DO FEATURE IMPORTANCE AND FEATURE RELEVANCE DIFFERENTIALLY INFLUENCE LEXICAL SEMANTIC KNOWLEDGE IN INDIVIDUALS WITH APHASIA?

A dissertation submitted to the Kent State University College of Education, Health, Human Services in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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This study investigated two classifications of semantic features, feature importance and feature relevance, to verify if they differentially influence lexical semantic knowledge in individuals with aphasia. Feature importance is defined as “how important a feature is in defining a concept” Hampton (1979), while feature relevance represents the “core meaning of a concept” (Sartori, Lombardi & Mattiuzi, 2005).

A sorting task was utilized with 20 aphasic volunteer participants to investigate the semantic processing involved in the association of semantic features with their appropriate nouns. A corpus of 18 nouns was displayed in front of each participant in groups of three along with a card containing the word “UNRELATED”. The participants were given a deck of 18 cards containing features corresponding to the nouns and to the unrelated category, and were verbally instructed to sort the deck of cards into one of the four designated piles. The semantic features on the cards were rated as high, mid and low importance (HI, MI, LI) and high, mid and low relevance (HR, MR, LR).

Analysis was completed using a two-way between-subjects ANOVA to determine was whether the mean scores at the three different levels (e.g., low, mid and high) of importance, and relevance differed and to analyze if there was an interaction between the
two classifications. The participants were able to sort *high importance* features with their nouns more accurately than they did *mid* and *low importance* features. Feature *relevance* did not differentially influence noun-feature association. These results indicated that the ability of individuals with aphasia to associate features with their nouns is influenced by levels of feature importance.

In conclusion, this study found that individuals with aphasia are more cognitively sensitive to *high* level versus *low* level feature importance and the effect does not extend to a *mid* level of importance. The study also demonstrated that the condition of feature *relevance* did not differently influence the ability of individuals with aphasia to associate semantic features with their appropriate nouns. Potential clinical implications and study limitations were discussed.
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CHAPTER I

INTRODUCTION

Aphasia is an acquired communication disorder caused by brain damage (e.g., cerebrovascular accident) that impairs a person’s ability to understand, produce and use language (La Pointe, 2001). This difficulty with comprehending as well as retrieving words may arise from the dysfunction of various aspects of the cognitive structure and processing function of the semantic memory in the brain (Raymer & Rothi, 2008).

Semantic memory is a subcomponent of memory that refers to the general knowledge that people share about the world, for example, that “bananas are long and yellow” (Tulving, 1972). Semantic memory is a system that supports long-term knowledge of words and objects meaning. This knowledge is stored separately from episodic memory; or, memories referring to a specific episode or context such as “I had a banana for breakfast today” (Tulving, 1972). It is critically important to understand how the semantic memory/system operates in a person’s brain due to its implications for language and cognitive functions, including the ability to recognize, recall, understand and produce words and sentences (Saumier & Chertkow, 2002). Impairments of semantic processing (i.e., the cognitive act of accessing stored knowledge about the world) have been reported in a variety of brain disorders such as fluent aphasia, Alzheimer’s disease, semantic dementia, schizophrenia, and autism (Binder, Desai, Grave, & Conant, 2009). (See chapter 2 for a more specific explanation of the semantic memory/system).
Most researchers argue that patients with aphasia comprehend common, frequently and familiar occurring materials better than uncommon, rare or unfamiliar materials (Shewan & Bandur, 1986; Funnel & Sheridan, 1992). Moreover, it has been widely acknowledged that the lexical semantic representation of a lexical-concept, that is, the knowledge of a word’s meaning, is composed of semantic features. Semantic features are characteristics that contribute to the meaning of a lexical unit (a word). For example, *has four legs*, *has fur*, *is a pet* and *barks* are semantic features of the word *dog*. The use of semantic features in aphasia therapy seems to be one variable that helps to improve comprehension and naming performance of individuals with aphasia (Boyle & Coelho, 1995; Coelho, McHugh & Boyle, 2000; Boyle, 2004). An important, yet unanswered question about semantic features is whether they are cognitively represented and organized in a certain way that would impact lexical semantic knowledge in individuals with aphasia.

The use of semantic features analysis (SFA) treatment has been reported as an important approach for word retrieval or naming deficits in aphasia (Boyle & Coelho, 1995; Coelho, McHugh & Boyle, 2000; Boyle, 2010). According to the lexical (word) processing theory, the use of semantic features in naming therapy increases the likelihood that the individual with word retrieval impairments will be able to activate and consequently produce the target word (Boyle & Coelho, 1995). Lombardi & Sartori (2007) posited that when one tries to name a lexical item (e.g., picture or object), the features for that item are activated in the semantic memory network. The lexical item with the greatest amount of feature activation in the semantic memory network is the one
that will be selected (Caramazza, 1997). The activation of the lexical item then spreads to the phonological representation and a motor program executes the production of the target word (Levelt, 2001). (See chapter 2 for a better explanation of the lexical processing theory).

Certain issues regarding the use of semantic features in naming therapy still arise as a central theme of investigation. First, there is still a need to see whether semantic features can be classified in a way that helps us better assess and treat language deficits in aphasia. Second, it is essential to determine whether semantic features can be scaled in a structured manner that would systematically affect lexical semantic knowledge in individuals with aphasia. Third, if that is the case, there is a need to determine whether presenting semantic features in a hierarchical manner serves as a more effective method of therapy for individuals with aphasia.

Some researchers have investigated the role of feature classification in individuals with aphasia (Germani & Pierce, 1995; Cox, 2009; Mason-Baughman & Wallace, 2013). These authors support use of feature importance as the method of scaling lexical semantic knowledge. Germani & Pierce (1995) investigated the type of semantic features available to subjects with unilateral brain damage as well as to subjects with no history of disorders in cognition and language. A sorting task involving nouns with high, mid, and low frequency-of-occurrence and high and low importance features of each noun was employed. The results showed that the individuals with brain damage identified high importance features across all levels (e.g., high, mid and low) of frequency of occurrence nouns as accurately as did the healthy individuals. On the other hand, the individuals
with brain damage were impaired in the identification of low importance features for mid and low frequency of occurrence nouns. Germani & Pierce (1995) only investigated two of the three possible levels of the feature importance hierarchy in individuals with aphasia. That is, their research studied “high” versus “low” importance features, but did not investigate the “mid” importance level.

Another study by Cox (2009) involved the investigation of semantic features by importance versus centrality. Although the authors studied the three levels (e.g., high, mid, and low) of the feature importance hierarchy and compared those with feature centrality hierarchical levels (e.g., high, mid and low), they found results consistent with Germani & Pierce’s (1995) research. Namely, Cox’s (2009) study showed that high importance features were identified with their appropriate nouns more accurately than were both mid and low importance features. In addition, the authors found that the ability of individuals with aphasia to sort semantic features with nouns is influenced more by levels of importance than by centrality. More recently, Mason-Baughman & Wallace (2013) investigated differences in distinctive feature knowledge across importance levels in individuals with aphasia grouped according to their ability to distinguish target words from semantically related foils. Results for this study showed that group of people with aphasia who demonstrated difficulty identifying target words among semantic related foils, also had greater deficits with low importance and distinctive features knowledge in comparison to those who were able to choose among semantic related foils.

The present study aimed to build upon the work of previous research in order to further investigate how lexical semantic knowledge is represented and organized in
individuals with aphasia. According to Sartori, Lombardi & Mattiuzi (2005), feature relevance indicates a parameter that indexes the salience of a feature in concept identification. Furthermore, Sartori and Lombardi (2004) proposed a model of semantic memory to measure semantic features for a concept. In this model, semantic relevance represents the “core” meaning of a concept (Sartori, Lombardi & Mattiuzi, 2005). The “core” meaning of the concept is defined as those features that most identify the concept and, at the same time, discriminate it from other similar concepts.

The results of a pilot study by Scheffel (2010) showed that organizing features by relevance did create a different hierarchy than organization by importance in adults with no history of disorders in cognition and language. Therefore, it is reasonable to examine whether individuals with aphasia are more cognitively sensitive to feature importance or feature relevance ratings. The key aim of this research is to be able to determine which feature classification, importance or relevance, best influences the lexical semantic knowledge of individuals with aphasia.
CHAPTER II

REVIEW OF THE LITERATURE

The Use of Semantic Tasks to Evaluate the Semantic Memory/System in Individuals with Aphasia

The effect of left hemisphere cerebral stroke on the language system usually leads to linguistic deficits. The field of cognitive neuropsychology has been critical to the development of assessment of these linguistic deficits in individuals who have aphasia. According to Caramazza (1984, pp. 9-10), the goal of cognitive neuropsychology is to “provide formal categorization of the mental structures and operations that subserve that human cognitive capacity.” Namely, cognitive neuropsychological assessment of language abilities has become a widely accepted approach to the assessment and treatment of individuals with aphasia because it aims to identify which components of language processing are impaired and which ones are functioning relatively normally (Cole-Virtue & Nickels, 2004). As a result, researches have employed a wide variety of tasks in order to assess the semantic structure and processing in the brain following a stroke. Two typical standardized tests used in the evaluation of semantic processing are the Florida Semantic Battery (Raymer & Rothi, 2001) and the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart, 1992). The tasks that are typically used in these standardized tests to investigate lexical semantic impairments include: Oral naming of pictures, written naming of pictures, oral naming to spoken definition, reading words aloud, writing words to dictation,
cross-modal matching (e.g., auditory and/or written word-to-picture matching), associative matching (e.g., match spoken words to associated spoken word and match picture to associate picture) and category sorting (e.g., sort pictures into semantic categories and sort written words into semantic categories). Each of these tasks involves a specific aspect of the semantic system processing; therefore, in order to understand the effect of any task on the language processing system, it is very important to know about the underlying cognitive-linguistic framework and the associated functional anatomy of the task. In the present study, two tasks involving the processing of single words in the semantic system were utilized: These were: sort written semantic features to the written corresponding semantic noun, and identification of heard-written words/phrases. The cognitive-linguist components of these tasks are described using the models of word production (Dell, Martin, Saffran, Schwartz, and Gagnon, 1997; Levelt, Roeolf, & Meyer, 1999; Goldrick & Rapp, 2002).

**Models of Word Production**

The inability to successfully retrieve words is a persistent symptom of language breakdown in aphasia (Dell et al., 1997). Contemporary researchers have developed theoretical models of spoken word production to explain how a word’s meaning and its sounds are retrieved in healthy individuals as well as in individuals with brain damage (Dell et al., 1997; Levelt et al., 1999; Goldrick & Rapp, 2002). The process of producing a word begins with an image in mind and ends with the articulation of a sound sequence that makes up the word a person has learned to associate with that concept (Martin, 2013). These theories all posit that there are at least three levels of cognitive
representation involved in the production of words: semantic, lexical, and phonological 
(Goldrick & Rapp, 2002). In addition, Goldrick & Rapp (2002) stated that the lexical 
level is linked to a set of syntactic features to specify grammatical categories such as 
voice, number, tense, word class, etc.

Although the theories of word production agree that naming involves the 
activation of semantic, lexical and phonological processes, and that these processes occur 
sequentially, there is a disagreement among authors whether the levels of cognitive 
representation are discrete or interactive (Caramazza, 1997, Goldrick & Rapp, 2002). 
Discrete theories assume that the semantic, lexical and phonological processes are 
independent, with the semantic processing level being completed before the lexical level, 
and the consequently before the phonological level processing begins (Levelt et al. 1999). 
Interactive theories assume instead that activation flows continuously between semantic, 
lexical and phonological stages (Dell et al. 1997). The fact that semantic, lexical and 
phonological processes overlap in time and influence each other can explain a variety of 
errors related to word production (e.g., paraphasias) (Dell et al. 1997). Figure 1 from 
Schwartz et al. (2009) shows a representation of the two models of word production.

These models of word production apply a psycholinguistic approach to the 
interpretation of the processes concerned with comprehension and production of spoken 
words and sentences. They generally assume that there are two cognitive-linguistic 
processes involved in mapping from a conceptual/semantic representations (e.g., furry, 
feline, domestic) to the set of phonemes (sounds) used to express that concept (/k/, /æ/, 
/t/) (Goldrick & Rapp, 2002). After hearing a word, seeing a picture or reading a word,
the process of understanding and producing a word begins at the conceptual level. A concept is a non-linguistic representation that can be stimulated either by intention of the speaker or by some sensory input (e.g., seeing a bird, hearing an ambulance or smelling a pie baking) (Martin, 2013). The first stage of the word production process begins when the conceptual semantic representation activates the semantic features network of the word in the semantic memory (Dell et al., 1997). If the word to be spoken is *cat*, then semantic features (e.g., animal, furry, domestic) linked to the concept *cat* will be activated. After that, the activation from semantic features spreads to the lexical semantic network where it activates the target word (i.e., *cat*) and also the syntactic

**Figure 1.** Discrete Model of Word Production by Levelt et al. (1999) on the left and Interactive Activation Model of Word Production by Dell et al. (1997) on the right.
information such as a word’s grammatical category (e.g., dog, rat). This syntactic information is referred as lemma (Level et al, 1999). The first stage ends with the selection of the strongest lexical activation, which should be the target word cat. However, semantic and syntactic competitors (e.g., dog, rat) might play a role and interfere in the activation of the target word. Next, once the word form is retrieved, the second stage, phonological encoding, is activated and the sounds of the target word are ordered and retrieved (Martin, 2013). In this stage, the phonemes of semantic and syntactic competitors also compete with the phonemes from the target word (Goldrich & Rapp (2002).

The loss of precision in the mapping from lexical-concepts to words, many times resulting in naming deficits, is a common symptom in aphasia (Schwartz et al. 2009). These deficits can occur either from incorrect activation of words in the lexical network (e.g., dogs share some features with cats - legs, walks, has fur) (Schwartz, Wilshire, Gagnon & Polansky, 2004) or from failure in the bi-directional linking between semantic features and words, and words and phonemes (Schwartz, Dell, Martin, Gahl, & Sobel, 2006). Individuals with aphasia presenting semantic related errors (e.g., “sofa” for “chair” or “elephant” for “zebra”) appear to have a deficit in the semantic level (Hillis, Rapp, Romani & Caramazza, 1990; Howard & Getehouse, 2006). That is, semantic errors arise when a correct semantic representation (e.g., semantic features for the concept bus) is mapped to the wrong word (e.g., truck) (Schwartz et al. 2009). On the other hand, individuals with aphasia who demonstrate phonological errors may have
impairment in the phonological level (e.g., “roast” for “road”) (Caramazza, Papano & Rumel, 2000).

**Lexical versus Conceptual Semantic Knowledge**

The distinction between lexical and conceptual levels of semantic representation has received significant attention in the last decades (Nickels, 2001). According to Bierwisch and Schreuder (1992), conceptual-semantics is “language independent and pre-linguistic” (pp. 25-26), and lexical-semantics is associated with “linguistic knowledge” (p. 26). For example, the lexical-semantic representation for “dog” would be its features: barks, has four legs, has a tail, has fur, is a pet. Moreover, Bierwisch and Schreuder (1992) argued that not all conceptual representations necessarily have a lexical word associated with it. For example, the concept of a male duck or male swan can be expressed respectively as drake and cob. In other words, there is a single lexical item that represents the gender of those concepts. On the other hand, there are no single lexical items that represent the concepts for the male robin or crow. That is, these concepts have to be expressed using two words (Bierwisch & Schreuder, 1992).

Another distinction that illustrates the difference between lexical and conceptual semantics comes from individuals with aphasia who, despite profound lexical-semantic impairment, continue to use objects appropriately (Nickels, 2001). That is, individuals with aphasia may have a problem with the meaning of a lexical item (i.e., they cannot point to a knife or a fork when asked to, but they will still cut with the knife and not with the fork) (Nickels, 2001). The claim in this case is that conceptual-semantics, “the
concept of knife,” is intact while lexical-semantics, “the meaning associated with the
word itself,” is impaired (Nickels, 2001).

Lexical-semantics implies that words in isolation have meaning (Miller, 1999). Levelt et al. (1999) postulated that what one tends to express should be interpreted as the “lexical-concept” for which there exist words in a specific language. It is assumed that words that are used referentially (i.e., nouns, verbs, adjectives, adverbs) acquire their meaning by virtue of the concepts that they represent (Miller, 1999). For the purpose of this paper, the term lexical-concept is used to refer to the conceptual entity and the term lexical-semantics is used to refer to the meaning of that entity.

![Diagram](image)

**Figure 2.** Lexical-concept versus lexical-semantics

**Neural Structures Underlying Semantic Knowledge**

Although the present research was mainly based on the functional structure of the semantic system (e.g., models of word production), understating the neuroanatomical network concerned with the comprehension and production of words can provide us important clues regarding the different regions of activation involved with different
functional components of the word production models. Several studies using
europsychological lesion studies of patients with brain damage as well as neuroimaging
studies (e.g., PET, fMRI) of neurological healthy individuals have attempted to answer
questions regarding the representation, organization and retrieval of semantic knowledge.
In the vast majority, for example, functional neuroimaging studies agree that language
relevant cortex includes Broca’s area in the inferior frontal gyrus, Wernicke’s area in the
superior temporal gyrus, as well as parts of the anterior and posterior temporal lobe, and
the inferior parietal and angular gyrus in the parietal lobe (Price, 2000; Martin & Chao,
2001; Friederice, 2011).

Auditory and visual analyses clearly take place in the auditory and visual cortices
in the respectively temporal and occipital lobes bilaterally. Syntactic and semantic
processes are supported by separable frontal-temporal networks in the left hemisphere
(Friederice, 2011). For example, a study using functional magnetic resonance imaging
(fMRI) by Hauk, Johnsrude, & Pulvermuller (2004) showed that reading action words
that are semantically related to different body parts (e.g., kick, pick, lick) activates the
frontal network in the motor and premotor cortex. Similarly, reading or naming words
associated with tool actions (e.g., hammer) activate the sensorimotor regions of the brain
(Chao, Haxby & Martin, 1999). In addition, neuroimaging studies suggest that
knowledge in the mental lexicon is represented by a distribute network of features mainly
processed in the left temporal cortex (Martin & Chao, 2001, McClelland & Rogers, 2003)
and it is selected and retrieved in the left prefrontal and frontal regions of the brain
(Thompson-Shill, 2003).
When referring to lexical semantic knowledge, some studies have demonstrated that the temporal cortex has been implicated in lexical semantic processing and naming impairment as a function of lesion location (Damasio et al., 1996, Antonucci et al., 2008). In particular, case studies documenting lesions to the left posterior temporal cortex (Brodmann Area 37) provide evidence of anomia (i.e., lack of recall for the proper word in the process of naming or in the course of a sentence) with preserved semantic knowledge (Damasio et al., 1996). Damage to this area, typically observed in chronic stroke patients, leads to semantic circumlocution naming errors (e.g., bed: it’s something to sleep on) with relatively intact conceptual knowledge as well as phonological abilities (Antonucci et al., 2008). This type of naming impairment, known as “pure anomia”, has been reported to result in a disconnection between preserved semantic knowledge and phonological word forms (Damasio et al., 1996; Raymer et al., 1997; Antonucci et al., 2008). On the other hand, naming impairments resulting from loss of semantic knowledge have been documented with damage to more anterior left temporal lobe regions (Brodmann areas 38, 20/21). Semantic dementia (Davies, Graham, Xuereb, Williams, & Hodges, 2004) epilepsy (Bell et al., 2001) and herpes simplex encephalitis (Moss, Rodd, Stamatakis, Bright, & Tyler, 2005) have been associated with damage to these areas of the brain. Antonucci, Beeson, Labiner & Rapcsak (2008) claimed that naming deficits in patients with more anterior left temporal lobe lesions seem to be related to degradation of semantic knowledge, resulting mostly in semantic anomia. In general, individuals with semantic anomia demonstrate semantic paraphasias (e.g., beaver; chipmunk), circumlocutions (i.e., speaking in a roundabout way), as well as
deficits in language comprehension (Antonucci et al., 2008). Taken together these neuroanatomical studies have attempted to provide us with an account of the brain-language related map corresponding to the theoretical framework of the language, which is represented by the semantic system in the models of word production.

**Lexical-Semantic Knowledge in Individuals with Aphasia**

**Comprehension in Aphasia**

Auditory verbal and reading comprehension deficits resulting from left hemisphere stroke are often seen in individuals with aphasia (Pierce, 1995; Jacobs, 2001). These deficits can range from severe to mild. Individuals with aphasia presenting severe auditory comprehension deficits usually demonstrate difficulties understanding common single words, whereas having trouble understanding certain aspects of a more extensive discourse is a characteristic of mild impairment (Pierce, 1995).

In order to comprehend a word, one rapidly activates a concept in the semantic memory (Davis, 2000). However, as mentioned above in the literature, knowledge of concepts and knowledge of words means two different things. A concept is related to the world knowledge and mental representation that we have about a class of objects or actions, while knowledge of a word’s meaning involves activation of the mental lexicon stored in the lexical memory (Davis, 2000). That is, our mental lexicon contains what we know about words: word form (lexeme) (Caramazza, 1997), grammatical category (lemma) (Levelt et al., 1999), and semantic features (e.g., “red skin”, “juicy” and “fruit” are features for the word “apple”) (Dell et al., 1997).
In addition, there are several factors (e.g., word frequency of occurrence, familiarity, word length, concreteness and/or imagery) that are thought to influence one’s understanding of spoken and written language (Toglia and Batting, 1978, Cole-Virtue & Nickels, 2004). Since the 1970s, word frequency of occurrence in a language has been an important domain in the discussion about which words should be selected in the treatment of individuals with comprehension problems (Toglia and Batting, 1978). Francis and Kucera (1982) established norms for frequency of occurrence based on how often words occur in a language as a general guideline for word selection. Their list consisted of high (>40/million), mid (10-15/million), and low (<8/million) frequency nouns.

A shared finding in studies of healthy language processing is that high-frequency words are perceived and produced faster and more efficiently than low-frequency words (Jescheniak & Levelt, 1994, Cole-Virtue & Nickels, 2004). In addition, models of lexical processing assume that high frequency words create higher levels of activation that allows them to overcome lexical competition more quickly (Dell, 1986). Butterworth, Howard & McLoughlin (1984) and Germani and Pierce (1995) investigated word frequency effects in relation to the performance of individuals with aphasia on spoken word-picture matching tasks. Butterworth et al. (1984) found no significant effects of word frequency on performance. However, Germani and Piece (1995) found that word frequency had a significant role in the accuracy of high versus low feature importance identification. They suggested that the comprehension of participants with aphasia was
influenced by word frequency and that it might also affect the depth of their comprehension.

Recent work by Hoffman, Jefferies & Lambon Raph (2011), however, suggested that word frequency effects are small or absent in individuals with aphasia due to stroke. The authors used a delayed repetition task with two patients with impaired semantic control to investigate word frequency effects in aphasia. Results showed that there was a significant repetition advantage for low-frequency words compared to high-frequency words. This advantage was related to many perseverative errors where low-frequency words were produced in place of high-frequency words. According to Hoffman et al. (2011), these preservative errors indicated that high-frequency words are more weakly activated than low-frequency words in individuals with aphasia. A possible explanation for these results was that comprehension of high-frequency words is more difficult for these patients because high-frequency words tend to appear in a wide range of linguistic contexts and can be also associated with different semantic information (Hoffman, Jefferies, & Lambon Ralph, 2011). Consequently, it seems that role of word frequency in the lexical process of spoken word recognition is well established (Francis and Kucera, 1982), but the effects of word frequency on the semantic processing of spoken word comprehension are not yet very clear.

Cole-Virtue & Nickels (2004) used a spoken-word to picture matching task from PALPA to investigate several psycholinguistic variables (e.g., frequency, imageability, number of phonemes, semantic and visual similarity and word association) affecting performance on comprehension in 54 participants with aphasia and 51 elderly control
participants. Three variables were found to significantly affect performance of the individuals with aphasia: Imageability, semantic similarity and word association. Improved performance was observed for those words that were highly imageable and associated, but less semantically similar to the target word.

Pierce (1995) pointed out that even when a patient selects a picture correctly from an array of verbally presented choices; one still does not necessarily know what that patient knows about that particular word. Butterworth et al. (1984) found that individuals with aphasia were able to identify the correct picture from an array of five pictures that were semantically unrelated (e.g., apple, shoe, car, horse and saw), but when the same task involved semantically related pictures (e.g., hammer, drill, screwdriver, axe, and saw), the subjects had significant difficulty identifying the requested word. Word comprehension has also been studied through word-sorting and other metalinguistic tasks (Davis, 2000). The study by Germani and Pierce (1995) noted above showed that individuals with aphasia were able to match “high importance” features to a noun (e.g., wings to bird), but were less accurate in matching “low importance” features (e.g., sings to bird).

The number of items displayed (e.g., array size), and the extent to which the items are related to each other appears to be an aspect that affects patients’ performance in diagnostic and treatment tasks in which individuals with aphasia are asked to point to a picture or printed word from a display of choices (Pierce and Patterson, 1996). These conditions were not observed by Howland and Pierce (2004). The authors examined the influence of semantic relatedness and array size on single-word reading comprehension.
in aphasia. Ten individual with aphasia were asked to point to the word said by the examiner. The words varied in terms of category (e.g., fruits, vegetables, sports, furniture, vehicles, clothing, toys, birds, weapons and tools) and array sizes (e.g., two, four, six, and eight related or unrelated words). Results showed that individuals with aphasia had significantly more difficulty choosing among related words than unrelated words at all array sizes. The authors postulated that this finding is consistent with the notion that many individuals with aphasia have impaired semantic representations (Germani & Pierce, 1995) and that it might be hard for them to distinguish among similar concepts (Butterworth et al., 1984). Another interpretation was that individuals with aphasia are more impaired in their knowledge of distinguishing features that are essential for choosing among related items (e.g., a cat purrs but a dog does not) than of shared features (e.g., cats and dogs are animals but a hat is not).

More recently, Mason-Baughman & Wallace (2013) investigated the relationship between feature knowledge and the ability to choose among semantically related and unrelated foils in individuals with aphasia. Tasks for choosing among semantically unrelated and related foils as well as sorting tasks involving common and distinctive features controlled for mid and low semantic features importance were completed by 14 individuals with aphasia (see the next section for an explanation of feature importance). The authors reported that the individuals with aphasia who had difficulty choosing among semantically related foils had significantly more difficulty identifying low importance and distinctive features than those who were able to choose among semantically related foils. The authors also reported significant correlations between scores on tests of
comprehension and distinctive feature identification, suggesting that distinctive feature knowledge contributes to the integrity of semantic representation in people with aphasia.

**Category Specific Deficits**

Humans’ semantic memory consist of knowledge about the world, such as what we know about tools, animals, clothes, negotiating, cooking, etc (Shelton & Caramazza, 2001). How semantic memory is represented and organized in the brain is still a central question of discussion among researchers. As result of brain damage (e.g., stroke), some individuals might demonstrate selective preservation or selective impairment of language processing for specific semantic categories (e.g., living things vs. nonliving things) (Hillis & Caramazza, 1991; Warrington, 1981; Warrington & McCarthy, 1987; Warrington & Shallice, 1984). For instance, Warrington (1981) presented the case of JBR, an individual with aphasia, who was 45/48 (94%) correct on identifying and demonstrating understanding (i.e., defining the attribute for particular semantic categories) of non-living things, and only 2/48 (4%) correct on identifying and demonstrating understanding of living things. In addition, JBR was impaired not only for living things but also for categories such as musical instruments, gemstones, metals, fabrics, and foods (Warrington & Shallice, 1984). These findings have motivated a second theory in which the major organizing principle of the semantic system is the type of semantic feature rather then different categories. Warrington and colleagues (Warrington & Shallice 1984; Warrington & McCarthy, 1987) stated that category specific effects result from damage to two separate semantic subsystems: perceptual or non-perceptual knowledge. The authors claimed that the identification and understanding
of categories such as musical instruments and gemstones functioned similarly to identification and understanding of living things, and therefore, these categories are viewed as part of a perceptual/sensory knowledge, whereas the identification and understating of non-living things such as body parts is associated with non-perceptual/functional knowledge.

In another study, Coltheart et al. (1998) described the case of AC, a left hemisphere stroke patient, who was diagnosed with impaired visual conceptual knowledge. Assessments showed that AC’s early visual processes were intact. However, AC demonstrated difficulty accessing the structural description of animals using vision. To be exact, when given pictures of real animals and nonsense animals, AC’s performance in distinguishing real and nonsense animals was close to chance (poor), while his performance on the same test using objects was within the normal range (good). He also scored below chance on questions about perceptual attributes of objects such as “Does a bicycle have wheel?” or “Is a bubble round?” On the other hand, AC performed normally for answering non-perceptual attributes, auditory and olfactory attributes questions, such as “Is an elephant Australian?” or “Is a snake dangerous?” The claim in this study was that AC had only a visual perceptual problem, an impairment to the visual semantic subsystem. However, the argument posed by Coltheart et al. (1998) regarding the association of visual perceptual problems to impairment to the visual semantic subsystem is subjective. Caramazza et al. (1990) argued that category-specific deficits could be explained by the unitary semantic theory when applying the organized unitary conceptual hypothesis (OUCH). According to OUCH theory, there are some salient
features of the visually presented object that are going to have privileged access to its semantic representation, and therefore, support the correct gesturing of the use of an object. That is, the OUCH theory explains that when seeing, touching or hearing something, some attributes that are going to be activated more strongly than others. As a result, this happens not because we have multiple semantic subsystems, but because there is privileged accessibility for different information depending on the task that is being performed. In addition, Caramazza et al. (1990) pointed out that AC’s visual semantic knowledge was not completely impaired. Most likely, AC was able to answer some visual attributes questions related to animals because some visual attributes had privileged accessibility in AC’s semantic system.

Furthermore, Funnell & Sheridan (1992) pointed out the importance of controlling for familiarity when investigating category-specific deficits. The authors argued that early studies of category-specific performance failed to control for the familiarity factor. Consequently, some other studies have shown that when familiarity is controlled, category-specific deficits tend to reduce or disappear (Funnell & Sheridan, 1992; Satori, Coltheart, Miozzo & Job, 1994). Sartori, Polezzi, Mameli & Lombardi (2005) claimed that semantic memory is based on the distinction between sensory and non-sensory semantic features rather than categories. The authors used the amplitude of N400, a negative-going ERP (event related potential) component that peaks at around 400 ms after the onset of a content word, as evidence for a neural organization of semantic memory based on semantic features. Twenty-four Italian undergraduate students were required to answer yes or no as an indication of whether the three semantic
features verbally described correctly indexed the concept presented or not (e.g., {has a carriage}, {found in the airport} and {found in the sky} following by the presentation of the target word {airplane}). A total of 80 concepts were used. The features presented were matched for low versus high relevance and sensory (e.g., “has four legs” for the concept “dog”) vs. non-sensory (e.g., “used for hunting” for the concept “dog”). Also, the target words were matched across categories (living and non-living). Scalp voltages were collected using an Electrocap and ocular movements were monitored through four electrodes fixed close to the eyes. The N400 signal was recorded in the frontal, temporal, parietal, and occipital areas of the brain. The study findings suggested a large N400 effect when semantic features with a low relevance were tested. This means that low relevance descriptions index with more difficult the target concept. In addition, the study showed that there was no difference between living and non-living concepts when relevance was matched. That is, when category-specific concepts were matched for relevance features, the category effect disappeared. In sum, perhaps paying attention to factors such as familiarity, frequency of occurrence, and representation of semantic features could help us to understand and determine how individuals with aphasia best access lexical semantic knowledge in the brain, thus playing an important role when developing new aphasia language treatment approaches.

Based on the hypothesis about category dissociations (e.g., living vs. non-living) and the claim that the structure of the conceptual system is represented by a set of features, some which are distinctive (e.g., occurring only in one or two concepts), and some of which are shared across many concepts, Randall, Moss, Rodd, Greer and Tyler
(2004) asked forty-five healthy adults to list all of the features they could think of for a set of 93 objects from living and non-living categories, including animals, fruits, vehicles, and tools. Participant’s responses were then compiled to produce a feature list for each concept in order to calculate the interaction between distinctiveness and correlation in the living and non-living domains. Results showed that the correlation strength among distinctive features was significantly greater for non-living things than for living things. The authors claimed that distinctive features in the living domain are more vulnerable because of their weak correlation to other features. This weak correlation makes them particularly slow to be activated in comparison with the distinctive features of non-living things, which tend to be correlated with each other. These results were confirmed in a speeded features verification task in which twenty-six college students, using a computer screen, were instructed to press “yes” if there words seen on the screen (e.g., word and feature) were related and “no” if they were not. Results indicated that participants had slower reaction times for verifying the distinctive features of living things when compared to the reaction times of distinctive features of non-living things. In conclusion, the authors claimed that in the conceptual structure theory, what will delay access and make performance more error-prone is the fact that the distinctive features of living things are weakly correlated with other features.

**Semantically Based Therapy**

One of the main components of treatment for individuals with aphasia is to improve their lexical-semantic knowledge. Recently, several single-subject studies have reported the use of semantically based therapy as a treatment for word retrieval
impairments in aphasia (Boyle and Coelho, 1995; Lowell, Beeson, & Holland, 1995; Drew & Thompson, 1999; Coelho, McHugh, and Boyle, 2000). Outcomes of these studies have shown improved confrontation naming of trained items, but results have varied regarding maintenance of treatment effects and generalization to untrained items.

One approach for improving lexical-semantic knowledge is Semantic Feature Analysis (SFA). Boyle & Coelho (1995) investigated whether SFA was successful for treating word retrieval deficits in an individual with mild aphasia. In this technique the participant was requested to produce words semantically related to the target. For example, the individual was asked to list the target word’s group, use, action, properties, location, and association. The authors believed that by activating the lexical-semantic network surrounding the target word, that word may be activated above threshold, thus facilitating retrieval of the target word. Results showed that SFA was associated with improved confrontation naming of trained and untrained stimulus items, but not with measures of connected speech. Coelho, McHugh, & Boyle (2000) replicated the Boyle & Coelho (1995) study using SFA treatment approach with an individual with a moderate fluent aphasia secondary to a closed head injury. Results indicated an improvement of confrontation naming on trained and untrained items. However, the authors reported only fairly small progress on measures of connected speech.

Another approach for improving lexical-semantic knowledge is the Typicality Treatment (Kiran & Thompson 2003; Kiran & Johnson, 2008; Kiran, 2008). Like most of the semantic treatments, the typicality treatment aims at facilitating access to lexical items to improve naming abilities (Kiran, 2008). With the goal of improving naming,
Kiran and Thompson (2003) investigated the effects of typicality on naming skills in four patients with anomia. Typical and atypical examples were used within semantic categories in a variety of semantic features related tasks (e.g., naming pictures, sorting pictures by category, identifying semantic attributes to a target example, and answering yes/no questions). Results showed that when participants were trained on naming of atypical items, they were able to demonstrate generalization to naming of intermediate and typical items. On the other hand, no generalization to naming effects on atypical or intermediate items was observed when participants were trained on typical items.

In a second study, Kiran and Johnson (2008) investigated the response of three other participants with fluent aphasia to typicality treatment by examining well-defined categories (e.g., shapes – typical: octagon; atypical: spade). Similar results to the Kiran and Thompson (2003) study were observed. Two of three participants trained with atypical features showed improvements to both trained and untrained typical features in the category. In the contrast, training typical features in one participant did not improve naming of atypical features. According to Kiran (2008), studies showing treatment on atypical items with emphasis on features relevant to atypical and typical item leads to an increase retrieval of trained and untrained items (generalization). In contrast, treatment on typical items does not emphasize features relevant to atypical items, therefore, showing no generalization to untrained items. Kiran’s claim is that focusing treatment on atypical items helps to strength access to a wide range of features across a certain category. On the contrary, treatment focusing on typical items contributes to strength access to features that are shared only by similar examples.
Drew and Thompson (1999) examined the effects of a semantic-based treatment on acquisition, generalization and maintenance of picture naming in four individuals with Broca’s aphasia and severe naming deficits. The treatment consisted of three parts: sorting tasks (e.g., for clothing items, participants were asked to sort by size, material, use and location in the body); yes/no semantic judgment task (e.g., “Is it used to tell time?” for the target “watch”) and definition-to-picture matching task (e.g., the examiner presented five food items, including lemon, and asked the participant to “point to the sour fruit that grows on trees”). After that, an additional semantic treatment with orthographic and phonological information about the target words was provided to all participants. Two of the four participants improved naming for both trained and untrained items after the semantic treatment. The other two only improved naming skills after treatment focusing on the phonological form of the word was stressed in the treatment.

Lowell, Beeson & Holland (1995) explored the effects of self-selected semantic cues on naming performance of three individuals with fluent aphasia. Training consisted of having each participant read four cues aloud (e.g., sit in, household, furniture and cushions), and then name the target word (e.g., sofa). Then, the subjects were probed for naming performance of untrained items. A written corrective option with three written choices, including the target, was given when items were named incorrectly. The participants were asked to read the correct choice aloud. Generalization was compared by examining the performance of trained versus untrained items. Results showed improvements of naming performance on trained items with robust generalization to untrained items for two of the three participants. The authors concluded that using
semantic cuing as a naming strategy can be beneficial when word retrieval difficulties arise.

These studies represent a variety of findings on improving naming skills in individuals with aphasia. However, the treatment approaches cited above disregard a systematic organization of semantic features. Therefore, there is still a need to investigate whether a systematic organization of semantic features in semantic-based treatment approaches would contribute or not to enhance comprehensive and retrieval of words abilities in individuals with aphasia.

**Ways of Classifying Semantic Features**

The literature described above underscores the notion that lexical-semantic knowledge can be represented by semantic features. Individuals with aphasia have differential abilities with some types of features compared to others. In addition, treatment based on improving feature knowledge may improve language skills in people with aphasia. Accordingly, efforts to determine effective ways to organize features may be beneficial. Three of the organizations that have been discussed in the literature are importance, centrality and relevance. Two of these have been studied in individuals with aphasia (importance and centrality). This study looked at the third, relevance. In addition, the study aimed to compare feature relevance and feature importance to determine which classification influences more the ability of individuals with aphasia to associates features with the appropriate nouns.
Feature Importance

Hampton (1979) investigated the importance of semantic features for defining lexical-concepts through a series of surveys completed by normal adults. Hampton suggested that features can be systematically ranked for importance in defining a lexical-concept. The study showed that when participants ranked features for their importance in defining a lexical-concept there was a significant relationship between the mean ranked importance of features and the frequency with which the features were produced.

Germani and Pierce (1995) investigated the effect of semantic feature importance in individuals with aphasia. The authors used a sorting task to investigate the ability to associate features with high, mid, and low frequency of occurrence nouns. An example of the importance rating was “four legs” and “mane” as high important features and “runs fast” and “eats oats” as low importance features in identifying the lexical-concept of “horse”. This study showed that individuals with aphasia could identify high-importance semantic features in high, mid and low frequency of occurrence nouns. However, the individuals with aphasia had impaired identification of low-importance features for mid and low frequency of occurrence nouns. Moreover, the results demonstrated that the ability to identify low-importance features was significantly correlated with naming and auditory comprehension skills. Mason-Baughman and Pierce (2007) found results consistent with those reported by Germani and Pierce (1995) in that individuals with aphasia had a better performance in the identification of high-importance semantic features when compared to low-importance semantic features. However, Mason-Baughman (2009) and Cox (2009) observed that differential effects did not extend to the
mid level of importance. That is, there were not three different levels in the ability of individuals with aphasia to associate semantic features with their nouns. High-importance features were identified more accurately than mid-importance and low-importance features which did not differ from each other in terms of accuracy. These studies showed that lexical-semantic knowledge in persons with aphasia is affected by the importance of features, but only in that high-importance semantic features are identified more accurately than are mid and low-importance semantic features.

**Feature Centrality**

Sloman, Love and Ahn (1998) defined centrality as the degree to which a feature is integral to the mental representation of an object, or the degree to which a feature lends lexical-conceptual coherence. For instance, a robin that does not eat is harder to imagine than a robin that does not chirp. Therefore, eating would be a more central feature to the concept of a robin than chirping. The authors claimed that feature centrality can be identified by examining the mutability of features. After studying feature centrality in the normal population, the authors found that features can be reliably ordered according to their mutability by using tasks that require people to imagine objects missing a feature. For example, tasks to measure feature centrality would include the following: (1) Surprise to encounter the object without the feature (i.e., How surprised would one be to encounter an apple that did not grow on trees?), (2) Ease-of-imagining the object without the feature (i.e., How easily can one imagine a real apple that does not grow on trees?), (3) Goodness-of-example without the features (i.e., How good an example of an apple would one consider an apple that does not grow on trees?), and (4) Similarity-to-an-ideal
object category (i.e., How similar is an apple that does not grow on trees to an ideal apple?). Strong correlations were found among the mutability measures suggesting that they were similar in content.

Cox (2009) carried out a pilot study to investigate whether feature importance and feature centrality represented different ways of organizing semantic feature knowledge. Twenty normal adults participated in a feature rating task. The author stated that, in an attempt to determine centrality ratings for each feature, the participants rated their level of “surprisibility” on encountering a real object (represented by each noun) that was missing a specific feature. (e.g., by responding to a question such as: “How surprised would you be to encounter a real cherry that does not grow on a tree?”). The following ratings were used: 0 = unrelated, 1 = not surprised, 2 = a little surprised, 3 = quite surprised and 4 = very surprised. Similar to the importance ratings established by Germani and Pierce (1995), Cox (2009) stated that high centrality had ratings of 4.0 - 3.0, mid-centrality ratings of 2.9 – 2.0 and low-centrality ratings of 1.9 – 1.0. A chi-square test determined whether the features had the same ratings for both importance and centrality. The results demonstrated that importance and centrality ratings were significantly different [$\chi^2$ (df=2, N=211), of 66.67, (p<.01)], consequently indicating that it is possible to examine whether individuals with aphasia are more responsive to feature centrality or to feature importance. The results of her subsequent dissertation (Cox, 2009) demonstrated that centrality does not have an effect on the association of semantic features with the appropriate nouns by individuals with aphasia.
Feature Relevance

Sartori and Lombardi (2004) proposed a model of semantic knowledge that measured the relevance of semantic features for a lexical-concept. Feature relevance is defined by these authors as the extent to which a feature defines the lexical-concept and differentiates it from similar lexical-concepts. For instance, “has a trunk” was considered a semantic feature of high relevance for the lexical-concept “elephant” because most of the participants used it to define “elephant”, whereas this same feature was seldom used to define other concepts. To the contrary, “has four legs” was a low relevance feature because few participants used it to define elephant although it was used to define other concepts.

Lombardi and Sartori (2007) postulated that semantic features may activate lexical-concept retrieval based on their degree of relevance to the target concept. Relevance has been computed as follows (Sartori, Lombardi and Mattiuzzi, 2005): If the semantic feature “yield milk” appears in 7 of 300 concepts, and the same feature is listed by participants 12 times in defining the concept “cow,” the semantic relevance of the feature “yield milk” for “cow” will be equal to \[ k = 12 \times \log_2(300/7) = 65.057 \].

After mapping the relevance of semantic features for 254 lexical-concepts including members of specific categories such as animal, musical instruments, vegetables and objects, Sartori and Lombardi (2004) used the semantic relevance model to investigate naming responses in seven individuals with category specific impairments (i.e., living versus nonliving). Findings suggested that when living and nonliving categories were equated on levels of relevance, the category-specific deficits disappeared.
Namely, no differences were detected between the naming of living and nonliving things when relevance was matched across categories. As a result, the authors stated that category effects emerge from differences in the relevance of features, and that lexical-concepts are better retrieved when semantic features with higher relevance are activated.

Sartori, Lombardi and Mattiuzzi (2005) investigated the effect of feature relevance on a naming-to-description task with 15 patients with dementia of the Alzheimer type (DAT) and semantic disorders. They were asked to retrieve the name of a concept after hearing a sentence that described the target concept. The sentences included a set of three semantic features. For example, the sentence “has a handle, has two wheels and has two pedals” was presented orally to the participants who were required to retrieve the name “bicycle”. The authors reported a significant correlation between semantic relevance and accuracy ($r = .443, p<.01$). According, the authors indicated that semantic relevance is a good predictor of name retrieval accuracy in a name-to-description task.

The results of this research by Sartori and colleagues suggested that feature relevance may be a useful way to organize semantic feature knowledge. However, it has not been studied in people with aphasia. Furthermore, there are potential issues in how relevance was determined by Sartori.

According to Lombardi and Sartori (2007), feature relevance is the result of two components. The first component, dominance, is a measure of how frequently a feature is used in defining a concept. The second component, distinctiveness, is the extent to which a feature is characteristic of only a few examples of a category. Feature relevance
scores are high when a semantic feature is often used in defining a concept (high dominance), but seldom mentioned in defining other concepts within the same category (high distinctiveness) (Lombardi & Sartori, 2007).

Sartori, Lombardi and Mattiuzzi (2005) computed feature dominance by dividing the number of times a feature was listed by the total number of features listed. However, this procedure could pose a problem because the total number of features can vary across different lexical-concepts even if the number of participants who listed a feature remains constant. Namely, changing the denominator across concepts would lead to different dominance ratings. For example: If the twenty participants list the feature “bark” for the lexical-concept “dog” and there are thirty different features listed, the dominance rating would be .67 (20/30). On the other hand, if the twenty participants list the feature “four legs” for the lexical-concept “cat” and there are 20 different features listed, the dominance ratings would be 1.0. This discrepancy among dominance ratings would influence the final relevance scores. Feature dominance should not change as a factor of the number of features identified. For example: a feature listed by 20 participants is no less dominant to a concept when 30 features are identified compared to when only 10 features are identified. Therefore, computing dominance based on the number of participants who listed that features should be considered.

In addition, Sartori, Lombardi and Mattiuzzi (2005) supported the idea that the complement of sharedness defines the distinctiveness of semantic features. Sharedness can be estimated by dividing the number of different lexical-concepts in which the semantic feature appears by the number of lexical-concepts in the database (Delvlin,
Gonnerman, Andersen, and Seidenberg, 1998). Therefore, Sartori, Lombardi and Mattiuzzi (2005) determined distinctiveness by calculating \((1 – \textit{sharedness})\) to a set of 254 concepts. A range between 0 and 1 was established where scores near “0” indicated that the semantic feature appears in all or many lexical-concepts and scores near “1” showed that the semantic feature appears only in one or a few lexical-concepts. However, as with dominance, the distinctiveness rating is influenced by the number of lexical-concepts in the database. Therefore, it would change as the size of the corpus changed. Alternative calculations of distinctiveness were employed by Garrard et al. (2001) and Mason-Baughman (2009). The authors calculated distinctiveness as the proportion of entries within a lexical-conceptual category for which the feature was considered characteristic. For example, Mason-Baughman (2009) had a group of 20 adults rating semantic features as typical or not typical for five lexical-concepts within a category. A feature was considered distinctive when it was rated as typical for only one or two of the five lexical-concepts within a category. This had the advantage of determining distinctiveness directly for each feature in a way that is independent of the size of the database. Mason-Baughman’s (2009) procedure for computing distinctiveness is a applicable approach and should also be considered.

**Rationale**

The existing literature suggests that some individuals with aphasia demonstrate category-specific deficits (Warrington, 1981; Warrington & Shallice, 1984; Warrington and McCarthy, 1987) that could be explained by differences in feature relevance (Sartori
and Lombardi, 2004; Sartori, Lombardi & Mattiuzzi, 2005, Lombardi and Sartori, 2007). Some studies have considered the use of semantic features as an important factor in the improvement of lexical-semantic knowledge in individuals with aphasia (Boyle and Coelho, 1995; Coelho, McHugh, & Boyle, 2000). Accordingly, the organization of these features may influence their effect on lexical-semantic knowledge in persons with aphasia. Three common ways of organizing features discussed in the literature are importance, centrality and relevance. Organization of features by importance has some influence on individuals with aphasia (Cox, 2009; Germani & Pierce, 1995; Mason-Baughman, 2009, Mason-Baughman & Wallace, 2013). Organization of features by centrality does not seem to have an effect on the association of semantic features with their appropriate nouns in individuals with aphasia (Cox, 2009). The organization of features based on relevance has not been studied yet in individuals with aphasia.

However, based on the work of Sartori and Lombardi (2004), Sartori, Lombardi and Mattiuzzi (2005) and Lombardi and Sartori (2007), relevance may represent a promising alternative to feature importance (Germani & Pierce, 1995). Therefore, before investigating feature relevance hierarchy in individuals with aphasia, there was a need to investigate whether feature importance and feature relevance represent the same or different ways of organizing lexical-semantic knowledge in adults with no history of disorders in cognition and language. The pilot study addressed the following question: Do feature importance and feature relevance represent different ways of organizing lexical-semantic knowledge? The null hypothesis of the pilot study was that feature
importance and feature relevance represent the same ways of organizing lexical-semantic knowledge.

**Pilot Study**

Three groups of 20 non-brain-damaged individuals each consist of, ten males and ten females, ages ranging between 41 and 80 years (M= 56.91, SD = 11.41), participated in the pilot study. All of the 60 participants graduated from high school, twenty-two had completed undergraduate studies completed and twenty-eight obtained a graduate degree. Also, all the participants were native speakers and readers of American English and had no history of cognitive, and/or language disorders related to impairment such as dementia, Parkinson’s disease, or cerebral vascular accidents (CVA). The participants voluntarily agreed to participate in the study approved by the Institutional Review Board (IRB) committee on June 25, 2009. Data for the pilot study were collected from July through December 2009.

A three step procedure was completed to determine feature relevance ratings. The relevance of a feature for a particular lexical-concept is characterized by the combination of two different components. The first component, dominance, is a measure of how frequently a feature is used in defining a lexical-concept (Sartori, Lombardi and Mattiuzzi, 2005). The second component, distinctiveness, is the extent to which a feature is characteristic of only a few examples of a category (Sartori, Lombardi and Mattiuzzi, 2005).

First, in order to determine dominance ratings, individuals in the first group of 20 participants were asked to describe target lexical-concepts from a list of ten mid and ten
low frequency nouns that have semantic features with previously established importance ratings (Germani, 1992). High frequency nouns not were used in the pilot study because the identification of high and low importance features for high frequency nouns remained intact in all participants with brain damage in the Germani (1992) study. The ten mid and ten low frequency nouns were selected from Germani (1992) based on diversity of nouns (i.e., not all animals) and category formation. The participants were instructed to write a list of as many features as they could for the 20 lexical-concepts. Subsequently, dominance was measured by counting the number of participants who listed a feature in defining a given concept. Features that were listed by only one participant were discarded as too idiosyncratic. Accordingly, each feature had a dominance rating from two to twenty. These were divided by five in order to have a final rating from zero to four. Reliability in this study was addressed by having two individuals independently develop a master list of features from the individual lists of features for each noun. Any differences in these two lists were resolved through discussion.

Then, to establish distinctiveness ratings, the second group of 20 participants were asked to indicate whether features belonged to a group of lexical-concepts from the same category. Each lexical-concept used for determining dominance ratings was presented along with three other lexical-concepts from the same category, along with the term (“none of them”) and a list of features obtained from step one (as well as some unrelated features). Participants were asked to place a check mark under each word that had this feature (or none of them). The number of lexical-concepts with a check mark was tallied for each feature, thus generating a rating that ranged from zero to four. A feature with an
average rating of 1-2 check marks was classified as distinctive. A feature with an average rating of 3-4 check marks was classified as common because it is associated with most or all of the lexical-concepts in that category (Mason-Baughman, 2009). However, in order to have the larger number reflecting a higher degree of distinctiveness, the numbers were then reversed (i.e., 1→4, 2→3, 3→2, 4→1).

Lastly, dominance and distinctiveness ratings were averaged to obtain relevance values for the 20 concepts. Ratings of 0 through 1.9 were considered as low relevance; of 2 through 2.9 were considered as mid-relevance, and of 3 through 4 were considered as high relevance.

To determine importance ratings, the procedure used by Germani (1992) was employed. A third group of 20 participants was asked to rate the same features used to measure relevance in terms of their importance in defining a lexical-concept. The rating scale is similar to the one proposed by Hampton (1987). Then, ratings were averaged across the 20 participants to provide a mean importance for each feature. Features with mean ratings between 3.0 – 4.0 were classified as having “high-importance”, features with mean ratings of 2.0 – 2.9 were classified as having “mid-importance”, and features with mean ratings between 1.0 – 1.9 were classified as having “low-importance”.

To compare whether feature importance and feature relevance represented different ways of organizing lexical-semantic knowledge, a chi-square ($\chi^2$) test was performed to compare the observed values of the high importance - high relevance, mid importance – mid relevance, and low importance – low relevance conditions to their expected values. Expected values were determined by assuming that all high importance
features would also be rated as high relevance features (same for the mid and low relevance and importance features). A significant $\chi^2$ would show that importance and relevance ratings are different.

A 3 x 3 matrix with high, mid and low importance on one side and high, mid and low relevance on the other side was constructed (see Table 1). The number of importance and relevance features falling in each box was tallied to obtain both observed and expected values required to compute a chi-square test.

Table 1. *Number of Features in Each Importance and Relevance Condition*

<table>
<thead>
<tr>
<th>Relevance</th>
<th>Importance</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High (4.0 – 3.0)</td>
<td>Mid (2.9 – 2.0)</td>
<td>Low (1.9 – 0.0)</td>
<td>Total</td>
</tr>
<tr>
<td>High (4.0 – 3.0)</td>
<td>28</td>
<td>13</td>
<td>10</td>
<td>51</td>
</tr>
<tr>
<td>Mid (2.9 – 2.0)</td>
<td>68</td>
<td>69</td>
<td>139</td>
<td>276</td>
</tr>
<tr>
<td>Low (1.9 – 0.0)</td>
<td>57</td>
<td>45</td>
<td>149</td>
<td>251</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>127</td>
<td>298</td>
<td>578</td>
</tr>
</tbody>
</table>

To compute the chi-square test, observed values (28 for the high-high condition, 69 for the mid-mid condition, and 149 for the low-low condition) were compared to their expected values. Expected values were established by assuming that all high importance features would also be rated as high relevance features, all mid importance features would also be rated as mid relevance features, and all low importance features would also
be rated as low relevance features. Consequently, the expected values were 153 for the high condition, 127 for the mid condition, and 298 for the low condition (see Table 2).

Table 2. Importance – Relevance Observed and Expected Values for High, Mid and Low Conditions

<table>
<thead>
<tr>
<th>Importance/Relevance</th>
<th>High-high</th>
<th>Mid-mid</th>
<th>Low-low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O = 28</td>
<td>O = 69</td>
<td>O = 149</td>
<td>246</td>
</tr>
<tr>
<td></td>
<td>E = 153</td>
<td>E = 127</td>
<td>E = 298</td>
<td>578</td>
</tr>
<tr>
<td>Total</td>
<td>181</td>
<td>196</td>
<td>447</td>
<td>824</td>
</tr>
</tbody>
</table>

The chi-square test is acknowledged as the sum of the square differences between observed and expected data divided by the expected data in all the possible categories (Aron, Aron and Coups, 2005). The results for the chi-square test in this study were statistically significant $\chi^2$ (df = 2, N = 824) of 203.11 (p<.01).

The results of the pilot study showed that feature importance and feature relevance represent different ways of organizing lexical-semantic knowledge in adults with no history of disorders in cognition and language. Similar to the results from the pilot study conducted by Cox (2009), a statistically significant difference was found when comparing feature importance ratings to feature relevance ratings. Cox (2009) obtained statistical significant differences when comparing feature importance to feature centrality.
The use of semantic features in the treatment of individuals with aphasia has been shown to enhance their ability to name trained and untrained items (Boyle & Coelho, 1995; Coelho, McHugh & Boyle, 2000). In fact, the employment of a semantic features approach seems to be an effective treatment procedure because it improves lexical retrieval by accessing lexical-semantic networks (Massaro & Tompkins, 1992). Namely, it is assumed that by activating the lexical-semantic networks surrounding the target word, that target itself will be sufficiently activated to allow retrieval of the word (Boyle & Coelho, 1995; Coelho, McHugh & Boyle, 2000). Although Boyle & Coelho (1995) and Coelho et al., (2000) have found that participants with aphasia benefited from the semantic feature analysis treatment by improving lexical retrieval, the authors have used a broad group of features in their studies. Perhaps, it might be better to organize features so they can be presented in a hierarchical manner.

There are three common ways of organizing semantic features that have been most discussed in the literature: importance, centrality and relevance. Cox (2009) and Mason-Baugham (2009) observed that feature importance has two levels of influence (i.e., high and mid/low). These authors’ studies demonstrated that lexical-semantic knowledge in persons with aphasia was more accurate for high-importance semantic features than for mid and low-importance, which did not differ from each other in terms of accuracy. Also, Cox (2009) found that individuals with aphasia were not affected by different levels of feature centrality. That is, the organization of features by centrality does not have an effect on the association of semantic features with their appropriate nouns in individuals with aphasia (Cox, 2009).
To continue this line of inquiry, it would be of interest to determine whether or not lexical semantic knowledge in individuals with aphasia is influenced by different levels of semantic feature relevance (Sartori and Lombardi, 2004; Sartori, Lombardi and Mattiuzzi, 2005, Lombardi and Sartori, 2007). However, similar to the study of feature centrality (Cox, 2009), it was necessary to first determine whether levels of feature relevance contained different features than do the levels of feature importance. The results of the pilot study indicated that organizing features by relevance does create a different hierarchy than organization by importance. Therefore, it is reasonable to examine whether individuals with aphasia are more sensitive to feature importance or feature relevance ratings.

**Research Questions and Hypotheses**

This study is built upon the work of Germani & Pierce (1995), Cox (2009), and Scheffel (2010) to answer the following questions:

(1) For each classification of semantic feature knowledge, relevance and importance, is there a hierarchy of high, mid and low levels in the mind of individuals with aphasia?

**Hypothesis 1:** Semantic feature knowledge in individuals with aphasia is influenced by high, mid and low levels of importance and relevance.

**Hypothesis 2:** Results will be consistent with Germani & Pierce (1995) and Cox (2009), supporting the notion that semantic feature knowledge in individuals with aphasia is influenced by the levels of high versus low importance.

**Hypothesis 3:** Semantic features knowledge in individuals with aphasia is influenced by the levels of high versus low relevance.
(2) Is the ability of individuals with aphasia to associate semantic features with their appropriate nouns influenced more by levels of feature importance or relevance?

**Hypothesis 1:** Feature relevance will have a greater effect than feature importance because features determined by relevance have shown to be strongly influential to the retrieval of words (Sartori & Lombardi, 2004; Sartori, Lombardi & Mattiuzzi, 2005). Namely, the ability of individuals with aphasia to associate semantic features with their nouns will be influenced more by levels of feature relevance than feature importance.

**Hypothesis 2:** Feature importance would have a greater effect than feature relevance. That is, the ability of individuals with aphasia to associate semantic features with their nouns will be influenced more by levels the feature importance than relevance.

**Hypothesis 3:** Feature importance and feature relevance will not significantly differ. That is, there will be an equal impact the ability of individual with aphasia to associated features by relevance and importance with their nouns.
CHAPTER III

METHODS

Participants

Twenty adults, ten males and ten females, with aphasia resulting from one (N=18) or two (N=2) unilateral cerebrovascular accidents (CVA) participated in this study. Participants’ ages ranged between 43 and 83 years of age (M=63.6 years, SD=11.7). Education level ranged from high school diploma to doctoral degree. All the participants were right-handed native speakers and readers of American English and had no medical history of mental deterioration such as Parkinson’s disease or dementia based on information from the referring speech-language pathologist and confirmation from each participant or family member. Participants were between 5 and 199 months post onset of aphasia (M=70.5, SD=60.9) and were classified as having fluent or non-fluent aphasia based on each participant’s responses during the Conversational and Expository Speech components of the BDAE-3. Table 3 contains relevant identifying information for each participant.

The participants with aphasia were selected from local stroke groups, hospitals outpatient clinics, and nursing homes, and agreed to participate in the study by signing a consent form (Appendix A). Subjects were compensated $20 for participating in the study. The presence of aphasia was diagnosed by the referring speech-language pathologist and confirmed by the investigator based on results on the standardized
comprehensive language testing. Also, it was required that the onset of the most recent stroke should be at least one month prior to participation, and that the participants had adequate visual and hearing acuity for performing the experimental tasks as determined by their ability to pass the screening training tasks.

In addition, in order to establish basic word comprehension and be accepted into this investigation, each participant was required to pass a screening test. Six sets of three nouns taken from the experimental task were used for the screening test. One at a time, nouns were auditorily presented by the examiner as the participant views three written nouns displayed in a vertical array. The purpose of the vertical array was to reduce any visual difficulty participants may experience scanning to the periphery to see all three written nouns. All the nouns were typed on 3”x 5” white index cards using Times New Roman 36-font upper-case letters. The screening test consisted of having each participant point to the target noun in the array in front of him or her. Responses were scored as either correct (+) or incorrect (-). A score of 5/6 or higher had to be achieved by a participant in order to be included in this investigation. No one was excluded from the study based on this criterion.

**Formal Tests**

After passing the screening test, participants completed subtests from the short version of the Boston Diagnostic Aphasia Examination Third Edition (BDAE-3) (Goodglass, Kaplan & Barresi, 2001) and Boston Naming Test Second Edition (BNT-2) (Kaplan, Goodglass, & Weintraub, 2001) to determine type (fluent vs. non-fluent) and severity of their aphasia. Four categories of the Boston Diagnostic Aphasia Examination
Table 3. Participant Characteristics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex(^a)</th>
<th>Aphasia Type(^b)</th>
<th>Age(^c)</th>
<th>TPO(^d)</th>
<th>Education(^e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>NF</td>
<td>72</td>
<td>199</td>
<td>BD</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>NF</td>
<td>45</td>
<td>65</td>
<td>DD</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>F</td>
<td>60</td>
<td>21</td>
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</tr>
<tr>
<td>5</td>
<td>F</td>
<td>NF</td>
<td>58</td>
<td>6</td>
<td>HSD</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>F</td>
<td>60</td>
<td>14</td>
<td>BD</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>NF</td>
<td>57</td>
<td>64</td>
<td>AD</td>
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<tr>
<td>8</td>
<td>M</td>
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<td>78</td>
<td>109</td>
<td>DD</td>
</tr>
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<tr>
<td>11</td>
<td>M</td>
<td>F</td>
<td>83</td>
<td>198</td>
<td>MD</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>NF</td>
<td>78</td>
<td>17</td>
<td>HSD</td>
</tr>
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<td>13</td>
<td>F</td>
<td>F</td>
<td>67</td>
<td>121</td>
<td>HSD</td>
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<td>F</td>
<td>NF</td>
<td>56</td>
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<td>NF</td>
<td>66</td>
<td>135</td>
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<td>16</td>
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<td>NF</td>
<td>77</td>
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<td>HSD</td>
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<td>18</td>
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<td>F</td>
<td>67</td>
<td>93</td>
<td>BD</td>
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</tr>
<tr>
<td>20</td>
<td>M</td>
<td>F</td>
<td>77</td>
<td>6</td>
<td>HSD</td>
</tr>
</tbody>
</table>

Mean: 63.6  SD: 11.7  Range: 40  194

\(^a\)M = male, F = female
\(^b\)F = fluent aphasia, NF = nonfluent aphasia
\(^c\)Age in years
\(^d\)Time post-onset in months
\(^e\)HSD = high school diploma, AD = associate degree, BD = bachelor degree, MD = master degree, DD = doctoral degree
Third Edition (BDAE-3) (Goodglass, Kaplan & Barresi, 2001) were used to determine aphasia classification: (a) grammatical form, (b) phrase length, (c) articulatory agility and (d) prosody. These four components were examined through speech samples collected from the participants by asking them to verbally describe the “cookie theft” picture in the BDAE-3 as well as from informal conversation. The participants’ speech samples were audio recorded and analyzed by the examiner and one other licensed speech-language pathologist with experience in aphasia. Eight participants had fluent aphasia and twelve had non-fluent aphasia. Inter-judge agreement was 100 percent.

Three sub-tests of the BDAE-3 short version were completed in order to obtain formal measures of auditory word comprehension. These measures included: (1) Basic Word Description, (2) Commands, and (3) Complex Ideational Material. Also, the short version of the Boston Naming Test (BNT-2) was used to measure the participants’ naming abilities. Aphasia severity was obtained from the Language Competency Index which comprise of above subtests as well as the Grammatical Rating Form. Table 4 contains the scores on independent measures for each participant.

**Development of Stimuli**

Nouns chosen as stimuli consisted of 9 low (<8/million) and 9 mid (10-25/million) frequency of occurrence nouns based on Francis and Kucera (1982) and their semantic features obtained in the pilot study (Scheffel, 2010). The semantic features were rated as high, mid and low importance (HI, MI, LI) and high, mid and low relevance (HR, MR, LR) (Scheffel, 2010). For example, the semantic features “red skin” for the noun “apple” was rated as low importance (LI) and high relevance (HR). Table 5
Table 4.  Participants’ Scores on Subtests of the Boston Diagnostic Aphasia Examination-3 Shorted Version and Boston Naming Test-2 Shorted Version

<table>
<thead>
<tr>
<th>Participants</th>
<th>BWD</th>
<th>COM</th>
<th>CIM</th>
<th>BNT</th>
<th>LCI</th>
</tr>
</thead>
<tbody>
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<td>13</td>
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<td>4</td>
<td>10</td>
<td>43</td>
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<tr>
<td>Mean</td>
<td>14.8</td>
<td>7.4</td>
<td>5.0</td>
<td>8.0</td>
<td>62.1</td>
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<tr>
<td>SD</td>
<td>1.9</td>
<td>2.3</td>
<td>1.3</td>
<td>3.9</td>
<td>26.1</td>
</tr>
<tr>
<td>Range</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>15</td>
<td>79</td>
</tr>
</tbody>
</table>

*Basic Word Discrimination (max = 16)
*Commands (max = 10)
*Complex Ideational Material (max = 6)
*Boston Naming Test (max = 15)
*Language Competency Index (percentile max = 100)
Table 5. *Features in Each Condition of High, Mid and Low Importance and Relevance. The Numbers are the Relevance Rate (RR) and the Importance Rate (IR)*

<table>
<thead>
<tr>
<th>HR</th>
<th>HI 3.0-4.0</th>
<th>MR 2.0 – 2.9</th>
<th>LR 0 – 1.9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RR</td>
<td>IR</td>
<td>RR</td>
</tr>
<tr>
<td>HI 3.0-4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Butterfly) colorful</td>
<td>3.2</td>
<td>3.8</td>
<td>(crayon) paper cover</td>
</tr>
<tr>
<td>(candle) made of wax</td>
<td>3.9</td>
<td>3.7</td>
<td>(diamond) used for engagement rings</td>
</tr>
<tr>
<td>(carrot) orange</td>
<td>3.9</td>
<td>3.7</td>
<td>(fox) red</td>
</tr>
<tr>
<td>(duck) quacks</td>
<td>3.8</td>
<td>3.7</td>
<td>(moccasin) slippers</td>
</tr>
<tr>
<td>(elephant) has a long trunk</td>
<td>3.9</td>
<td>4.0</td>
<td>(owl) nocturnal</td>
</tr>
<tr>
<td>(lemon) sour</td>
<td>3.4</td>
<td>3.0</td>
<td>(rabbit) two long ears</td>
</tr>
<tr>
<td>(pie) crust</td>
<td>3.4</td>
<td>3.0</td>
<td>(stove) gas</td>
</tr>
<tr>
<td>(sailboat) sails on water</td>
<td>3.4</td>
<td>3.7</td>
<td>(stove) heat</td>
</tr>
<tr>
<td>(stove) used for cooking</td>
<td>3.5</td>
<td>4.0</td>
<td>(strawberry) has many seeds</td>
</tr>
<tr>
<td>(trumpet) brass instrument</td>
<td>3.4</td>
<td>3.5</td>
<td>(trumpet) has three valves</td>
</tr>
<tr>
<td>MR 2.0 – 2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(blouse) buttons</td>
<td>2.4</td>
<td>3.8</td>
<td>(candle) melts</td>
</tr>
<tr>
<td>(butterfly) four wings</td>
<td>2.4</td>
<td>3.7</td>
<td>(crayon) source of vitamin A</td>
</tr>
<tr>
<td>(carrot) root</td>
<td>2.5</td>
<td>4</td>
<td>(elephant) trumpets</td>
</tr>
<tr>
<td>(crayon) many colors</td>
<td>2.6</td>
<td>3.4</td>
<td>(fox) similar to a dog</td>
</tr>
<tr>
<td>(duck) water bird</td>
<td>2.6</td>
<td>4</td>
<td>(lemon) juice</td>
</tr>
<tr>
<td>(elephant) large/big animal</td>
<td>2.3</td>
<td>4</td>
<td>(rabbit) twitchy nose</td>
</tr>
<tr>
<td>(fox) soft fur</td>
<td>2.5</td>
<td>3.2</td>
<td>Soap (slippery)</td>
</tr>
<tr>
<td>(lemon) tart</td>
<td>2.4</td>
<td>3.5</td>
<td>(stove) electric</td>
</tr>
<tr>
<td>(trumpet) mouthpiece</td>
<td>2.6</td>
<td>3.6</td>
<td>(strawberry) low growing plant</td>
</tr>
<tr>
<td>LR 0 – 1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(blouse) garment</td>
<td>1.1</td>
<td>3.6</td>
<td>(blouse) worn with suit</td>
</tr>
<tr>
<td>(butterfly) lays eggs</td>
<td>1.2</td>
<td>3.5</td>
<td>(diamond) valuable</td>
</tr>
<tr>
<td>(candle) burns</td>
<td>1.4</td>
<td>3.5</td>
<td>(duck) dark meat</td>
</tr>
<tr>
<td>(diamond) dig from mines</td>
<td>1.7</td>
<td>3.5</td>
<td>(fox) bright eyes</td>
</tr>
<tr>
<td>(duck) feathers</td>
<td>1.5</td>
<td>4</td>
<td>(moccasin) footprint</td>
</tr>
<tr>
<td>(elephant) four feet</td>
<td>1.1</td>
<td>4</td>
<td>(owl) small ears</td>
</tr>
<tr>
<td>(owl) bird</td>
<td>1.3</td>
<td>3.5</td>
<td>(rabbit) animal</td>
</tr>
<tr>
<td>(stove) appliance</td>
<td>1.1</td>
<td>3.6</td>
<td>(stove) float</td>
</tr>
<tr>
<td>(trumpet) musical instrument</td>
<td>1.6</td>
<td>4</td>
<td>(trumpet) treble notes</td>
</tr>
</tbody>
</table>
shows the thirty nouns as well as their semantic features for each combination of importance and relevance condition (high, mid, and low). The following criteria implemented by Cox (2009) to determine centrality features were used in order to select the importance and relevance features in this study: (1) features with relevance and importance ratings at or near the boundaries were removed. For example, if a feature was rated 1.9 or 2.9, this feature was considered near the boundary of 2.0 and 3.0 respectively and therefore was removed from the experimental stimuli; (2) features were identified near the middle of relevance and importance ratings (e.g., 1.3, 1.4, or 2.5, 2.6, or 3.5, 3.6, 3.7); (3) when a noun had more than one feature in a condition (high, mid, and low), one or more noun-feature pairs were removed; (4) if more than ten features remained after these steps, then features were randomly removed until ten remained. The HR-LI condition had only 10 features, consequently all of them were selected. Also, the HR-MI condition had only 13 features, thus 10 of 13 nouns were chosen. Although we tried to follow the above criteria, there were two features in one condition for the nouns “apple” (HR-LI), “soap” (HR-LI), and “stove” (HR-MI). Because the intention in the experimental task was to present three nouns at a time to the participants, we decided to randomly eliminate two nouns from the corpus of 20 nouns investigated in the pilot study (Scheffel, 2010). This way the investigation had a corpus of 18 frequency nouns. In addition, four unrelated features were added to each of the six sets of three nouns. The unrelated features were taken from the pilot study (Scheffel, 2010). As a result, the investigation had a total of 83 semantic features. To avoid displaying nouns from similar categories, the 18 nouns were arranged in two pseudo-randomized orders. For example,
“apple”, “blouse”, and “butterfly” were selected for a set as opposed to “apple”, “lemon” and “strawberry.” All the nouns were typed on 5” x 8” white index cards using a size Times New Roman 36-font in capital letters. The semantic features for each noun and also for the unrelated features were typed on 4” x 6” white index cards using Times New Roman 36-font lower case letters.

**Procedures**

This investigation was divided into two stages: (1) training and experimental task, and (2) feature comprehension task.

**Stage 1:**

Participants were engaged in a training task prior to the experimental task. In the training task, participants were verbally presented with nine nouns taking from a corpus of stimuli used by Germani (1992). These nouns were not be used in the experimental task. All nouns were type using Times New Roman 36-font upper-case letters on a 5” x 8” white index cards. The nouns were shown in groups of three accompanied by the word labeled “UNRELATED”. Each of the three sets of nouns and the “UNRELATED” word were displayed in a vertical array on the table in front the participant. The participants were instructed to sort a deck of features into one of the three nouns or into the unrelated word if the feature does not match with any of the nouns presented. The features for the training task were typed on 4” x 6” cards using Times New Roman 36-font lower case letters. All features were said aloud by the investigator. Responses for the training task were also scored as correct (+) or (-) incorrect. Participants were required to achieve a minimum of 7/9 correct responses to move on to the experimental
task. If this score was not achieved, then participants were reinstructed and presented with a demonstration of the sorting task before attempting it the second time.

The experimental task involved a sorting task. Each participant viewed 6 groups of three nouns and the word “unrelated.” A corpus of 18 nouns was displayed in front of each participant in groups of three together with the word “UNRELATED”. These nouns were presented in random order with the consideration that only one noun from a specific category was in each set of three nouns. Each set of three nouns and the word “UNRELATED”, each printed on 5” x 8” white index cards, were placed vertically in front of the participant. The sets of three nouns were presented one at a time and read aloud by the examiner. The participants were given a 4” x 6” deck of white cards containing features corresponding to the nouns and to the unrelated category, and were verbally instructed to sort the deck of cards into one of the four designated piles. Each feature word or phrase was said aloud by the examiner. The size of the deck per set of nouns varied, but there was an average of 18 cards in each deck. See Appendix B for sample arrays. After a card or phrase was sorted into one of the four piles, it was removed from the table. This avoided having participants to determine a pattern of features in any given pile. This sorting task was repeated 6 times for each participant for a total of 18 nouns. Sorting responses in this stage were scored as either correct (+) or incorrect (-).

**Rationale for the Experimental Task:**

In clinical studies, lexical semantic knowledge is commonly studied with word sorting and other metalinguistic tasks with words and objects (Davis, 2000). Sorting
tasks have been considered a widely accepted and used method of investigating semantic processing (Davis, 2000; Cole-Virtue & Nickels, 2004). Assessment of semantic processing using sorting tasks aims to identify which cognitive components of language processing are impaired and which are functioning well (Cole-Virtue & Nickels, 2004). In addition, sorting tasks appear to be an important task for the verification of word comprehension skills in clinical standardized tests (e.g., Boston Diagnostic Aphasia Examination, Goodglass & Kaplan, 1972; Western Aphasia Battery, Kertesz, 1982). The Pyramids and Palm Trees Test (PPT), originally developed by Howard and Patterson (1992), is another clinical standardized clinical test that uses sorting words to assess semantic memory. More specifically, the individual with aphasia is presented with three written words, one above the other two, and the task is to match the top word (e.g., bottle) to one of the other words that is mostly associated (e.g., cup and grass).

Knowledge of word meaning is represented as a connection between the lexical semantic system level and the lexical level (Nickels, 2002). Consequently, the use of sorting task allows us to indirectly infer whether or not the connection of semantic features and words are preserved in the brain of individuals with aphasia. Namely, when using sorting task, one’s brain is linking between the lexical semantic system (i.e., semantic features) and the lexical level (i.e., words). In one study, McCleary (1988) showed that fluent and nonfluent individuals with aphasia demonstrated knowledge of categorical and functional organization when sorting words into requested categories. Moreover, Germani & Pierce (1995) observed that individuals with aphasia were able to sort “high importance” attributes to a noun (e.g., wings to bird) but were deficient in
sorting “low importance” attributes (e.g., sings to birds). The present study also used a matching/sorting task to investigate:

1. For each type of semantic feature, relevance or importance, is there a hierarchy of high, mid and low features in the mind of individual with aphasia? Based on the individuals’ performance (e.g., number of correct features and words sorted), we were able to verify whether there is a cognitive distinction among “high, mid and low” levels of importance and relevance features in the mind of individuals with aphasia.

2. Which connection of semantic features (e.g., relevance or importance) and words are better preserved in individuals with aphasia? (Please see Figures 3, 4, and 5)

Success with a spoken-written feature-to-word sorting task requires the integrity of particular components of the language processing model (Figure 4). In order to complete this process, first the phonological and orthographic input lexicons are activated for the acoustic and written information of the feature. Second, the task requires the processing and activation of stored meanings from both lexical semantic level (for the spoken-written feature) and the conceptual semantics level (for the perceptual attributes of the feature). After that, spreading activation from lexical semantic level to the lexical level allows for the recognition of the feature. The correct processing of this information will determine the person’s target word selection response. For example, if the target
Feature Importance and Relevance have equal influence on the lexical semantic system

Feature Importance has greater influence than feature relevance on the lexical semantic system

Feature Relevance has greater influence than feature importance on the lexical semantic system

*Figure 3.* Influence of importance and relevance features on the language processing
word is “dog”, the subject will be reading and listening to the word “bark” and have a choice of words of a dog, a carrot, a piano, and the word “unrelated”. If there is no impairment, then the subject will be able to recognize “bark” as a semantic feature of “dog”. That is, the lexical semantic system stores meaning for the word “bark” as being a semantic feature of “dog”. The activation of this information in the lexical semantic system and intact access to the lexical level should enable the correct identification of the target word (Figure 4). However, if the lexical semantic system or the access of it to the lexical level is impaired, then on hearing and reading “bark” a set of other features could be activated in the system that would determine the incorrect choice (Figures 5a and 5b). A mistake in this task can suggest us two things about feature knowledge in individuals with aphasia:

1. If the lexical semantic system is damaged, the individual with aphasia will not comprehend the meaning for the word “bark” and possibly the full meaning of the word “dog”, therefore sorting “bark” with the wrong word choice.

2. Also, if the lexical semantic system or access to the lexical level is impaired, some features (e.g., low importance/relevance) may be more vulnerable to error because they are not strong enough to activate meaning for the target word, consequently leading to the incorrect choice. Namely, the knowledge of that feature is no longer associated with the target word.
Experimental Task Limitations

Even though the participants had a choice to sort features to a target noun and three other semantic unrelated distractors, the feature-to-noun sorting task does not inform us whether or not the individuals with aphasia have a complete knowledge of the features they were matching the nouns with. This argument is recognized as a possible limitation that could influence the results of the study. On the other hand, we assumed that the individuals with aphasia know all the nouns because they were required to pass a screening task for testing basic comprehension. The screening task used the same nouns designated for the experimental task. In addition, all the nouns appeared on the Dolch lists at the level of sixth grade and below. Since the subjects were required to have at least eight years of education, they should know the tested nouns.
(a) Lexical Semantic level

(b) Deficit of access

*Figure 5:* Representation of how a language impairment at the lexical semantic level (a) and a deficit of access (b) would influence the language processing for the comprehension and production of words (Nickels, 2000)
Stage 2:

The second stage of the procedures involved a test of comprehension of mid and low levels of importance and relevance features. These features were taken from all conditions investigate MI–MR, MI-LR, LI-MR and LI-LR as shown in Table 5. The comprehension task consisted of 12 presentations of three features from the mid and low level of importance and relevance. That is, each row contained three words or three phrases. These words or phrases were typed in Times New Roman 36-font lower case letter on unlined sheets of paper and placed in front of the participant. Then, each participant was instructed to point to the feature that was verbally requested by the investigator. The sheets of paper were removed as soon as the participant provide the response and the same was scored correct (+) or incorrect (-).

The study was conducted in the following order: (1) screening test, (2) formal linguistic testing, (3) training and experimental tasks, and (4) feature comprehension task. The tasks were completed in one session with participants taking short breaks as needed.

Statistical Analysis

This study had three major variables. The dependent variable was the performance score for correct features sorted with target words. The performance score was a ratio scale from zero to 20. Two independent variables, feature importance and feature relevance, were measured each by high, mid and low rating levels.

Since performance was a ratio scale and the study aimed to compare the differences between three levels of two groups of features (e.g., feature importance and feature relevance), analysis of variance (ANOVA) was thought to be a good fit.
Therefore, a two-way between-subjects ANOVA was performed for feature *importance* main effect, feature *relevance* main effect, and the interaction of these two conditions.
The purpose of the present study was to investigate what kind of semantic features best influence lexical semantic knowledge in individuals with aphasia. Two types of feature classification were examined: *relevance* and *importance*. In addition, we aimed to find out whether individuals with aphasia are more sensitive to levels (e.g., high, mid and low) of feature important or feature relevance.

Data were first analyzed to look at feature importance versus feature relevance means, standard deviations, and range scores for the performance of 20 participants with aphasia in the sorting experimental task. Table 6 contains the descriptive analyses for each separate condition of *high*, *mid*, and *low* levels of feature *importance* and feature *relevance*. The means and standard deviations are also displayed in Figure 6.

| Importance | | | | Relevance | | |
|---|---|---|---|---|---|
| | Low | Mid | High | Low | Mid | High |
| N | 28 | 29 | 26 | 27 | 29 | 27 |
| Mean | 14.7 | 16.1 | 17.3 | 15.2 | 15.8 | 17.0 |
| SD | 3.9 | 3.2 | 3.4 | 4.4 | 3.5 | 2.7 |
| Range | 14 | 12 | 17 | 17 | 12 | 9 |
Results from the experimental task were computed using SPSS software 20.0. A two-way between-subjects ANOVA was used to examine whether the three different levels (e.g., low, mid and high) of importance and relevance means differ or not, and to analyze whether there was an interaction between feature importance and feature relevance levels.

Namely, participants in the study were tested to in order to determined which classification of semantic features (importance or relevance) is more preserved in their brain, and whether or not there are a difference in performance according to these levels (e.g., low, mid and high) of importance and relevance features. The null hypothesis was that there are no differences between importance and relevance features and their
respectively low, mid, and high levels of importance and relevance. It was assumed 95% confidence intervals for rejecting the null hypothesis.

Data for 20 participants with aphasia were prepared for ANOVA. First, in order to assure that the data met the assumptions for ANOVA, Levene’s Test was used to check for the homogeneous variances component of the dependent variable (i.e., performance on the sorting task) at different levels of the grouping variables. Result for the Levene’s Test indicated that equal variances among high, mid and low groups were assumed (p=0.09>0.05). Therefore, homogeneity of variances can be assumed at 95% confidence level. In addition, multivariate normality means on ANOVA was examined to see whether the dependent variable (i.e., performance on the sorting task) was normally distributed at the different levels of high, mid and low levels of feature importance and feature relevance. Skewness and Kurtosis values were analyzed for this purpose. A Skewness value higher than 2 and Kurtosis value higher than 7 represent non-normal (skewed) data (Curran, West & Finch, 1996). Analyzes of multivariate normality for this study showed Skewness for feature importance (S=.045<2) and for feature relevance (S=.000<2), and Kurtosis for feature importance and feature relevance (K= -1.5<7) reflecting a normal distribution. Therefore, multivariate normality and similar sample size in the groups were assumed. Consequently, assumptions for ANOVA were met indicating the robustness of the statistical test and reliable results.

Results of the two-way between subjects ANOVA showed a statistically significant main effect for feature importance $F(2, 82) = 3.36, p=.04<0.05$. This result indicated that the ability of individuals with aphasia to associate features with their nouns
is influenced by the importance of semantic features. The study results showed that the strength of relationship between feature importance and performance in the sorting task was weak, with $\eta^2 = 0.083 < 0.2$ (small effect size). However, a Power of 62% ($\beta = .62$) was observed, minimizing the risk that the null hypothesis was true. See Table 7 for the ANOVA results.

Bonferroni Post-hoc analysis was used to determine which pairs of means were and were not statistically significant among the different levels of feature importance. Bonferroni results showed that only “low” and “high” feature importance were statistically significant different ($p = .03 < .05$), indicating different means between these two groups. For the post-hoc analysis among the levels of “high” and “mid” ($p = .69$), and “low and “mid” ($p = .47$) feature importance, Bonferroni test did not provide statistically significant results, indicating equal means among this levels of feature importance.

No statistically significant main effect of feature relevance and performance in the sorting task was found $F(2, 82) = 1.70, p = .18 < 0.05$. The strength of relationship between feature relevance and performance in the sorting task was very weak, with $\eta^2 = 0.046 < 0.2$ (very small effect size). Also, the analysis of Power of the study was weak ($\beta = 0.36$), suggesting that the null hypothesis is true. Although, Bonferroni post-hoc test did not provide statistically significant results which indicates equal means among 3 groups (high, mid and low levels), visual inspection demonstrated a slightly better performance on the ability to associate higher relevant features compared to mid and lower features consequently. See Table 7 for the ANOVA results. See figure 6 for visual inspection of relevance means.
In addition, the comparison between feature importance and feature relevance failed to reveal an interaction effect \((F = 0.14; df = 4; p = 0.96 > 0.05)\). This result means that the type of feature, *importance versus relevance*, had no effect on the participants’ performance in the sorting task. Both classifications seemed to be equally preserved in the brain of participants with aphasia. Furthermore, the interaction between feature relevance and feature importance indicated a very small effect size (with \(\eta^2 = 0.008 < 0.2\)) and very weak power \((\beta = 0.078)\). See table 7 for the ANOVA results.

Table 7. *Results of the Two-Way Between-Subjects ANOVA for Feature Importance and Feature Relevance (N=20)*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Partial Eta Square</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>2</td>
<td>0.083</td>
<td>44.1</td>
<td>3.36</td>
<td>0.04</td>
<td>0.62</td>
</tr>
<tr>
<td>Relevance</td>
<td>2</td>
<td>0.046</td>
<td>23.4</td>
<td>1.78</td>
<td>0.17</td>
<td>0.36</td>
</tr>
<tr>
<td>Importance x Relevance</td>
<td>4</td>
<td>0.008</td>
<td>1.86</td>
<td>0.14</td>
<td>0.96</td>
<td>0.78</td>
</tr>
</tbody>
</table>

To investigate the associative relationship between feature knowledge and comprehension and naming skills, Person correlations were computed among scores from the three levels in the experimental conditions of feature importance (HI, MI, and LI); the three levels of feature Relevance (HR, MI, LR); the Language Competency Index (LCI) of the Boston Diagnostic Aphasia Examination, 3rd edition (BDAE-3) Short Form; the Boston Naming Test 2nd edition Short Form (BNT-2) and the Feature Comprehension Task (FC) derived from the experimental stimuli. Table 8 shows the correlation matrix.
Table 8. *Correlations among Participant’s Scores (N=20)*

<table>
<thead>
<tr>
<th></th>
<th>HI$^a$</th>
<th>MI$^b$</th>
<th>LI$^c$</th>
<th>HR$^d$</th>
<th>MR$^e$</th>
<th>LR$^f$</th>
<th>BNT$^g$</th>
<th>LCI$^h$</th>
<th>FC$^i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI</td>
<td>....</td>
<td>0.62**</td>
<td>0.71**</td>
<td>0.57**</td>
<td>0.76**</td>
<td>0.82**</td>
<td>0.51*</td>
<td>0.49*</td>
<td>0.38</td>
</tr>
<tr>
<td>MI</td>
<td>....</td>
<td>0.72**</td>
<td>0.57*</td>
<td>0.90**</td>
<td>0.86**</td>
<td>0.77**</td>
<td>0.69**</td>
<td>0.65**</td>
<td></td>
</tr>
<tr>
<td>LI</td>
<td>....</td>
<td>0.87**</td>
<td>0.82**</td>
<td>0.75**</td>
<td>0.53*</td>
<td>0.46*</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>....</td>
<td>0.52*</td>
<td>0.57**</td>
<td>0.52*</td>
<td>0.53*</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR</td>
<td>....</td>
<td>0.80**</td>
<td>0.67**</td>
<td>0.51*</td>
<td>0.47*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR</td>
<td>....</td>
<td>0.60**</td>
<td>0.63**</td>
<td>0.58**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNT</td>
<td>....</td>
<td>0.81**</td>
<td>0.63**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCI</td>
<td>....</td>
<td></td>
<td>0.59**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**p<.01 level (two-tailed test)
*p<.05 level (two-tailed test)

$^a$ high importance
$^b$ mid importance
$^c$ low importance
$^d$ high relevance
$^e$ mid relevance
$^f$ low relevance
$^g$ Boston Naming Test
$^h$ Language Competency Index
$^i$ Feature Comprehension
Significant correlations were observed among the Boston Naming Test (BNT), the Language Competency Index (LCI), and the Feature Comprehension (FC) task. Moreover, all the experimental conditions correlated significantly with the BNT and the LCI. Of interest was the fact that FC did not correlate significantly with high importance (r=0.38), low importance (r=0.34) and high relevance features (r=0.25), but did correlate significantly with mid importance (r=0.65), mid relevance (r=0.47), and low relevance (r=0.47). All these significant correlations indicated that the participants who are less affected by aphasia tend to perform better in the language and experimental conditions tasks. Those who had difficulty sorting semantic features with their appropriate nouns also demonstrated difficulty performing comprehension and naming tasks.
CHAPTER V

DISCUSSION

The purpose of this study was to examine two classifications of semantic features to verify if they differentially influenced lexical semantic knowledge in 20 individuals with aphasia. To this end, we utilized a sorting task to evaluate the semantic processing involved in language comprehension after a stroke. Namely, the performance of 20 participants with aphasia who had completed spoken-word to sorting task was evaluated. The overall results of the study suggested that the ability of individuals with aphasia to associate semantic features with their appropriate nouns in influenced more by levels of importance than by relevance. Further, the results showed that high importance features were identified with their nouns more accurately than were mid and low importance features.

This chapter begins with a discussion on the different levels of importance versus relevance and how they impact the ability of individuals with aphasia to associate semantic features with their nouns. This is followed by a discussion about why feature relevance statistically failed to influence the association of feature to appropriate noun. Next, the results regarding semantic feature knowledge and its relationship with naming and comprehensive standardized test will be discussed. Finally, some suggestions for future investigation, clinical implications and limitations of the study will be addressed.
Levels of Feature Importance and Lexical Semantic Knowledge

The first research question of this study was addressed to investigate whether there was a cognitive distinction among “high, mid, and low” levels of importance and/or relevance features in the mind of individual with aphasia. The results revealed that different levels of feature importance significantly influence feature-noun association task in those individuals. The same was not observed for feature relevance. The results concerning differences at the different levels of feature importance will be discussed first, followed by the results regarding different levels of feature relevance.

In this study, high importance features were identified with their appropriate nouns more accurately than were low importance features. On the other hand, a statistically significant result was not observed in the comparison of high and mid, and mid and low importance features, meaning that these two set of levels of feature importance were identified by individuals with aphasia with similar degrees of accuracy.

Past studies further support a distinction between “high versus low” importance features. In research aiming to investigate the ability of individuals with aphasia to associate features importance with high, mid, and low frequency of occurrence nouns, Germani & Pierce (1995) found that individuals with aphasia identified high-importance semantic features in all three (high, mid and low) frequencies of occurrence nouns with high levels of accuracy. However, those same individuals showed impaired identification of low-importance features for mid and low frequency of occurrence nouns. The results of the present study also corroborate a study by Cox (2009) who found that individuals with aphasia identified high importance features with their appropriate nouns more
correctly than with low importance features. Likewise, Cox’s study did not show a statistically significant difference between the high and mid, and mid and low levels of feature importance. Mason-Baughman (2007) and Mason-Baughman & Wallace (2013) found that individuals with aphasia, who demonstrated difficulty choosing among semantically related foils, had significantly more difficulty matching low importance distinctive features with nouns when compared to matching high importance distinctive features with nouns.

The results of this study reinforce the notion that, when using tasks of associating features (e.g., sorting/matching) with a target noun, semantic feature knowledge in persons with aphasia is influenced by two main hierarchical levels of semantic features difficulty: high versus low importance (Germani & Pierce, 1995; Mason-Baughman, 2007; Cox 2009; Mason-Baughman & Wallace, 2013). In addition, the findings of the present study did not reveal a statistically significant difference between high and mid, and/or mid and low importance feature levels. Mid importance level seems not to be strongly represented in the mind of individuals with aphasia. Namely, the hierarchy of semantic features knowledge was not extended to a third level of difficulty: mid level of importance. Again, this result was consistent with previous studies by Cox (2009) and Mason-Baughman (2009). These authors also failed to find a statistically significant difference between levels of mid versus low levels of feature importance. It should be noted that, although the finding in this study did not show a numerical trend between the levels of mid and low importance - that is, both conditions were equivalent in
difficulty - visual inspection of the results clearly demonstrate that individuals with aphasia tend to perform better when associating/sorting mid important features with their appropriate nouns than low importance features. Although there was not as much variability in performance when compared to low versus high levels of feature importance, Figure 6 suggests that the means for the levels of low and mid feature importance are indeed different. Perhaps a study containing a larger stimulus corpus might demonstrate different degree of accuracy between mid and low levels of importance, and consequently, a third level of difficulty in the mind of individuals with aphasia.

A statistically significant difference on hierarchy levels of relevance was not observed in the individuals with aphasia. Also, visual inspection analysis showed that the variability in performance among the levels of high, mid and low feature relevance is smaller when compared to the high, mid and low levels of importance (see figure 6).

**Feature Importance versus Feature Relevance and their Influence in the Lexical Semantic Knowledge of Individuals with Aphasia.**

Difficulty understanding and producing language by individuals with aphasia may be related to deficits in the lexical semantic knowledge (e.g., semantic features) of concepts. Very few studies have investigated the role of semantic feature classification in the lexical semantic knowledge in people with aphasia (Germani & Pierce, 1995; Cox, 2009; Mason-Baughman & Wallace 2013). Two types of feature classification were investigated in the present study: Relevance and importance.
According to Sartori, Lombardi & Mattiuzi (2005), feature relevance is defined as those features that most identify the concept and, at the same time discriminate it from other similar concepts. Lombardi and Sartori (2007) proposed that feature relevance is the result of two components. The first component, dominance, is a measure of how frequently a feature is used in defining a concept. The second component, distinctiveness, is the extent to which a feature is characteristic of only a few examples of a category. Feature relevance scores are high when a semantic feature is often used in defining a concept (high dominance), but seldom mentioned in defining other concepts within the same category (high distinctiveness). On the other hand, Hampton (1979) defined feature importance as “how important a feature is in defining a concept.” The author proposed that features could be systematically ranked for importance when lexically defining a semantic representation. He used a series of surveys completed by healthy adults to determine the importance of features. High importance features were those rated as very important to the definition of a concept and/or necessarily true of all possible exemplars of the representation. Low importance features were those rated as not true or usually true of the object.

The primary hypothesis of this study was that relevance and importance are different ways of classifying semantic features and, therefore, it was possible that individuals with aphasia could be more cognitive sensitive to one or the other. The findings support feature importance as the classification of features that best facilitates feature comprehension in individual with aphasia. The results from this study indicated a differential impairment of high importance versus low importance semantic features in
participants with aphasia, supporting previous findings of Germani and Pierce (1995) and Cox (2009). A significant main effect of importance was also found that replicated the findings of Germani & Pierce (1995), Cox (2009) and Mason-Baughman & Wallace (2013) in that high importance features were sorted more accurately than low-importance features.

Current finding did not support relevance of features as a significant factor that contributes to the comprehensives of semantic representation in persons with aphasia. The fact that feature relevance did not have a significant difference in the ability of individuals with aphasia to sort feature what their appropriate nouns possible suggests that these individuals did not perceive the essential nature of feature relevance (e.g., the combination of common and distinctive features) to a concept. Mason-Baughman (2007; 2009) pointed out that the intact knowledge of features considered common to a semantic category is necessary in order to distinguish a target word from different semantic categories. On the other hand, knowledge of distinctive features may be required to distinguish the target from words within the same category. Namely, distinctive feature knowledge is necessary to process the subtle difference when choosing a target from an array of semantic related foils, but not always needed to choose a target from an array of semantic unrelated foils. Mason-Baughman & Wallace (2013) found that individuals with aphasia who had difficulty choosing among semantic related foils were more impaired with the identification of low importance distinctive features when compared to high importance distinctive features and the identification of common features.
Features that have a strong distinctive component in nature might also play a role in how individuals with aphasia access lexical semantic knowledge from different categories. It should be noted that when looking at individuals with aphasia performance score in the sorting task and comparing it with the relevance ratings for dominance and distinctiveness separately, most of the semantic features that had a low score of performance in the sorting task were rated as having a low dominance (e.g., low commonality) and high distinctiveness (See Appendix C). Moreover, those same semantic features were also rated as having low or mid levels of importance. These results might inform us as to why relevance did not emerge as significant factor in the ability of individuals with aphasia to sort features with the target words. Perhaps as stated by Mason-Baughman & Wallace (2013), intact feature distinctiveness contributes to the comprehensiveness of lexical semantic knowledge in persons with aphasia. It is possible that the high distinctiveness component of feature relevance affected the ability of individuals with aphasia to sort features with target nouns. Therefore, an intact knowledge of distinctive features is needed in order to have more robust feature knowledge and to be able to distinguish among items from same categories (Mason-Baughman & Wallace, 2013) and items from other broad categories.

It is also interesting to point out that the majority of semantic features which received a lower performance score in the sorting task were features belonging to the domain specific of “living things” and rated as highly distinctive. Randall et al. (2004) claimed that there are few correlations among distinctive features and living things and that is why feature distinctive for certain concepts are more vulnerable to damage. After
calculating the interaction between features and the domains of living and nonliving things, the authors found that the correlation strength among distinctive features was significantly greater for nonliving things than for living things. In addition, the results of a speed feature verification task showed that participants had slower reaction times for verifying the distinctive features of living thing when compared to the reaction times of distinctive features of nonliving things. The authors concluded that the weak correlations among living things with other features can affect the speed in which the meaning of a concept is activated, and therefore delay access and make performance more error-prone.

The Randal et al. (2004) findings help to explain why individuals with aphasia in the present study had more difficulty sorting relevant features than importance features with target nouns. Perhaps because semantic features tend to be distributed differently across concepts, it is more likely that feature importance captures the salience of any giving concept. That is, features that are important in nature will always have privileged access in the structure of the semantic system because they robustly facilitate access to activate meaning and recognition of a concept. On the contrary, the same is not always true for feature relevance because the “distinctive” component of it may be sometimes weakly correlated with other features, and therefore affect the strength of the relationship with the concepts.

The findings from this study support Germani & Pierce (1995), Cox (2009) and Mason-Baughman & Wallace (2013) in determining that feature importance contributes to the comprehensiveness of semantic representation in individuals with aphasia. Also, the results of this study corroborate the Mason-Baughman & Wallace (2013) study in a
way that persons with aphasia who had impaired knowledge of highly distinctive features also showed decrease accuracy sorting features with target nouns.

**Feature Correlations and Language Skills**

The relationship of comprehension and naming abilities to feature knowledge was investigated using correlations. Scores on measures of comprehension from the BDAE-3 Language Competency Index correlated significantly with scores on experimental feature conditions knowledge. These findings suggest that individuals with aphasia who have intact feature representations, for both feature importance and feature relevance, have better overall language abilities. Consequently, improved feature knowledge helps them to successfully sort features to target nouns.

These results support previous findings from Germani & Pierce (1995) and Mason-Baughman & Wallace (2013) who found significant correlations among scores for auditory comprehension skills with low importance features (Germani & Pierce, 1995), and with common and distinctive features of high and low importance (Mason-Baughman & Wallace, 2013). Moreover, there were some correlations among the various scores for features conditions and features comprehension (FC) task. However, a meaningful pattern among these correlations was difficult to determine. It is likely that the nature of the feature comprehension task was too easy and did not capture the essence of the impairment.

The relationship between naming abilities and semantic feature knowledge was also significantly correlated. That is, individuals with aphasia who demonstrated a more intact lexical semantic knowledge were the ones who obtained a higher score on the
Boston Naming Test. The findings of the present study also corroborate studies by Pierce & Germani (1995) and Mason-Baughman & Wallace (2013) who found statistically significant correlations among importance feature conditions and naming abilities.

**Clinical Implications**

The use of semantic features as a variable to improve lexical semantic knowledge has been considered by many researchers as an effective way of treating semantic deficits in individuals with aphasia. Boyle & Coelho (1995) and Coelho, McHugh & Boyle (2000) use the Semantic Feature Analysis (SFA) treatment to prompt persons with aphasia to produce features that describe group, use, action, properties, location, and association. A problem observed in this type of treatment was that it does not always progress on generalization to connected speech. Perhaps by focusing on training features that are classified as *high importance* versus *low importance* during treatment would lead to more generalization to connected speech.

Likewise, Kiran and colleagues created the Typicality Treatment aiming to facilitate access to lexical items and improve naming abilities. Kiran and Thompson (2003) investigated the effects of typicality on naming skills in four patients with anomia. Typical and atypical examples were used within semantic categories in a variety of semantic features related tasks (e.g., naming pictures, sorting pictures by category, identifying semantic attributes to a target example, and answering yes/no questions). Results showed that when participants were trained on naming of atypical items, they were able to demonstrate generalization to naming of typical items. On the other hand, no generalization to naming effects on atypical items was observed when participants
were trained on typical items. Kiran’s claim was that focusing treatment on atypical items helps to strength access to a wide range of features across a certain category. On the contrary, treatment focusing on typical items contributes to strength access to features that are shared only by similar examples. The concept of typicality treatment perhaps could be also applied to the classification of feature importance, in which by focusing on low importance features would result in richer lexical semantic representations improving overall receptive and expressive language skills.

Drew and Thompson (1999) also investigated the effects of a semantic-based treatment on naming skills. They used three semantic features based tasks to treat four individuals with severe naming deficits: sorting tasks (e.g., for clothing items, participants were asked to sort by size, material, use and location in the body); yes/no semantic judgment task (e.g., “Is it used to tell time?” for the target “watch”) and definition-to-picture matching task (e.g., the examiner presented five food items, including a lemon, and asked the participant to “point to the sour fruit that grows on trees”). Results showed some improvement on naming for trained and untrained items, however the authors did not analyze measured on conversational speech. Again, as pointed out in chapter 2, these studies disregarded a systematic organization of semantic features and focus on a more broad treatment semantic feature approach. Possibly, by using semantic-based treatments that are organized by high versus low importance features would help enhance comprehensive and naming abilities in persons with aphasia.
Limitations of the Study

Although the findings of the present study support previous research by Germani & Pierce (1995), Cox (2009) and Mason-Baughman & Wallace (2013), a larger sample size could increase the power of data analysis leading to results that support the current findings. In addition, a larger and more uniformed corpus of importance and relevance features (e.g., HI, MI, LI, HR, MR, and LR) could confirm or show different measures of effect size accounting for the real variance found among the different levels of feature importance and feature relevance. Data were also collected from a mixed representation of participants in terms of aphasia classification (e.g., fluent versus non-fluent) and severity. It was noted that five out of twenty participants obtained 87% or higher score (up to 100%) in the Language Competency Index (LCI) of the Boston Diagnostic Aphasia Examination-3 Shorted Version. As a result, their level of performance of the experimental sorting task may have been closer to that of non-brain damaged individuals. An investigation testing more severely impaired fluent individuals with aphasia could show changes in the variability scores among the levels of feature importance and feature relevance leading to different mean results. Moreover, a sorting task has been used in all the previous studies that investigated the role of classification and organization of semantic features. Perhaps using a different task to investigate whether feature importance and feature relevance differently influence lexical semantic knowledge in individuals with aphasia would certify that the results are not task dependent. Lastly, Sartori, Lombardi and Mattiuzzi (2005) proposed a different way of obtaining rating values for feature relevance. Although we do not agree with Sartori and colleagues’
method as explained in chapter 2, we acknowledge that following their way of computing feature relevance could have changed the results in the present study.

**Future Studies**

Future studies should explore a larger and more homogeneous sample size. Also, using a larger corpus of semantic features could provide more information about how semantic features are cognitively organized in the brain of individuals with aphasia. Furthermore, although this study corroborates previous research by Germani & Pierce (1995), Cox (2009) and Mason-Baughman & Wallace (2013), there is still a need to explore whether semantic features can be scaled in a structure manner that would systematically affect lexical semantic knowledge in individuals with aphasia by using different tasks. This will ensure that the findings of all the studies cited above are not task dependent. For example, a speed feature verification task measuring the reaction times of different levels of feature importance versus feature relevance could be used to investigate whether the classification and hierarchy of features affect or not the speed in which the meaning of the concept (word) is activated in the brain. Finally, the role of feature importance and feature relevance as factors that might differentially influence lexical semantic knowledge should also be explored in other populations. For instance, persons with primary progressive aphasia (PPA), a neurodegenerative disorder characterized by progressive aphasia in the absence of early cognitive deficits, are well identified as presenting a semantic variant impairment characterized by loss of word meaning and impaired comprehension of single words (Graff-Radford, Duffy, Strand & Josephs, 2012).
Conclusion

The findings of the present study suggest that individuals with aphasia are more sensitive to high versus low importance feature in sorting features with their correspondent nouns. That is, high importance features were identified more accurately than low importance features; however, mid importance features were not. Feature relevance was not shown to influence lexical semantic knowledge in a hierarchical manner. These results support previous research investigating how semantic features are cognitively classified and organized in the brain of individuals with aphasia. Semantic features can be organized according to their importance of features.
APPENDIX A

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY
APPENDIX A

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Study Title: “Do Feature Importance and Feature Relevance Differentially Influence Semantic Knowledge in Individuals with Aphasia?”

Principal Investigator: Lucia Scheffel, Ph.D candidate. Advisor: Kate Krival, PhD.

We want to do a research on word knowledge in individuals with aphasia. We want to do that because we are interested in learning more about how the brain organizes and processes words in people with aphasia. This consent form will provide you with information about the study. I’ll read this form carefully for you. You will also watch a movie showing what you will do in the study. You will receive a copy of this document to take with you.

Purpose:
You are being asked to participate in this research study because you have had a stroke and you have language problems because of the stroke. You are between the ages of 18 and 85. If you take part of this study, you will be assisting me in developing ways of treating some types of language disorders in aphasia.

Procedures
You will be asked to perform several simple tasks. Together, all of the tasks will take one to two hours of your time. You will be given frequent breaks during the session if you wish.

1) I will first give you a screening test. You will be asked to point to one of the three words that are on index cards in from of you. This task will be repeated 12 times. If you are able to complete this task with 80% accuracy, you may participate in the experiment. If you are not able to complete this task well enough, we regret that you will not be able to participate in this experiment.
2) If you have passed the screening test, you will be asked to answer several questions from two short standardized tests: one in verbal expression (speech) and one in verbal auditory comprehension (understanding). I will be voice recording your responses for further analysis.

3) Then, for the experiment, you will be asked to perform two tasks:

First, you will be taught how to sort printed words and phrases into piles. When you understand what you need to do, you will be asked to sort words and phrases into one of the four piles. You will repeat the sorting task 6 times.
Second, you will be asked to point to one of the three written words or phrases that will be displayed in front of you.

**Benefits**
The study will contribute to understanding how knowledge of word meaning is facilitated and organized in individuals with aphasia. Treatment based on improving word knowledge can improve language skills in people with aphasia. However, there will be no direct benefit to you for participating in this study.

**Risks and Discomforts**
Your participation in this study involves minimal physical risk to you. You may feel uncomfortable sitting in a chair for approximately 2 hours of testing. To reduce this possible discomfort from sitting for a long period, we will allow you to take small breaks between the tasks.

**Privacy and Confidentiality**
Your answers to the tasks will be confidentially stored in the Speech and Language Department at Kent State University. Your name will not be attached to your responses. Your signed consent form will be kept separated from your study data, and answers will not be linked to you. In addition, your name will not be identified in any publication or presentation of research results, only aggregate data will be used.

**Compensation**
No monetary compensation will be provided for the screening test. Participants will be provided with $20 compensation for participating in this study as long as they attempt to complete parts of the experimental tasks. In addition, parking permits will be provided at the scheduled visit if the participant decides to come to Kent State University.

**Voluntary Participation**
Taking part in this study is entirely up to you, and no one will hold it against you if you decide to not do it. If you do take part, you may stop at any time.
**Contact Information**
If you want to know more about this research project, please contact me at (330) 389 2668, or contact my advisor Dr. Kate Krival at (330) 672 0244. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complains about the research, you may call the IRB at (330) 672-2704.

**Consent Statement and Signature**
I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I understand that a copy of this consent will be provided to me for future reference.

___________________________________________________________
Participant Signature                                      Date
APPENDIX B

LIST OF RANDOMIZED WORDS AND FEATURES THAT WERE USED IN THE EXPERIMENTS TASKS
APPENDIX B

LIST OF RANDOMIZED WORDS AND FEATURES THAT WERE USED IN THE EXPERIMENTS TASKS

Butterfly
Candle
Carrot
Unrelated

Colorful
Made of wax
Read it
Orange
Smells
Four wings
Write with
Root
Melts
Source of vitamin A
Tallow
Tells time
Underground
Lay eggs
Burns
Used for shaving
Emergency light
Good in soups

Duck
Lemon
Sailboat
Unrelated

Come in pairs
Quacks
Sour
Blankets
Sails on water
Jib
Water bird
Tart
Silverware
Juice
Feathers
Cotton
Dark meat
Float
Grows in California or Florida

Trumpet
Owl
Stove
Unrelated

Keep feet dry
Brass instrument
Nocturnal
Used for cooking
Hold it with both hands
Gas
Wise
Humps
Musical instrument
Treble notes
Heat
Eats mice
Electric
Mouthpiece
Bird
Peel
Small ears
Appliance
Has three valves
Buzz
Made of metal
Elephant
Crayon
Strawberry
Unrelated

Has a long trunk
Paper cover
Has many seeds
Large/big animal
Trumpets
Made by Crayola
Tie it
Many colors
Large/big animal
Low growing plant
In circus
Beak
Short cake
Four feet
Wild
Vacation
Pencil like
Royalty
Jelly

Diamond
Rabbit
Apple
Unrelated

Informal
Used for engagement rings
Two long ears
Liquid
Twitchy nose
Red skin
Yellow skin color
Soft fur
Used to make cider
Small
Blow
Cut glasses
Has a core
Can eat the skin
Insect
Dig from miners
Valuable
Animal
Bright

Fox
Moccasin
Soap
Unrelated

Red
Slippers
Bar
Used for cooking
Liquid
Soft fur
Similar to a dog
Vegetable
Slippery
Shower
Sugar
Made by native American/Indians
Bright eyes
Foot wear
Baked
Beautiful
Different scents
APPENDIX C

WORDS WITH MOST NUMBER OF ERRORS
APPENDIX C

WORDS WITH MOST NUMBER OF ERRORS

<table>
<thead>
<tr>
<th>Word</th>
<th>Feature</th>
<th>Importance</th>
<th>Dominant</th>
<th>Distinctive</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot</td>
<td>Source of Vitamin A</td>
<td>2</td>
<td>1.2</td>
<td>3.55</td>
<td>13</td>
</tr>
<tr>
<td>Carrot</td>
<td>Underground</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Carrot</td>
<td>Root</td>
<td>3</td>
<td>1.2</td>
<td>3.85</td>
<td>14</td>
</tr>
<tr>
<td>Candle</td>
<td>Tallow</td>
<td>1</td>
<td>0.8</td>
<td>2.15</td>
<td>8</td>
</tr>
<tr>
<td>Candle</td>
<td>Smells</td>
<td>1</td>
<td>3</td>
<td>3.2</td>
<td>13</td>
</tr>
<tr>
<td>Candle</td>
<td>Burns</td>
<td>3</td>
<td>0.8</td>
<td>2.15</td>
<td>16</td>
</tr>
<tr>
<td>Candle</td>
<td>Emergency light</td>
<td>1</td>
<td>0.4</td>
<td>2.6</td>
<td>12</td>
</tr>
<tr>
<td>Butterfly</td>
<td>Lay eggs</td>
<td>3</td>
<td>0.8</td>
<td>1.55</td>
<td>3</td>
</tr>
<tr>
<td>Butterfly</td>
<td>Colorful</td>
<td>3</td>
<td>2.8</td>
<td>3.5</td>
<td>14</td>
</tr>
<tr>
<td>Lemon</td>
<td>Grows in California or Florida</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Duck</td>
<td>Dark meat</td>
<td>2</td>
<td>0.4</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Duck</td>
<td>Feathers</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Sailboat</td>
<td>Jib</td>
<td>1</td>
<td>1.4</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Owl</td>
<td>Wise</td>
<td>1</td>
<td>1.8</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Owl</td>
<td>Eats mice</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Trumpet</td>
<td>Has three valves</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Trumpet</td>
<td>Hold with both hands</td>
<td>1</td>
<td>0.8</td>
<td>3.7</td>
<td>15</td>
</tr>
<tr>
<td>Stove</td>
<td>Made of metal</td>
<td>2</td>
<td>0.8</td>
<td>1.7</td>
<td>8</td>
</tr>
<tr>
<td>Moccasin</td>
<td>Slippers</td>
<td>2</td>
<td>2.6</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Fox</td>
<td>Soft fur</td>
<td>3</td>
<td>2.2</td>
<td>2.8</td>
<td>15</td>
</tr>
<tr>
<td>Fox</td>
<td>Beautiful</td>
<td>1</td>
<td>0.4</td>
<td>2.05</td>
<td>6</td>
</tr>
<tr>
<td>Fox</td>
<td>Bright eyes</td>
<td>2</td>
<td>0.6</td>
<td>2.75</td>
<td>9</td>
</tr>
<tr>
<td>Fox</td>
<td>Red</td>
<td>2</td>
<td>2.2</td>
<td>3.75</td>
<td>15</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Quantity</td>
<td>Length</td>
<td>Width</td>
<td>Height</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------</td>
<td>----------</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Soap</td>
<td>Different scents</td>
<td>1</td>
<td>0.6</td>
<td>2.15</td>
<td>12</td>
</tr>
<tr>
<td>Soap Bar</td>
<td></td>
<td>1</td>
<td>2.8</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Soap Slippery</td>
<td></td>
<td>2</td>
<td>1.2</td>
<td>3.3</td>
<td>15</td>
</tr>
<tr>
<td>Diamond Cut glass</td>
<td></td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Rabbit Small</td>
<td></td>
<td>1</td>
<td>1.6</td>
<td>3.35</td>
<td>8</td>
</tr>
<tr>
<td>Rabbit Twitchy nose</td>
<td></td>
<td>2</td>
<td>1.2</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Apple Yellow skim color</td>
<td></td>
<td>1</td>
<td>2.2</td>
<td>3.85</td>
<td>11</td>
</tr>
<tr>
<td>Strawberry Low growing plant</td>
<td></td>
<td>2</td>
<td>1.2</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Elephant Trumpets</td>
<td></td>
<td>2</td>
<td>1.2</td>
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