Abstract

Title of Thesis: VERB NAMING TREATMENT FOR INDIVIDUALS WITH AGRAMMATIC APHASIA: EFFICACY DATA.

Lauren Elaine Graham, Master of Arts, 2009

Thesis Directed by: Dr. Yasmeen Faroqi-Shah
Department of Hearing and Speech Science

Some individuals with aphasia present with agrammatism, which is characterized by short, syntactically ill-formed utterances and a paucity of verbs. These patients demonstrate marked difficulty with verb production both in confrontation naming and sentence production tasks. However, previous studies of syntax-based verb treatments have failed to show generalization to naming of untrained verbs. Therefore, the present study investigated the efficacy of a verb naming treatment that focused on purely semantic features of verbs. This research examined whether training semantic features of a verb class would facilitate within- and between-class generalization. Two male patients with agrammatic aphasia participated, with treatment aimed at training *cut* and *contact* verb classes. While only one participant (Participant B) improved in naming accuracy of trained *cut* verbs, neither participant displayed within-class generalization to untrained *cut* verbs. Only Participant B received training with *contact* verbs and demonstrated a trend of within-class generalization. Both participants improved on two standardized measures of aphasia performance, indicating that this treatment may have provided a generalized retrieval strategy for verb features. These results have implications for verb naming treatments, including stimuli-specific factors (i.e., number of verb features, verb frequency) and participant-specific factors (i.e., premorbid education, phonological vs. semantic deficit). Implications for future treatment research are also discussed.

VERB NAMING TREATMENT FOR INDIVIDUALS WITH AGRAMMATIC APHASIA: EFFICACY DATA

By

Lauren E. Graham

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Advisory Committee:
Professor Yasmeen Faroqi-Shah, Chair
Professor Nan Bernstein-Ratner
Professor Froma Roth

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Chapter 1: INTRODUCTION

The mental representation of a word, frequently referred to as the word's lexical entry, is assumed to represent semantic, syntactic, phonological, and morphological aspects (Bock & Levelt, 1994; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Kemmerer, 2003). The former two aspects are assumed to be packaged together and are often referred to as a word's lemma. During language production, selection of a lemma depends on the semantic-conceptual features encoded in the message (Bock & Levelt, 1994; Chialant, Costa, & Caramazza, 2002). Hence, a message consisting of +action, +oven, +pie might lead to selection of the verb *bake,* while +action, +grill, +backyard, +burger might result in the selection of *barbecue* from the mental lexicon.

The characteristics used to retrieve verbs are often referred to as semantic features because they encode aspects of the verb relevant to its meaning. Many factors, including compatibility with the intended message (also known as congruence), play a role in verb retrieval. Herb Clark (1969) discussed the principle of congruence as being an underlying factor for language formulation in that speakers must find the most congruent, or compatible, lexical entries to form a meaningful sentence. This selection process involves accessing and retrieving semantic features encoded by the desired verb or verbs to be used in the sentence.

Retrieval of verbs begins with access to individual semantic features, which are variable in number among verbs along a heavy-light continuum. Some verbs (such as *make* or *do*) are associated with fewer semantic features and are referred to as "light verbs," or primitives (Breedin, Saffran, & Schwartz, 1998). These verbs are called “light” because they encode fewer semantic features about the manner or result of an action than do those verbs that are called “heavy.” Light verbs are typically characterized by two to three features, and can be seen as a transition between open and closed class words (Breedin, Saffran, & Schwartz, 1998). For example, the light verb *make* can be said to consist of the features +action, +creation, but unlike the semantically heavy verb *barbecue* (+*make* features, +grill), the verb *make* does not encode the manner of the action (i.e., it does not specify how something is made). Contrastingly, heavy verbs (such as *bake* or *barbecue*) are associated with a larger number of semantic features. Though heavy verbs share many features that are also common to light verbs (e.g., +action, +motion), these verbs also encode characteristics which imply the manner or result of an action (Breedin et al., 1998; Gordon & Dell, 2003). It is possible that acquisition of heavier verbs is a function of age and experience. Scrambled or incomplete access to one or more of a verb’s semantic features could result in retrieval of the incorrect word. For example, if the desired verb is *barbecue* but the features accessed include +action, +oven, +pie, one might incorrectly retrieve *bake* instead. It is plausible that verb naming difficulties may be linked to limited access to purely semantic features. If this is the case, training semantic features common to verb classes should facilitate naming of verbs within the class.

In recent years, linguists have used semantic features to categorize verbs into several classes and subclasses (Levin, 1993). Although selection of the correct semantic features is important for effective lexical retrieval, it is proposed that the semantic features encoded in lexical entries are not all equally pertinent to the verb’s meaning. Only some of the characteristics encode purely semantic aspects of the verb, while other features are more relevant to syntax. The two-level theory of semantic features in verb representation outlines the organization of semantic and syntactic features of verbs. This theory was adapted from neuropsychology research by Pinker (1989) and became called the "grammatically relevant semantic subsystem hypothesis." Pinker's (1989) theory is consistent with the larger theory that all words are classified on two levels (Levelt, 1989, 1999), and posits that there are two levels of verb representation in the brain: 1) purely semantic features; and 2) semantic features that are dependent on syntactic context (semantic-syntactic features). The latter is a subset of verb features that are contingent on the grammatical context in which the verb appears. These features are said to encompass the result of an action and/or the manner in which the action occurs in the context of a sentence. For example, Kemmerer (2003) makes the point that, due to constraints of semantic-syntactic features, one can *be hit on the arm* but not *be broken on the arm*. In other words, *hit* and *break* have different semantic-syntactic features, but mostly overlapping purely semantic features. With regard to purely semantic features, *hit* and *break* are both verbs of hitting that are +contact, +impact, and +motion; however, *break* is also +change of state.

Accessibility of Features

Several theories and models have been proposed that describe lexical retrieval and semantic feature access in normal individuals (Bock & Levelt, 1994; Chialant, Costa, & Caramazza, 2002; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997). Neuroimaging evidence exists both for individuals with aphasia and for non-brain damaged individuals that suggests that accessing semantic features leads to activation in the left primary motor cortex (Bookheimer, 2002; Demb, Desmond, Wagner, Vaidya, Glover, & Gabrieli, 1995; Kemmerer & Gonzalez-Castillo, in press). This evidence provides support for the mirror neuron system, which is said to activate the motor cortex for facilitation with verb retrieval. Some researchers suggest that, when accessing semantic features of verbs that are linked to body movements (e.g., +hand motion, +leg motion), individuals activate kinesthetic knowledge of these features stored in the motor cortex (Iacoboni, Molnar-Szakacs, Gallese, Buccino, Mazziota, & Rizzolatti, 2005). The mirror neuron system has gained acceptance in verb retrieval literature over the past decade, and while it may provide some clues for lexical retrieval, other models exist that may account more comprehensively for retrieval of individual features.

Cognitive economy is the result of the hierarchical networks theory proposed by Collins and Quillian (1969) that accounts for storage and retrieval of semantic features. In the following section, this proposed method of feature storage and retrieval is discussed in terms of nouns in an effort to be consistent with the research of the original authors. It should be noted that Collins and Quillian (1969) did not discuss either the hierarchical networks theory or the model of cognitive economy in terms of verbs. However, the manner in which the authors propose that individual features of nouns are retrieved is also applicable to retrieval of verb features, and examples will be provided in the following section where appropriate. Collins and Quillian (1969) hypothesized that there are two general types of words stored in individuals' semantic memory: 1) superordinates, or words that could stand alone as a semantic category (e.g., noun: *bird*; verb: *cut*); and 2) properties, or words that are inherently part of a larger category and cannot stand alone as a class (e.g., noun: *canary*; verb: *mince*). Properties have also been referred to in aphasia literature as subordinates (Harley, 2008). Using a sentence semantic judgment task, Collins and Quillian (1969) obtained reaction times for sentences containing features of objects (e.g., “A canary is yellow,” “A canary can fly”). Participants were required to answer “yes” or “no” to whether the sentence was correct or not. Some of the features were specific to the canary (e.g., +yellow), while others were common to the entire *bird* class (e.g., +can fly). The authors found that reaction times were shorter for sentences in which the feature was more closely related to the superordinate (i.e., for “A canary can fly” versus “A canary sleeps in a cage”). These data support Collins and Quillian’s model of cognitive economy, which proposed that individuals store semantic features general to classes (or superordinates) of words and, when retrieving a subordinate from the general category, an individual automatically retrieves all features common to the superordinate class in addition to specific features of the property. In the case of verbs, this would mean that when retrieving a specific verb (e.g, *mince*), an individual automatically accepts all features inherent to the *cut* class, of which *mince* is a subordinate. This automatic acceptance of superordinate class features is done in order to maximize cognitive “space,” per se, used for storing semantic features. By utilizing one semantic network for retrieval of several words within one class, an individual maximizes his cognitive economy by making more networks available for additional semantic categories and features. Conrad (1972) further investigated the nature of cognitive economy, and found that frequency of access to semantic features may also facilitate more rapid lexical retrieval in non-brain damaged individuals.

In explaining their model of cognitive economy, Collins and Quillian (1969) discussed access to semantic features via nodes of a "semantic tree" (see Figure 1), in which the subordinates branch off from the superordinate class, which is located at the top of the tree. The Collins and Quillian semantic tree model as applied to lexical access originated from engineering research developed to prove theorems (Kowalski & Hayes, 1969). When searching for a verb (e.g., *mince*) within the semantic tree model, the first specification is within the verb class (i.e., the superordinate *cut* is retrieved). Retrieval of class-general features (e.g., *cut*: +5 features, see Table 2 or Figure 1) is then followed by access to specific features of subordinate verbs (e.g., *mince*: +5 *cut* features, +results in finer pieces). The features specific to the desired verb, rather than the general characteristics of the entire verb class, facilitate retrieval of the most congruent message. Contrastingly, these authors posited that, when presented with a subordinate (e.g., *mince*), a normal individual retrieves features in a bottom-to-top fashion (i.e., working up toward the superordinate). This method of subordinate retrieval (i.e., normal individuals process in a top-down fashion) is counter-intuitive to aphasic production, as individuals with aphasia tend to process in a bottom-up fashion. This is based on studies of heavy and light verb naming, which have shown that individuals with aphasia may be relatively less impaired with heavy verb naming (Barde, Schwartz, & Boronat, 2006; Breedin et al., 1998; Kim & Thompson, 2004).

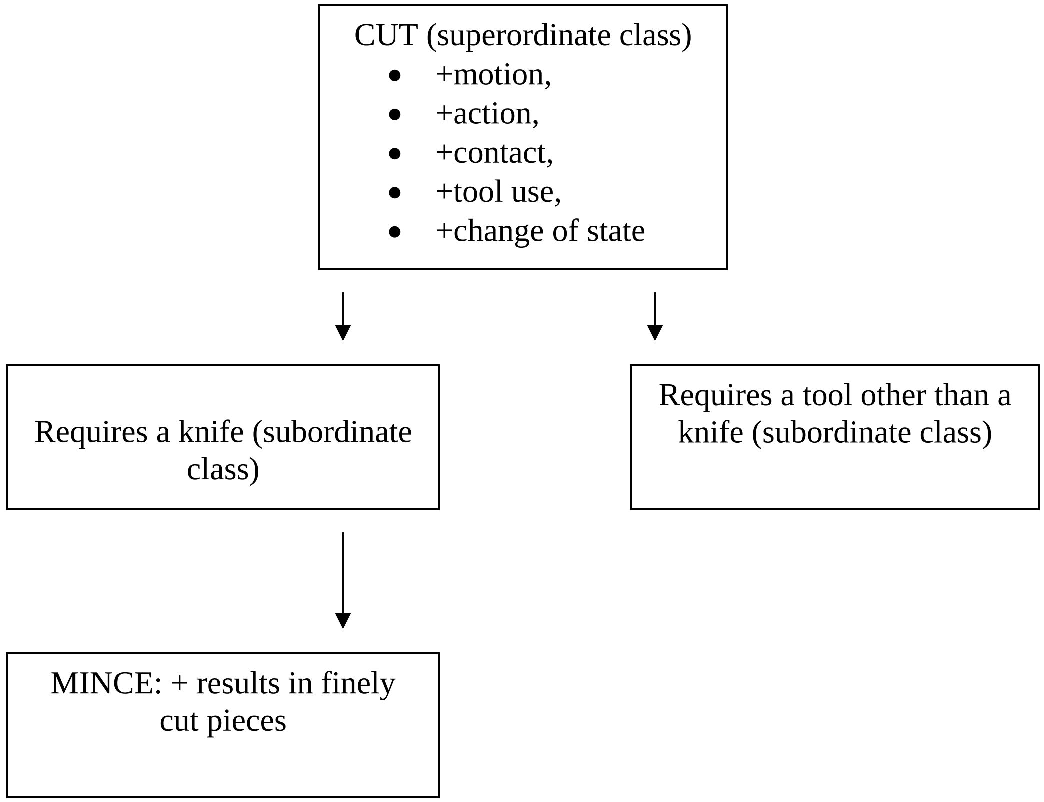


Figure 1. Semantic tree for the verb *mince*.

Priming studies and neurolinguistic evidence from brain-damaged individuals revealed theoretical incongruencies within the framework of Collins and Quillian's (1969) semantic tree nodes. Again, these theoretical implications will be discussed with regard to nouns to remain consistent with the original research, but implications for verb retrieval will be discussed. One anomaly of the Collins and Quillian framework revealed by priming studies was that non-brain damaged individuals responded quicker on a correctness judgment task when presented with the sentence "A cow is an animal" than when presented with "A cow is a mammal." According to Collins and Quillian, +mammal is further down on the semantic tree (i.e., closer to *cow*) and should theoretically be retrieved before +animal. These data suggested that access to features could be affected by frequency of the features and strength of relation to the subordinates. This notion would hold true for verbs as it would for nouns, and would indicate that individuals would have higher accuracy when retrieving more frequently used verbs (or word frequency effect).

To alleviate the methodological confounds identified within Collins and Quillian's (1969) theory of semantic access, Collins and Loftus (1975) proposed a revised model known as the "spreading activation theory." Rather than subordinates being linked to the category in a straightforward manner through nodes of features increasing in specificity, links were established based on strength of features and frequency of subordinates. For example, *canary* is a more common subordinate of the *bird* class than *penguin*. *Canary* also has features that are more strongly linked to the *bird* class than *penguin* (e.g. canaries can fly, while penguins cannot) (Harley, 2008). Therefore, when retrieving *penguin* from the superordinate *bird*, individuals will activate general features of the category (e.g., +wings, +two legs, +beak). Activation of these features will lead the individual to retrieve other features and subordinates before eventually retrieving the desired target (i.e., *penguin*; -can fly, which is not a feature that is strongly linked to the *bird* class in meaning). In the case of verbs, this might mean that retrieval of a less commonly occurring verb within the *cut* class (e.g., *hack*) might occur through activation of more common subordinates (e.g., *chop*) and their features. As a cautionary note, this theory has only been discussed in terms of word retrieval in the English language, and no assumptions are made about the cross-linguistic information on frequency of these words.

The theories of lexical access described above have been linked to verb retrieval, although these models are described in terms of noun retrieval and are often used to describe lexical access for objects (Collins & Loftus, 1975; Collins & Quillian, 1969). However, some authors (Harley, 2008) postulate that verbs are more likely retrieved through specificity of features within a certain class (i.e., all *cut* verbs require tool use, while features specifying results or manner are encoded by subordinate verbs. In other words, *mince* is +tool use and +results in finely cut pieces, while *slice* is +tool use and +results in long, thinly cut piece. Please see Table 1 for class-general features). Other verb classes include *contact* (e.g., *pinch, kiss, nudge*) and *nonverbal expression* (e.g*., yawn, smile, cough*), which are both used in the present study. The latter is a class of verbs that encode facial expressions to convey a current state or emotion (Levin, 1993). The present study prescribes to the notion that retrieval of individual verbs requires automatic access to features of the superordinate class.

Overall, there is experimental evidence supporting the psychological and neuroanatomical reality of the semantically-based classifications of verbs (Kemmerer, Castillo, Talavage, Patterson, & Wiley, 2008; Kuipers & Heij, 2008; Tyler, Bright, Fletcher, & Stamatakis, 2004). Neuroimaging studies exist that maintain the notion of semantic features based on psycholinguistic characteristics. For example, Kemmerer et al. (2008) examined brain activity through functional magnetic resonance imaging (fMRI) for five verb classes (running, speaking, hitting, cutting, change of state) when participants made semantic judgments. The verb classes were selected on the basis of presence/absence of five features from Levin’s (1993) system of categorization: motion, action, contact, tool use, and change of state (see Table 1). It should be noted that Kemmerer et al. (2008) used *change of state* verbs (e.g., *burn*, *dissolve*), a class that Levin (1993) describes as most often being verbs which describe a change that has been brought on by external factors.

Table 1. Features of verb classes examined through fMRI in Kemmerer et al. (2008) study.

Verb Class	Action	Motion	Contact	Change of State	Tool Use
Running	+	+	-	-	-
Speaking	+	+	-	-	-
Hitting	+	+	+	-	-
Cutting	+	+	+	+	+
Change of State, e.g., *evaporate*	-	+	-	+	-

Kemmerer et al. (2008) found unique cortical activation for each semantic feature. For example, the feature *contact* was associated with activation in the left inferior parietal lobe (IPL), more specifically the angular gyrus, while *motion* was associated with activation in the left posterolateral temporal cortex (PLTC). This study reveals that normal cortical activity associated with a specific verb is the sum of all the semantic features represented by the verb. The results of this experiment also have implications for the present study. Kemmerer et al.'s data reveal that retrieval of one feature, even for multiple verbs, will result in activation in the same cortical regions. For example, retrieving the feature +motion will activate the same region for *chop* as it will for *mince*. Theoretically, this means that training retrieval of a specific verb should build cortical networks that will facilitate naming of untrained verbs sharing the same features. The present study utilized the same features as Kemmerer's (2008) study in selection of stimuli to investigate whether training verbs would generalize to untrained stimuli that share the same features for individuals with aphasia who present with impaired verb retrieval. Presence or absence of the five features used by Kemmerer et al.—contact, motion, action, tool use, change of state—were used for stimuli selection (see Table 2).

Table 2. Semantic features of treatment and generalization verbs.

Verb Class	Contact	Motion	Action	Tool Use	Change of State
Cut	+	+	+	+	+
Contact	+	+	+	-	-
Nonverbal Expression, e.g., *yawn, smile*	-	-	-	-	-

While studies of cortical activation in normal individuals have become more extensive in recent years, there is far less evidence to demonstrate activation during lexical retrieval in individuals with aphasia. Reaction time studies of individuals with neurogenic brain damage have provided support for activation of the left prefrontal cortex during semantic feature retrieval (Shapiro, Pascual-Leone, Mottaghy, Gangitano, & Caramazza, 2001). Psycholinguistic evidence suggests normal individuals utilize similar neural networks in feature retrieval as do individuals with aphasia.

Most psycholinguists agree that nouns and verbs are distinct grammatical categories and are, thus, retrieved via separate neural networks (Damasio & Tranel, 1993). However, because of the complexity with object and action naming observed in aphasia, some psycholinguists have suggested that researchers divest traditional grammatical categories (e.g., nouns and verbs) and instead classify words by features alone. The implications of this suggestion could be profound for the direction of future treatment, as training of multiple general features could build semantic networks to facilitate naming of words in all grammatical classes. The present study was designed to operate on the notion that training features of verbs may facilitate more effective retrieval of other verbs with similar features.

Verb retrieval in agrammatic aphasia

Some individuals with aphasia present with agrammatic speech, which is characterized by short, telegraphic utterances and a paucity of verbs and grammatical morphemes (Berndt, Mitchum, Haendiges, & Sandson, 1997; Luzzatti, Raggi, Zonca, Pistarini, Contardi, & Pinna, 2002). Studies of word retrieval in this population have demonstrated that verb naming in isolation (e.g., confrontation naming tasks) and in sentence contexts (e.g., sentence construction tasks) is more severely impaired than noun naming (Berndt et al., 1997; Kim & Thompson, 2000; Luzzatti et al., 2002; Zingeser & Berndt, 1990).

Given that the structure of a sentence is so inherently tied to the verb that is retrieved, researchers have often questioned whether the fragmented (so-called agrammatic) speech that is produced by this population is an outcome of difficulty with verb retrieval. Perhaps inability to access specific features of verbs either leads to retrieval of an incorrect verb or failure to retrieve any verb. In other words, when attempting to retrieve the verb *hit*, an individual with aphasia may produce a semantic paraphasia such as *break* and produce the grammatically incorrect sentence **She broke me on the arm*. Berndt et al. (1997) systematically investigated this question and found that individuals with agrammatic aphasia presented with difficulty in retrieving verbs that impacted their ability to produce well-formed, meaningful sentences. Berndt et al. assessed single-word naming in eleven individuals with aphasia (one patient with non-agrammatic Broca's aphasia, four with agrammatic Broca's aphasia, two with Wernicke's aphasia, three with anomic aphasia, one with transcortical sensory aphasia). Participants were asked to name actions and objects in a variety of task demands (i.e., confrontation naming of black and white pictures, confrontation naming of 7-second video clips). In the picture naming condition, three of the four agrammatic patients showed a dissociation for noun and verb naming, with verbs more impaired than nouns (noun naming approximately 74%, verb naming approximately 51%). The fourth agrammatic patient and the individual with non-agrammatic Broca's aphasia showed no difference between object naming (approximately 76%) and action naming (approximately 80%) accuracy.

In a follow-up study published in the same journal issue, Berndt, Haendiges, Mitchum, and Sandson (1997) investigated the nature of verb naming on sentence production in ten out of the eleven participants from the aforementioned single word naming study. These researchers found that the five participants with a relative verb impairment constructed over 50% of their sentences using semantically light verbs. The participants without a verb deficit relative to object naming used a variety of both heavy and light verbs. The investigators also found that the noun/verb ratio was negatively correlated with mean length of utterance for all participants. Results of these studies suggest that verb retrieval can be a relative deficit for individuals with agrammatic aphasia and could affect sentence formulation. Specifically, lack of verb variability and low instances of heavy verb usage could impact creativity and variability of sentence formulation, as the number of light verbs is relatively limited.

This pattern is unlike that for individuals with Alzheimer's or for children with specific language impairment (SLI), as these populations tend to display more impaired naming of heavy verbs (Kim & Thompson, 2004; Thordardottir & Weismer, 2001). Therefore, treatment of verb retrieval deficits and training of semantically heavy verbs for individuals with aphasia is likely to have a broader impact on overall lexical retrieval and sentence production ability.

The verb retrieval impairment in agrammatic aphasia has generated considerable interest in the past few years, especially because it reveals some interesting patterns of performance. For instance, most individuals with aphasia show a production pattern that is consistent with an argument structure hierarchy (i.e., three-place verbs are more difficult than one-place verbs), but these same individuals are relatively spared in their ability to retrieve and identify argument structure in judging the well-formedness of sentences with argument structure violations such as **The boy gave* (Kim & Thompson, 2000). The syntactic components of verbs (i.e., agents of action, recipients of action) have implications for grammaticality of a sentence, and incorrect verb selection from the mental lexicon may result in production of a grammatically implausible sentence. Because verbs are so inherently tied to the meaning and grammaticality of sentences, much research has focused on syntactically-based verb retrieval treatments that target tasks such as sentence completion and sentence formation.

While selection of the appropriate syntactic components of verbs is necessary for formation of grammatically correct sentences, semantic features of verbs are also essential as they convey the meaning of the action of sentences. When considering verb impairments in agrammatism, interesting patterns arise for semantic aspects of actions. First, there is evidence indicating that the verb deficit in agrammatic aphasia affects the ability to discriminate between subtle semantic features of subordinates within verb classes, a purely semantic task (Kemmerer & Tranel, 2000a, 2000b). Kemmerer and Tranel evaluated verb naming of 100 standardized stimuli for fifty-three brain-damaged participants and analyzed the effect of a variety of variables on naming accuracy. They investigated whether conceptual factors (i.e., does the action require tool/instrument use; does the action result in a change of state) affect naming accuracy. The authors found that participants had higher naming accuracy for verbs that were +change of state/location than for verbs that were –change of state/location (e.g., *sending* vs. *bouncing*). However, they found no significant effect of +hand action versus +body action (e.g., *shaking* vs. *skating*) or +tool/instrument use versus –minus tool/instrument use (e.g., *coloring* vs. *interviewing*) on verb naming accuracy. This study shows that, while the presence of some semantic features may facilitate verb naming for some individuals with aphasia, the presence of other semantic features may have no impact on verb retrieval.

The second interesting pattern revealed by investigations into verb deficits in agrammatism is that patients with agrammatic aphasia show a relative difference along the heavy-light verb dimension. They are relatively more successful in retrieving and producing semantically heavy verbs when compared to light verbs (Barde, Schwartz, & Boronat, 2006; Breedin et al., 1998; Kim & Thompson, 2004). Evidence of this comes from a study by Breedin et al. (1998), who used a delayed story completion task to assess production of semantically heavy and light verbs (e.g., *go* vs. *run*) in eight participants with Broca's aphasia. Individuals were read a three-sentence story containing a target heavy or light verb. For example, "The bus stopped and let people on. Marty *went/walked* to the back. There were plenty of seats there" (p. 5). The researchers then asked participants a question relevant to the verb target in the story, such as, "What did Marty do when he got on the bus (p. 5)?" These authors found that, when asked a question relevant to the target verb, total verb naming accuracy across participants was 40.8% for heavy verbs and 27.6% for light verbs. Breedin et al. found that, when required to produce light verbs, four of the eight participants erred on the side of producing a heavy verb instead of the correct light verb. Heavy verb substitutions were noted on 97 occasions of 204 attempts across these four participants. Conversely, two of the eight participants had more difficulty with heavy verbs, and replaced these with light verbs on 71 of 152 attempts. The final two participants were judged to have statistically insignificant errors among heavy and light verb substitutions. It was noted that these participants replaced light verbs for those that were semantically heavier on only 24 of 158 attempts.

Kim and Thompson's (2004) findings corroborate the results from Breedin et al.'s (1998) study. Despite a significant difference in the proportion of heavy versus light verbs, the investigators found that the agrammatic aphasic patients had relatively similar accuracy of verb production between these two categories (with correct heavy verb production in a sentence completion task at 49.6% accuracy versus 42.9% accuracy for light verbs). Overall, the findings of Breedin et al. (1998) and Kim and Thompson's (2004) investigations provide some evidence for verb retrieval in agrammatic aphasia. It is possible that some patients with agrammatism may display differential impairments in heavy versus light verb naming in both single word and sentence contexts. However, more research is necessary to corroborate this idea and to determine the implications of heavy versus light classification on verb naming in this population.

Overall, reaction time studies, neuroimaging evidence, and investigations into heavy/light verb retrieval demonstrate some difference in activation of semantic features of verbs. Although prior research suggests that at least some individuals with agrammatic aphasia may be less impaired in retrieval of heavy verbs compared to light verbs, heavy verbs are still low in accuracy and could benefit from treatment to improve naming. Improving retrieval of heavy verbs may serve to improve sentence production as well, although this needs to be investigated further. Given that individuals with agrammatic aphasia demonstrate difficulties for semantic aspects of verbs, it raises the question of whether training of semantic features would improve verb naming accuracy. Support for an investigation of semantically based treatment includes previously mentioned neuroimaging evidence showing discrete cortical activity for individual semantic features (Kemmerer et al., 2008, Tyler et al., 2004). The present study investigated whether intensive training of semantic features of a subset of verbs can improve retrieval of related classes of verbs (see Table 2).

Previous treatments of verb naming in aphasia

Researchers have found limited generalization to untrained verbs with verb naming treatments that incorporate both purely semantic and semantic-syntactic features of verbs. Generalization refers to improvement for untrained stimuli, tasks, and settings following treatment, and is considered the gold-standard for aphasia therapy, as it translates to more efficacious treatment. The limited success of syntactically-based verb naming treatments in facilitating generalization to untrained verbs suggests that other treatment options need to be explored and, as previously noted, demonstrates that verb naming difficulties may be linked to limited access to purely semantic features.

However, there have been relatively few studies of semantic feature training to improve verb naming in aphasia.

There have been far fewer investigations of verb naming treatment when compared to noun naming treatment in aphasia. Moreover, verb naming therapies have not reported as significant generalization to untrained stimuli as have treatments of noun naming. Perhaps the lack of reported generalization is due to verb selection based on parameters such as frequency and imageability. These studies trained verbs from several semantic classes with a variety of features.

Additionally, a majority of the previous studies of verb retrieval treatment have been modeled on noun naming therapies, which typically use a combination of phonemic cueing and semantic cueing, and/or semantic features analysis (Wambaugh, Linebaugh, Doyle, Martinez, Kalinyak-Fliszar, & Spencer, 2001; Wambaugh, Doyle, Martinez, & Kalinyak-Fliszar, 2002). In two studies examining the effects of phonological cueing (PCT) and semantic cueing treatments (SCT) on lexical retrieval of verbs and nouns, Wambaugh et al. (2001) and Wambaugh et al. (2002) found mixed results based both on the participant characteristics and on order of treatment application. The same three individuals who had suffered left hemisphere cerebrovascular accidents (CVA) participated in both treatment studies. The three participants' profiles were characterized by the following deficits: one participant with primarily semantic deficit (SD); one participant with primarily phonological deficit (PD); and one participant with mixed semantic and phonological deficit (MD).

During the first study, Wambaugh et al. (2001) trained naming of nouns using SCT and PCT in an alternating treatments design. Each participant was trained with four different sets of 12 nouns, with two alternating applications of SCT and PCT. Following treatment, the participant with a primarily semantic deficit (SD) responded similarly to both treatments. The participant with a primarily phonological deficit (PD) demonstrated greater improvement with SCT than with PCT. Finally, the participant with a mixed semantic and phonological deficit (MD) demonstrated similar responses to both treatments during both applications. Two participants (SD and PD) demonstrated generalization to untrained nouns over probe sessions. However, MD displayed no significant generalization to untrained stimuli. This may be likely due to the fact that the deficit was more severe, and thus impacted learning and generalization with both treatment applications.

In a subsequent study, the same three participants underwent verb naming treatment using two alternating phases of PCT and SCT each (Wambaugh et al., 2002). Two participants (SD and PD) were trained with three sets of 12 verbs, while the third participant (MD) was trained with three sets of 6 verbs each. Different sets of verbs were selected for different phases of application of SCT and PCT. A criterion level for cessation of this verb naming treatment was set at 90%, and generalization was tested to determine naming accuracy with untrained stimuli. The first participant, SD, did not meet the criterion level of 90% on verb naming when

SCT was administered first. He did, however, reach criterion during the second phase during which PCT was administered. The second participant (PD) demonstrated rapid improvement when SCT was administered during the first phase, meeting criterion before the end of the first phase. The third participant (MD) did not improve enough to meet criterion with PCT during phase one. However, during phase two with SCT, this participant improved to reach the 90% criterion (Wambaugh et al., 2001, 2002). These findings suggest that a participant's primary deficit (i.e., phonological, semantic, mixed phonological-semantic) can affect responsiveness to a treatment that targets only semantic features of verbs.

Overall, Wambaugh et al.'s (2001, 2002) studies demonstrated that participants with primarily semantic deficits benefited from PCT, while participants with phonological deficits showed the greatest improvement with SCT. These studies found no generalization to untrained verbs, but did see generalization to untrained nouns with shared semantic features. The lack of generalization to untrained verbs was likely a result of several factors. First, although each participant was designated as having a primarily semantic deficit or a primarily phonological deficit, in reality the participants likely displayed a deficit in more than one area of function. In other words, the participant with a primary semantic deficit may have had some degree of phonological impairment. Therefore, application of semantic and phonological treatment processes for generalization may have been limited by these compound deficits. A second factor that may have affected generalization was stimuli selection. The treatment verbs were not selected based on a semantic category and thus there was no core set of semantic features trained for any verb class. Instead, features of individual verbs were trained irrespective of any semantic category. Thus generalization would not have been expected to verbs within a category because class-general features were not directly trained.

In a 2002 case study, Raymer and Ellsworth examined the efficacy of three different verb retrieval treatments in a multiple baseline alternating treatments design (phonological, semantic, rehearsal) with one participant with nonfluent aphasia. A different set of verbs was used during each of the three treatments phases to prevent carryover from previous phases. Results from this study show that the participant's verb naming in a confrontation naming task improved from 8.33% accuracy across baselines to 90% with phonological treatment, from 17.5% accuracy across baselines to 100% with semantic treatment, and from 12.2% accuracy across baselines to 85% with rehearsal treatment. Maintenance at one-month post-treatment was determined to be between 75% and 95% for the three verb sets. As with previous studies, generalization to verb naming of untrained stimuli was not reported in this study.

One approach to noun naming treatment that has been adapted for use with verb retrieval is semantic feature analysis (SFA), which involves training features of objects relevant both to the specific noun and to its category. SFA differs from semantic cueing treatment (SCT) in that the latter provides a hierarchy of semantic cues—both visual and verbal—to facilitate object naming (Wambaugh et al., 2001). The participant is provided with a picture of the target word, as well as two semantically related words and one unrelated distracter. The clinician provides a phrase description of the target, and the participant is asked to point to the correct picture. For example, if the target word is *duck*, the participant is provided with a picture of a duck, a bird, a fish, and a chair. The clinician provides a description of the target word. A specific cueing hierarchy is followed for incorrect responses to the target items (Wambaugh et al., 2001). On the other hand, SFA (as described by Boyle and Coelho, 1995) requires the individual to verbalize features of an object that have been provided in writing by the clinician. These features are inherent to the word's group (what category the object is in), use, action (what the object does), properties (the object has), location (the object is found in), and association (what the object reminds one of). For example, the participant might have a picture of a chair and be required to verbalize the feature "You sit on it" for the *Use* column. In a study to treat naming with one participant with anomic aphasia, Boyle and Coelho (1995) tested SFA as a treatment approach for object naming. The semantic features analysis task required the participants to generate six features (mentioned above) about a target noun picture. Oral and written assistance was provided as necessary.

While SFA has found considerable success as a treatment approach for noun retrieval, there is less evidence to support this method as an efficacious therapy approach for verb naming. Only one study has reported efficacy data for use of SFA as a treatment application for verb naming. This study was conducted by Wambaugh and Ferguson (2007), who used semantic feature analysis treatment to train verb names in one participant with anomic aphasia. These investigators used forty black and white line drawings to treat confrontation naming of pictures of actions. The participant was asked questions pertaining to semantic characteristics of the verbs as well as syntactic features, including the agent and purpose of the action. Following treatment, the participant demonstrated increased naming of trained items (from 30-

40% during baselines to 80% at the final treatment session), but did not show generalization to untrained stimuli. Some maintenance was observed, as the participant scored 60% on verb naming at the 6-week follow-up.

To summarize, a majority of the previous studies of verb retrieval treatment have been modeled on noun naming therapies with limited success in generalization (Wambaugh et al., 2001, 2002; Wambaugh & Ferguson, 2007). Unfortunately, few of these verb naming treatment studies have reported maintenance, an important measures for determining sustainability of treatment gains. One possible reason why prior studies of verb naming treatment have reported low generalization to untrained stimuli may be because these studies did not directly measure improvement within the confines of verb classes that share features (Marshall, Print, & Chiat, 1998). In other words, verb selection in these studies was based on lexical factors (including frequency and imageability) or on participant naming accuracy during baseline (with incorrectly named verbs placed into arbitrary treatment lists). Since selection of stimuli was not based on categorization into verb classes, within- and between-class generalization was not tested. It is relevant to assess generalization of verb naming to semantic classes that contain an overlapping subset of the trained semantic features, as studies of noun naming treatment have reported successful generalization to nouns with shared, but fewer, features (e.g., *penguin* to *robin*) (Kiran & Thompson, 2003; Pashek, 1998; Wambaugh et al., 2002).

Given the limited reports of generalization findings with prior verb treatment studies, it is worth examining if recent advances in our understanding of the lexical representations of verbs can be utilized to develop a treatment protocol that is more likely to generalize to untrained verbs. The concept of overlapping semantic features between verbs (e.g., *cut* verbs, which are +5 features, which may generalize to *contact* verbs, which are +3 of the same features, in Table 2) and the recent neuroimaging support for this concept is worth examining as a treatment principle. Teaching these features by training specific verbs within class could possibly facilitate naming to a larger number of verb classes encoding the trained class-general features. This complexity account of treatment is supported by data from Kiran and Thompson (2003), who found that treatment of more specific stimuli (e.g., *penguin*) improved naming of more typical items (e.g., *robin*). An adapted version of the semantic feature analysis described by Boyle and Coelho (1995) was utilized in the current thesis (see *Treatment Protocol* for treatment steps). SFA was relevant for use in the present study—in which treatment focused on training of semantic features of verbs including action, motion, tool use, change of state, and contact—because of its emphasis on training semantic aspects of target words.

The Present Study

Purpose and Research Questions

The purpose of the present study was to investigate the efficacy of a novel treatment approach that trained semantic features of verbs. The researcher wanted to determine whether generalization would occur with verbs 1) within the same class that share all features of trained verbs, 2) in a different class that share some, but not all, of the features, and 3) in a different class that share no semantic features with the trained verbs. The treatment specifically focused on semantic aspects and avoided other linguistic aspects of a verb such as syntax (e.g., argument structure).

The aim of the study was to facilitate naming of a larger scope of verbs by training semantic features of only a few verbs from a select semantic class. The current research study posed three questions: 1) would a semantically based treatment facilitate within-class generalization to naming of verbs within the same semantic class; 2) would this same treatment facilitate between-class generalization to verbs that encode similar features; and 3) would the treatment facilitate naming to a class of verbs that share no common features with either class of treatment verbs?

Hypotheses

The first research question asked whether a semantically based treatment facilitate naming of verbs within the same class (within-class generalization). In particular, would training of *cut* (or *contact*) verbs generalize to naming of other *cut* (or *contact*) verbs? It was hypothesized that treatment of verb naming of one semantic class would generalize to naming of other verbs within the same semantic class. More specifically, training of *cut* (or *contact*) verbs should generalize to naming of other *cut* (or *contact*) verbs. The second question addressed in this study was whether semantic treatment would facilitate naming of verbs in a related semantic class that had partial feature overlap with the trained verbs (between-class generalization). Additionally, the researcher was interested in whether there was a specific direction of generalization. More specifically, will training of *cut* verbs generalize to *contact* verbs? It was hypothesized that training of *cut* verbs (+5 features, see Table 2) would generalize to *contact* verbs (+3 features). This assumption was based on noun naming treatments, which have reported generalization to untrained nouns with fewer, but similar, semantic features (Pashek, 1998; Wambaugh, Doyle, Martinez, & Kalinyak-

Fliszar, 2002). However, the reverse pattern of generalization to *cut* verbs after training of *contact* verbs was not expected. Third, this research also questioned whether treatment of one verb class (*cut* or *contact* verbs) would generalize to a different category of verbs that did not share any semantic features (*nonverbal expression* verbs). Generalization to *nonverbal expression* verbs was not predicted after training of *cut* (or *contact*) verbs because there was no feature overlap (see Table 2). The additional purpose of including verbs of nonverbal expression was to establish that treatment effects would be restricted to the trained verb category (as per a multiple baseline design).

Design

A multiple baseline alternating treatments (ABACA) single participant design was used in the current study (see Figure 2 for an illustration of the design). For each participant, baseline performance (A) was established over a period of baseline testing. A period of treatment (B) was then initiated, with daily treatment probes to monitor progress for trained stimuli. Intermittent generalization probes were also administered once every three sessions to assess improvement to untrained stimuli. Generalization was assessed every third session in order to control for improvement in untrained items due to overexposure resulting from frequent testing. Post-treatment testing was completed immediately upon cessation of treatment to determine changes in language measures (i.e., Western Aphasia Battery, Object and Action Naming Battery). Also following cessation of treatment, maintenance (A) of verb naming for trained and untrained stimuli was tested. Maintenance is an essential component in efficacy studies of treatment research, as it measures the sustainability of treatment gains over a period of time. For the second participant (Participant B), a second phase of treatment (C) was initiated after a two-week break following phase 1 (to ensure lack of carryover from the previous treatment phase).

Again, daily treatment probes and intermittent generalization probes were administered following the same time frame as the first phase to assess improvement in naming for both trained and untrained stimuli. To summarize, Participant A received an ABA design while Participant B received an ACABA design (B=cut verbs, C= contact verbs).

The present study was designed as a pilot research study of treatment efficacy. It is anticipated that the findings of this preliminary study will inform future research on verb retrieval treatments. Since the current study used a purely semantic (and single word) approach to treatment, no claims were made about improvement to sentence production, although some research has suggested that improved verb retrieval could facilitate more effective sentence formulation (Bastiaanse, Rispens, Ruigendijk, Rabadan, & Thompson, 2002).

BASELINE	TREATMENT	POST-TREATMENT TESTING	TREATMENT (2 weeks later)	POST-TREATMENT TESTING
Both participants Session 1: Eligibility testing Sessions 2 to 4: Verb naming baseline measures for participant A Sessions 2 and 3: Verb naming baseline measures for participant B	Participant A: *Cut* Verbs Participant B: *Contact* Verbs *Treatment probes every session *Generalization probes every third session *15-session limit if criterion for cessation is unmet	**Both Participants** Immediate post-treatment: Repeat tests from session 1 and generalization probe Participant A 4-week follow up: 1 treatment probe, 1 generalization probe	Participant B: *Cut* Verbs *Treatment probes every session *Generalization probes every third session *15-session limit if criterion for cessation is unmet	**Participant B** Immediate post-treatment: Repeat tests from session 1 and generalization probe 4-week follow up: 1 treatment probe, 1 generalization probe

TIME →

Figure 2. Illustration of treatment study design.

Chapter 2: METHODS

Participants

Two participants (both male) were recruited from a database of individuals with aphasia at the University of Maryland's Aphasia Research Center from among those who had consented to participate in future studies. Please see Table 3 for demographic information for both participants. Neither participant was enrolled in any individual language therapy at the time of the treatment phase of this study. The participants had developed aphasia consequent to a single left hemisphere cerebrovascular accident (CVA), were at least one-year post onset, were pre-morbidly fluent speakers of English (Participant B was a bilingual speaker of English and Chinese), had at least high school education, and had no pre-morbid history of psychiatric, neurological, cognitive, or speech-language deficits. One participant (Participant B) was self-reportedly a native speaker of Chinese but was a fluent speaker of English. He reported having been fluent in English for thirty years. Both participants passed puretone audiometric screening (Participant A: unaided; Participant B: aided) at 500, 1000, and 2000Hz (ANSI: 1969 at 25dBHL) in both ears and passed a vision screen, defined as at least 20/40 corrected or uncorrected vision and the absence of spatial neglect and visual field deficits. Similarly, both participants demonstrated adequate reading for single words and short phrases, as determined by a screening test before initiation of treatment. Exclusionary criteria for participants in this study included the presence of significant verbal apraxia as defined by a score of severe on the Apraxia Battery for Adults-2nd edition (ABA-2) (Dabul, 2000).

Table 3. Participant demographic information.

	Age	Years of Education	Years:Months Post-Onset	Location of Lesion	Occupation Prior to Illness
Participant A	47;7	12	2;10	Left MCA	Transportation
Participant B	62;10	24	5;0	Left MCA	Small business owner

The participants recruited for the study met the following language criteria: 1) language profile consistent with Broca's aphasia per the Western Aphasia Battery (WAB) (Kertesz, 1982); 2) an agrammatic speech production profile as determined from narrative speech samples elicited from the picnic picture of the WAB; 3) verb retrieval difficulty present in narrative speech as well as confrontation naming; and 4) relatively stable verb naming across baselines (see Table 5 for participant pre-treatment language testing scores). For the purpose of this thesis, a verb retrieval difficulty was operationally defined as the number of verbs produced being less than half the number produced by a normative sample for the same narratives[1], confrontation naming accuracy of 75% or less for verbs on the Object and Action Naming Battery (Druks & Masterson, 2000), and accuracy variability within 20% for verb naming across multiple baselines. The language tests used to determine eligibility are further described under the *Language Testing* section.

[1] Normative data was obtained from description of WAB (Kertesz, 1982) picnic picture by age-matched normals at the Aphasia Research Center. Data from 12 normal individuals was gathered, and these individuals produced an average of 14.58 verbs during the picnic picture description task (range: 5-21; sum: 175).

Stimuli and materials

Presence or absence of the five features used by Kemmerer et al. (2008)—contact, motion, action, tool use, change of state—were used to select the verb stimuli for the present study (see Table 2). Thirty-five verbs were selected from Levin's (1993) categorization of verbs grouped by semantic category. The verbs chosen for this study fell into the following three categories: 14 *cut* verbs, 14 *contact* verbs, and 7 *nonverbal expression* verbs (refer to Appendix A for a complete list of treatment and generalization verbs). All stimuli were controlled for argument structure.

For each of the thirty-five verbs, a 5-second video clip was filmed. All video clips showed an actor performing the target action on a recipient (e.g., for the verb *chop*, an actor was recorded chopping a piece of celery). All of the video clips were set against a solid background in order to minimize visual complexity. Seven of each of the *cut* and *contact* verbs were used as treatment stimuli, while the other seven were used to assess generalization. To avoid over-exposure of treatment verb videos, two separate video clips were filmed for each treatment target. One set was used for treatment steps (i.e., naming, sentence production) and the second set was used for testing acquisition of treatment verbs (henceforth called treatment probes). The two sets of videos had a different actor completing the actions on different recipients. For example, the verb *dice* had a treatment video displaying a male actor dicing an onion and a treatment probe video with a female actor dicing a piece of celery. Normative naming accuracy for the video clips was obtained by showing the videos to fifteen non-brain-damaged, native English-speaking volunteers (8 males and 7 females, see Table 4 for demographic information). Non-brain damaged participants were asked to provide a name for the action and give another possible answer/synonym in the case that the target verb was not elicited. The same verbal corrective prompts were used for normative procedures as were provided to participants during treatment (refer to *Verb Deficit* section under *Procedure* heading). For example, if a participant provided *cut* for the verb *slice*, he was given a verbal prompt to “Give a more specific name for this action.” Only videos of verbs with a naming accuracy score of 80% across normal control participants were used in the study. Videos for which 80% naming accuracy was not achieved were re-filmed and normative procedures were re-administered. Verbs for which video naming accuracy failed to reach 80% following two norming procedures were not used in the study.

Table 4. Non-brain damaged participant demographic information.

Gender	Age	Years of Education	Occupation
M	52	18	Insurance underwriter
M	49	14	Sales associate
F	50	14	Medical assistant
F	63	16	Retired school teacher
F	51	14	Homemaker
M	54	18	Construction manager
F	59	14	Insurance auditor
M	56	19	Certified public accountant
M	56	18	Regional sales manager
M	54	18	Retired lawyer
F	52	14	Retired administrative assistant
M	67	18	Priest
F	46	14	Homemaker
M	58	19	Computer engineer
F	56	14	Homemaker

For each of the fourteen target verbs (7 *cut* and 7 *contact*), a still shot of the action was obtained from the 5-second video clip. These still shots were provided for the participants to view during two treatment steps: generation of semantic features and semantic feature analysis. Figures 3a and 3b shows the still shots used for two *cut* treatment verbs (Fig. 3a) and two *contact* treatment verbs (Fig. 3B).

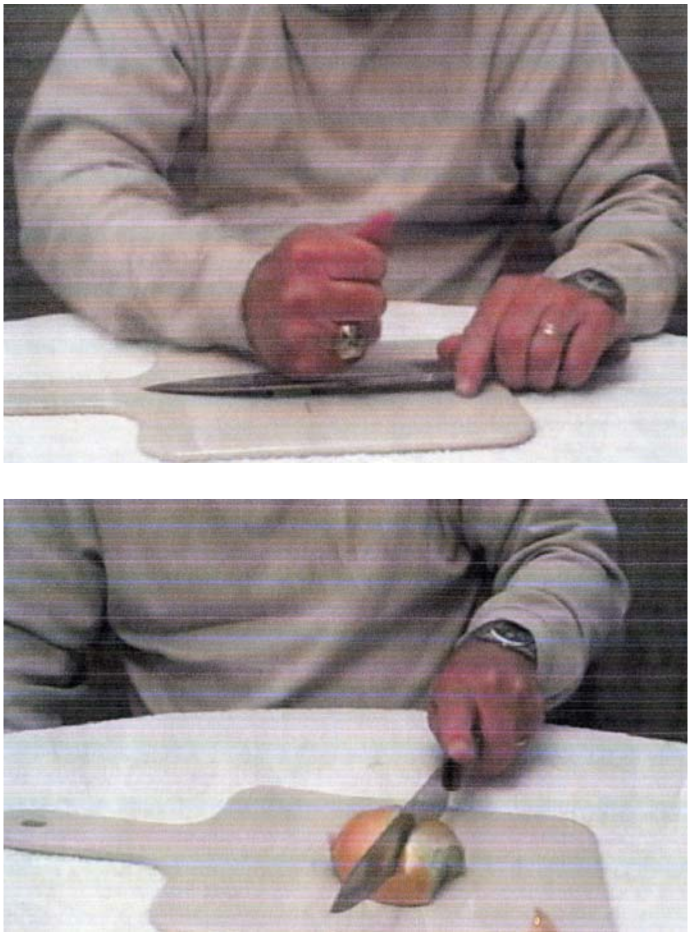


Figure 3a. Still shots depicting two *cut* treatment verbs (*hack* on the top; *crush* on the bottom).

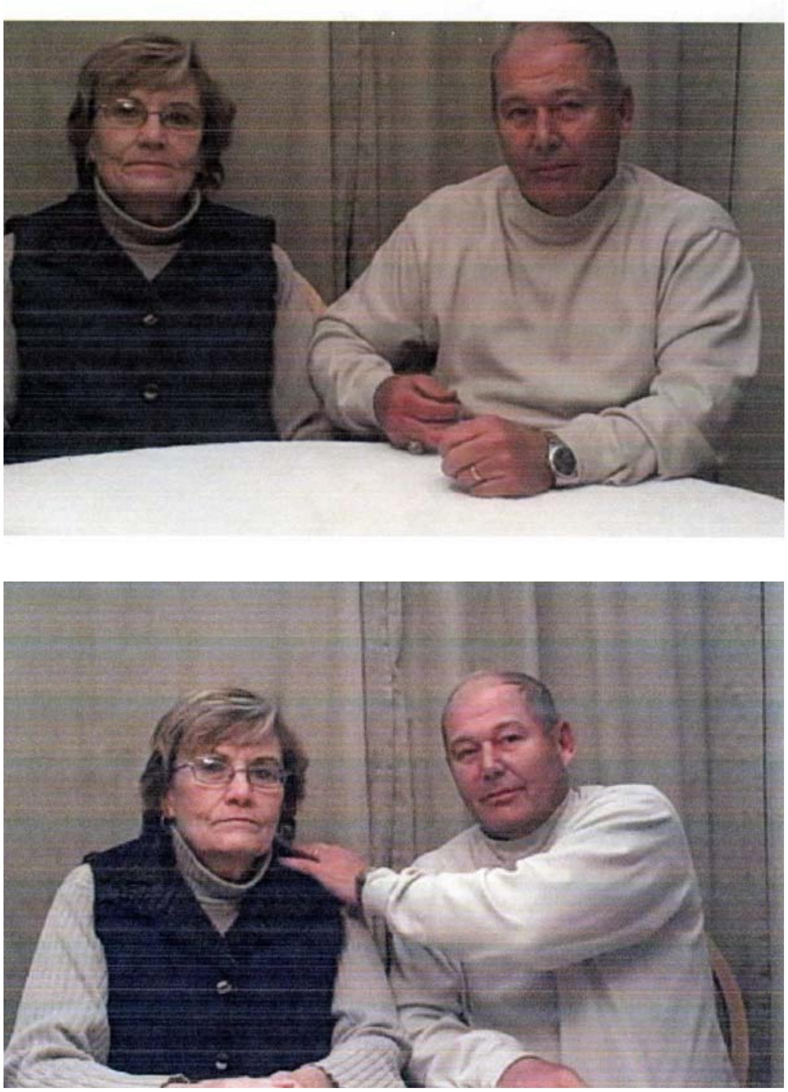


Figure 3b. Still shots depicting two *contact* treatment verbs (*nudge* on the top; *touch* on the bottom).

Due to limited filmability of some actions, treatment and generalization verbs were not matched for frequency. Appendix B provides the lemma frequencies of all treatment and generalization verbs used in this study per the CELEX database. Based on the CELEX database of lemma frequency (Baayen, Piepenbrock, & van Rijn, 1993), the seven *nonverbal expression* verbs used for generalization in the present treatment study had an average frequency rating of 31 occurrences per one million words (range: 4-161) compared to an average frequency of 27 for *contact* and 9 for *cut* verbs. There were two verbs (*smile*, *touch*) for which lemma frequency was determined to significantly inflate the average frequency of the verb class. Therefore, these outliers were removed for statistical analysis. The resulting lemma frequencies were as follows: *cut* verbs= 9; *contact* verbs= 20.7; and *nonverbal expression* verbs= 20.3. T-test values (alpha= 0.05) were not significant for *nonverbal expression* versus *contact* verbs (p value= 0.836) or for *nonverbal expression* versus *cut* verbs (p value= 0.167), but were significant for the frequency difference between *cut* and *contact* verbs (p value= 0.036).

Procedure

All participants signed a consent form approved by the University of Maryland Institutional Review Board; therefore, this treatment study was conducted in accordance with ethical standards set forth by the Declaration of Helsinki. The following section will outline: a) language tests used to determine eligibility, b) steps to be used in verb naming treatment, c) procedures used to assess naming accuracy of trained (treatment probes) and untrained (generalization probes) verbs, and d) post-treatment testing.

Both participants underwent an initial testing phase (2-3 sessions) to determine eligibility and baseline verb naming accuracy. Baseline and pre-treatment language testing were followed by verb naming therapy (Participant A: one phase; Participant B: two phases), which was subsequently followed by post-treatment testing. Please refer to *Design* section in Chapter 1 for a more thorough description of the treatment design. During phase 1, Participant A was treated with 7 *cut* verbs, and generalization was tested to seven other *cut* verbs (overlap in all five trained semantic features), *contact* verbs (three feature overlap), and *nonverbal expression* verbs (no semantic feature overlap). In phase 1, Participant B received treatment with 7 *contact* verbs, while generalization was tested to *cut*, other *contact* and *nonverbal expression* verbs. The stimuli selection for this phase (i.e., *cut* verbs: + five semantic features; *contact* verbs: + three features) allowed the researcher to test generalization to verbs with fewer semantic features (Participant A) and to verbs with more semantic features (Participant B). Since it was not expected that Participant B would generalize to improved production of *cut* verbs in phase 1, he underwent a second phase of treatment during which he received treatment with seven *cut* verbs.

Language testing

The following language measures were assessed during initial testing and post-treatment testing.

Western Aphasia Battery. Participants' aphasia profiles were obtained by administering the Western Aphasia Battery (WAB) (Kertesz, 1982). This standardized test was used to obtain an aphasia quotient, which is a composite severity score that includes picture description, auditory comprehension, repetition, and naming tasks. The participants demonstrated impaired syntactic forms on the picture description (fluency score of 5 or less, per WAB normative data), with relatively spared auditory comprehension and repetition (auditory comprehension score of 4.0 or higher, repetition score greater than 7.9) per Kertesz (1982) normative data on performance of participants with Broca's aphasia.

Profile of agrammatism. Participants' agrammatic profiles were determined for eligibility by using narrative speech samples from the WAB (Kertesz, 1982) picnic picture narrative. A participant was determined to have a profile of agrammatic speech if his proportion of sentences was less than 0.5 for the WAB picnic picture narrative.

Verb deficit. Presence of a verb deficit for inclusionary criteria was determined using three measures: 1) Object and Action Naming Battery (OANB; Druks & Masterson, 2000); 2) verb omission in narrative context; and 3) naming accuracy for treatment and generalization verbs. The OANB, which involves confrontation naming of line drawings, was administered to ensure that the participants for the current study presented with verb retrieval deficits. A verb retrieval deficit was operationally defined as an accuracy score below 75% on this test. Although noun retrieval was documented for descriptive purposes, this measure was not used as an eligibility factor for the current study.

The proportion of verbs used in a narrative task was computed. Since agrammatic speech is characterized by a paucity of verbs in connected speech, inclusionary criteria for participation in the current study included production of fewer than half of the verbs of the normative sample in narrative context. The researcher used normative data from the Aphasia Research Center for the WAB (Kertesz, 1982) picnic picture to determine verb deficit for participants describing the same picnic picture (a black and white line drawing).

The third measure for determining a verb deficit was baseline naming accuracy for all thirty-five verbs. As is typical with single participant designs, each participant received a different number of baseline tests in order to demonstrate that changes in verb naming are related to the onset of therapy and not to the amount of exposure to treatment stimuli. Verb naming was elicited thrice for Participant A and twice for Participant B. The procedure for the naming task involved asking participants to, “Name this action,” while 1) asking for alternative names if a semantic paraphasia or synonym was produced, 2) accepting minor phonemic paraphasias as long as the target was unambiguous, and 3) accepting correct written responses after one incorrect verbal attempt. Independently self-corrected responses were accepted within 10 seconds of an initial incorrect response. Responses were recorded on-line by the researcher, but were also audio and video recorded for later verification and reliability testing.

Treatment protocol

Participants received four one-hour treatment sessions every week. The criteria for cessation of treatment were when participants met one of three conditions: 1) accuracy of 6 out of 7 on three consecutive treatment probes; 2) less than 30% increase from baseline treatment verb naming accuracy after eight sessions; or 3) failure to meet 6 out of 7 criteria at the end of 15 sessions. These cessation criteria were determined a priori based on clinical practices and previous research from Faroqi-Shah (2008).

Every treatment session, including treatment and generalization probes, was audio and video recorded for reliability scoring (see *Reliability* section under *Results*). Treatment probes, consisting of video clips of the seven treatment verbs, were administered at the beginning of every session to determine acquisition of trained verbs. Generalization probes were administered once every third session in order to assess improvement to untrained stimuli. During treatment and generalization probes, the researcher provided the participants with the following prompts, as needed: 1) (S)- Specific (e.g., the participant provided *cut* for *slice*): the researcher requested that the participant "Give a more specific name for this action;" 2) (W)- Written: if the participants were unable to say the word, the researcher provided the opportunity to "Write the name of this action." These were the only two prompts provided during probe sessions. Treatment and generalization probes were scored using the same criteria as baseline naming (refer to *Verb Deficit* section for these scoring procedures). The treatment steps used in this study targeted semantic features of verbs. The treatment stimuli were presented in a random sequence during each session to avoid effects caused by order memorization. The following sequence of treatment steps were used for each of seven treatment verbs:

Naming. This step was used as a warm-up to familiarize the participant with the target. The participant viewed a 5-second video clip showing the treatment verb. The researcher then instructed the participant to "Name the action in this video clip." If the participant provided an incorrect response, the researcher offered a verbal correction by saying, "No, the action in this video clip is __(mince)__." If the participant provided the correct response in this step, the researcher continued with following treatment steps.

Generation of semantic features. A "still shot" from the video clip was displayed, and the participant was instructed to independently generate three features for the target verb (e.g., "It requires a tool."). If unable to independently produce three features, the researcher provided a verbal yes/no prompt (e.g., "Does it _require a tool?") The researcher provided one yes/no prompt for each semantic feature the participant was unable to generate (i.e., a maximum of three prompts were provided). The participant repeated features provided by the researcher in order to facilitate their repertoire of semantic characteristics for each treatment verb.

Semantic feature analysis. As previously mentioned, this step was adapted from the semantic feature analysis treatment described by Boyle and Coelho (1995). For this task, a card with the printed verb name was placed in front of the participant (please see Figure 4 for a sample layout of this step). Two columns (one on either side of the printed treatment verb name) were labeled with index cards, one reading *YES* and the other reading *NO* (i.e., to indicate "YES, this feature is characteristic of this verb," or "NO, this feature does not belong with this verb.") Four cards, each containing a semantic feature that was relevant or irrelevant to the verb in the picture, were placed in a row in front of the participant. Each of the four cards contained a different characteristic: 1) one characteristic of the target verb; 2) one characteristic common to the entire class of treatment verbs; 3) one characteristic of another verb in the same class, but that did not apply to the target verb; and 4) one irrelevant characteristic. For example, the features to be classified for the verb *mince* included: 1) Results in finer pieces; 2) Tool use; 3) Results in large, coarse pieces; and 4) Requires one's leg. The researcher read the features on the cards, and the participant was asked to repeat each one. The participant was then instructed to place each feature in the correct (YES or NO) column. For example, a card reading, "Tool use," would be placed in the *YES* column for the verb *mince.* If the participant put a feature in the incorrect column, the researcher moved the card to the proper column and provided an explanation for why a particular characteristic did/did not belong in that column (e.g., “This feature, ‘Tool use,’ goes with *mince* because, in order to mince a piece of meat, you need a tool, such as a knife.”) As with the previous treatment step, a “still shot” of the video clip was displayed for each verb during this task.

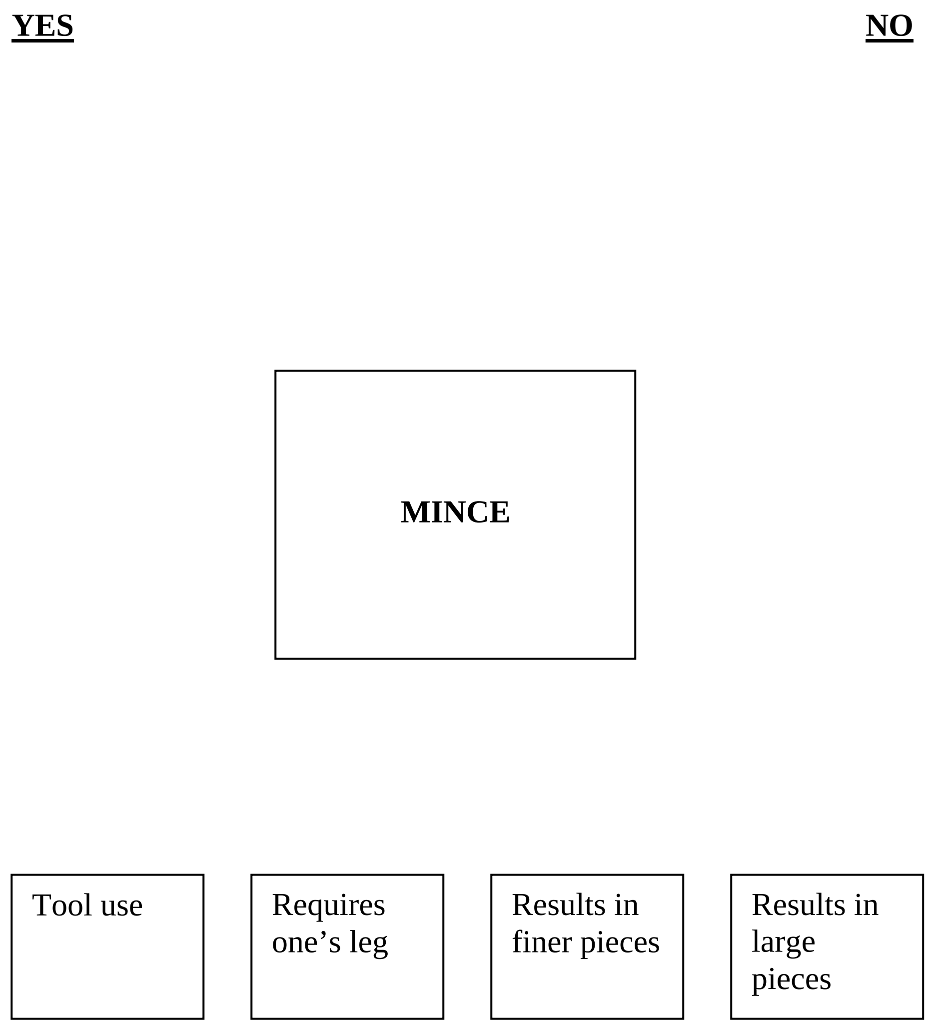


Figure 4. Sample set-up of semantic feature analysis task

Sentence production. For this step, the video clip of the target verb was re-played. The participant was instructed to, “Use a complete sentence to describe this video clip and be sure to include the action name we practiced.” If the participant produced a sentence that did not contain the target verb, the researcher prompted him by saying “Remember to use the action word _(mince)_ in your sentence.” If the participant used the target verb but did not produce a complete sentence, the researcher provided a verbal prompt to “Remember to use a complete sentence.” If the participant was still unable to produce a complete sentence using the target verb, the researcher provided an exemplar for him. For example, the researcher said, “For this clip, you could say, ‘She minced the celery,’” and the participant repeated the sentence.

Post-treatment testing

The measures assessed during initial testing were repeated during the post-treatment session immediately following cessation of treatment. The participants underwent post-treatment testing to: 1) determine treatment gains in verb naming (treatment probes); 2) assess generalization to untrained verbs (generalization probes); and 3) assess changes in aphasia quotient (WAB). Additionally, a four-week post-treatment testing session was conducted to evaluate maintenance of treatment gains in naming of trained verbs.

Data analyses

Participants in this single-subject design study served as their own control and, thus, changes in each participant’s pre- and post-treatment naming accuracy for trained and untrained stimuli were used to determine the effects of treatment. Where appropriate, McNemar’s change test (1969) was used to determine statistical significance (alpha level of 0.05). Effect sizes for level were calculated to determine magnitude of treatment and generalization gains for treatment and generalization probes using the following formula:

$$\frac{\text{Final post-treatment naming accuracy score} - \text{Mean pre-treatment naming accuracy}}{\text{Standard deviation of pre-treatment naming accuracy scores}}$$

Reliability

Inter-rater reliability was obtained for verb naming scores (the dependent variable) for trained and untrained stimuli by having a trained research assistant watch video of baselines, treatment probes, generalization probes, and administration of treatment protocol. Stimuli were randomly chosen for reliability, excluding responses that were obscured by technical failure of the video or audio equipment. The reliability scorer was trained by providing written and oral guidelines. Inter-rater reliability scores were obtained for scoring for 30% of all baselines, treatment probes, and generalization probes and exceeded 90%.

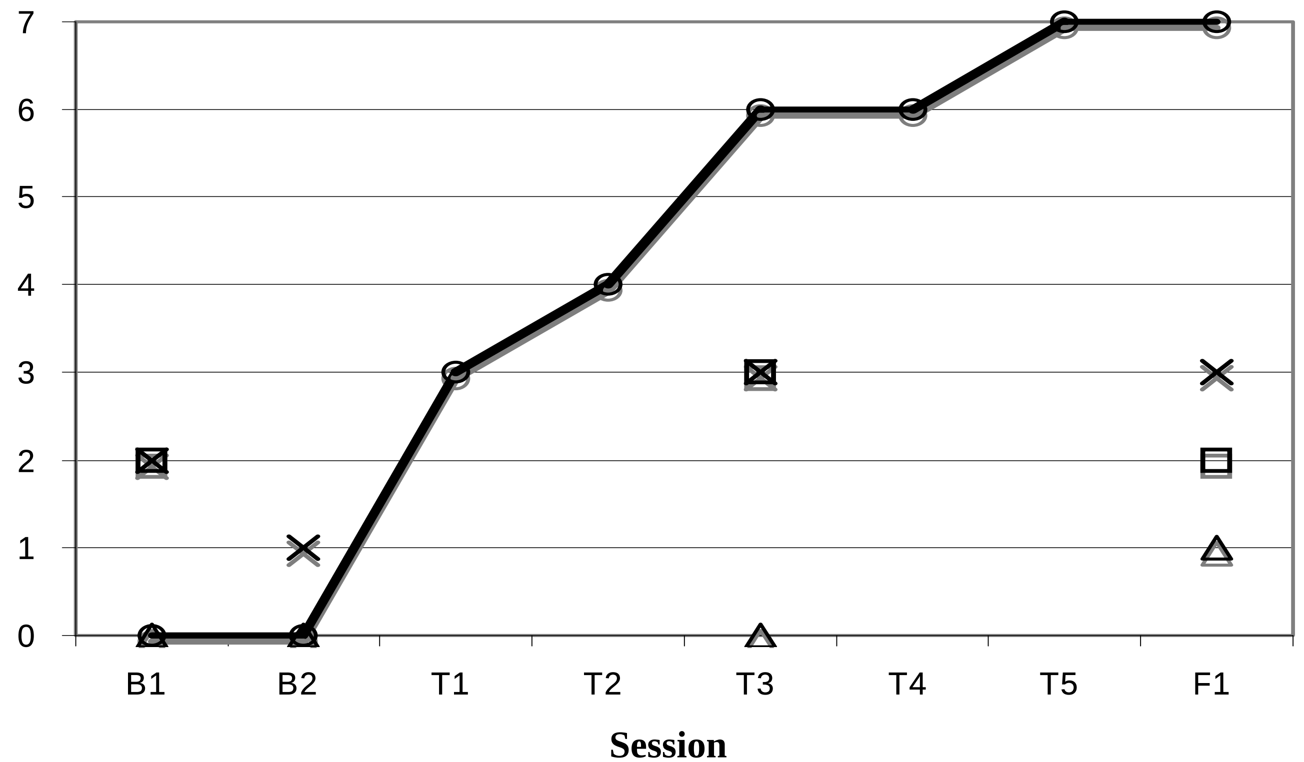
Administration of treatment protocol was scored for inter-rater reliability across 45% of treatment sessions. In order to obtain this measure, the trained research assistant watched video of treatment sessions and rated the primary researcher on a binary scale for whether steps set forth in the protocol were administered properly during treatment sessions (i.e., (+) for steps correctly administered, (-) for steps improperly administered.) Inter-rater reliability for administration of treatment protocol was 100%.

<u>Chapter 3</u>: RESULTS AND DISCUSSION

Participant A received treatment with *cut* verbs only, while Participant B was trained on *contact* verbs followed by *cut* verbs. In the following sections, the results are described by verb class.

Response to "contact" verb treatment

Figure 5 shows Participant B's naming accuracy of trained and untrained stimuli in response to treatment with *contact* verbs. By the end of five sessions, Participant B's naming of trained *contact* verbs showed a statistically significant improvement to 7 out of 7 (treatment effect size= 2.86; McNemar's change value= 6; p-value= 0.01). There was no observed generalization effect observed for untrained *contact* verbs, but some improvement to *nonverbal expression* verbs was seen (effect size= 0.357). This effect was not judged to be statistically significant (p= 0.26). On the other hand, a negative generalization effect was observed for untrained *cut* verbs (effect size= -3.9). Treatment with *contact* verbs concluded for Participant B at the end of five sessions because he met cessation criteria by scoring at least 6 out of 7 on three consecutive treatment probes. Participant B scored 7 out of 7 for trained *contact* verbs during the immediate post-treatment testing, but displayed minimal maintenance for these verbs over a period of several weeks (following treatment with *cut* verbs). He scored 2 out of 7 for *contact* verbs on the maintenance probes following treatment with *cut* verbs (up from 0 out of 7 on baseline probes).



<u>Figure 5</u>. Naming accuracy of treatment and generalization probes during baseline (B), treatment (T), and follow-up (F) for trained *contact* (● - circle) and untrained *contact* (Δ- triangle), *cut* (X), and *nonverbal expression* (■ - square) verbs for Participant B. This figure depicts Participant B's first phase of treatment (with *contact* verbs), and represents data points for treatment that occurred prior to T1(6) on Figure 6b. Treatment probes are connected by a solid line. Generalization probes were administered intermittently and thus not connected.

Response to "cut" verb treatment

Each participant's accuracy for trained *cut* verbs and the three categories of generalization verbs are given in Figures 6a and 6b. Figure 6a shows that Participant A failed to reach the criterion of 6 out of 7 verbs by the end of eight sessions and hence his treatment was terminated. There was no significant change in overall verb naming accuracy from baseline to post-treatment (McNemar's change test, $\chi^2= 2$; p= 0.0856). Additionally, this participant displayed negative effect sizes for all generalization verb classes- *cut* (effect size= -6.5), *contact* (effect size= -5), and nonverbal expression (effect size= -1.5). None of Participant A's changes in naming accuracy reached statistical significance. Participant A's accuracy for trained *cut* verbs showed little change from baseline in follow-up testing (scores of 2 at data point [F1B] and 1 at data point [F2B] in Figure 6a).

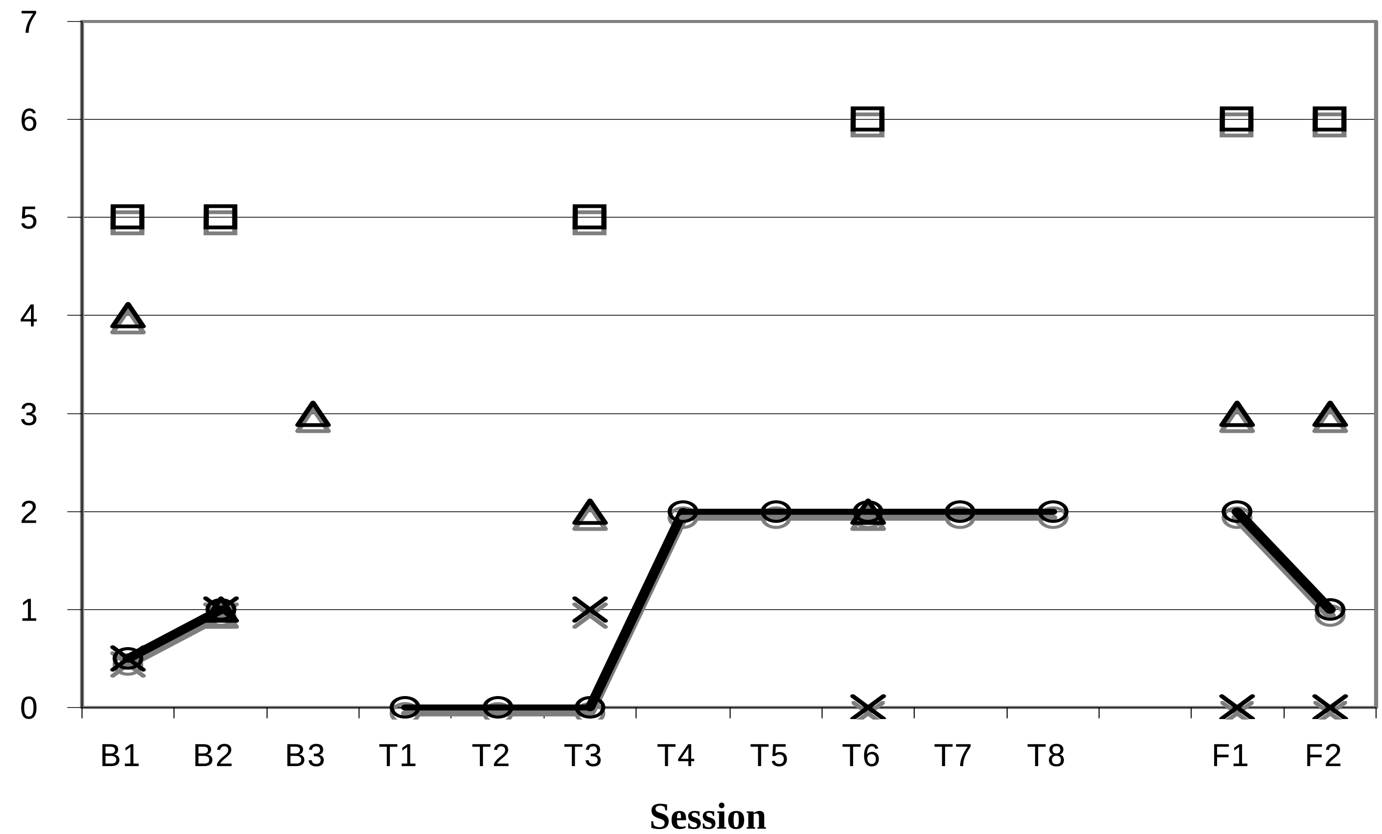


Figure 6a. Naming accuracy of treatment and generalization probes during baseline (B), treatment (T), and follow-up (F) for trained *cut* (● - circle) and untrained *cut* (X), *contact* (Δ- triangle), and *nonverbal expression* (■ - square) verbs for Participant A. Treatment probes are connected by a solid line. Generalization probes were administered intermittently and thus not connected.

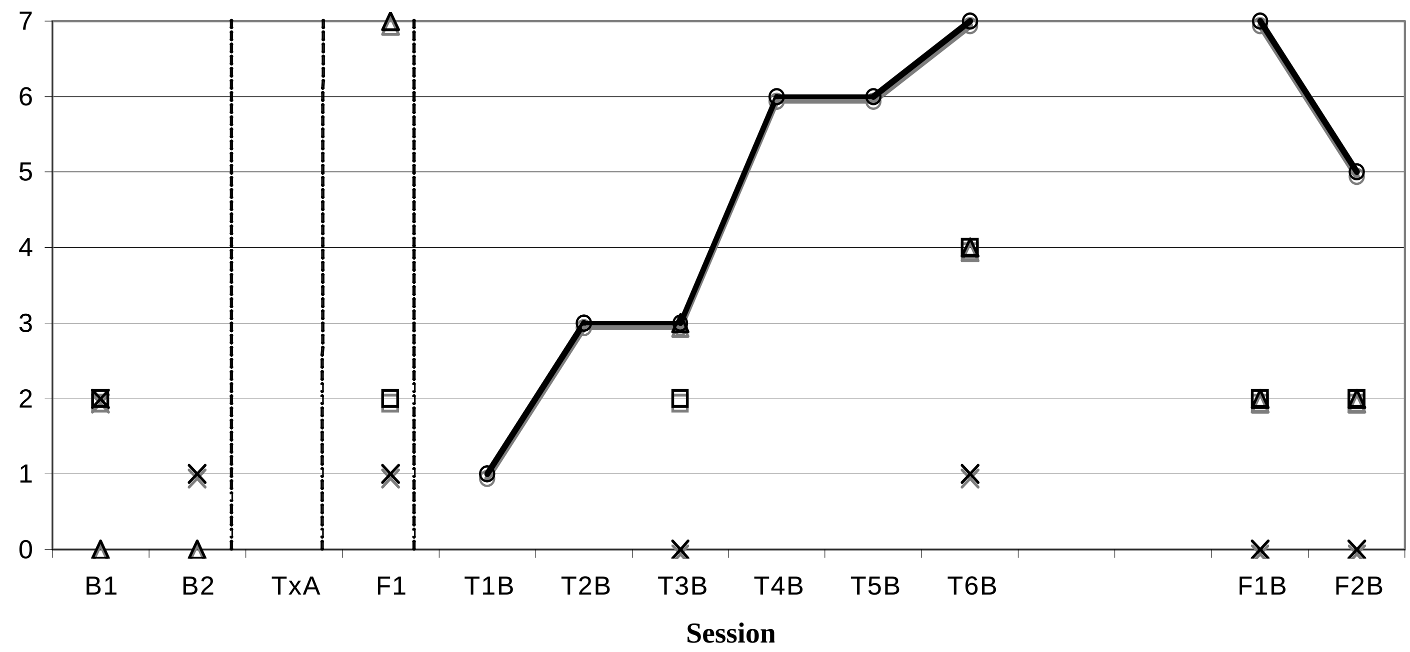


Figure 6b. Naming accuracy of treatment and generalization probes during baseline (B), treatment (T), and follow-up (F) for trained *cut* (● - circle) and untrained *cut* (X), *contact* (Δ- triangle), and *nonverbal expression* (■ - square) verbs for Participant B. This graph represents this participant's second phase of treatment (which followed treatment with *contact* verbs), thus the phase of treatment with *contact* verbs is demarcated by dotted lines and represented by the label TxA (hence, "A" is intended to represent the first phase of treatment). Similarly, the first follow-up value (F1) depicts the follow-up scores from *contact* treatment. These are a more accurate representation of baseline performance for the second phase of treatment (with *cut*), although initial baseline scores (B1 and B2) are also provided. In this graph, F1B refers to the first follow-up session with *cut* for Participant B, but the second overall follow-up session for this participant (hence, "B" is intended to represent the second phase of treatment). Similarly, T1B depicts the first treatment session with *cut* for Participant B, but his sixth overall treatment session. Treatment probes are connected by a solid line. Generalization probes were administered intermittently and thus not connected.

During treatment sessions, it was observed that Participant A had mastery of the semantic aspects of treatment verbs as demonstrated during the SFA task. However, he was still unable to name the verbs during treatment probes. Hence, during the fourth treatment session's probe elicitation, Participant A was given a choice of verbs for naming ("Is this a video of *mince* or *chop*?"). When given this choice, he revealed accurate knowledge of the verb name with an accuracy of 5 out of 7. This suggests that Participant A's performance during probes might have been limited by additional phonological output impairments. This is discussed more in the *Discussion* section. After the fourth treatment session, the researcher orally reviewed the treatment stimuli list with this participant prior to eliciting verb names (without any video clip context). This review was done in order to refresh phonological constructions of the treatment verbs. A one-minute conversation break followed review of the verb list. Ultimately, a review of treatment stimuli failed to improve Participant A's performance on treatment probes. Again, possible reasons for this will be discussed in more detail in the *Discussion* section.

Figure 6b shows that Participant B achieved the criterion of 6 out of 7 verbs in six treatment sessions. He was significantly more accurate with verb naming in post-treatment testing compared to baseline (treatment effect size: 2.86; McNemar's change value= 7; $\chi^2 = 2$; p-value= 0.08). This improvement in naming accuracy for trained verbs reached statistical significance. Additionally, there was a positive generalization effect for untrained *contact* verbs (effect size= 0.357). However, this generalization effect was not judged to be statistically significant (p-value= 0.68). No statistically significant positive generalization effect was observed for *cut* verbs or for verbs of *nonverbal expression*. Participant B displayed moderate maintenance of trained stimuli, with accuracy at 5 out of 7 during 4-week post-treatment follow-up testing.

To summarize, Participant A failed to improve in his response to treatment with *cut* verbs, while Participant B showed positive acquisition for both *cut* and *contact* verbs. Participant B also showed minimal generalization to untrained *contact* verbs during treatment with the same category. Interestingly, Participant B showed some (though inconsistent) improvement on naming of *nonverbal expression*, a category that was not predicted to change. Possible reasons for this result will be discussed later.

Error patterns

An analysis of the probe responses revealed unique error patterns for each participant. In the case of Participant A, there were 9 instances (across all eight treatment probes, or 56 stimuli) for which he provided no response. When he did provide a name for treatment probe videos, this participant occasionally used the names of treatment verbs with which he was more successful during therapy (e.g., *dice* for *slit, chip, shred*). This occurred in 11 out of 21 instances over three treatment probes. This same participant frequently provided *cut* as a response to multiple videos in a single treatment probe (in 7 out of 21 instances over the three aforementioned treatment probes).

While Participant A's errors were more reflective of his lack of acquisition of treatment stimuli, the incorrect responses provided by Participant B were characterized more by 1) within-class substitutions and semantic paraphasias during treatment with *cut* verbs and 2) phonemic paraphasias during *contact* treatment. More specifically, during treatment with *cut* verbs, 6 out of a total 16 errors were substitutions of the general class name (*cut*) for the correct response, while another 6 out of 16 errors were within-class paraphasias (e.g., *crush* for *hack*, *hack* for *crush*, *punch* for *chip*). During *contact* treatment, 3 out of the 8 errors made were phonemic paraphasias (e.g., *lip* for *lick*, *sinch* for *pinch*, and *nidge* for *nudge*). The *Discussion* section provides possible explanations for both participants' errors during probes.

Change in standardized language measures

Please see Table 5 for pre- and post-treatment language testing data. Statistical significance in changes is indicated, where appropriate. Both participants' changes in WAB aphasia quotient (AQ) and action naming on the OANB reached statistical significance on McNemar's change test. Not surprisingly, there was no significant change in object naming on the OANB for either participant. Implications for these findings are discussed in more detail in the *Discussion* section.

Table 5. Participants' pre- and post-treatment scores.

	Participant A		McNemar's Change Test Score	Participant B		McNemar's Change Test Score
	Pre-Tx	Post-tx		Pre-Tx	Post-Tx	
Western Aphasia Battery (Kertesz, 1982)						
Aphasia Quotient	68.8	76.4	7.6**	77	87.7	11.7**
Information Content*	7	9		8	10	
Fluency*	4	4		5	9	
Auditory Verbal Comprehension*	7.9	8.5		8.8	8.55	
Naming*	8.4	8.8		8.6	8.8	
Object and Action Naming Battery (Druks & Masterson, 2000)						
Objects (out of 100)	86	87	1	89	90	1
Actions (out of 100)	75	84	9**	66	71	5**
Number of verbs produced in picnic picture narrative	5	0		7	8	

* WAB subtest scores out of a possible 10 points

** Indicates statistical significance on McNemar's change test (alpha = 0.05)

Discussion

The present study investigated whether treatment of semantic features of a specific verb class would facilitate generalization 1) within the same class that share all features of the trained verbs, 2) to a different class of verbs that share some, but not all, of the features, and 3) to a different verb class that share no semantic features with the trained verbs. These research questions were methodologically approached by using a single participant ABA (Participant A) or ACABA (Participant B) treatment design that alternately trained *contact* and *cut* verbs.

Overall, the two participants responded differently to treatment. The possible reasons for this are discussed later. The primary finding of this study (based on Participant B's performance) is that, to some extent, treatment aimed at naming of verbs with a larger number of semantic features (*cut* verbs) facilitated naming of verbs with fewer semantic features (*contact* verbs), while the reverse direction of generalization (improvement of *cut* verbs upon treatment of *contact* verbs) was not observed. This finding supports previous research from noun naming studies, which revealed that exposure to a larger set of semantic features improved access to untrained stimuli with a smaller, overlapping subset of characteristics (Pashek, 1998; Wambaugh, 2001). However, two findings undermine this conclusion: first, Participant A failed to show any treatment gains, even on trained items; and second, there was no improvement for untrained verbs within the same semantic class (other *cut* verbs, which shared all five class-general overlapping semantic features).

It is noteworthy that Participant B first received training on *contact* verbs, followed (after a period of no treatment) by treatment of *cut* verbs. Within-class generalization was observed during *contact* treatment, and therefore it is plausible that improved naming of *contact* generalization verbs observed during the *cut* verb treatment phase could have been due to minimal carryover from prior treatment with *contact* verbs (Fig. 6b at data point [F1]). There was a two-week period between treatment with *contact* and *cut* verbs during which Participant B received no therapy. However, given that he demonstrated some maintenance of treatment gains with *cut* verbs up to four weeks following cessation of treatment (Fig. 6b [F2B], it is possible that this participant also retained some of the treatment gains from *contact* verbs, which would have inflated generalization scores for *contact* verbs during treatment with *cut* verbs.

Within-class generalization

Previous treatment studies of noun naming (Pashek, 1998; Wambaugh et al., 2002) have reported positive generalization to untrained stimuli that encode semantic features shared by treatment items. For this reason, the researcher expected both participants to demonstrate improved naming to untrained verbs within the treatment category, as these verbs share all class-general characteristics trained during treatment. However, no statistically significant within-class generalization effects were observed for either participant during treatment with either *cut* or *contact* verbs. This finding supports evidence from previous treatment studies of verb naming (Raymer & Ellsworth, 2002; Wambaugh & Ferguson, 2007), which reported no improvement to untrained items.

This study and other studies of verb naming have reported little to no generalization of untrained stimuli when compared to noun naming studies, which have reported positive generalization effects. It has been proposed that verbs are more complex than nouns on several dimensions. Their syntactic representations, including argument structure specification, poorer imageability, dynamicity, and later age of acquisition, are only a few of the factors that make the mental representation of verbs more complex (Conroy, Sage, & Lambon Ralph, 2006). In addition, there are neuropsychological double dissociations between verb and noun deficits: agrammatic aphasic patients are far more susceptible to verb deficits while anomic and Wernicke's aphasic individuals are more likely to have noun deficits (Berndt et al., 1997; Kim & Thompson, 2000; Kim & Thompson, 2004; Luzzatti et al., 2002; Zingeser & Berndt, 1990). Hence it is likely that these are two very different neuropsychological problems that warrant different therapy approaches. What works for noun naming therapies may not necessarily work for verb naming therapies.

Another factor that could have negatively affected both participants' generalization to untrained *cut* verbs was opacity of the videos used during treatment for this semantic class. Although, per CELEX (Baayen, Piepenbrock, & van Rijn, 1993), there was no statistically significant difference in lemma frequency for *nonverbal expression* verbs versus *cut* verbs (as previously discussed in the *Stimuli* section of Chapter 2: Methods), videos portraying verbs of *nonverbal expression* were more semantically transparent than those for *cut* verbs. While difficulty discerning subtle features of the *cut* verbs in treatment videos is may have negatively affected generalization outcomes, this would not explain the lack of within-class generalization for *contact* verbs.

Between-class generalization

As was the case for within-class generalization, it was hypothesized that both participants would improve to naming of generalization *contact* verbs following treatment with *cut*, an assumption based on data from noun naming treatments that reported generalization to categories with shared features (Pashek, 1998; Wambaugh et al., 2002). Although not statistically significant, this pattern was observed for Participant B (Fig. 6b [T6B]). While this finding contradicts previous studies of verb naming that have not reported generalization to untrained stimuli (Raymer & Ellsworth, 2002; Wambaugh & Ferguson, 2007), improvement to *contact* generalization items might have been due to residual treatment effects from the previous phase of therapy with this same verb class (Fig 6b [F1]). Although possible treatment carryover is one possible explanation for this pattern of generalization, this is not likely the cause given that Participant B improved in naming two untrained stimuli during the course of treatment. In other words, it is more plausible that, during the course of intense training of feature storage, retrieval, and generation with both treatment verb classes, Participant B acquired an effective method, or generalized strategy, for feature retrieval.

Participant B did not display the reverse pattern of generalization (improvement of *cut* verbs following treatment with *contact* verbs) (Fig. 5). This finding was expected, given that category-general features of the *cut* class were not trained and could thus not be retrieved for naming during generalization probes.

Participant A did not demonstrate between-class generalization following treatment with *cut* verbs. As previously discussed, several participant factors and linguistic aspects were believed to have negatively impacted his treatment and generalization effects.

Unrelated verb class generalization

Improvement to *nonverbal expression* verbs was not expected because the verbs these verbs shared no features common to either treatment verb class (*cut* or *contact*). Interestingly, however, Participant B showed some positive generalization effect for verbs of *nonverbal expression* during treatment with *cut* verbs (Fig. 6b). The reason for this improvement is unintuitive. The improvement could not have been due to the frequency of *nonverbal expression* verbs because, as previously mentioned in the *Stimuli* section of Chapter 2, there was no statistically significant difference between verbs of *nonverbal expression* and *cut* or *contact* verbs. A likely explanation for the positive generalization effects for this class could be the semantic distinctiveness and rather transparent imageability of these verbs. For example, *cough* and *yawn*, although both mouth/face verbs, are semantically more distinct than *dice* and *chop*, for which verb-specific features are more subtle. Evidence from previous studies suggests that individuals with aphasia have difficulty discerning subtle semantic differences among verbs in the same class (Kemmerer & Tranel, 2000a, 2000b). It is suspected that the subtlety of the *cut* features was not as easily conveyed through the treatment videos as were the actions conveyed by the *nonverbal expression* verbs.

Participant A's response to treatment

There are several possible factors that may have impacted Participant A's limited treatment outcome. Broadly, these could be based on his aphasic deficit or his pre-morbid characteristics. Verb naming deficits could arise from a variety of sources: a phonological deficit (an inaccessibility of the word form, as in the tip-of the tongue state) or a semantic deficit (loss or impaired access to semantic information). It is believed that Participant A showed some evidence of a phonological access deficit. For example, during treatment sessions, he performed very well on all the semantic feature steps, but was unable to name verbs during treatment probes. When given a forced choice ("Is this *dice* or *mince*?"), he was accurate in selecting the verb. Hence he demonstrated knowledge of the verb, but seemed limited in independent phonological access.

Loss or impaired access to verb specific semantic knowledge could also have affected Participant A's inability to acquire select treatment verbs. Traditionally, semantic loss is characterized by consistent errors in which the patient is unable to retrieve a word despite repeated exposure to the target (Raymer & Rothi, 2001). Semantic knowledge loss differs from semantic access deficits, which are characterized by inconsistent naming errors (Raymer & Rothi, 2001). The former (semantic loss) is more congruent with Participant A's errors during treatment. While he was able to retrieve the general class (*cut*) and two of the treatment verbs consistently (*shred* and *dice*), Participant A was unable to independently name the other target verbs during treatment, despite repeated exposure during the course of the session. Prior research has shown that, while superordinate categories (e.g., *cut* verbs) may be spared in the case of a semantic knowledge loss, less frequently occurring subordinates (e.g., *dice*, *slit*) are likely to be lost (Harley, 2008; Kim & Thompson, 2004). Wambaugh et al. (2001, 2002) described a participant with a semantic deficit who improved from phonological treatment, and vice versa. Participant A, with a suspected semantic deficit, may therefore benefit from a phonological treatment aimed at improving verb naming. This needs further investigation.

In addition to phonological and semantic deficits, it is possible that pre-morbid education, vocabulary, and learning styles played a role in the outcome differences for each participant. The two participants had vastly different levels of education (Participant A has a high school diploma, while Participant B has a doctoral degree). It is possible that Participant A's premorbid vocabulary and work-related lexical demands may not have included such verbs as were used in the present treatment study.

Standardized language scores

Aside from patterns of acquisition observed for treatment and generalization effects, the data from the present study also yielded interesting results with regard to standardized language measures following treatment. One noteworthy finding from the present study was the statistical significance in the change of pre- and post-treatment action naming on the Object and Action Naming Battery (OANB; Druks & Masterson, 2000). Both participants demonstrated a significant improvement in action naming, despite lack of training for these verbs or their classes. The *cut* verbs trained in treatment encode 5 features that are common to several verb categories (+motion, +action, +contact, +tool use, +change of state). It is possible that, for both participants, training these features with *cut* treatment strengthened semantic network access to the features, subsequently improving naming of verbs on the OANB that encode the trained features. For example, the verb *pouring* is +motion and +action (as well as being a hand verb, like all *cut* verbs). This notion is supported by neuroimaging evidence from Kemmerer et al. (2008), which shows unique cortical activation for retrieval of features.

Evidence for this pattern of generalization is further provided by data from both participants' performance on the OANB. For example, Participant A incorrectly named the following verbs during the pre-treatment evaluation, but provided correct responses during post-treatment testing: *waving, knitting, pulling, drawing*. Participant B improved on the following verbs: *raking, ringing, watering, pouring*. Interestingly, while none of these verbs were directly targeted during treatment, they all share features common to trained *cut* stimuli (+hand motion, +tool use, +action, +motion) with the exception of *waving*, which is –tool use. It is possible that through training neural networks (Kemmerer et al., 2008), naming improved for a larger number of verbs sharing these common features. This is further supported by evidence from two studies by Kemmerer and Tranel (2000a, 2000b), which showed that verb naming in aphasia may be affected by the encoding of certain characteristics (i.e., +change of state). Thus action naming on the OANB could have improved for stimuli that encode facilitative features that were trained during treatment.

Participant A's improvement on the Object and Action Naming Battery was particularly interesting, given his lack of acquisition of trained items. Evidence from Participant A's OANB results demonstrates that, despite lack of treatment gains, Participant A made some gains through treatment in order for action naming scores on this test to have improved. His increased action naming on this test cannot be attributed to repeated exposure to test items, as object naming scores did not improve.

As a cautionary note, both participants had previously received the WAB; therefore, it is possible that improvements in the aphasia quotient observed on this test were secondary to generalized practice effect. However, the treatment described in the current study seemed to provide generalized strategies, which facilitated improvements on two standardized measures of aphasia performance. Therefore, it is believed that gains for these standardized language measures were a function of improved verb naming rather than repeated exposure to test stimuli. Perhaps what was taught during the course of therapy was not only the names of seven specific treatment verbs, but rather a strategy for accessing features to facilitate verb retrieval. Evidence for this is supported by improvements in action naming on the OANB, as none of these test stimuli were trained during treatment.

Implications for aphasia therapy

Overall, evidence from this study supports findings from previous verb naming treatments (Raymer & Ellsworth, 2002; Wambaugh & Ferguson, 2007), which have found limited generalization to untrained items. And while one participant in the current study demonstrated between-class generalization to a verb class (*contact*) that encoded the same, though fewer, features, this improvement is suspected to be secondary to residual treatment effects with the same class.

Similar to the verb treatment study reported by Wambaugh and Ferguson (2007), the current research utilized an adapted semantic feature analysis task (Boyle & Coelho, 1995). The SFA task adapted for the present research was similar to that used by Wambaugh and Ferguson in that both treatments required patients to identify verb-specific features for treatment stimuli. However, the SFA step in the present treatment also required patients to identify class-general features. Given that treatment outcomes in the current study revealed some, although minimal, between-class generalization, it is suspected that training features of general semantic categories of verbs may be a more efficacious approach than simply training stimuli-specific factors.

Given the specificity of verbs trained in the current treatment and the relative complexity of verbs in general (Gentner, 1981), it may be beneficial to assess the performance of non-brain damaged individuals before future applications of this treatment. Analysis of errors and acquisition patterns displayed by normal participants may give further insight into what to expect when this treatment is applied with aphasia.

Limitations of the current study

Limitations arising from the small sample size should be considered when interpreting broader results of the present study, as inclusion of more than two participants is ideal for studies of treatment efficacy. The current thesis was designed to be a pilot study examining the effects of a verb naming treatment with only two participants enrolled in the experimental research. Therefore, any results need to be interpreted with caution, and follow up studies with larger sample sizes and alternating phases of treatment are necessary to provide affirmation of findings from the current study. Because Participant A could not participant in the second phase of treatment with *contact* verbs, a complete alternating treatment design could not be implemented.

Aside from limitations with sample size and treatment design, there were some stimuli-specific limitations encountered in the course of the present study. One factor that restricted the choice of treatment stimuli was the limited filmability of treatment and generalization verbs. The researcher initially intended to train each participant with ten verbs in each class (*cut* and *contact*) and test improvement to ten verbs in each generalization category. Some of the verbs (e.g., *pulverize*) were determined a priori to be too difficult both to film and to elicit, and were thus preemptively omitted from the selection process. Videoclips of filmed verbs were normed to test for naming agreement (discussed in the *Stimuli and Materials* section; Chapter 2: Methods). Normative measures were intended to ensure agreement upon targets of the video clips. As a result of poor naming agreement for some verb videos, these had to be eliminated from the study and hence the final list of stimuli was shorter than ideal. Limitations imposed by issues surrounding filmability left only seven verbs in each treatment verb set and seven verbs in each generalization verb class. Ideally, the treatment procedure proposed in the current study would be conducted with ten or more treatment verbs. The limited number of stimuli subsequently led to further issues with the present study: 1) treatment intensity; 2) matching stimuli for frequency; and 3) calculation of effect sizes.

The limited number of treatment stimuli negatively affected the number of treatment hours for each participant, thus resulting in less intense therapy. The researcher intended for each participant to receive eight hours of intensive therapy per week, as Bhogal, Teasell, Foley, & Speechley's (2003) meta-analysis found that participants receiving eight or more hours of treatment per week demonstrated the greatest maintenance of therapy gains. However, each participant took only fifteen to twenty minutes to complete one full cycle of treatment (with all seven treatment verbs). On a typical treatment day, therefore, both participants completed three cycles of treatment in approximately one hour. Future applications of this treatment would ideally utilize a longer list of training stimuli, which would subsequently result in more intensive treatment.

The second issue presented by limited verb filmability arose when matching the treatment and generalization verbs for lemma frequency with the CELEX database (Baayen, Piepenbrock, & van Rijn, 1993). The researcher was concerned with frequency of treatment and generalization verbs because previous studies of lexical access suggest that individuals with aphasia occasionally display more accurate, consistent retrieval of higher frequency words. Ideally, the treatment and generalization verbs would have been matched for lemma frequency to avoid inflated probe scores caused by stimuli with higher frequency ratings. Investigations into frequency of treatment and generalization verbs based on CELEX (Baayen, Piepenbrock, & van Rijn, 1993) revealed a statistically significant difference between frequency of *contact* and *cut* verbs, with a higher lemma frequency for the former (please refer to Appendix B for lemma frequencies of treatment and generalization verbs as obtained from CELEX). Therefore, it is possible that *contact* therapy outcomes were comparatively affected by frequency ratings. This is supported by performance data from the current study, as Participant B had a faster acquisition rate for *contact* verbs (average lemma frequency: 27; range: 4-59) than for *cut* verbs (average lemma frequency: 9; range: 1-21) because *contact* verbs are used more frequently.

Finally, the limited number of treatment videos negatively affected calculation of effect sizes during data analysis. With only seven treatment verbs, an improvement in naming of only one item resulted in a 14% increase in accuracy, which exponentially inflated effect sizes. This issue could be easily alleviated with the use of a larger number of treatment stimuli.

One a posteriori concern arose with regard to the SFA task (see *Treatment Protocol* in Chapter 2: Methods). Four written features (one specific to the treatment verb, one relevant to the entire class, one specific to another verb in the class but irrelevant to the treatment verb, and one feature unrelated to the verb) were presented on cards and participants were asked to identify whether the feature was a characteristic of the target verb or not. There is some likelihood that one or both of the participants memorized the features listed on the cards over the course of treatment. In future studies that incorporate this treatment step, it may be judicious to utilize randomized selection of eight feature cards (two verb specific, two class specific, two specific to another verb in the class, and two unrelated features) to avoid inflated performance on this task caused by memorization.

In general, several participant considerations and stimuli-specific factors are hypothesized to have impacted treatment outcomes. In some cases, these factors are believed to have inflated treatment outcomes (higher generalization effects for *nonverbal expression* verbs, which are more imageable). On the other hand, some participant factors (premorbid education, phonological and semantic deficits) and stimuli-related aspects (low frequency of *cut* verbs) were thought to have negatively impacted therapy outcomes.

Chapter 4: CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The results of this study demonstrate that training semantic features of verb classes may improve access to these features for some individuals with agrammatic aphasia. Retrieval of these features may facilitate naming of untrained stimuli in the case of some verb classes with a smaller, shared subset of characteristics. However, there are participant variables (i.e., pre-morbid education level, pre-morbid breadth of vocabulary) and stimuli-specific variables (i.e., filmability, variable training items for treatment steps) that may affect desired treatment outcomes. When considering treatment gains, the participant who seemed to present with some degree of both phonological and semantic deficits did not demonstrate as much improvement as did the other participant. In the future, it would be judicious to carefully consider participant factors for inclusion in this verb naming treatment, as the therapy described in the present study requires preserved phonological forms of words. Similarly, patients with semantic knowledge loss would likely not benefit from this treatment, as some preserved access to semantic features is necessary.

The nature of semantic deficits observed in aphasia are vastly complex and can co-occur with other deficits (i.e., phonological deficits) among individuals. Therefore, there is some likelihood that participant factors would interfere with anticipated treatment outcomes. To exclude the possibility that participant factors, and not complications imposed by treatment stimuli, were the driving factor in improvement following treatment, future applications of this design should incorporate equal administration of treatment phases (with both *cut* and *contact* verbs) among all participants. In other words, future research should uniformly utilize an ABACA or an ACABA design (B=*cut*, C=*contact*) to allow the researcher to correlate improvement from treatment with feature analysis.

The findings of the current study present some promising outcomes for future directions of semantic feature training for individuals with aphasia who demonstrate relative verb deficits. Given the between-class generalization observed following training with *cut* verbs (+5 features), future treatment studies should focus on training broader categories of features while assessing generalization to a wider variety of semantic classes that share subsets of trained characteristics. It is possible that training of class-general characteristics could improve naming of other semantic categories that share these features. Support for this is provided not only by generalization effects observed in this study, but also by the statistical significance in change observed between pre- and post-treatment action naming on the Object and Action Naming Battery (Druks & Masterson, 2000).

Appendix A. Treatment and generalization verbs for the current treatment study. Transitivity is a variable for all treatment verbs, as well as for most generalization verbs (*contact* verbs, *cut* verbs), with the exception of verbs of *nonverbal expression*, which are intransitive.

PHASE 1			
		Participant A	**Participant B**
	Treatment Verbs	*Cut* Verbs 1. Chip 2. Crush 3. Hack 4. Dice 5. Punch 6. Shred 7. Slit	*Contact* Verbs 1. Bite 2. Knock 3. Lick 4. Nudge 5. Pinch 6. Tickle 7. Touch
	Generalization Verbs	*Nonverbal Expression* Verbs 1. Cough 2. Gasp 3. Smile 4. Sneeze 5. Snore 6. Whistle 7. Yawn *Cut* Verbs 1. Chop 2. Cube 3. Grind 4. Perforate 5. Scrape 6. Slice 7. Spear *Contact* Verbs 1. Bump 2. Kiss 3. Pat 4. Rap 5. Scratch 6. Stroke 7. Tap	*Nonverbal Expression* Verbs 1. Cough 2. Gasp 3. Smile 4. Sneeze 5. Snore 6. Whistle 7. Yawn *Cut* Verbs 1. Chop 2. Cube 3. Grind 4. Perforate 5. Scrape 6. Slice 7. Spear *Contact* Verbs 1. Bump 2. Kiss 3. Pat 4. Rap 5. Scratch 6. Stroke 7. Tap

PHASE 2			
			Participant B
	Treatment Verbs		*Cut* Verbs 1. Chip 2. Crush 3. Hack 4. Dice 5. Punch 6. Shred 7. Slit
	Generalization Verbs		*Nonverbal Expression* Verbs 1. Cough 2. Gasp 3. Smile 4. Sneeze 5. Snore 6. Whistle 7. Yawn *Cut* Verbs 1. Chop 2. Cube 3. Grind 4. Perforate 5. Scrape 6. Slice 7. Spear *Contact* Verbs 1. Bump 2. Kiss 3. Pat 4. Rap 5. Scratch 6. Stroke 7. Tap

Appendix B. Lemma frequencies for treatment and generalization stimuli based on CELEX. Average frequencies are shown both for all verbs in the class (regular font) and with outliers removed (in bold italics).

		Frequency per million of verb form	Frequency per million of noun form
Cut			
	Chip	6	15
	Chop	19	6
	Crush	21	3
	Cube	2	9
	Dice	1	2
	Grind	27	2
	Hack	6	2
	Perforate	1	NA
	Punch	10	7
	Scrape	12	1
	Shred	4	4
	Slice	12	18
	Slit	3	5
	Spear	2	12
Mean frequency		9 / ***9***	6.61
Contact			
	Bite	27	15
	Bump	11	5
	Kiss	59	17
	Knock	54	8
	Lick	11	1
	Nudge	5	1
	Pat	17	2
	Pinch	9	4
	Rap	4	2
	Scratch	24	7
	Stroke	19	25
	Tap	25	20
	Tickle	4	0
	Touch	110	57
Mean frequency		27 / ***20.7***	11.7

Nonverbal Expression			
	Cough	12	12
	Gasp	16	5
	Smile	161	83
	Sneeze	3	1
	Snore	4	1
	Whistle	13	9
	Yawn	8	2
Mean frequency		31 / ***20.3***	16

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