will require two (2) visits: the first should last approximately 1½ to 2 hours, the second should last approximately 2½ hours. If the study does not take place at my home, transportation can be arranged for me or I will be reimbursed for my travel. Since this test is not diagnostic in any manner and is for research purposes only, I understand that individual results will not be made available to me.

Confidentiality:

I understand that my participation in this study is *confidential*, that is, the researcher will know but will not disclose my identity in any published report or scientific communication. My records will not be identified by name; instead a code will be used. If the present study is published, only group results will be mentioned, insuring my confidentiality as a participant in this experiment.

Withdrawal from the Study:

I understand that my participation in this study is voluntary and, if I agree to participate, I may withdraw my consent and discontinue participation *at any time* without affecting my medical care or any other negative effects.

Questions:

If I have any questions regarding my rights as a research participant I may contact the hospital's patient representative at **tel: 340-8222 ext. 5833.**

The following is the name, address, and telephone number of the researcher whom I may contact for answers to questions about the research: **Dr. Natalie Phillips, Dept. of Psychology, Concordia University, 7141 Sherbrooke Street W., Montreal, QC, H4B 1R6; tel: 848-7546**

May 2003

All participants will receive a copy of this consent form

Participant's/Patient's Rights:

I have fully discussed and understood the purpose and procedure of this study and have had the opportunity to ask any questions.

Signature:
I have understood the contents of this consent form and have had the opportunity to ask questions. I agree to participate in this study.

Date	Signature of Participant	Print Name
Date	Signature of Investigator	Print Name

RESEARCH ETHICS
0 9 JUIN 2003
APPROVAL
INITIALS

All participants will receive a copy of this consent form

Appendix C

List of Stimuli

CATEGORICAL PI CONTINUED: ANIMALS/ANIMALS
FEATURAL PI RELEASE: NOT TRANSPORTATION/TRANSPORTATION

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE:ANIMALS/NOT TRANS	CATEGORICAL	FEATURAL
SHARK	REDWOOD	TAXI
WHALE	LAGER	CANOE
MONKEY	MILK	LIMOUSINE
LION	JUICE	TRAM
CAT	COLA	JET
EAGLE	RUM	SCOOTER
ANT	VODKA	AUTOMOBILE
MOOSE	POPLAR	SNOWMOBILE
GRASSHOPPER	WILLOW	YACHT

CATEGORICAL PI RELEASE: OBJECTS/ANIMALS
FEATURAL PI CONTINUED: TRANSPORTATION/TRANSPORTATION

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: OBJECTS/TRANS.	CATEGORICAL	FEATURAL
TRAIN	YELLOW	RING
BICYCLE	TURQUOISE	NECKLACE
AIRPLANE	PURPLE	BRACELET
BUS	CRIMSON	LILY
HELICOPTER	PLATINUM	CARNATION
MOTORCYCLE	VIOLET	CROWN
TRUCK	COPPER	BROACH
FERRY	BRASS	ROSE
SUBWAY	TEAL	BANGLE

TRIAD 4*

TARGET WORDS	DISTRACTORS	
CUE: ANIMALS/TRANS	CATEGORICAL	FEATURAL
HORSE	STEEL	TAPE
CAMEL	ANKLE	STAPLER
MULE	PEWTER	ERASER
DONKEY	SILVER	MASCARA
ELEPHANT	TITANIUM	PERFUME
OX	PELVIS	PEN

***SIX WORDS FOR ABOVE TWO CONDITIONS**

CATEGORICAL PI CONTINUED: ANIMALS/ANIMALS
FEATURAL PI RELEASE: EATEN/NOT EATEN

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: ANIMALS/EATEN	CATEGORICAL	FEATURAL
LAMB	TENT	WHIP
CHICKEN	COTTAGE	DAGGER
TURKEY	HUT	ONYX
RABBIT	IGLOO	PISTOL
DUCK	TEA	AMBER
SALMON	BOURBON	TOPAZ
TUNA	SODA	GRENADE
TROUT	MANSION	MISSILE
PIG	BARN	BOMB

CATEGORICAL PI RELEASE: OBJECTS/ANIMALS
FEATURAL PI CONTINUED: NOT EATEN/NOT EATEN

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: OBJECTS/NOT EATEN	CATEGORICAL	FEATURAL
PIANO	DENTIST	CHEESE
SAXOPHONE	FLORIST	YOGURT
TRUMPET	RED	PASTA
DRUM	JANITOR	CAKE
VIOLIN	BURGUNDY	CEREAL
GUITAR	NURSE	CHOCOLATE
FLUTE	CHEF	MUFFIN
TUBA	BEIGE	SOUP
HARP	FIREMAN	TOFFEE

TRIAD 4*

TARGET WORDS	DISTRACTORS	
CUE: ANIMALS/NOT EATEN	CATEGORICAL	FEATURAL
PORCUPINE	LIPSTICK	OMELET
BEE	CHECKERS	COOKIE
PENGUIN	BLUSHER	PIE
HAMSTER	LOTION	STEW
TIGER	BLACKJACK	CUSTARD
SKUNK	COLOGNE	FUDGE

***SIX WORDS FOR ABOVE TWO CONDITIONS**

CATEGORICAL PI CONTINUED: OBJECTS/OBJECTS
FEATURAL PI RELEASE: LARGE/SMALL

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: OBJECTS/LARGE	**CATEGORICAL**	**FEATURAL**
SOFA	ARCHITECT	TULIP
REFRIGERATOR	POLICEMAN	DAISY
CABINET	FLANNEL	EARRING
BOOKCASE	LINEN	WATCH
LADDER	SATIN	CHRYSANTHEMUM
BATHTUB	VELVET	DANDELION
MATTRESS	WAITRESS	ORCHID
STOVE	DENIM	POPPY
DRESSER	CANVAS	PENDANT

CATEGORICAL PI RELEASE: F&V/OBJECTS
FEATURAL PI CONTINUED: SMALL/SMALL

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: F&V/SMALL	**CATEGORICAL**	**FEATURAL**
PEACH	SKIRT	PLATEAU
ORANGE	CASTLE	ICEBERG
PLUM	CABIN	WATERFALL
STRAWBERRY	SWEATER	MIAMI
MUSHROOM	TRAILER	VOLCANO
POTATO	SCARF	TORONTO
RADISH	GLOVE	CLIFF
MANGO	BLOUSE	OCEAN
LIME	CAP	WASHINGTON

TRIAD 4*

TARGET WORDS	DISTRACTORS	
CUE: OBJECTS/SMALL	**CATEGORICAL**	**FEATURAL**
KETTLE	OUNCE	MONTREAL
CLOCK	GRAM	ATLANTA
TOASTER	AUNT	CANYON
CANDLE	MILE	BEACH
THERMOM	FATHER	VANCOUVER
ASHTRAY	GALLON	SEATTLE

***SIX WORDS FOR ABOVE TWO CONDITIONS**

CATEGORICAL PI CONTINUED: FRUITS & VEGETABLES/FRUITS & VEGETABLES
FEATURAL PI RELEASE: ROUND/LONG

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: F&V/ROUND	CATEGORICAL	FEATURAL
PEA	SISTER	OAK
BLUEBERRY	GRANDSON	SPEAR
GRAPEFRUIT	NIECE	PINE
COCONUT	SHORTS	ELM
TURNIP	SHIRT	BIRCH
CABBAGE	UNCLE	SPRUCE
TOMATO	GRANDAD	SWORD
ONION	JACKET	CANNON
CHERRY	STEPMOTHER	SYCAMORE

CATEGORICAL PI RELEASE: OBJECTS/FRUITS & VEGETABLES
FEATURAL PI CONTINUED: LONG/LONG

TRIADS 1-3

TARGET WORDS	DISTRACTORS	
CUE: OBJECTS/NOT EATEN	CATEGORICAL	FEATURAL
SCREWDRIVER	WRESTLING	DIAMOND
PLIERS	HOCKEY	RUBY
CHISEL	COTTON	SAPPHIRE
WRENCH	TENNIS	EMERALD
HAMMER	WOOL	PEARL
AXE	SKIING	BASEBALL
RAKE	SOCCER	BASKETBALL
SHOVEL	TWEED	VOLLEYBALL
DRILL	RUGBY	GARNET

TRIAD 4*

TARGET WORDS	DISTRACTORS	
CUE: FRUIT/LONG	CATEGORICAL	FEATURAL
BANANA	CHESS	ELBOW
RHUBARB	GLUE	WRIST
CUCUMBER	POKER	INCH
LEEK	PENCIL	LIPS
CELERY	ROULETTE	NOSTRIL
ZUCCHINI	CRIBBAGE	MILLIMETER

***SIX WORDS FOR ABOVE TWO CONDITIONS**

Appendix D

Verbal Instructions

INSTRUCTIONS

- There are two tasks involved with this study: a memory task and a learning task
  - First you will be shown a cue which will tell you the type of words you have to remember
    - For example, the cue might be something like animals, objects, used for transportation, or large, etc.
  - After the cue, two words will appear on the screen
    - Your task is to say out loud, and try to remember the word that corresponds to the cue
    - For example if the cue was ***flowers*** and the two words were ***tulip*** and ***computer***, you would say "**tulip**" and we would go on to the next screen
  - Three screens will appear like this, so you will have three words that you have to choose and try to remember
  - After the words appear, you will be shown a number
  - Your task will be to start counting backwards from 3's as quickly as possible without making any errors
    - This is the new task and we will be measuring how well you learn this new task and how you improve as the session progresses
  - When the question mark appears on the screen, you should stop counting and try and remember the three words that you had just seen
    - **Please recall the words in the order they were shown.**
    - **However, if you can't remember the order, but remember the words, let me know the words as you will receive partial credit for telling me the words.**

- I am going to give you some practice trials just to make sure you understand the task.

- Also you should realize that you may not always remember all the words, but all we ask is that you try your best in both the memory and learning part of the experiment.

- After a certain number of trials a happy face will appear on the screen, at this point we will take a short break.

- Do you have any questions?

Appendix E

Average Recall Scores

PARTICIPANTS	CONDITION	TRIAD	MEAN	STD. ERROR	LOWER BOUND	UPPER BOUND
Younger	Categorical PI continued	1	3.00	0.02	2.95	3.05
		3	2.06	0.13	1.80	2.32
		4	2.15	0.13	1.89	2.41
	Categorical PI release	1	2.98	0.03	2.91	3.04
		3	2.09	0.12	1.85	2.32
		4	2.41	0.11	2.19	2.64
	Featural PI continued	1	2.99	0.02	2.95	3.02
		3	1.94	0.12	1.69	2.18
		4	2.61	0.08	2.45	2.77
	Featural PI release	1	3.00	0.01	2.98	3.02
		3	2.04	0.13	1.78	2.30
		4	2.36	0.11	2.14	2.59
Older	Categorical PI continued	1	2.95	0.02	2.90	3.00
		3	1.88	0.13	1.61	2.14
		4	1.94	0.13	1.67	2.20
	Categorical PI release	1	2.90	0.03	2.83	2.97
		3	1.78	0.12	1.54	2.01
		4	2.38	0.11	2.15	2.60
	Featural PI continued	1	2.96	0.02	2.93	3.00
		3	1.61	0.12	1.37	1.86
		4	2.39	0.08	2.23	2.55
	Featural PI release	1	2.98	0.01	2.95	3.00
		3	1.74	0.13	1.48	2.00
		4	2.14	0.11	1.91	2.36
AD	Categorical PI continued	1	2.08	0.08	1.92	2.24
		3	1.14	0.14	0.85	1.43
		4	1.28	0.16	0.96	1.60
	Categorical PI release	1	2.03	0.09	1.86	2.21
		3	1.25	0.14	0.97	1.53
		4	1.58	0.12	1.33	1.83
	Featural PI continued	1	2.02	0.09	1.84	2.19
		3	1.08	0.12	0.83	1.33
		4	1.31	0.12	1.06	1.56
	Featural PI release	1	2.05	0.09	1.86	2.23
		3	1.11	0.16	0.78	1.44
		4	1.44	0.14	1.16	1.71

Appendix F

Comparison of Three and Six Point Data

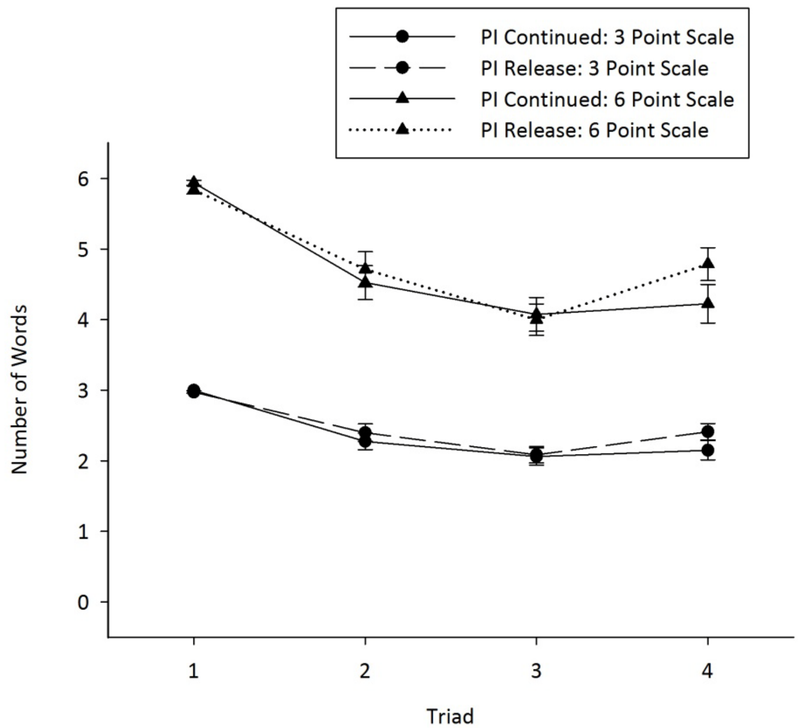

Figure E1. Average recall for categorically cued stimuli for younger adults, using a three and six point scoring scale.

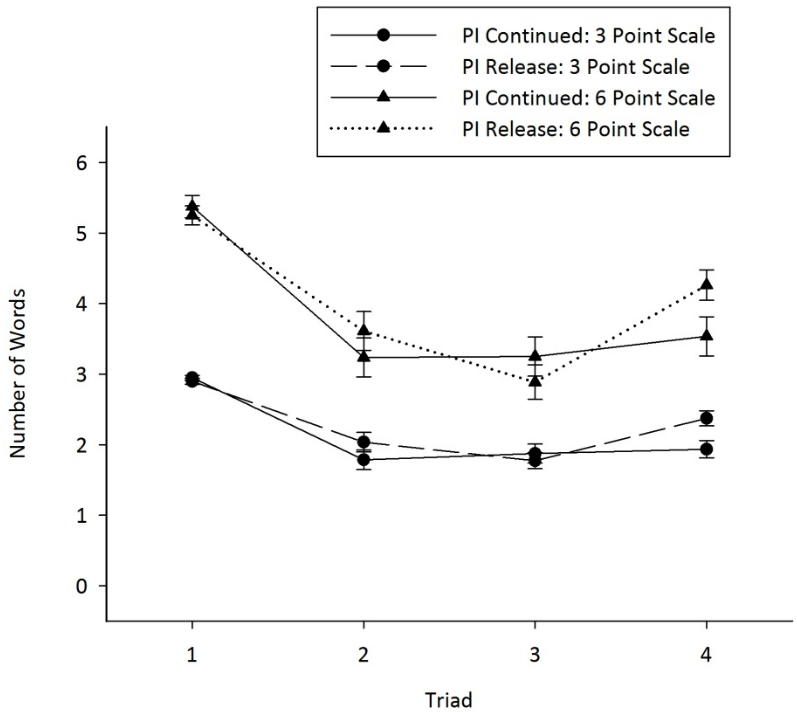

Figure E2. Average recall for categorically cued stimuli for older adults, using a three and six point scoring scale.

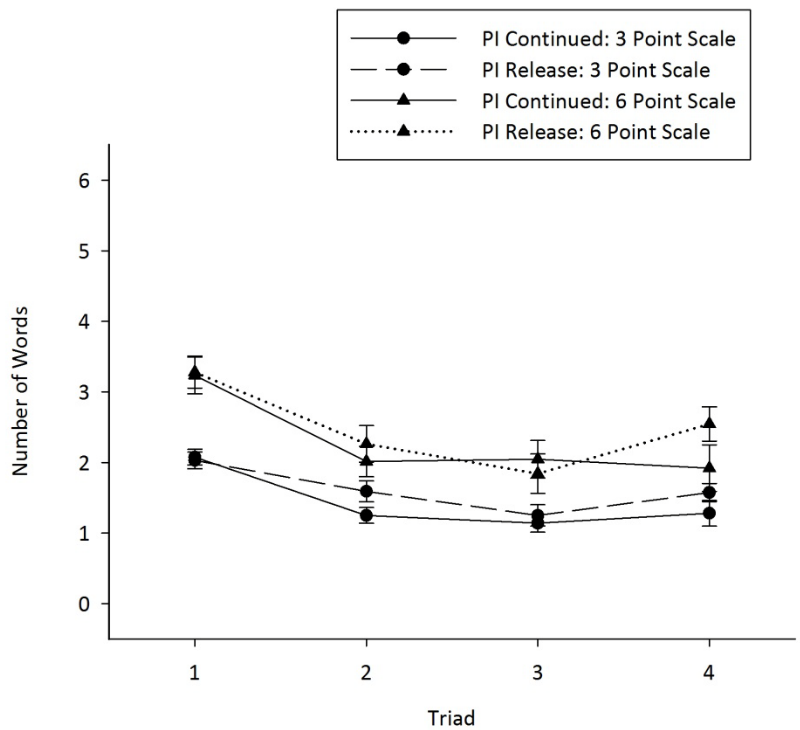

Figure E3. Average recall for categorically cued stimuli for AD participants, using a three and six point scoring scale.

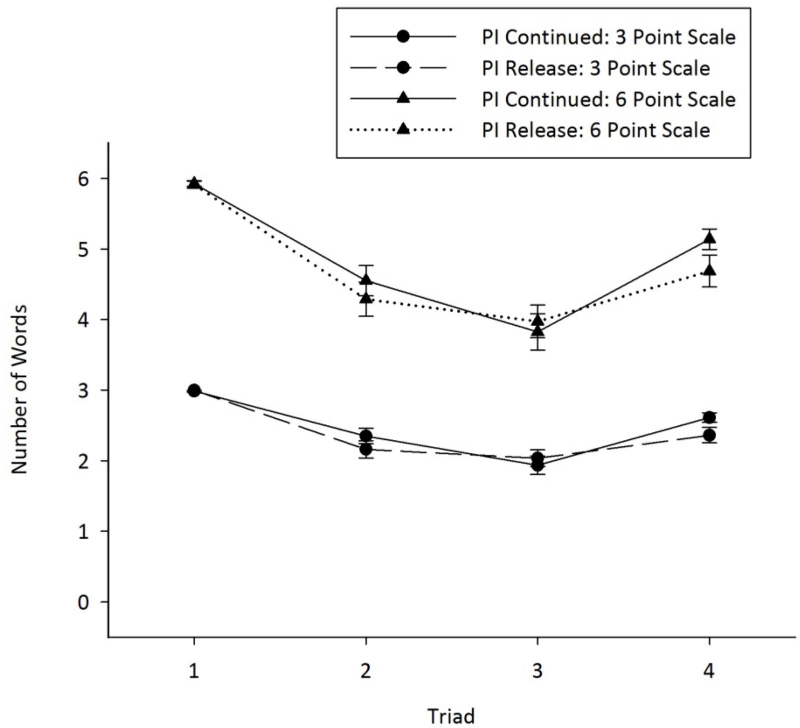

Figure E4. Average recall for featurally cued stimuli for younger adults, using a three and six point scoring scale.

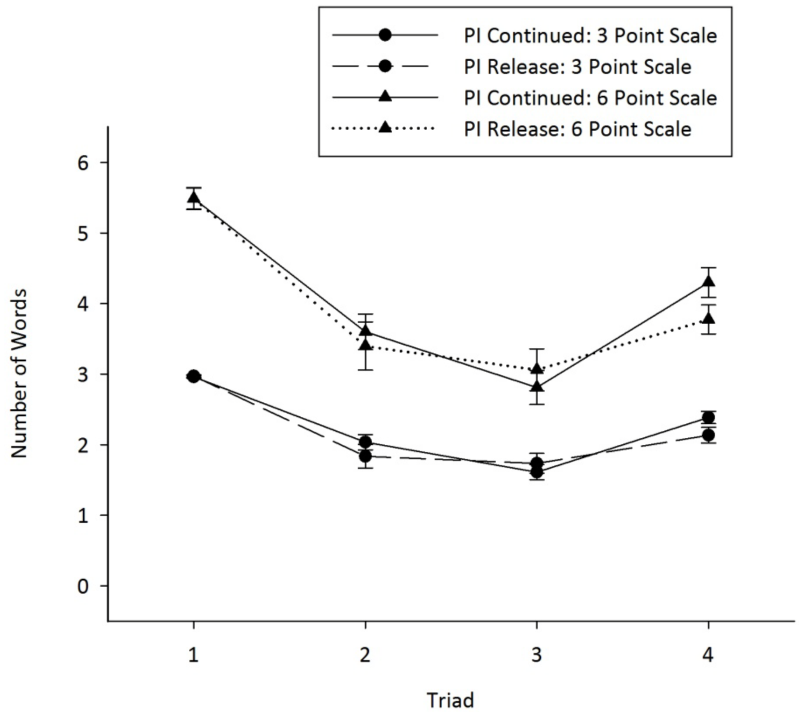

Figure E5. Average recall for featurally cued stimuli for older adults, using a three and six point scoring scale.

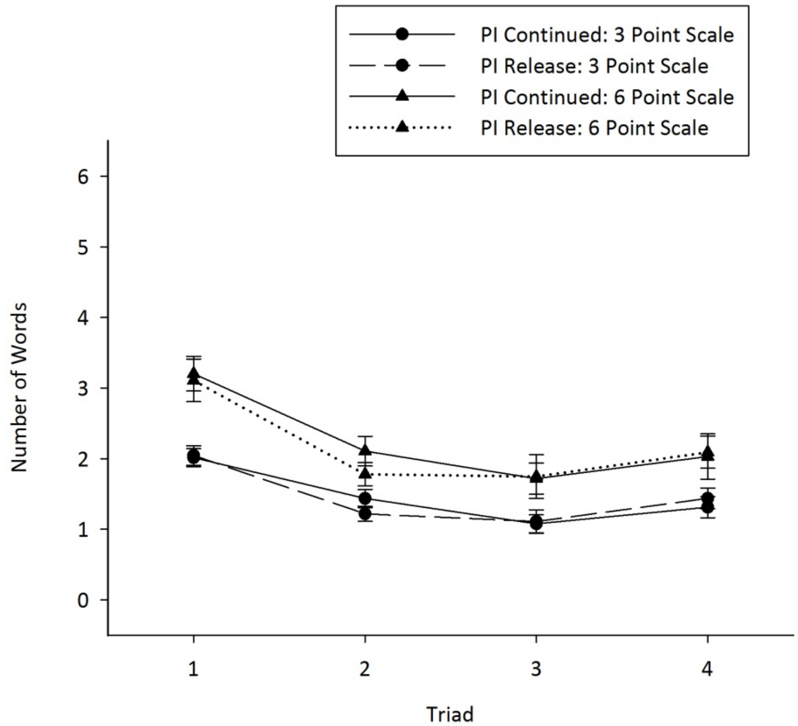

Figure E6. Average recall for featurally cued stimuli for AD participants, using a three and six point scoring scale.

Appendix G

Average Intrusion Error Scores

PARTICIPANTS	CONDITION	TRIAD	MEAN	STD. ERROR	LOWER BOUND	UPPER BOUND
Younger	Categorical PI continued	1	0.00	0.02	-0.04	0.04
		3	0.15	0.08	-0.01	0.31
		4	0.06	0.06	-0.05	0.18
	Categorical PI release	1	0.01	0.02	-0.03	0.06
		3	0.11	0.08	-0.05	0.28
		4	0.01	0.02	-0.04	0.06
	Featural PI continued	1	0.00	0.01	-0.02	0.02
		3	0.14	0.09	-0.05	0.32
		4	0.03	0.04	-0.07	0.12
	Featural PI release	1	0.00	0.00	0.00	0.00
		3	0.16	0.07	0.01	0.31
		4	0.11	0.04	0.03	0.19
Older	Categorical PI continued	1	0.03	0.02	-0.01	0.06
		3	0.56	0.08	0.40	0.73
		4	0.40	0.06	0.29	0.51
	Categorical PI release	1	0.05	0.02	0.00	0.10
		3	0.68	0.08	0.51	0.84
		4	0.09	0.02	0.04	0.14
	Featural PI continued	1	0.03	0.01	0.00	0.05
		3	0.93	0.09	0.74	1.11
		4	0.15	0.04	0.06	0.24
	Featural PI release	1	0.00	0.00	0.00	0.00
		3	0.71	0.07	0.56	0.86
		4	0.23	0.04	0.15	0.30
AD	Categorical PI continued	1	0.27	0.05	0.16	0.37
		3	1.19	0.14	0.91	1.47
		4	1.13	0.12	0.88	1.37
	Categorical PI release	1	0.28	0.07	0.13	0.43
		3	1.39	0.14	1.10	1.68
		4	0.75	0.11	0.52	0.98
	Featural PI continued	1	0.27	0.05	0.16	0.37
		3	1.30	0.14	1.01	1.58
		4	1.03	0.15	0.74	1.33
	Featural PI release	1	0.27	0.09	0.09	0.44
		3	1.13	0.13	0.85	1.40
		4	0.80	0.12	0.55	1.04